PN-ACP-857
115035

VIABILITY OF POWER EXPORTS FROM BANGLADESH TO INDIA

PRE-FEASIBILITY REPORT

Prepared by

Bechtel National, Inc.
San Francisco, California, USA

for
Government of Bangladesh
Funded by
The United States Agency for International Development

SEPTEMBER 2000

23865-234-107-0001

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CONTRACT LAG-I-00-98-00006-00
Delivery Order 200 Work Order 107

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LIST OF ACRONYMS

BSCIC	Bangladesh Small and Cottage Industries Corporation
CERC	Central Electricity Regulatory Commission
EPZ	Export Processing Zone
GAIL	Gas Authority of India Ltd.
GHG	Greenhouse Gas
GOB	Government of Bangladesh
GOI	Government of India
GPSA	Gas Purchase and Sale Agreement
GTA	Gas Transportation Agreement
HVDC	High Voltage Direct Current
IA	Implementation Agreement
IPP	Independent Power Producer
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
MBM	Market-Based Mechanism
MEMR	Ministry of Energy and Mineral Resources (Bangladesh)
NTPC	National Thermal Power Corporation Ltd. (India)
PBA	Pipeline Build-Own-Operate Agreement
PCF	Prototype Carbon Fund
PGC	Power Grid Company of Bangladesh Ltd.
PGC	Power Grid Corporation of India Ltd.
PPA	Power Purchase Agreement
PSA	Production Sharing Agreement
PTC	Power Trading Corporation India Ltd.
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WRIP	Western Region Integrated Power

Executive Summary

The purpose of this pre-feasibility report is to assist the Government of Bangladesh (GOB) in evaluating the viability of entering into an agreement with the private sector to build a combined cycle gas-fired power plant in the range of 500 – 1,000 MW, with a portion of the electric power output exported to India after meeting the domestic demand of Bangladesh. This study has been undertaken at the request of the GOB and is funded by the United States Agency for International Development (USAID). In addition to conducting a preliminary assessment of a conceptual power export project, this report outlines the principal steps necessary to implement the project, should the GOB make a decision to proceed with the project.

Section 1 of the report explains the purpose and scope of the analysis. Section 2 provides background information on the power sectors of Bangladesh and India, and Section 3 explains the components needed for development of a viable power export project. Sections 4 through 7 provide an assessment, respectively of the market viability of the project, the technical viability, economic and financial requirements, and commercial and legal issues. Section 8 of this report provides information on social and environmental issues and Section 9 lists conclusions and recommended next steps.

The conclusions of this pre-feasibility analysis include:

- Exports of up to 400 MW of power to India via the Eastern Grid of India by the year 2005 are technically feasible (within existing and planned transmission infrastructure).
- Of the four potential sites reviewed, the sites in the western region of Bangladesh (Bheramara and Sirajganj) appear to be preferable, due to their favorable cost advantage (lower transmission requirements) in addition to the fact that the plant would promote economic development and employment in this region of Bangladesh.
- Levelized cost of power from new generation additions in India range from $0.027 to $0.036/kWh for hydro; $0.049 to $0.062 for new coal-fired IPPs and $0.050 to $0.060 for LNG-based power generation.
- The estimated delivered price for exported power would be competitive against future new generating sources for India. Estimates of the delivered tariff range from $0.044 to $0.047/kWh.
- Power exports will support a minimum gas price (at the wellhead) of $1.5 to $1.85/mmBtu.
- Gross foreign revenues to Bangladesh from power exports for the Phase I concept would be $120 million to $130 million per annum (based on most competitive power price).
- Credit-worthy and motivated buyers exist in India including PTC and NTPC.
- Power exports can be implemented using private investment.
- The current status of energy sector reforms in Bangladesh and India makes development of power exports timely.

Next steps that should be undertaken by GOB include:

- Conduct a detailed project feasibility study suitable for RFP solicitation.
- Evaluate market-pricing options, including for peaking power exports.
- Draft project agreements based on the WRIP/IPP projects (incorporating MEMR latest review).
- Review and Assess the Existing Power Export Agreements Between India and Neighboring Countries (e.g., Nepal, Bhutan).
- Update the Fourth Natural Gas Plan for the Purposes of Establishing That Sufficient Gas Production Exists to Support Power Exports.
- Draft a "Bulk Power Export Purchase Agreement."
- Confirm adequacy of Payment Security Mechanism for Power Trading Corporation (India).
- Draft legislative amendments to authorize and regulate power exports.
- Determine potential added value for the plant under the Market-Based Mechanism (MBM).

Foreword

This report is intended to represent the initial findings of Nexant's[1] assessment of the viability of a proposed power export project for the GOB. Also included are preliminary comments as possible resolutions to the identified concerns. This report is based on a review of currently available information, meetings and discussions with all principal entities representing GOB and Government of India (GOI), multilateral banks and private sector companies presently engaged in private power development and gas exploration.

Nexant would like to gratefully acknowledge the cooperation and direction provided by the Government of Bangladesh and principal Bangladesh energy sector organizations including the Ministry of Energy and Mineral Resources (MEMR, Bangladesh), Petrobangla, Power Grid Company (PGC, Bangladesh), Bangladesh Power Development Board (BPDB), Bangladesh Small and Cottage Industries Corporation (BSCIC). In addition, we would also like to thank the Indian Ministry of Power (MOP, India), Power Grid Corporation (India), Power Trading Corporation (PTC, India), National Thermal Power Corporation (NTPC, India), Gas Authority of India Ltd. (GAIL), Central Electricity Regulatory Commission (CERC, India), West Bengal State Electricity Board (WBSEB), Power Department (Govt. of West Bengal, India), West Bengal Power Development Corporation (India), all of whom generously provided their cooperation for our study. Finally, we would like to recognize the special efforts of Mr. Bruce McMullen and his energy team in Dhaka (Mr. Kamaruzzaman, Mr. Hassan) as well as the energy team in USAID-New Delhi (Jim Bever, Richard Edwards, S. Padmanaban, NV Seshadri, Kavita Sinha) all of whom provided unfailing support facilitating our local meetings and follow-up data collection. This study was funded by USAID.

[1] Nexant, Inc. is a Bechtel technology and consulting company formed on January 1, 2000.

1. Purpose and Scope

The purpose of this pre-feasibility report is to assist the GOB in evaluating the viability of entering into an agreement with the private sector to build a combined cycle gas-fired power plant in the range of 500 – 1,000 MW, a portion of which would be exported to India after meeting the domestic demand of Bangladesh.

In addition to conducting a preliminary assessment of a conceptual power export project, this report will outline the principal steps necessary for project implementation by addressing the following topics:

Market Supply/Demand, Technical Requirements and Social/Environmental Impacts

- What are reasonable expectations for electricity demand in Bangladesh and India? What technical requirements are needed to make the proposed project feasible? What social and environmental impacts e.g., emissions reductions, employment opportunities, are associated with the plant?

- What are the sources of natural gas in Bangladesh that could be made available to a power export project and how should the recommended gas sources serve the project, considering the available options for optimal plant siting, the requirements for pipeline and transmission interconnection, and domestic sociopolitical and environmental impacts and suitable mitigation measures?

Economic/Financial Parameters

- What is the estimated benchmark range for the wholesale energy tariff (expressed as a high option and a low option), in order for the export plant to be competitive with India's other energy options? Also, what are the available fuel pricing options in order to achieve a competitive energy market structure, using economic and financial models consistent with those of the Multilateral Development Banks and major foreign investors?

- Is a power export project economically and commercially viable, considering potential available financing, projected supply and demand, capacity and compatibility of the grids, and load dispatch capability in and between both countries?

Commercial/Legal Considerations

- What are the options for ownership and operational arrangements for structuring a power export project?

- What are the principal risks and benefits of a power export project and how should they be allocated and managed by the various project participants?

- What legal steps are necessary to authorize and finance electricity trade between India and Bangladesh, based on existing policies and legal provisions compatible with energy trade? What additional policies, legal provisions, regulations, or protocols would be necessary to implement a power export project?

- What additional technical assistance is required to undertake a competitive bid and proposal evaluation for contracting all project components, including the plant, transmission lines, fuel supply, but excluding gas production?

2. Background and Approach

Although private capital investment is needed to upgrade and expand the electric power and oil & gas sectors of Bangladesh and to generate foreign revenues, only limited and qualified support has been given to exploring the opportunities of exporting power to India from Bangladesh.

To a great extent the lack of support stems from power export being viewed primarily as an "either-or" option on a competitive basis with initiatives to export natural gas. Typically, separate plans have been formulated to develop power and gas projects in order to meet the unmet domestic demands for electric power and natural gas supply .

On this basis, it is not surprising that GOB and other stakeholders in Bangladesh have only expressed a general interest in exporting natural gas and even less support in promoting power exports. For example, ADB recently recommended that, given the constraints in the existing power and gas generation and transmission systems in Bangladesh, Bangladesh export only limited gas (250 mmcf/day) and limited power (100-250 MW).

To consider these prevailing views and yet to accomplish the purpose of objectively assessing the viability of a power export project, the general approach and premise taken in this pre-feasibility report is that the sale of power exports from Bangladesh to India need not preclude direct sale of gas exports to India nor compete with existing plans to develop other sources of domestic power production in Bangladesh. Stated otherwise, this report will assess whether and how a power export project could be implemented in Bangladesh, outline the issues affecting implementation of a power export project, and suggest means of mitigating the associated risks including their allocation among the various implementing parties.

Power exports could facilitate concurrent gas exports as and when Bangladesh Determines that Appropriate Reserve-to-Production Ratio Exists

The approach taken has been to consider the following:

- Characterize the need for new generating capacity additions in Bangladesh and how this may play a role in the development of a dual domestic/export power project.
- Identify and characterize the Indian market for export of power including competing sources of new generation.
- Assess the economic viability of a power export project in the 500 to 1,000 MW size range.
- Quantify the technical requirements necessary to permit power exports and provide first-order estimates of the associated investment requirements.
- Identify and characterize natural gas sources and gas transmission requirements taking into consideration likely domestic socio-political implications.
- Develop conceptual ownership and operational arrangements for structuring the project as well as recommendations for optimal partners to the arrangement.
- Assess Indian and Bangladesh policies and legal provisions and their compatibility with promoting energy trade, plus any additional policies, regulations, or protocols necessary to implement a bilateral project.
- Estimate the projected wholesale energy tariff for different plant options.
- Address the allocation of risks and benefits to all parties of a power export project.

As with any other power or gas project being developed by GOB with the private sector, in order to be viable a power export project must address a number of complex implementation problems related to project development and financing. However, such obstacles are neither unique to Bangladesh nor attributable per se to exporting power. They are shared by any infrastructure project developed by GOB and the private sector.

In considering the viability of an export power project, Bangladesh should recognize and be credited for additional associated benefits such as export earnings, displacement of imported oil and foreign exchange costs, and promoting greater economic cooperation and trust between Bangladesh and India.

Moreover, a viable power export plant using natural gas in Bangladesh offers significant environmental benefits to the region. By selling a portion of the power to displace power generation otherwise produced by existing and planned coal projects in eastern India, GOB and GOI can demonstrate how to meet the demands of future power supply while also reducing greenhouse gas (GHG) emissions in the region. This could also demonstrate methods for attracting private foreign capital investment, which would otherwise not be available, through the accumulation and sale of carbon emission credits.

3. The Components of A Viable Power Export Project

An assessment of a power export project should consider discrete sub-components of different measures of project viability, expressed in terms of a range of projected "low/possible – high/likely" scenarios:

- Market Supply/Demand: There are three sub-components of a market analysis: the electric power and gas supply and demand scenarios, defined in terms of tariff competitiveness of new generation additions, in Bangladesh, India and other exporting countries in South Asia.

- Technical Requirements: There are five sub-components of a technical analysis of a power export project: the combined-cycle power plant; the natural gas pipeline; the electric transmission line interconnection from the plant to the Bangladesh grid system; the electric transmission grid interconnection to the Indian grid system; and interconnection between Bangladesh and India grid systems.

- Economic/Financial Parameters: The economic analysis consists of three sub-components: the cost of delivered gas to the plant (including gas transmission); the cost of delivered power to the buyer in India (including power transmission) and a sensitivity analysis of selected costs.

- Commercial/Legal Considerations: The commercial/legal analysis involves an assessment of four sub-components that are critical in the decision-making of the private sector: the standard economic and non-economic factors that are involved in making any major capital investment: the ownership structure and contractual arrangements that allow for a fair allocation and management of defined project risks; the adequacy of the existing legal and regulatory system; and the need and desirability for amended or new laws and regulations.

- Socio-Environmental Impacts: The socio-environmental analysis involves two sub-components: social impacts, both positive and negative, to Bangladesh and India, and environmental impacts to Bangladesh and India.

4. Market Supply/Demand

4.1 BANGLADESH MARKET

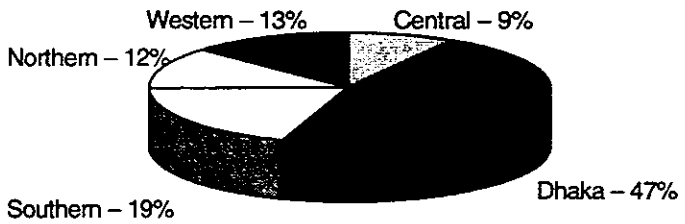
4.1.1 Geographic Segmentation

The Bangladesh electricity market is slightly over 2,300 MW at peak and consumption is approximately 8,000 MWh. Figure 4.1 illustrates the relative demand of the various geographic areas of Bangladesh.

The Dhaka, Central and Southern regions are east of the Jamuna River. The Dhaka region constitutes about half of the entire Bangladesh electricity market with the other two regions making up about 25%. The remaining 25% of the market is in the western and northern regions, west of the Jamuna River. Economic and gas sector development has been confined to the eastern part of Bangladesh, resulting in a widening economic disparity between the eastern and western parts of Bangladesh.

Figure 4.1 Relative Regional Market Size (MW) in Bangladesh

(Total Size 2,300 MW)



There are high levels of self-generation in all areas of the country and large, financially solvent, unserved markets for electricity (includes industrial, commercial, residential customers).

4.1.2 Interconnection of Market Regions

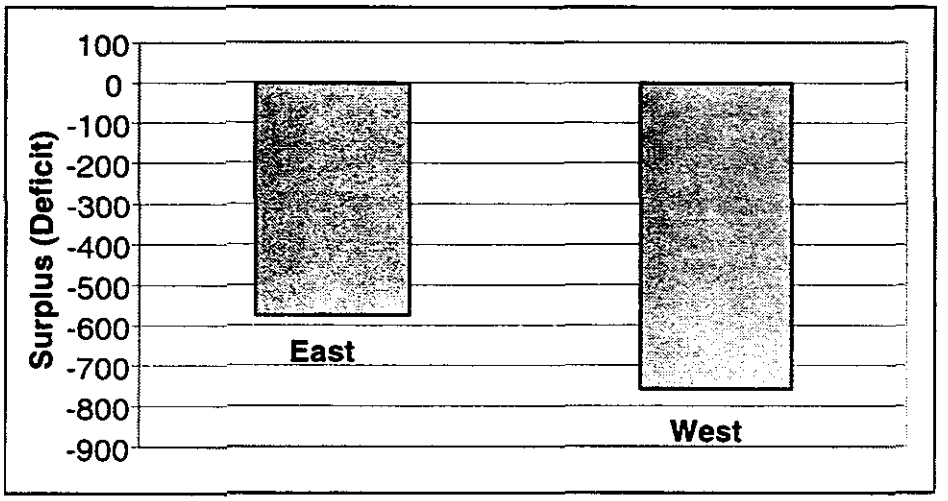
The Bangladesh transmission system consists of an integrated network of 132 kV to 220 kV and lines covering the main load centers of the country. The main deficiency that could affect an export project are the limitations of the east-west interconnection, having about a 360 MW capability, and the limitations of 132 kV lines connecting the Central region where gas field development is taking place.

4.1.3 Need for Power by Region

The World Bank has projected the peak demand for Bangladesh to be about 3,900 MW in 2005, based on the effect of certain power sector reforms, such as higher tariffs and lower losses. Higher forecasts, up to 4,600 MW, have been made that do not consider such reforms. To supply this demand, approximately 2,400 MW of capacity additions are required from the end of 1998 to 2005. Some of this capacity is under construction (e.g., 420 MW at Ghorasal and Siddirganj, 120 MW of combustion turbines at Mymensing and Shajibaza, an additional 100 MW from combustion turbine conversion to combined cycle at Haripur). Additional capacity is being phased in by independent power producers (IPPs) such as the 360 project MW at Haripur and the 450 MW project at Meghnaghat. However, most of this generation is located east of the Jamuna River. The only projects west of Jamuna are the rehabilitation of Khulna 100 MW steam plant and a 100 MW gas-fired plant at Baghabari, which is still under negotiation.

Even if all of the projects that are underway or under negotiation are completed, there will still be a serious deficit of capacity in Bangladesh. Figure 4.2 shows how this deficit is distributed between east and west. The larger capacity deficit is in the west (i.e., the western and northern electrical regions), where the cost of power production is highest due to the reliance on liquid fuels and smaller plant size. Moreover, because of the power deficit in the east, the east-west inter-connector will provide little relief even if capacity in the east is upgraded.

Figure 4.2 Projected Supply and Demand in Bangladesh- 2005



In summary, there is a need for future electricity supply to meet the expected demand on both sides of the Jamuna River. The demand requirement is somewhat greater in western Bangladesh, where the opportunity to displace liquid fuel generation is higher.

Projected Requirement of 750 MW in Western Region by 2005

The Sirajganj EPZ (Within West Region) Has Projected Requirement of 375 MW

Projected Requirement of 550 MW in Eastern Region by 2005

4.2 INDIA MARKET

4.2.1 Geographic Segmentation

The Indian electricity market is segmented into distinct regions. Total demand is approximately 70,000 MW at peak with a consumption of over 400 million MWh. The relative demand of the regions is shown in Figure 4.3. The Eastern and Northeastern regions are shown together because they are interconnected and the Northeastern region has very low demand.

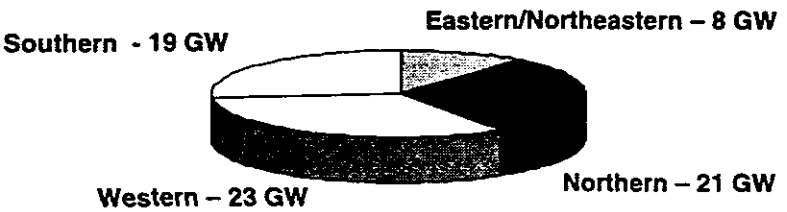


Figure 4.3 Relative Regional Market Size in India

4.2.2 Interconnection of Market Regions

Prior to 1989, these regions operated completely separately except for the Eastern and Northeastern regions. There are now five major interconnections, but transactions are limited by transfer capability. The existing inter-regional transfer capability is summarized in the following table.

Table 4.1 Capacity of Existing Transmission Interconnections in Indian Regional Electricity Grids

	East/Northeastern (MW)	*Southern (MW)*	*Western (MW)*	*Northen (MW)*
East/Northern	—	500	150	150
Southern	500	—	1,000	—
Western	150	1,000	—	500
Northern	150	—	500	—

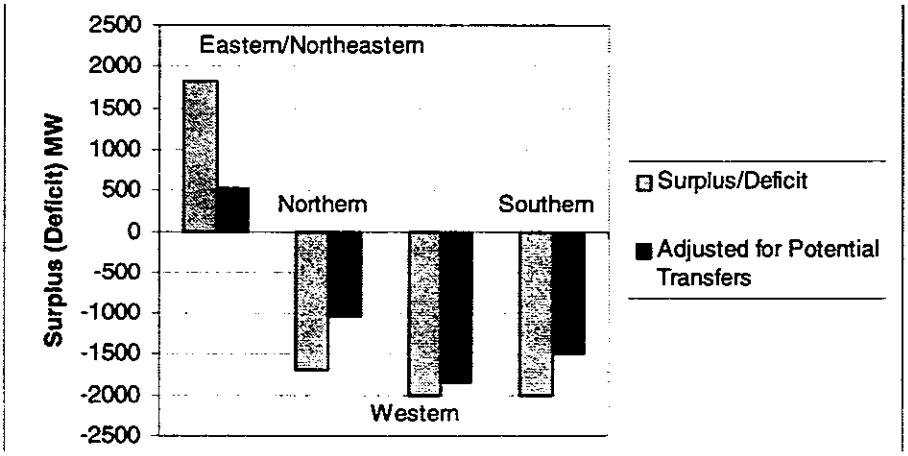
The Bheramara and Sarajganj sites for the proposed power export project are located nearest (60 km) to India's Eastern grid, while the Sylhet and Fenchuganj sites are nearest to the Northeastern grid. Hydro resources are concentrated in the Northeastern region of Bangladesh and in Nepal and Bhutan; coal resources are concentrated in the Eastern Region of India. Planned projects based on the resources of these regions have associated inter-regional interconnections to bring output from the project to markets in the Northern, Western and Southern regions. The 150 MW interconnections of the Eastern region with the Western and Northern regions are at 220 kV. The 500 MW interconnection with the South is 500 kV HVDC (high voltage direct current). A 500 MW HVDC connection with the Northern region is under construction.

Nearest Indian Grid/Substation is 60 km from Bangladesh Border (Western)

4.2.3 Need for Power by Region

A region's available capacity compared to peak load is one measure of its need for new capacity. Figure 4.4 illustrates the current supply/demand situation in the various regions using this comparison. The combined Eastern and Northeastern regions are running at nearly 2,000 MW of surplus while each of the other regions has approximately 2,000 MW of deficit. The 220 kV interconnection with the Western region, the HVDC interconnection with the Southern region and the HVDC interconnection with the Northern region under construction will allow some of the surplus of the Eastern and Northeastern regions to supply the deficit in the other regions, as shown in Figure 4.4. Even with this adjustment, the Eastern and Northeastern regions are still about 500 MW to 800 MW in surplus.

Figure 4.4 Current India Electric Supply/Deficit Requirement by Region



The Western region with its long coastline in Gujarat and Maharashtra, has been strategically designated as the location for stations using imported fuels (e.g., LNG). There are also coal-based stations under consideration. By the end of 2007, official estimates indicate that the Western region will be close to self-sufficiency. On the other hand, the Northern and Southern regions are expected to remain in significant deficit for the foreseeable future and will require imports from other regions. These imports will come from the Eastern and Northeastern regions, which will help to utilize their surplus. However, with several projects planned for the Eastern region, new hydro projects in the Northeastern region, imports from Bhutan and low expected growth relative to other regions, the Eastern and Northeastern regions will remain in surplus (Fig. 4.4). Much of the surplus will be transmitted to the Southern and Northern regions, but the Eastern and Northeastern region should remain well supplied.

Based on this analysis, it appears that there is sufficient demand in Eastern and Western Bangladesh to support development of a power project that also would export to India. Particularly in Western Bangladesh, such a facility could provide an "anchor" for further domestic economic development. In India, the Northern and Southern regions appear to be the best export markets for the plant, and the present transmission network, including current and planned upgrades, is sufficient to carry the power to these markets.

Eastern Grid Region Has High Un-Met Peaking Power Requirement

Northern and Southern Regions Have a Need for Baseload and Peaking Power Additions

4.2.4 Potential Effect of Power Sector Reform

The introduction of reforms in the power sector has the potential to affect the supply/demand situation. The Central Electricity Regulatory Commission (CERC) of India has estimated that about 5% of the total electric energy supplied to all Indian grids is traded (Reference 5). Trading between utilities and the State Electricity Boards (SEB) selling surplus power commitments to other SEBs has taken place since 1996. An open-access policy for the transmission system is in place, but available transmission capacity constrains inter-regional trade. Short-term trades are currently brokered by Regional Electricity Boards. Power Trading Corporation (PTC) is the first bulk power marketer in India. Pooling arrangements are yet to develop, but the system is evolving in this direction. This will mean that regional surpluses will more easily reach other regions in deficit, customers who want more reliable services will be able to obtain them, and it will become possible to develop generation projects on a merchant plant basis. While these changes will come about during the lifetime of a power export project, at present they will have little effect on its development.

In summary, the Northern, Western and Southern regions of India all provide potential markets for a power export project. While some previous studies have discounted the Western region because of projects being developed there, delays in those projects or changes in the imported fuel price could open the region to alternatives. However, the Northern and Southern regions are the markets most in need of new capacity based on today's projections. Our estimates of transmission costs will be based on the Northern market, as that has the greatest need for power. Analysis by Power Grid of India suggests that transmission costs associated with reaching the Northern region are somewhat less than those for the Southern region. However, it is too early in the development of a power export project to discount markets in the Western and Southern regions.

5. Technical Requirements

5.1 SYSTEM OPERATIONAL ISSUES

The Bangladesh electric transmission system is managed and operated by the Bangladesh Power Development Board (BPDB). There are plans to shift this responsibility to Power Grid Corporation (PGC) Bangladesh, however, this is not expected before 2004. A primary operational difficulty of the existing power system is due to the wide variation in peak and off-peak loads and the lack of spinning reserve due to capacity shortages. As a result, load shedding is performed more often than would be justified by the supply/demand balance in the country.

The Indian systems are dispatched at the regional level. As in Bangladesh, the actual supply situation in the Eastern and Northeastern regions is worse than supply and demand statistics indicate because of system control factors. For example, CEA statistics indicate that the two regions are experiencing low frequency (<49 Hz), normally associated with capacity shortages about 5% of the time. Based on discussions with West Bengal SEB, we also know that load shedding is a common practice in the Eastern region. However, this has less to do with the availability of capacity and more to do with system control and economics of buying electricity during peak hours.

Power systems have to maintain generation levels that match load at all times. With less industrial load than other regions, there is much more variation between night-time and day-time loads in the Eastern region than elsewhere. Matching the load each hour requires significant changes in the output of plants. Many of the stations designed for baseload operation are incapable of operating in this fashion. The alternative is to leave some capacity idle so as to be able to reach the low night-time loads. With the idle capacity unavailable to meet peak loads, SEBs are faced with the choice of load-shedding or using their small capacity of peaking generation, or both. Adding more baseload generation capacity to the system will not alleviate this problem, although it would be partially addressed when a planned 900 MW of pumped storage is added to the Eastern region. There may remain a market for load-following and peaking capacity in the Eastern region; however, the technical and economic characteristics of a power export project make it unsuitable for this type of service.

There is no dispatching capability between Bangladesh and India primarily because of lack of grid interconnections. Discussions began two years ago concerning a potential 220 kV link having 150 MW transfer capability to provide for exchange between the countries. These talks were abandoned before the difficult technical issues associated with synchronizing the Eastern region of India with the Bangladesh system could be addressed. This issue is critical to a power export project since it is to serve both the Indian and Bangladesh markets. The only way the synchronization issues could be dealt with would be through a High Voltage Direct Current (HVDC) interconnect. However, this would likely be cost-prohibitive for the export levels being envisioned at the present time. As a result, the initial power export project should be designed so that part of its generation is dedicated to the Bangladesh market and part is dedicated to the India market. If and when the two grid systems are interconnected, it would allow more flexible operation of a power export project.

5.2 COMBINED-CYCLE POWER PLANT

A combined cycle plant consists of a combination of an open gas-turbine cycle and a closed steam-turbine cycle. A combined cycle power plant is presently the most efficient and cost effective way of generating power from natural gas, as well as being the most environmentally attractive. Consequently, combined cycle plants are the most commonly used type of power plants deployed worldwide today.

For the purposes of this pre-feasibility report, a conceptual combined cycle plant is proposed in stages, with the first plant sized at 750 MW, consisting of two identical units of 375 MW nominal capacity each. A two-unit plant (2x375 MW) instead of a single-unit plant (1x750 MW) is proposed as two separate units would facilitate flexibility of operation and ease of power transmission to both India and

Bangladesh. Each 375 MW unit is a standard advanced combined cycle system consisting of the following major components:

- One advanced combustion turbine (CT).
- One unfired, three-pressure, reheat, natural circulation, heat recovery steam generator (HRSG).
- One single-flow, reheat, dual-admission, down-exhaust, condensing steam turbine (ST) mounted on a common shaft along with the combustion turbine.
- One electric generator mounted on the same shaft as the gas turbine and the steam turbine.
- One surface condenser cooled by a multi-cell cooling tower.
- Distributed control system.
- Civil structure for the turbine-generator sets for protection from rain. Civil structure is shared by both the units.

This type of unit comprising one CT, one HRSG, and one ST is referred to as 1 x 1 x 1 configuration. Since both the CT and ST are mounted on the same shaft, there is only one electric generator generating power at 11 kV.

At standard ambient conditions (15°C at mean sea level), commonly referred to as ISO conditions, the gross efficiency of this unit is 57.3 percent and the net efficiency, after accounting for plant auxiliary power, is 56.2 percent. These efficiencies translate to gross and net heat rates of 5,955 Btu/kWh and 6,071 Btu/kWh, respectively. Under ISO conditions, the unit generates 393.9 MW (251.2 MW by the combustion turbine and 142.7 MW by the steam turbine) and 386.5 MW gross and net power, respectively. The difference of 7.4 MW is needed for station auxiliary power.

Meteorological data for the four sites considered for the study indicates that an annual average temperature of 25°C is a reasonable approximation for all the sites. At this temperature, the unit generator output (gross) will be 378.4 MW. Considering auxiliary power, and losses in the transformer and elsewhere, the net unit output will be 367 MW at the transformer outlet or at the grid.

The gross unit heat rate remains essentially unchanged at 25°C ambient temperature. Here it is assumed that the gross heat rate is 6,000 Btu/kWh when the unit generates 378.4 MW. The net heat rate is estimated to be 6,200 Btu/kWh (approximately 6,500 kJ/kWh) corresponding to the net output of 367 MW. At this heat rate, the annual gas consumption is estimated to be 17 billion cubic feet per unit or 34 billion cubic feet per year for the plant. The peak gas flow rate during plant operation at 100% capacity factor is estimated to be 110 million cubic feet per day.

The installed capital cost of the plant is estimated to be USD $338 million, excluding interest during construction. This translates to a unit price of $460 per kW based on the 2x367 MW net output (2x375 MW nominal).

5.3 POWER PLANT SITING CHARACTERISTICS

5.3.1 Physical Characteristics

A key factor in optimizing a power project is site selection. For the purposes of this assignment three broad areas were selected for study. The first area is the northeast of the country centered around Sylhet, one of the major gas producing areas. The principle here is that the power plant would be close to an existing source of fuel, namely the natural gas of the Sylhet fields. The second area is the center of the country near Sirajganj, which is on the west bank of the Jamuna river close to the Jamuna Bridge. This is a central area with good accessibility via road, rail and river as well as proximity to connections with the

national gas and electricity grids. The third area is located in the west, close to the border with West Bengal, India, at Bheramara. This area offers the advantage of being close to the potential market in India.

The major characteristics considered for differentiating potential sites include proximity to the source of gas supply, proximity to electrical grid, availability of adequate cooling water, availability of adequate land, and accessibility to the site by road, rail, and river for transport of heavy equipment.

For the purposes of this study attention has been focused around four sites of existing power plants. Already being linked to the national electrical grid, being close to a source of cooling water, and having the necessary road/rail infrastructure close by, these locations were the obvious starting point when searching for suitable sites. In addition, all but one of these sites was supplied directly or close to the existing gas grid. The map of Bangladesh presented in Annex 3 shows the locations of the sites.

Bheramara

General site description: The existing power plant at Bheramara is situated approximately 10 km from the Indian border on the south side of the Padma River on a slightly elevated position, free from flooding, less than 1 km from the river banks and approximately 3km north of Bheramara town center. The site which is jointly owned by the Water Development Board and the Power Development Board occupies 28 hectares and consists of a diesel fired power plant, substation, support buildings and living quarters. Adjacent and to the west of the current location there is an area of land (approximately 400m x 30m) designated for a 450 MW power plant expansion.

The nearest population center is Bheramara town with approximately 200,000 residents located 3 km to the south of the plant. Bheramara is the center of local administration and while the main occupation is agriculture there are some local industries. The regional center situated 23km to the southeast is Kushtia with a population of approximately 500,000.

Gas supply: GTC is planning to build a 30-inch gas pipeline, beginning at Nalka, stretching the distance of 90km to Bheramara to supply the proposed 450 MW plant for 2001.

Distance to electric grid: Indian grid 60 km; close to Bangladesh 230 kV.

Water supply: year round source (Padma) near by. Navigable river near by.

Analysis: Sufficient land available; would be dependent upon gas pipeline being extended; close to Indian market; close to Indian border provides incentive for future gas export; may provide cornerstone for development of Western Region.

Sirajganj

General Site Description: This proposed site is located within an existing industrial park (Export Processing Zone, EPZ) managed by the Bangladesh Small and Cottage Industries Corporation (BSCIC). The park is situated on the west bank of the Jamuna River 4km beyond the bridge, and occupies an area 1.5km square (400 acres). The site has the benefits of being close to road, rail and river transport as well as links to the existing gas and power grids. Prior to its designation as an industrial park the area consisted of riverbed, flood plain and rice paddy. The industrial park has yet to be developed and consists of an area of low-lying land, currently under water due to the monsoon floods.

The closest habitation is a village between three and five kilometers to the west of the site consisting of scattered housing. Sirajganj, with a population of approximately 100,000, is located 15 km from the site. Sirajganj is approximately 90 km from the Indian border.

There is space available for development of a power plant on this site but as the land is under the ownership of the BSCIC certain conditions would be imposed. One such condition is that the power

plant would be obliged to supply power to industries located within the park. There are currently no fixed plans for industrial development but enquiries have been received from several sectors including steel, cement, textiles, ceramics and food processing.

Gas supply: close to gas grid. Enough remaining capacity for 750 MW plant.

Distance to electric grid: 165 km to Indian grid; 60 km to Bangladesh grid;

Water supply: year round source (Jamuna) near by. Navigable river near by.

Analysis: Sufficient land available; may provide cornerstone for development of Western Region with development of EPZ.

Sylhet

General site description: Located in a 15 acre site the existing 20 MW power plant is located between the Sunamganj Road and the Surma River approximately 6 km from the town of Sylhet. Immediately adjacent to the site, is a small village with a population of approximately 1,000. The southern edge of the site is bounded by the Surma River.

Within the site itself is a section of staff housing, a gas turbine generating unit, a pressure reducing station and a substation linking the plant to the 132kV electric grid. An 8 inch gas line running under the road links the power plant to the main gas grid. The site is raised above the flooding level of the river, and even in the heavy floods of 1998 the site remained above the high water mark. The plant is air cooled and groundwater is used for domestic purposes, thus water is not abstracted from the river.

Gas supply: close to gas grid and gas fields.

Distance to electric grid: 110 km to Indian grid (NE region); 150 km to Bangladesh grid.

Water supply: seasonal source (Surma) near by. Navigable river nearby.

Analysis: Close to gas fields; significant distance from Indian Grid and from areas of Bangladesh that most require power; alternative is to connect to high voltage grid in North East India.

Fenchuganj

General site description: The existing Fenchuganj 90 MW combined cycle power plant is located approximately 2 km south of the town of Fenchuganj and 25 kilometers from Sylhet, in between the Sylhet to Dhaka road and the Kushira River. The site, which at its closest point is only 100m from the river, is built on a raised area located on the primary flood plain, which is currently submerged in the monsoon floods. Despite this apparent abundance of water there is insufficient cooling water in the dry season for the plant to operate a once through cooling system. A closed cooling system with cooling towers is currently being constructed at the plant that will facilitate full operation throughout the dry season.. Directly to the north of the existing site is an open area stretching approximately 1 km to the road. This area appears to be most suitable for any future power plant development.

Gas supply: close to gas grid and gas fields.

Distance to electric grid: 100 km to Indian grid (NE region); 125 km to Bangladesh grid.

Water supply: seasonal source (Surma) near by. Navigable river near by.

Analysis: Close to gas fields; some distance from Indian Grid and from areas of Bangladesh that most require power; alternative is to connect to high voltage grid in North East India.

5.4 ELECTRIC TRANSMISSION LINE INTERCONNECTION

Our preliminary analysis indicates that the most likely markets for the 750 MW plant under consideration are the Western Region of Bangladesh and the Northern region in India. Transmission requirements within Bangladesh will be dependent upon plant siting and the development of the transmission grids in Bangladesh and India. Table 5.1 shows the distance of sites from existing grid interconnects (substations). The distances for Bheramara and Sirajganj are from the Indian Eastern grid. For Sylhet and Fenchuganj the distances are from the Northeastern regional grid. The Sylhet and Fenchuganj sites are approximately 300 km from the Eastern grid.

5.4.1 Connection from Plant to Existing Grids

A power export project would be connected to the Bangladesh grid by way of two double-circuit 230 kV lines to the nearest points on the existing 230 kV system, or the Ishurdi substation for Bheramara and Sirajganj sites and the Ashuganj substation for Fenchuganj and Sylhet sites. The Bheramara site is on the 230 kV system and would require little investment for connection. The remaining sites are currently connected to the 230 kV system by way of 132 kV lines. Additional 230 kV lines would be required. Sirajganj is on the route of a planned 230 kV line, but funds have not been available for completion of this line. There have also been plans to link the Sylhet and Fenchuganj sites by 230 kV lines, but there is currently no funding.

Evaluated Project Sites

Western Region	*Eastern Region*
Jamuna Bridge/Sirajganj EPZ Near Existing Pipeline Near Planned EPZ (375 MW Demand) 60 km To Bangladesh Grid (230 kV) 165 km To Indian Grid Jamuna Pipeline Capacity of 385 mmcf/day Planned Pipeline Extension	**Sylhet** Near Gas Fields Near Existing 20 MW Power Plant 150 km to Bangladesh Grid 110 km to Indian Grid (NE Region)
Bheramara 450 MW Addition Planned Nalka-Bheramara Pipeline Planned For 2001 Near Existing 230 kV Grid; 60 km To Indian Grid	**Fenchuganj** Near Gas Fields Near Existing 90 MW Power Plant 125 km to Bangladesh Grid 100 km to Indian Grid (NE Region)

Existing Natural Gas Production Capacity Can Support Incremental Demand of up to 250-300 mmcf/day

Table 5.1.Transmission Distance to Connect Project Sites to Nearest Substation

	Distance to (km)			
	Bangladesh 230 kV Grid		**Indian Substation**	
Bheramara	0	(Ishurdi)	60	(Bharampur)
Sirajganj	60	(Ishurdi)	165	(Bharampur)
Sylhet	150	(Ashuganj)	110	(Badarpur)
Fenchuganj	125	(Ashuganj)	100	(Badarpur)

There are technical constraints to the plant serving both the Bangladesh and Indian markets. The Indian and Bangladesh grids are not interconnected. One solution is to interconnect the systems. However, synchronization difficulties are likely to require an HVDC interconnection for the same reason that

regional interconnections in India are dominated by HVDC technology. However, such a connection is likely to only be justified for transferring large blocks of power, primarily because of the investment requirement in converters at each end of the line. The transfer of a few hundred MW, as envisioned by the first phase of a power export project, would not justify such a connection.

A more economic alternative for a 750 MW power plant is to have two separate power units of 375 MW each, with one unit normally supplying power to Bangladesh and the other unit supplying power to India. Switching equipment could be provided to allow switching between systems in emergencies, but day-to-day operations would require each unit to supply power to its designated system. If at some time in the future the two systems become interconnected the power units would then be able to serve either system.

The unit serving the Indian grid would be connected to a new substation in the Indian system by way of two double circuit 400 kV lines. (Two separate lines are required for reliability reasons). If a power export project were sited at Bheramara or Sirajganj, it would be connected to the Eastern regional grid of India. For such an application, Power Grid of India (Reference 3) proposes locating the new substation at Baharampur between existing substations at Farakka and Jeerat. The existing Farakka-Jeerat circuits, which pass near Baharampur would be looped in and out at the new substation.

If eastern sites, such as Sylhet and Fenchuganj, were connected to the Eastern grid, the Power Grid analysis would apply. However, a connection from any of these sites to the Indian Eastern grid would require traversing Bangladesh, including an expensive river crossing of the Jamuna River. A seemingly better solution for these sites would be to connect with India's Northeastern regional grid. Badapur, a major substation, is approximately 100 km from these sites. Power Grid of India has not studied this scheme and the requirements within the Northeastern grid could differ significantly from a connection with the Eastern grid. For the purposes of this pre-feasibility analysis, we have assumed a connection to the Badapur substation; however, such a link will require greater study should the results indicate economic viability.

Nearest Indian Grid/Substation Located 50 km From Bangladesh Border (West)
India's Eastern Grid Interconnects to Northern, Southern, Western Grids (100, 200, 300 MW Respectively)
Indian Eastern Grid Links Totaling 1,550 MW Under Construction to All Four Regions
Indian Eastern Grid Interconnects Planned by 2004:

2,000 MW East to South	**Talcher**
1,000 MW East to Bhutan	**Tala**
3,000 MW East to North	**Hirma**

5.4.2 Required Upgrades to the Bangladesh System

Some upgrades to the Bangladesh system will probably be required. Grid flow studies will be required to assess the impacts on the existing grid to determine the exact nature of these upgrades.

5.4.3 Required Upgrades to the Indian System

As previously discussed, the Northern grid is the most promising market in India for output from a power export project. The nearest grid to the proposed power export project is the Eastern grid, however, the Eastern and Northern grids are not interconnected with sufficient power transfer capability. There are plans to connect the two systems with a 500 MW capacity HVDC connection by 2001 and the addition of another such connection by 2003, along with plans to synchronize the regional systems and build additional links at 400 kV and 765 kV. These interconnections are associated with generation projects. Based on discussions with Power Grid of India, it is possible to evacuate 375 MW from Bangladesh using

the interconnections currently planned and with relatively minor upgrades to the Eastern grid. However, if currently planned generation projects and their associated transmission were delayed, upgrades to the Eastern grid and interconnections would be required specifically to evacuate power from a power export project.

A recent study for Power Grid of India considered the requirements for evacuating different levels of power from Bangladesh in which the Bangladesh plant was dedicated to export to India and was connected to the Indian Eastern grid by way of a double circuit 400 kV AC line.[1] For a 750 MW transfer the addition of two single circuit 765 kV lines, operated at 400 kV, would be required. The lines would run from the Biharshariff substation in the Eastern region to the Allahabad substation in the Northern region. The reliability of this interconnection would depend on others also being available. If other generation projects and their associated transmission were delayed, additional investment would be required to increase reliability at this level of transfer. Based on this analysis, higher levels of transfer are achieved through incremental investments in the Eastern grid and operating the two single circuit lines at 765 kV.[2]

Exports Of Up To 400 MW To India Are Technically Feasible Via Eastern Grid Power Exports Can Be Implemented Using Private Investment Despite Existing Infrastructure Constraints.

5.4.4 Transmission Pricing

Bangladesh and India have different pricing approaches for transmission charges. Bangladesh has an embedded cost approach with all users implicitly paying the same rate. These charges are currently internal to BPDB and are reflected in its wholesale rate. Transmission responsibilities are to be transferred to PGC Bangladesh by 2004 at which time there will be explicit charges for transmission. Discussions with PGC Bangladesh indicate that current charges are about $3.3 per MWh. It is currently envisioned that transmission investments to new generation projects would be added to the rate base and paid for by all users of the transmission system.

The evacuation of power from a power export project would require an international interconnection between Bangladesh and India and inter-state transmission within India. Under the Indian Grid Code, the Central Transmission Utility has the responsibility for supervision and control of this activity. Power Grid Corporation of India has been designated as the Central Transmission Utility. CERC has the responsibility for the pricing of inter-state transmission in India. Currently, the costs of the services provided by Power Grid of India are added together and charged to the SEBs and State Transmission Utilities (in states where such entities have been formed) in proportion to their energy withdrawals for the inter-State grid.

As generation projects are added which require the addition of interconnections between grids and plans to encourage private investment in the transmission system are implemented, a different transmission pricing approach will be introduced. In cases where the costs are attributable to specific users, the intended beneficiaries would pay the costs. Thus, if an SEB contracts with a power generator and the transaction requires the construction of a transmission line, the SEB pays a transmission tariff covering the costs of that line.[3] This is the situation that would most likely apply to a power export project of significant size to necessitate construction of a new transmission line. The costs associated with

1 The plant in this study was not connected to the Bangladesh grid.

2 An HVDC interconnection of the Eastern and Northern grid was also considered in the Power Grid of India analysis for transfer levels of 1500 MW and above. However, it was found to be less economic than the 765 kV AC interconnection for this application. The HVDC approach would be very expensive for lower levels of transfer and so is difficult to apply on a phased basis.

3 If private investors financed the line, their return on investment would come from the transmission tariff.

transmission additions that would be covered by the tariff would include return of debt and equity, depreciation, operation and maintenance cost, administrative and general expenses, insurance, taxes and losses. If the transmission facilities are 95% available, or higher, the full fixed costs of transmission would be charged.

In the case of projects consisting of several thousand MW in size and well defined contracts, it is reasonably easy to determine the transmission facilities that are associated with that facility. However, in the case of the limited transfer of 300-400 MW that is being proposed for the first power export project, new transmission capacity is not required, so that existing and planned facilities would simply be more heavily loaded. Discussion with CERC staff indicated that in such a situation the transmission charges would be comparable to other current users of the transmission facilities. Discussions with Power Grid of India and the Power Trading Corporation indicate that planned transactions between generation projects located in the Eastern and Northeastern grid and customers in the Northern grid have estimated transmission charges in the range of $10 to $15 per MWh.

A continuation of the embedded cost pricing approach used in Bangladesh has been assumed. However, recognizing the regulatory uncertainty and the lack of funds available for transmission investment, consideration has also been given to the impact of implementing an incremental pricing approach similar to the one being introduced in India. In the case of service to the Indian market, it is assumed that a power export project would pay for the connection to the Indian grid and charges on the Indian grid would be comparable to other projects being planned for the Eastern and Northeastern grids.

6. Economic/Financial Parameters

6.1 METHODOLOGY

The approach used to assessing the economic viability of a power export project is based on estimating the wholesale energy tariff required to cover its costs in the appropriate markets (i.e., western Bangladesh for the unit serving Bangladesh if sited at Bheramara or Sirajganj, eastern Bangladesh if sited at Sylhet or Fenchuganj and the Indian Northern grid for the unit serving India). The analysis was conducted from the point of view of a wholesale purchaser in the appropriate markets using a simplified financial analysis of costs reflecting an assumed financial structure and taxes and use charges for existing pipeline and power transmission facilities. The cost components include plant non-fuel operations and maintenance, fuel and fuel transportation, depreciation, electric power transmission to the appropriate wholesale market, taxes and insurance, interest, and return on equity. Of these factors, the cost of gas and the electric power transmission costs have the most significant impacts. A sensitivity analysis was performed to test their impact over a range of possible values.

Gas transmission charges consist of the incremental investment and operating costs of required connections to existing pipelines plus any charges for use of the existing pipeline. Both the Bheramara and Sirajganj sites would utilize the existing pipeline to Sirajganj at a levelized cost of $ 0.5/MmBtu of gas.

Power transmission charges for both the Bangladesh and Indian grids are calculated as the sum of investment and operating costs associated with connecting to the respective grids and a grid use charge. The grid use charge is calculated based on the larger of the two following values: (i) incremental investment and operating costs, including operations and maintenance, depreciation, taxes and insurance, interest and return on equity; or (ii) a value comparable to users with similar requirements. Thus, even if the transfer requirements were such that they could be made using existing transmission facilities in India and those planned facilities for other projects, the transmission charge for use of the Indian system would be comparable to the estimated charge for projects planned for the Eastern grid with customers in the Northern grid. Based on discussions with Power Grid of India, this value is between $10 - 15 per MWh.

Site-specific data was considered in order to provide a preliminary screening of the four sites considered. These costs were primarily based on the distance of the sites from the Eastern grid of India and from the backbone 230 kV grid of Bangladesh and whether or not major river crossing would be required, the amount of gas pipeline that would be required for the site, and whether or not the site would utilize existing pipeline facilities.

The required wholesale energy tariff to cover the costs of production and transmission was compared with estimated wholesale energy tariffs in the appropriate markets over the life of the project to determine the first order economic/financial feasibility of a power export project. Given the imperfections in the power markets of both India and Bangladesh, a simple comparison of cost with current wholesale energy tariff can be misleading if one assumes that future tariffs will become more cost-reflective with additional power sector reform. Consequently, this analysis tries to reflect the effects of expected reform into our wholesale energy tariff projections and to use sensitivity analysis to reflect the uncertainty associated with future pricing.

6.2 WHOLESALE ENERGY TARIFFS IN THE INDIAN NORTHERN GRID AND IN BANGLADESH

The Northern region of India is projected to remain short of power for the indefinite future. The ability to reduce even the current level of shortage will depend on the amount of power imports from other regions, primarily the resource-rich Eastern and Northeastern regions and from Nepal and Bhutan. Various estimates exist for the cost of generation from coal-based projects in the Eastern region and for hydro projects in the Northeast region. First-year price estimates for hydro generally fall in the range of $27 to $40/MWh. Similar figures for new coal-based projects range from $0.047/kWh to $0.067/kWh. In addition, various estimates also exist for the cost of generation from LNG-based projects in the other

regions. These generally fall in the range of $50 to $60/MWh. The cost of transmission from these projects to the Northern grid is similar to the Indian portion of the transmission costs for this Project (i.e., $10 to $15/MWh). The resulting wholesale energy tariff in India ranges from $40 to $75/MWh. This range reflects the kind of tariffs that would be required for projects to be developed by the private sector, and there are financially viable customers who have demonstrated an ability to pay much higher costs of self-generation. However, this range is higher than current tariffs and it may be difficult to realize the high end of this range without continued reform. Projects at the high end will probably not be developed in the near future. For this reason, $50 to $60/MWh is expected to be the competitive range for the Northern region wholesale energy tariff (first year price), given the assumed timeframe of the first power export project.

The costs of supply are significantly different in the eastern and western areas of Bangladesh, primarily because the western portion does not have access to natural gas. Power shortages in the east have prevented adequate power flows to the west on the East-West Interconnector to equalize supply costs. Even if adequate supply were available, congestion on the Interconnector would limit power flows to less than 200 MW. Dhaka Electric Supply Authority (DESA) is the largest distributor in the east while BPDB is the largest distributor in the west.

One indicator of wholesale energy tariffs in the east is the $37/MWh that has been charged by BPDB to DESA in 1998. New projects at Haripur and Meghnaghat have levelized tariff closer to $30/MWh, adjusted for transmission costs based on a delivered gas price of $2.40/MmBtu (although other details of the price calculation were not made available). Consequently, for wholesale energy tariffs in the east a reasonable range is $30 to $37/MWh.

As a vertically integrated utility, wholesale sales to BPDB distribution in the west are not recorded transactions. The World Bank has indicated that BPDB has been operating at a loss since 1995, so that any implied transfer tariff at the wholesale level is unlikely to reflect true costs. A cost-reflective tariff level in the west would be based on heavy fuel oil-based generation in the range of $60 to $70/MWh. As gas is transmitted to the west in greater quantities and additional transmission links are added, the costs between east and west should equalize. On a levelized basis this would mean costs of $40 to $50/MWh over the lifetime of the first power export project.

Cost for New Coal-Fired Generation in India is $47/MWh to $67/MWh

Cost for Imported Hydro Generation is $25/MWh to $40/MWh

6.3 PROJECT ECONOMIC ANALYSIS

For the purposes of assessing the economic competitiveness, a conceptual project has been defined as the Base Case. The Base Case assumptions for the economic analysis of a power export project are presented in Table 6.1 (VAT, import duties and tax holidays and other potential investment incentives are not considered).

Table 6.1 Base Case Project Concept

Phase I	*Phase II*
2 x 375 CCGT Plant 375 MW For Bangladesh 375 MW Export to India	*1,500 MW CCGT Plant* 375 to 750 MW Bangladesh 750 to 1125 MW Export to India
Start up in 2005	*Start up in 2010*
Nalka-Project pipeline (planned) by 2001 (to Bheramara)	*East-west pipeline by 2010*

Potential pipeline for gas export	*Potential pipeline for gas export*

The Bheramara site is used for the Base Case analysis. It is located on the 230 kV grid of Bangladesh and 60 km from the Indian grid. The pipeline that ends at Sirajganj has to be extended to reach Bheramara, a distance of about 90 km. Table 6.2 lists the Base Case project evaluation assumptions.

Table 6.2 Base Case Project Evaluation Assumptions

Capacity	2x367 MW net	*Debt to Equity Ratio*	80/20
Installed Cost[4]	$460/kW net	*Debt Interest Rate*	12%
Depreciable life	25 Years	*Loan Term*	15 Years
Operating Costs		*Return on Equity*	20%
Variable O&M	2.2 $/MWh	*Insurance (Un-depreciated Assets)*	5%
Fixed O&M	5.1 $/kW/Yr	*Average Capacity Factor*	85%
Average net heat rate	6500 kJ/kWh	*Annual Escalation*	2%
Working Capital	1% of Capital Cost		

Estimated costs of gas pipeline and electric power transmission are summarized in Table 6.3.

Table 6.3 Estimated Gas Pipeline and Electric Power Transmission Costs for Bheramara Site2

Gas Pipeline Transportation ($/MWh)	
Charge for existing pipeline	2.1
Charge for extension of pipeline	2.2
Total Gas Transportation Charge	4.3
Electric Power Transportation Charge ($/MWh)	
Charge for connecting to Bangladesh Grid	0.0
Charge for use of Bangladesh Grid	2.6
Total Transmission Charge for serving Bangladesh Market	2.6
Charge for connecting to India Grid	1.6
Charge for use of India Grid	11.8
Total Transmission Charge for serving India Market	13.4

[2] Costs expressed in Year 2000 $

Table 6.4 shows wholesale energy tariff for a Base Case wellhead gas price of $1.50 per mmBtu. The portion of a power export project serving the Bangladesh market could deliver power at a levelized wholesale cost of about $33/MWh. This is well below other projects in the region. At this tariff some power could be sold in the east using the East-West Interconnector, although it is expected that adequate demand will exist in the west. A summary of wholesale energy tariffs for each project site evaluated is presented in Table 6.4.

The portion of a power export project serving the Indian market could deliver power to the Northern region at approximately $45/MWh. This is well within the $40 to $50/MWh range for the wholesale energy tariff expected in the region.

[4] Cost expressed in Year 2000 dollars. Does not include VAT or import duties. Interest during construction calculated separately.

Table 6.4 Wholesale Energy Tariff Summary

	Bheramara	*Sirajganj*	*Sylhet*	*Fenchuganj*
Gas Price @ Wellhead ($mmBtu)	$1.50	$1.50	$1.50	$1.50
Gas Transmission Cost ($/mmBtu)	$1.02	$0.50	$0.50	$0.50
Generation Cost ($/MWh)	$31.0	$29.6	$30.1	$30.1
Wholesale energy tariff to Bangladesh ($/MWh)	$32.6	$31.9	$32.9	$32.8
Indian Transmission Charge ($MWh)	13.4	17.8	25.2	24.2
Wholesale energy tariff to India ($/MWh)	$44.4	$47.4	$55.3[1] $50.3[2]	$54.2[1] $49.2[2]

1. *Interconnect to Eastern Grid*
2. *Interconnect to Northeastern Grid*

Delivered Power Price Would Be Competitive Against Future New Generating Sources Ranging From $0.044 to $0.047/KWh

Table 6.5 Bheramara Site - Levelized Wholesale Energy Tariff

Unit (generating module)	1	2
Dedicated Market	Bangladesh	India
Unit Size, (MW)	367	367
Capacity Factor	85%	85%
Sales (GWh)	2678	2596
First Year Operational	2003	2003
Busbar Generation Cost ($/MWh)	30.0	31.0
Levelized Wholesale energy tariff ($/MWh)		
Fuel cost at wellhead	10.4	10.7
Gas Transport	4.3	4.4
Power Transmission Cost	2.6	13.4
Operation & maintenance	3.6	3.7
Return on equity	2.9	3.0
Depreciation, interest, insurance	8.8	9.1
TOTAL ($/MWh)	**32.6**	**44.4**

6.4 SENSITIVITY ANALYSIS

Each proposed project site has slightly different requirements for gas pipelines and for connecting with the existing grids. While Bheramara is the nearest site to both the Bangladesh 230 kV system and to the Indian Eastern grid, its requirements for gas pipeline investment are also the greatest. Table 6.6 summarizes the Base Case economic analysis for these sites.

As previously stated, the assumed wellhead price of gas is $1.50 per mmBtu for the Base Case. Because of differences in gas transportation cost, the delivered cost of gas to the Bheramara site is $2.52 per mmBtu and $2.00 for the Sirajganj, Sylhet and Fenchuganj sites. All sites pay a uniform embedded charge of $0.50 per MmBtu.

It appears that a power export project, if located at either of the western sites, can deliver power at a lower rate than if it were located at one of the eastern sites, primarily because of the higher power

transmission costs from the eastern sites to the India grid. The Bheramara site has an advantage over the Sirajganj site for serving the India market because of its closer proximity to the India grid. However, the Sirajganj site appears to have a slight advantage over the Bheramara site for serving the Bangladesh market because of lower fuel transport charges. This result is highly dependent upon the use of an embedded cost methodology for transmission cost (discussed in a later section).

Wholesale energy tariffs from any of the two western project sites would be competitive with supply options available to the Indian Northern region (i.e., within the $42 to $50/MWh range). The eastern project sites are less competitive. The potential for connecting these two sites with the Northeastern grid of India has also been considered. That appears to be even less favorable than connecting the Eastern grid of India because of longer transmission distances and higher transmission losses.

Table 6.6 Summary of Levelized Wholesale energy tariff at Evaluated Project Sites

Bangladesh Market ($/MWh)	*Bheramara*	*Sirajganj*	*Sylhet*	*Fenchuganz*
Fuel Transport	4.3	2.8	2.9	2.9
Power Transmission	2.6	3.1	3.8	7.1
Others)	25.7	26.0	26.2	26.3
Total	**33.6**	**31.9**	**32.9**	**36.3**
India Market ($/MWh)	*Bheramara*	*Sirajganj*	*Sylhet*	*Fenchuganj*
Fuel Transport	4.4	2.9	3.0	3.0
Power Transmission	13.4	17.8	25.2	24.2
Others)	26.6	26.7	27.1	27.0
Total	**44.4**	**47.4**	**55.3**	**54.2**

6.5 FUEL COST

Fuel and pipeline costs make up 34 % of Base Case cost from the Bheramara site for power supply to India and almost half of the cost for delivery to Bangladesh. Figure 6-1 shows the relationship of the wellhead price of gas to the levelized wholesale energy tariff in the Northern region of India for the Bheramara site. Power to the Northern region at $45/MWh would support gas pricing at the wellhead of approximately $1.50 $/MmBtu. To deliver power at $50/MWh, the wellhead gas price would approximate $1.85/MmBtu (i.e., well above the cost of production).

6.6 TRANSMISSION COST AND PRICING

Transmission costs make up between 30% and 40% of the wholesale costs to the Northern region of India. The Base Case assumption is that these costs would be $10/MWh for transmission in India with losses of 5%. The cost of connecting with the Indian Eastern grid from the Bheramara site was estimated at $1.50/MWh (the cost of interconnection to the Indian grid is significantly higher for the other sites). Discussions with Power Grid of India indicate that the charges for use of the Indian grid could vary between $10 and $15/MWh and technical losses could vary between 5% and 10%.

The contribution of transmission costs for delivery to the Bangladesh market is relatively small. The embedded cost approach currently used spreads out the costs of transmission over all users, further reducing the impact of transmission charges.

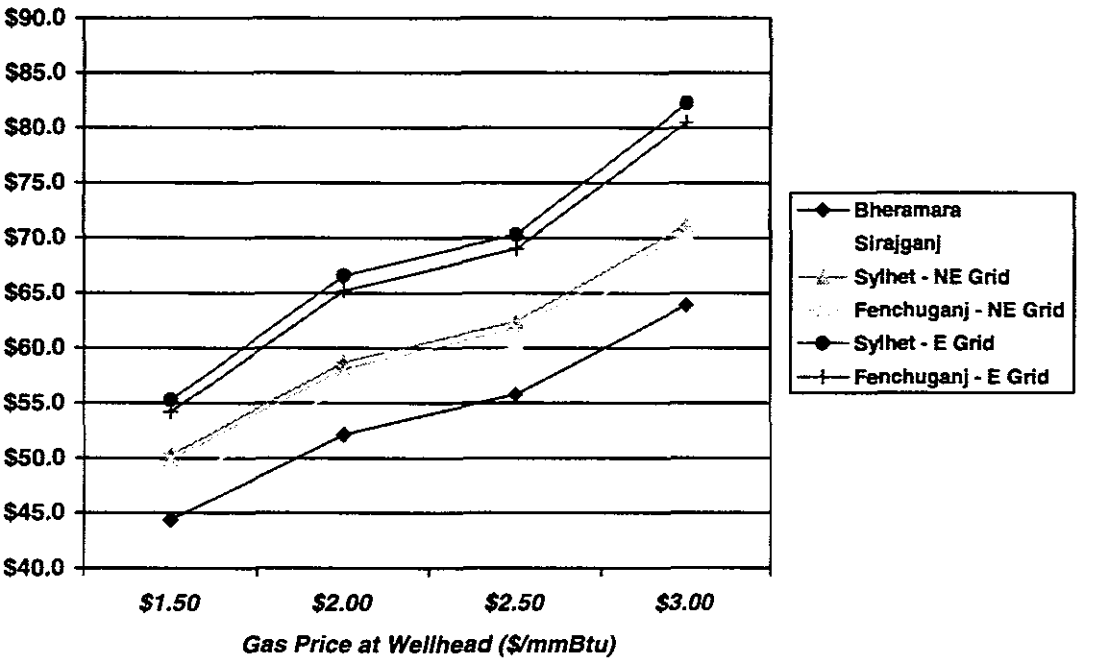


Figure 6-1. Wholesale Energy Tariff Sensitivity to Gas Price at the Wellhead

Figure 6-2 shows the effect of transmission cost on the wholesale energy tariff in the two markets required to cover costs for the Bheramara site. The variation of transmission costs over a reasonable range has only a small impact on overall cost of delivery (i.e., a range of $3/MWh).

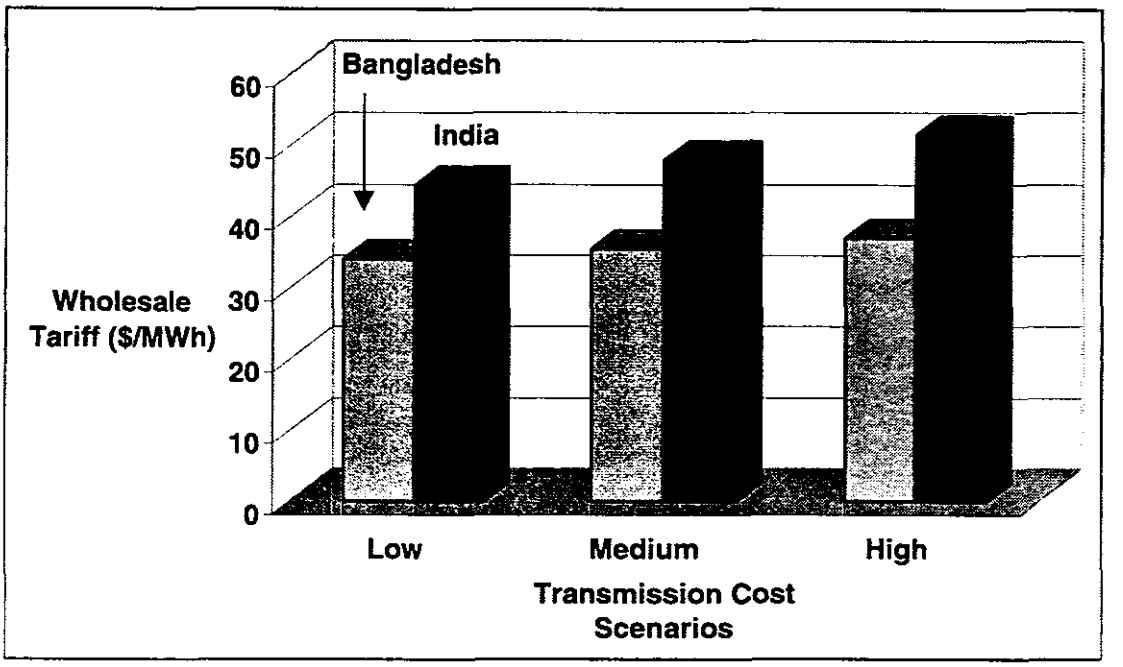
Since there is no cost for connecting the Bheramara site to the Bangladesh grid, the cost of transmission has little impact on the wholesale energy tariff required to cover costs. The other sites have higher transmission costs than Bheramara; however, the embedded cost pricing approach spreads these costs over all users so that site advantages for transmission within Bangladesh are not recognized at the wholesale energy tariff level.

The effect of transmission costs on delivery to the Indian market is more significant, both because of greater cost contribution and because of the incremental pricing approach being adopted. At the low end of the range of transmission charges, the wholesale energy tariff from a power export project at the Bheramara site would be at about the midpoint of the $40 to $50/MWh estimate range for wholesale energy tariffs in the Northern region of India. At the high end, the required wholesale energy tariff would be slightly above the range. The total range is about $8/MWh.

Many competing projects will have significant transmission requirements. If the transmission charges for the Bheramara site are comparable to the charges for the competing projects, a power export project can remain competitive. The issue of transmission pricing will be critical to Project success.

Power Export Will Support a Minimum Gas Price (Wellhead) of $1.50 to $1.85/mmBtu, and potentially up to $2.50/mmBtu or more.

Figure 6-2. Effect of Transmission Charges and Losses on Required Wholesale Energy Tariff in the Northern Region of India



6.7 COMPARISON TO OTHER MARKETS FOR GAS

The scope of this pre-feasibility study is limited to power supply to markets in Bangladesh and India. However, other options for the use of natural gas exist. As estimates of gas reserves are verified over the next few months, the GOB will be faced with decisions on how to best utilize available resources. A number of sources have suggested that the revenues that can be obtained from direct sale of natural gas from India are greater than from power, either domestically or for power exports. This alternative should be given careful consideration, as a power export project need not be incompatible with direct sales of gas to India.

Phase I Will Generate Gross Annual Foreign Revenues to Bangladesh of $120 - $130 Million

A power export project would also serve as an anchor for bringing gas to the western region of Bangladesh. With the addition of compressors to the existing line to Sirajganj and the proper sizing of the extension to Bheramara, significant volumes of gas could be made available for additional power projects and industrial development in the west.

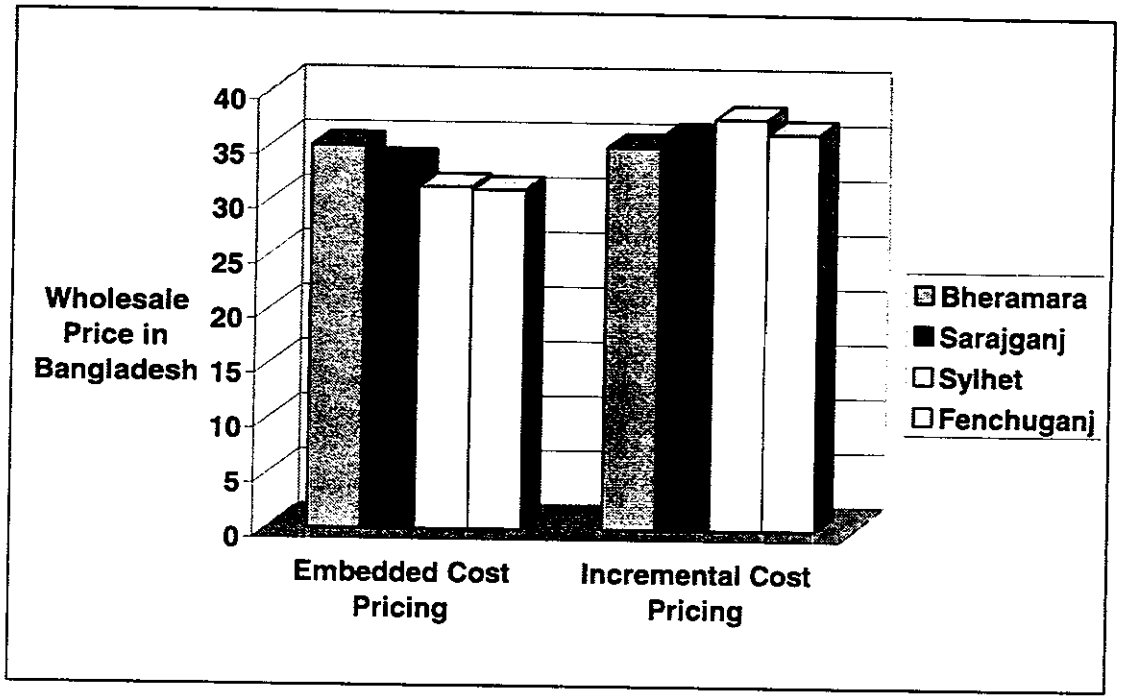


Figure 6-3 Effect of Transmission Pricing Approach on Required Wholesale energy tariff in Bangladesh

7. Commercial and Legal Considerations

7.1 COMMERCIAL ASSESSMENT

For the purposes of this pre-feasibility report, the principal measure of viability of a power export project is whether it is "commercially" viable, as defined from the viewpoint of the private sector. To be commercially viable, a power export project should be assessed using the standard corporate criteria prospective private developers and investors traditionally use in conventional investment decision-making. These criteria include a combination of economic and ancillary factors:

- The economic factors applied by a private company primarily consist of the expected rate of return from an investment and other financial calculations which have an impact on a company's bottom line (such as debt coverage ratios and non-recourse project financing through a special purpose company so that the project obligations are treated as a footnote on the company's balance sheet as a contingent liability). Risk-adjusted rate of return is generally recognized as the prime criterion for investment decision-making that demonstrates to stockholders that the investment will maximize present value and meet the required profit margins.

- Ancillary factors that a private company uses to determine commercial viability refer to the non-economic objectives that add value to a company's project. These include the ability to attain geographic and other strategic business goals, like relationship building, public relations benefits, and realizing competitive advantages gained from acquiring new knowledge and promoting environmentally and socially sustainable development.

With regard to a power export project, a prospective private developer and investor will apply these factors to address the fundamental questions that determine whether or not to invest time, capital and other resources in view of competing corporate opportunities:

- What is the expected rate of return on the investment for a power export project?

  The internal rate of return (IRR) technique determines a time-adjusted rate of return based on the time value of money. The IRR is the discount rate expressed as a percentage that makes the net present value of an income stream equal to a project's net outflows or investment. It is the maximum cost of capital that a company can pay for a project and expect to break even. Private developers normally require an IRR of 15-20% on the total project cost or, for most developing countries, it is well established that internal rates of return (unleveraged equity) need to be in the 20 – 30 % range in order to generate private sector interest for a well-structured project.

  The Base Case for a power export project in Bangladesh has been set at 20%, taking into consideration the risk sharing arrangements that have been negotiated for independent power producers (IPPs) in Bangladesh that have reached financial closure. In this regard, it is important to understand that Bangladesh should resist taking the position that rates of return should be capped at less than 20%, based on making comparisons with other types of investments that are less capital intensive and involve fewer project risks. A 20% benchmark should be considered as the minimum equity return necessary to attract the type and amount of foreign capital that is needed to upgrade and expand the energy sector in Bangladesh. In this regard, it is important to understand that the rate of return is a relatively insensitive cost item in terms of its effect on the resulting wholesale energy tariff. It is also important for Bangladesh to continue with its energy sector reform including passage of legislation that will establish an independent regulator. Progress in the reform process will do much to instill investor confidence in Bangladesh and reduce the cost of capital for the proposed export power plant and other energy sector investments.

- What is the probability of hidden costs/ and or high transaction costs of a power export project?

There is a low probability that a power export project will be burdened by hidden or high transaction costs. This is primarily due to the learning curve that has been achieved in Bangladesh over the past several years in which several projects have successfully reached financial closure. By following the approach that has been well established, whereby GOB has agreed to assume those obligations that it is better positioned to assume (e.g., acquisition of site control), transaction costs to the private sector can be minimized.

At the same time, it is well understood that financing any project on a non-recourse basis, especially in developing countries that do not have established long-term debt markets, will involve incurring significant transaction costs. This is because the principal asset being pledged to lenders and investors is not the sponsor's corporate assets but it is the right to future cash flows under the project agreements. To preserve these contract rights, the parties to a project export agreement will have to expend the time and capital needed to identify and address all of the significant risks that affect the project revenue stream. However, experience has shown that the most significant transaction cost relates primarily to the amount of time expended to negotiate project agreements. Relying on model agreements adapted from IPPs and utilizing the limited competitive bidding procedures that have been successfully used in Bangladesh in IPP and PSC solicitations can minimize this.

- Are there Sources of Reasonably Available Private Investment Capital?

  Properly conceived and developed in stages, a power export project can be financed similar to the success in Bangladesh of closing or near closing of five IPPs in only the past three years. The principal source of private equity is the consortium members that would bid on the project. Given the importance of managing the fuel risk and interconnection requirements, investors and lenders will be comforted if the fuel supplier or other related parties that are credit-worthy (such as NTPC) participate in project ownership. Discussions with the World Bank and ADB in Dhaka indicate that they would participate in a pool of commercial lenders. In the bid solicitation of the Meghnaghat project, ADB made $50 million available and, in ADB's recent fact finding mission of the Gas Sector Development Program, ADB specifically indicated its support for funding a power export project. The World Bank identified several existing source of project debt, including the PSIP Fund. Although most of the existing $235 million is being committed to other projects, the World Bank would consider injecting additional funds if international competitive bidding was employed. Other sources of existing financial support include the Partial Risk and Credit Program, Adaptive Program Lending, IDA Lending and various grant and loan programs that exist for demonstration CDM projects.

- Does the proposed scale and timeline of a power export company fit the near-term or long-term corporate strategy of the company?

  A power export project should be implemented in phases so that the first stage can be developed and commissioned by the year 2005. This is a reasonable time frame for a private company experienced in Bangladesh and India to show results, while at the same time allowing for the time that will be needed for GOB to undertake related activities, such as completion of planned pipeline and transmission interconnections and updating Bangladesh's proven gas reserves.

- Will the investment provide a geographic or market-oriented strategic benefit to the company?

  As in the case of previous IPPs, it will be relatively easy to identify the several international and domestic private companies that will commit its resources to a power export project, based upon qualifications and experience. In the case of a power export project relying upon natural gas, the principal companies that can be expected to show serious interest would include the oil & gas companies that are already committed to a long-term business strategy in Bangladesh. Indeed, it is

for this reason, even if the first phase of a power export project involves a relatively small project size with marginal economics, the proposed project offers substantial benefit as a means to gain a strategic advantage should sufficient gas reserves be proven to justify direct exports of natural gas.

- Does the project yield environmental or social benefits to Bangladesh, India and local communities that also provide commercial value?

  A power export project has the singular ability to provide environmental and social benefits by virtue of utilizing natural gas, a relatively clean-burning fuel, and serving as an anchor for future development, especially in western Bangladesh. By allowing for fuel substitution of diesel fuel oil products now used in western Bangladesh and displacing some of the power generation that would otherwise by produced using high-sulfur coal in Eastern India, conceptually, a power export project would qualify as a demonstration Clean Development Mechanism ("CDM") project. If this materializes, a power export project would attract the interests of private investors that will be in the market for buying carbon emission credits, assuming the Kyoto treaty is successfully ratified.

- Will the investment improve or damage corporate image? Will the investment have a public relations value?

  Properly conceived and successfully implemented, a power export project will produce important public benefits to both Bangladesh and India that, correspondingly, will provide significant opportunities for the project sponsor to enhance its corporate image and standing in the industry. By providing a means to generate foreign currency revenues using clean fuels to stimulate economic development, a power export project can be seen as a model for utilizing private sector investment while also meeting corporate economic and non-economic objectives for doing business in Bangladesh.

7.2 LEGAL ASSESSMENT

A related component of commercial viability involves an assessment of the legal viability of a power export project, particularly as it relates to three fundamental concerns of prospective private sponsors and investors:

- Is there a high level of risk associated with the investment due to an inconsistent regulatory environment?

- Do adequate legal precedents exist for establishing the necessary ownership and operational arrangements that enable project risks to be identified, properly allocated and managed?

- Are there clearly defined, established legal steps that are in place that will enable a power export project to be successfully financed and implemented along a reasonable time line?

7.2.1 Regulatory Environment: Adequacy of Existing Framework and the Opportunity to Enact Supportive Laws and Regulations

From a legal/regulatory standpoint, this is an opportune time to develop and implement a power export project. Since the National Energy Policy and Power Sector Power Generation Policy were adopted by GOB in 1996, establishing the Power Cell to regulate private power projects, GOB has developed a Vision Statement to provide access to affordable and reliable electricity by year 2020. These policies are presently being further strengthened by recent efforts to develop a draft Bangladesh Electricity Reform

Utilize Existing Legal and Regulatory Framework in Bangladesh and India

Amend Draft Legislation Currently Under Consideration in Bangladesh and India to Provide for and Regulate Power Exports

Act, which will establish a structure of a regulatory commission, as well as proposed legislation to reform the oil & gas sector. Moreover, in the past few years, policies and regulations have been clarified and vetted by the limited competitive bidding procedures that have been employed for soliciting and awarding IPP contracts and Production Sharing Contracts. While these advancements and precedents have combined to establish an adequate regulatory framework, GOB could provide greater impetus to power exports by amending the draft Bangladesh Electricity Reform Act, 2000 to explicitly authorize power exports under jurisdiction of the proposed Energy Regulatory Commission and submitting it for approval by Parliament. The amendment would be directed at addressing the fundamental underlying issue that has undermined support for either power or gas exports, namely: can Bangladesh enjoy the benefits of exporting power to India and other export markets and still be assured of adequate domestic gas supply? Such an amendment could be relatively simple and follow the approach used by other power exporting countries which have explicitly authorized power exports by providing for an independent, objective determination of the amount of excess power and gas that is available for export once domestic requirements have been met. As supply and demand change, the regulatory commission would periodically update the amount of available excess power and gas. In this way, the emotional, nationalistic pressures that presently obscure the issue of power and gas exports can be de-politicized.

A favorable regulatory environment for power exports also presently exists in India. Various policies and initiatives have been adopted to encourage private sector participation in generation, transmission and distribution since India first enacted power sector reforms in 1993. India is presently considering a codification of laws in the power sector through the proposed Electricity Bill 2000 (presented to MOP of GOI by NCAER, July 11, 2000).

Current Status of Reforms in Bangladesh and India Makes Power Exports Timely

Among these regulatory initiatives has been the creation in 1997 of the Power Trading Corporation (PTC). PTC was established to serve as a single window agency for power trading with SEBs to optimize power resources in India and to promote power trading with neighboring countries.

At present, PTC is responsible for one operational export project, the Chukha project in Bhutan, a 336 MW hydro project developed by Chukha Hydro Power Corporation. However, PTC is in the process of expanding its operations by virtue of administering the purchase of power from several export projects that are under development, including: the Tala Project in Bhutan, a 1,020 MW hydro project being developed by Tala Hydro Electric Power Authority; the West Seti Project in Nepal, a 750 MW hydro project being developed by Snowy Mountain Engineering of Australia (note: Nepal is a net importer of power); the Maithon Project in Bihar, a 1,000 MW coal-fired project being developed by Damodar Valley Corporation & BSES; and the Ennore Project in Tamil Nadu, a 1,800 MW LNG project being developed by Dakshin Bharat Energy Consortium.

The equity stakeholders in PTC include Power Grid of India (30%), NTPC (15%), Power Finance Corporation (15%) and various financial institutions and SEBs (40%). Hence, PTC is well positioned to serve as the single contracting party representing GOI, especially as its initial capital authorization is increased to the planned Rs. 10,000 million and as PTC establishes its Payment Security Mechanism (for back-to-back PPAs with SEBs based on priority rights to a state's central plan allocation from the central government).

From the standpoint of power exports, other GOI advancements that will facilitate power exports include the recent (1999) execution of Bulk Power Transmission Agreements between Power Grid of India and several SEBs. These agreements will be used in conjunction with back-to-back PPAs between PTC and SEBs to facilitate the wheeling of exported power throughout India.

GOI recently announced its further support of implementing inter-country and inter-regional power sales through PTC by announcing further details of the Payment Security Mechanism as it relates to the revised mega projects (Hirma in Orissa, Ennore in Tamil Nadu and Pipavav in Gujarat). Under the new scheme, the central plan allocation which was made available to PTC for securing payments to the project developers in the revised mega power policy will now be replaced by GOI guarantees. The guarantee will cover payments only in the event of termination and will be limited to the entire outstanding amount of foreign debt for generation and transmission projects. To avoid termination in the event of SEB default, it is also proposed that PTC will pay project developers by way of issuing bonds with backing and guarantee of GOI. This would be subject to a maximum of six months payments of generation, including "take-or-pay" commitment of fuel and also transmission cost. This would provide PTC sufficient time to find an alternate buyer, thereby avoiding termination by payment default. Under the new payment security scheme, PTC will also have a charge ion the revenues of SEBs, distributors and bulk consumers in cases of payment default. A separate mechanism is being worked out for payment for energy purchase.

Credit-worthy and motivated buyers of power exports exist in India: Power Trading Corporation, National Thermal Power Corporation.

7.2.2 Ownership Structure and Contractual Arrangements that Allow for a Fair Allocation and Management of Defined Project Risks

There are two basic approaches to take in structuring a power export project with India. The first approach is to implement the project on a government-to-government basis, similar to the bi-lateral contractual arrangements that have been previously used by India in Nepal and Bhutan involving concessionary funding (soft loans and grants) provided through the National Thermal Power Corporation (NTPC). Given the lack of financial resources of GOB and GOI, however, and to be consistent with the prevailing private power policies of both countries, the favored approach is to enlist the private sector to develop, own and operate a power export project following limited competitive bidding procedures, as done in awarding IPP contracts and PSCs. A bidder may be an individual or sole proprietorship, a corporation, partnership or a joint venture or consortium that can demonstrate that it is an established business and the individuals that are designated to manage the project are properly authorized and nominated. A special purpose project company is established that is separate from its sponsor so that liability and risk to the project are limited. Project ownership can be structured in a number of ways, although the types of project structures conceptually available to implement power exports involve variations of a basic financial arrangement:

Build, Lease, Transfer (BLT): This financing arrangement is when a private sponsor agrees to develop and build a power plant, then sells and leases it back for a period of years (usually 10 to 30 years), and then transfers the facility to an entity in the government, a corporation or a joint venture partner. The transfer price may be fixed, or fair market value, or may be zero.

Build, Own, Operate, Transfer (BOOT): This financial arrangement is when a private sponsor agrees to develop and build a power plant, and own and operate it for a period of years (usually 10 to 30 years), and then transfer the facility to an entity in the government, a corporation or a joint venture partner. The transfer price may be fixed, or fair market value, or may be zero.

Build, Own, Operate (BOO): This financial arrangement is when a private sponsor agrees to develop and build a power plant, and own it for a period of years (usually 10 to 30 years), without an obligation to transfer the facility to an entity in the government, a corporation or a joint venture partner.

Consistent with the Private Sector Generation Policy of Bangladesh, it is assumed that a power export project would be operated on a BOO following the terms of an international solicitation administered by

the Power Cell, MEMR in accordance with negotiated terms and conditions of a project security package consisting of model agreements.

7.2.3 Bid Solicitation Process

As provided for in GOB's Private Sector Generation Policy (Section 8), private power projects are to be implemented through the Power Cell, MEMR through international solicitations of specific projects. In this way, a Request for Proposals (RFP), including draft project agreements, is issued to pre-qualified bidders along with bid evaluation criteria. Well-defined evaluation criteria and a transparent evaluation process lend credibility to the procurement process as responding to an RFP is expensive and potential bidders are reluctant to submit proposals if criteria are not clearly defined.

In a structured RFP solicitation, competitive bids are requested for the development of projects that have a specific and proven technology, size and location. Prior to the solicitation of competitive bids, a comprehensive project feasibility study is prepared to establish project requirements to ensure the project fits into the planned generation mix as intended and to allow bidders to evaluate the basic features of a specific project, including: (i) capacity and energy requirements (including opportunities to wheel excess capacity), (ii) operational characteristics (including type of plant operations, such operating as a baseload, peaking or dispatchable unit), (iii) schedule (to allow for flexibility in response to possible construction delays or changing conditions), (iv) technology (the favored generation technology is assessed and requirements related to emission control equipment, site arrangements and availability of cooling water), (v) fuel (sources, costs and available modes of transportation), (vi) plant location (electrical interconnection costs of transmission lines and substations, (vii) costs (project capital, O&M, engineering, interest during construction, contingencies and cost of electricity produced) and (ix) environmental impact (compliance with host country and international lender standards). While the advantage of completing a project feasibility study that establishes project parameters is that it simplifies the bid evaluation process by minimizing variations among bids, the disadvantage is that it fails to take advantage of the possibility that other approaches exist which are more economic or otherwise attractive.

A power export project can be expeditiously implemented following the bid solicitation process used in the past by BPBD, as exemplified by the solicitation of the Meghnaghat Power Project in 1997, which was subsequently awarded to AES. Under this approach, BPBD pre-qualified project sponsors that were competitively selected based on bids submitted in response to an RFP that provided detailed and defined project information and project financing agreements including: Volume One (Information from Sponsors, Instructions to Sponsors, Plant Functional Specifications and Sponsor's Proposal and Supporting Data); Volume Two (Draft of Implementation Agreement, Draft of Power Purchase Agreement, Draft of Fuel Supply Agreement and draft of Land Lease Agreement), and Volume Three (Ground Investigation Report and Hydrographic and Bathymetric Report). In this case, prior to the RFP solicitation, BPBD established a local project company, the Meghnaghat Power Company (that was to be assumed by the selected bidder upon reimbursing BPBD $5 million in pre-development costs). Pre-qualified bidders were invited to purchase bid documents for $20,000 and to submit proposals accompanied by an unconditional bank guarantee for $4 million. A two-envelope evaluation process was used to award the bid: Envelope I contained only the bidders' responses to the technical, commercial and financial aspects of the proposal, while Envelope II contained the bidders' Tariff Rate Proposal. BPBD first determined which bidders were responsive, based solely on evaluating Envelope I. Once identified, BPBD then opened Envelope II of the responsive bidders and selected the successful bidder solely on the evaluation of the Envelope II tariff proposals. Once selected, the first ranked bidder was given a stipulated period of time to submit a performance guarantee and reach financial closure. This same solicitation process should be applied after adapting the pre-qualification process that has been used for IPPs to ensure a competitive response from qualified bidders to include factors that are particularly suitable for implementing a power export project. In addition to private power developers, this includes soliciting companies that are experienced in gas production and transmission. Pre-qualified sponsors should be selected on the basis of their ability to have either in-house expertise to cover all development

tasks, or the capability of forming a team by taking on partners having the following skills and capabilities:

- Prior knowledge and understanding of the development process in Bangladesh, including knowledge of all key project contacts;
- Demonstrated sound business practices, management skills and the ability to conduct business in Bangladesh;
- Technical expertise relating to project engineering, project management and plant operations of combined cycle facilities, power and gas transmission and gas field development;
- Financial expertise, including knowledge of doing business and project financing in Bangladesh;
- Demonstrated ability to make critical connections and to develop relationships with key foreign parties, including multilateral debt and equity sources.

To Attract Qualified and Experienced Private Sponsors and Investors, a Power Export Project Must:
Provide Minimum Expected Rate of Return of 20%
Have No Hidden Costs/Nominal Transaction Costs/Reasonable Timeline
Involve Limited Competitive Bidding Among Pre-qualified Bidders

7.2.4 Negotiation of Security Package

To close the financing plan and actually start construction of a power project, a sponsor needs to negotiate a set of agreements (the "security package") that satisfies not only the government and itself, but also the investors and banks that contribute capital and provide debt financing of the investment. The security package seeks to reduce the risks of investors and lenders by establishing legally binding obligations, financial structures and operational procedures. Before loan funds can be disbursed, the lenders will wish to be satisfied that all of the principal agreements meet their requirements and have been executed. Lenders may want legal opinions, independent engineering reports and copies of governmental approvals. Lenders will also want to confirm the parties to each agreement are creditworthy and capable of performing under the terms of their respective agreements. Lenders look to the project security package to provide security for the loan and in the event of breach they may seek the right to takeover the company and install their own managers within the framework of the agreements. The preparation of the various agreements must be coordinated and made consistent so that there is no conflict among them. The principal agreements that comprise the security package include:

- Implementation Agreement (this agreement is between the project company and GOB, representing the governmental entities that provide the inducements, guarantees, commitments, assurances and support necessary to develop the project); the Power Purchase Agreement (this agreement establishes the power sales obligation between the project sponsor and the power purchaser committing the sponsor to operating under specified conditions over a defined period and committing the purchaser to compensate the producer by an established amount and tariff rates whenever the facility is available and capable of generating power); the Gas Supply Agreement (this agreement provides commitments as to the amount, quality price and delivery of fuel on a firm and reliable basis with incentives and disincentives designed to encourage contract performance). Other agreements that comprise the security package include the Land Lease Agreement, the Project Ownership Agreement, the Engineering Procurement and Construction (EPC) Agreement, the Operations and Maintenance (O&M) Agreement and various project financing agreements. In negotiating the terms and conditions of the project security package, a balance needs to be achieved that reflects the basic interests of each project participant:

- GOB: GOB wants to encourage least cost, most efficient and environmentally acceptable projects, sized and located so as to best serve the power needs of the country. The government does not want to become, or be perceived as, an obstructionist to developing viable projects. It wants to promulgate clear, comprehensive guidelines which facilitate all participants in a project to make choices and decisions which best serve the public interests while being responsive to private interests such as lender requirements, owner return on investment and developer profit. By drawing upon the documentation of completed projects, GOB can encourage certain projects and discourage or otherwise screen out undesirable projects. By establishing a clear regulatory framework, supported by standard agreements which serve as a starting point for project approvals, government can focus its limited resources on evaluating and negotiating terms and conditions of selected projects which best serve public interests.

- Developers: A project developer cannot waste scarce development funding on ill-conceived or troubled projects, expending time and resources on identifying and developing projects which, ultimately, cannot be approved by regulatory authorities or which cannot be built, owned and operated on an economically financially sound basis.

- Equity Owners: An equity owner, as an active or passive investor, does not want to make capital contributions without assurances that a project can be developed so as to meet operating and financing requirements. An owner does not want to invest in a project which is economically marginal because of the long lead times and excessive development costs expended to identify and manage project risks. In addition to securing necessary regulatory approvals and attractive financial terms, a project owner wants assurances that cost overruns are protected against with fixed price, turnkey contracts and operating reserves are adequately funded and supported by an operation & maintenance contractor which can ensure operations will be in line with the operating assumptions of project financial projections. Without such contract assurances, the confidence of investors will not be sufficient to attract competing private capital sources.

- Lenders: Like other project participants, especially project owners, project lenders do not want to commit debt funding to projects which are not contractually protected against resource risks, market risks, technical risks, currency risks and political risks. Lenders must require contractual provisions to ensure adequate working capital, project completion and performance and such other assurances as contractual protection against interruption of project revenue and project abandonment.

- Contractors, Legal and Financial Advisors: Like other project participants, contractors engaged to assist in project development and financing want to provide services without being exposed to undue project risks. Because of the substantial development costs involved in project development, often contractors are under pressure to compete for clients and provide services that cannot be realistically assumed because of the nature of the work or because of low budgets developed in response to competing contractors. Many contractors must either "buy" into a project or provide services on a contingency basis until such time as a proposed project becomes a reality, either by obtaining government approvals or construction financing. By participating in projects that are supported by proper documentation to manage project risks and obtain timely approvals, contractor risks are also minimized. Moreover, having access to standard project agreements does not compete with the services provided by contractors, including legal advisors. The availability of standard project contracts that draw upon the success of predecessor projects will only facilitate the market for services. Even with standard contracts, experienced project advisors understand that the work remains to be done. Every project is different from a technical, financial and regulatory standpoint. The project financing documentation for each project consists of general terms and conditions and specific terms and conditions reflecting, among other considerations, the location, size, fuel requirements, combustion technology and economics of individual projects. Instead of spending time on unimportant or non-controversial issues,

working from standard contracts, project participants can focus on those unique or special terms and conditions that must be established and negotiated on an individual project basis.

In developing and negotiating the terms and conditions of project agreements, each project participant, whether it be the private sponsor or a GOB entity, is expected to take project risks which are foreseeable and manageable and for which it is adequately rewarded. In doing so, "proper risk allocation" means that good faith negotiations will result in having the party best able to manage a given risk actually bear that risk while receiving fair compensation for its risk-bearing. Once allocated, measures should be included to mitigate losses and the parties should establish a reasonably swift process for dispute resolution.

Properly undertaken, proper risk allocation results in the lowest achievable project cost and the most attractive return if the parties systematically define and quantify the risks before any allocation is made. Proper risk allocation allows for distributing the returns, profits and other available project benefits to fairly reflect the risks assumed by each project participant. However, in contractually agreeing to perform certain undertakings with respect to allocated obligations, each participant should recognize that each has a "bottom line" which establishes the maximum risk-reward it is willing to accept. If a risk is inadequately defined or improperly allocated, debt and equity markets will either refuse to finance the project or demand inordinately higher fees and returns in compensation of that misallocated risk. In a competitive market, where the aim is to minimize cost by managing risk, inadequately defined risks or improperly allocated risks cause rate payers to suffer by losing competitive supply options or by having tariffs increased.

Negotiate Project Security Package Based on Fair Risk Allocation Principles Established in Financing Documentation for Recent Domestic Projects (e.g. WRIP Project, IPPs)

For a power export project, perhaps the best project agreements to use for exemplary purposes is the project security package that has been recently under development for the Western Region Integration Project (WRIP). In this case, MEMR has recently engaged the consultancy services that has provided a detailed independent review of the project benefits and risks that are defined, allocated and managed in seven inter-locking project agreements whereby a private company would be given rights for gas production, transportation and power generation, by agreeing to:

- Explore and develop the allocated gas field under a Production Sharing Agreement ("PSA") through an affiliated contractor/concessionaire ("Field Company").
- Enter into a Gas Purchase and Sale Agreement ("GPSA") whereby Field Co. delivers to Petrobangla at a delivery point a certain minimum annual Take-or-Pay quantity of gas.
- Enter into a Pipeline Build Own Operate Agreement ("PBA") whereby another affiliate of Bidder ("Pipeline Co.) designs, engineers, builds, owns and operates a gas pipeline for delivery of gas to the power project (owned by Power Co, another affiliate of Bidder).
- Enter into a Gas Transportation Agreement ("GTA") under which Petrobangla will sell, transport and deliver to the power plant a quantity of gas corresponding to the fuels needs of the plant per the minimum volumes under the GPSA And shipped under the GTA.
- Enter into a Power Purchase Agreement ("PPA") between Power Co. and BPDB whereby BPDB will pay capacity payments for plant availability (to cover capital cost of construction, including debt service, fixed and variable operating expenses and a return on equity) and energy payments to cover the marginal cost to produce such energy as requested under dispatch orders (including a pass through of fuel expense).

- Enter into an Implementation Agreement ("IA") whereby GOB provides certain assurances to complete the project on time and without interference as well as guarantee the timely payment and performance of the various GOB entities that are contracting parties.
- For the purposes of a power export project, this security package would be expanded to include a Bulk Power Export Purchase Agreement between BPDB/Power Co. and PTC/NTPC covering the exported power sales portion of the project.

In identifying and allocating risks for a power export project, it is instructive to consider the comments of the MEMR consultants to the WRIP draft agreements as they relate to the conclusion that there are instances when the agreements allocate risk unequally from the bidder to GOB, as summarized below:

- Fuel supply and transportation risk should not fall on GOB, as the bidder's affiliates control gas production (through Field Company) and gas transportation (through Pipeline Company). The obligations of the bidder to supply gas to GOB under the GPSA, and of GOB to supply to the bidder under the GSA should be parallel so that if the bidder is excused from supplying gas, then GOB is excused from its supply obligation under the GSA and the minimum transportation ship-or-pay quantity under the GTA.
- Inter-locking project agreements should be properly linked. For example, if a Force Majuere Event excuses one party under one agreement, the affected parties under other agreements should be equally excused. If there is arbitration under more than one agreement, the arbitration should take place as a single hearing. All contracts shall have the same governing law (Bangladesh). Terms should be commonly defined and made consistent in all agreements.
- There should be no double recovery by the bidder of compensation for events. For example, if two or more events have occurred under which BPDB would be liable for liquidated damage payments (e.g., delay in testing and in completion of interconnection facilities), GOB should not pay twice for the same period of delay.

7.2.5 Steps for Financial Closure

Financial close occurs when all agreements have been executed and financing arranged and disbursements from the proceeds of the financing can take place. In practice, execution of most agreements occurs at the time of financial closing, except for agreements that required prior signature. The obvious requirement for financial close is to deliver final agreements that are signed by the parties on terms acceptable to lenders. Other contracts and certifications are also delivered at closing.

In a typical non-recourse financing structure, the entity formed by the ownership agreement is the central point to which all project documents connect and is where the ultimate recourse to lenders and other parties lie. Consequently, the entity is limited in all matters relating to its business and is referred to as single purpose or special purpose. The project company is obligated to cause all other parties to perform under the project agreements and furnish documentation required by the company or lenders.

Again, for the purposes of a power export project, the project structure and project implementation steps outlined in the competitive bidding process of the Meghnaghat Project provides a general framework By BPBD creating a special purpose company prior to initiating the bidding and transferring the company and all of its financial tax incentives and other assets, such as site control, to the successful bidder, the pre-closing development activities are minimized Moreover, by using model agreements under the umbrella of the Implementation Agreement, which consolidates the consents required for financial closure (for the AES Haripur project, no less than forty consents were identified), the only additional closing requirement is execution of a power export purchase agreement between the project company and Power Trading Corporation of India The prototype for this agreement will be the bulk power purchase agreement PTC is presently developing for the mega projects.

8. Social/Environmental Assessment

8.1 SCOPE OF ASSESSMENT

Environmental and social issues are an integral part of any project. At this stage in the development of a project, the pre-feasibility stage, any analysis of environmental and social issues should be restricted to potentially major, or key, issues (such impacts are often known as "show stoppers") which might significantly impact upon project schedule and cost, two of the key determinants of project viability. The aim of this section is to report on the potential environmental and social impacts, both positive and negative, on each of the selected sites and on the region as a whole. To set the environmental assessment in context, a brief report outlining the baseline environment in Bangladesh is attached in Annex 2.

8.2 KEY ISSUES

8.2.1 Regional Reduction in Pollution

Development of Bangladesh's gas resources will result in the substitution of traditional fuels (coal, charcoal, diesel, fuel oil, naphtha, etc.) by relatively clean gas for use primarily in power generation. Power generated in Bangladesh and used locally will displace diesel currently used in power generation, and the resulting electrification of near by towns and communities will rapidly reduce the burning of charcoal and liquid petroleum gases (LPGs) for domestic cooking and lighting. In addition power exported to India will act to defer any further new coal-fired power generation in India.

The following section illustrates the change in atmospheric pollution brought about by substitution of natural gas for traditional fuels. In all the potential project scenarios, a large quantity of the gas or power will be utilized in India. Therefore, in order to best illustrate the resultant changes in atmospheric pollution, emissions factors have been selected for combustion of Indian coal in power production.

Step 1: Emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_x), suspended particulate matter (SPM) and carbon dioxide (CO_2) resulting from both coal- and gas-based generation are estimated, using emission factors for gas and Indian coal burnt in Indian thermal power stations.

Step 2: The difference in the emissions, for each pollutant, between the two types of generation illustrates the change in emissions for the power sector. This generic example is based on power generated by burning gas and Indian coal, in which 1000 m^3 of gas produces approximately the same power as 3.5 tons of coal.

Table 8.1 below shows the atmospheric emissions generated when 1,000 m^3 of gas and 3.5 tonnes of Indian coal – the equivalent amounts to generate the same quantity of power - are consumed in a power plant. The difference, which in all cases is a reduction, is also shown.

This shows that the regional impact of generating power by gas as opposed to continued generation using coal is positive with net reductions in atmospheric emissions of particulates (SPM), sulphur dioxide (SO_2), oxides of nitrogen (NO_x) and carbon (C). In addition there is no fly/bottom ash or other solid waste generated by gas fired power production.

Table 8.1: Emissions generated by combustion of a unit of gas and coal to produce the same quantity of power

	Fuel		*Reduction using Gas*
	Gas (1,000 m3)	**Coal (3.5tonnes)**	
SPM (kg)	0.08 – 0.24	112	111
SO_2 (kg)	0	29	29
NO_x (kg)	11	34	23
CO_2 (kg of C)	207	605	398

8.2.2 Reduction in CO_2 and Carbon Trading

The principle of carbon trading revolves around the fact that climate change, strongly influenced by a post industrialization increase in atmospheric carbon, is a global issue. Any resolution to this issue is therefore not dependent upon the specific part of the world in which the emissions are created or reduced but upon action taken on a global scale. In light of this, several mechanisms have been created and some introduced, to facilitate reductions in carbon emissions on a global scale. These include the concept of carbon trading. This mechanism would depend upon target limits being set for carbon emissions. When the emissions limits are not reached then credit is gained per unit of carbon under the set limit. Similarly if the emissions limits are exceeded then the perpetrator may purchase credit from another entity to the amount required to bring emissions in line with the set limits. This way, units of carbon become a valuable commodity that may be traded. Carbon trading schemes could be set up at many different levels, from within the same company (typically large multinationals) right up to between different nation states.

Under the United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol of 1997, several flexibility mechanisms were adopted as methods by which Annex I countries could meet their greenhouse gas (GHG) emissions obligations at a cost lower than actions taken domestically, including carbon trading. These mechanisms also were designed to foster collaboration both among industrialized countries and between industrialized countries and developing countries to achieve environmental benefits.

The carbon trading mechanism was designed to allow developed (Annex I) countries to sponsor projects in developing (non-Annex I) countries with the aim of reducing atmospheric concentrations of greenhouse gases. For example, such projects may be designed to reduce the carbon emissions by improving the efficiency of the energy sector or to increase carbon "sinks" by preserving or expanding forests. The carbon trading mechanism was due to come into effect in 2000 whereby an Annex I country, by undertaking this investment, may gain emissions credits to offset against agreed target levels which must be reached within the period 2008 – 2012, however, it has not yet been put into place.

At present (at the time of this study) the carbon trading mechanism has not been formally created and therefore cannot be used, but there are still potential benefits to be gained from the principle of carbon trading, assuming that such a mechanism is put into place in the future (which must be stressed cannot be guaranteed). If the proposed export project does lead to a reduction in GHG emissions, then it is still possible for the investor to accumulate carbon credits that may be saved until the time that the mechanism becomes functional. Such a project could act as a demonstration project. There have been funds created to assist such demonstration projects, one being the Prototype Carbon Fund (PCF), which aims to provide money for certified savings of carbon in advance of the market being developed for trading said credits. Use of these funds requires certain project conditions to be met, but this is an avenue that could be explored by project sponsors.

8.2.3 Social Impacts

When attempting to assess the social impacts, both positive and negative, arising from the project it is necessary to look at the four scenarios (export gas, export power, generate power for domestic and export markets, and the "do nothing" scenario) and their impacts at three levels of society:

Economy as a whole: the sale of natural gas or power to export markets will generate foreign currency for the Government of Bangladesh (Chapter 2). In addition, by utilizing the country's gas reserves for power generation for use within Bangladesh, a significant amount of foreign currency, which is currently being spent on the import of liquid hydrocarbons (diesel used in the Western Region), will be saved. These foreign currency revenues could be invested in the country resulting in socio-economic benefits. Such social benefit channeled through the government would be distributed across the country. At this level the most favorable scenario would be that which combines to maximize the foreign currency revenue from export sales and minimize the reliance on imported fuels.

Regional: there would be regional benefits according to where the power will be generated or the gas developed. The main benefits are felt by industrial and residential areas that obtain a reliable power supply in the vicinity of the power plant and more generally with a cleaner source of fuel resulting in reduced emissions. The Western Region of Bangladesh currently accounts for the entire consumption of diesel utilized in power generation as well as having large areas without electricity at all, and would therefore benefit the most from a new power project. A new power project would also contribute towards building a better peace and stability within the regions.

Household: at this level there are three key indicators: the impact upon the household income level; the improvement in the quality of life, for example the benefits of having a power supply; and employment which may be direct (employed by the power or gas company) or indirect (companies that support the power/gas industries). Household benefits are likely to be more noticeable as a result of power generation within Bangladesh, and will be felt more strongly by households closer to the site of power generation.

With a large population engaged in agriculture, any power plant development is likely to displace some agricultural land and potentially some small residences. However, these localized, negative impacts are insignificant in the light of the positive impacts of such a development. A full environmental assessment of a power plant development should address these localized inputs.

8.2.4 Cumulative impacts.

Cumulative impacts are those that result indirectly from the project and act to build up over time. For example, as well as the direct impacts of construction and operation of a power plant, industry drawing on the new source of power will often be developed with associated communities etc. close by. There will be some increase in localized atmospheric emissions and, with an increased human population, levels of sewage effluent, municipal waste, etc. There are of course positive social impacts related directly to this development of local industry as outlined above.

On the other hand gas pipelines have very few operational or post construction impacts, and in the case of this project in which the gas will be used primarily for power production, there will be few industries developed to consume the gas.

Economic and Development Benefits Favour Western Region Sites.

9. Next Steps

This report was prepared primarily based on existing written information and discussion with most stakeholders likely be involved in a power export project in Bangladesh and India. In addition, some of the analyses and conclusions were based on verbal information that requires substantiation and follow-up.

Suggested next steps for the GOB should include the following:

- Conduct Detailed Project Feasibility Study and Adapt the Meghnaghat Bid Documents for a Limited Competitive Solicitation for a Power Export Project.
- Evaluate Market Pricing for Peaking Power Exports and other higher-value power export options.
- Draft Project Agreements Based on WRIP/IPP Projects (reflecting recommendations identified in March 2000 preliminary report prepared for MEMR.)
- Prepare Bulk Power Export Purchase Agreement to facilitate power export.
- Review and Assess the Existing Power Export Agreements Between India and Neighboring Countries (e.g., Nepal, Bhutan)
- Update the Fourth Natural Gas Plan for the Purposes of Establishing That Sufficient Gas Production Exists to Support Power Exports.
- Confirm Adequacy of Payment Security Mechanism for Power Trading Corporation of India.
- Draft Legislative Amendment to Authorize & Regulate Power Exports.
- Determine Potential Added Value and current emissions trading benefits that could enhance financing of an export project (Kyoto Protocol).

Annex 1: Gas and Power Transmission Requirements and Charges

	Bheramara	*Sirajganj*	*Sylhet*	*Fenchuganj*
Gas Pipeline Requirements	90 km 24" new pipeline from Sirajganj needed	Use existing pipeline. No new pipeline needed	Located at the gas field. No new pipeline needed	Located at the gas field. No new pipeline needed
Gas Transmission Charges	Incremental cost of new line + use of existing pipeline (0.5 $/mmBtu)	Use of existing pipeline (0.5 $/mmBtu)	No use of existing pipeline	No use of existing pipeline
Electric Transmission Requirements				
Bangladesh Connection	Adjacent to 230 kV line. No additional line needed	Connect to Iswurdhi SS. Need new 2x2-circuit 230 kV lines	Connect to Ashuganj SS. Need new 2x2-circuit 230 kV lines	Connect to Ashuganj SS. Need new 2x2-circuit 230 kV lines
India Connection	Connect to Baharampur SS in the East. Need new 2 x 2-circuit 400 kV lines Plus Substation	Connect to Baharampur SS in the East. Need new 2 x 2-circuit 400 kV lines Plus Substation	Connect to Badarpur SS in the Northeast. Need new 2 x 2-circuit 400 kV lines + Plus Substation	Connect to Badarpur SS in the Northeast. Need new 2 x 2-circuit 400 kV lines + Plus Substation
Electric Transmission Charges				
Bangladesh Connection	Use of existing line (3.30 $/MWh) with adjustment for new generation	Incremental cost of new line use of existing line 3.30 $/MWh) adjusted	Incremental cost of new line use of existing line (3.30 $/MWh) adjusted	Incremental cost of new line use of existing line (3.30 $/MWh) adjusted
Pricing Option				
Incremental Pricing	No incremental cost	New line priced incrementally	New line priced incrementally	New line priced incrementally
Embedded Cost Pricing	Use existing adjusted embedded price 3.30 $/MWh	Cost of new line added to the existing adj. embedded price	Cost of new line added to the existing embedded price	Cost of new line added to the existing embedded price
Minimum Charge for incremental pricing	Adjusted embedded price	Adjusted embedded price	Adjusted embedded price	Adjusted embedded price
India Connection	Incremental cost of new line	Incremental cost of new line	Incremental cost of new line	Incremental cost of new line
Charges in India	Use of existing facilities (10 to 15 $/MWh)	Use of existing facilities (10 to 15 $/MWh)	Use of existing facilities (10 to 15 $/MWh)	Use of existing facilities (10 to 15 $/MWh)
Minimum Charge	10 to 15 $/MWh	10 to 15 $/MWh	10 to 15 $/MWh	10 to 15 $/MWh

Annex 2: Environmental and Social Assessment.

SCOPE OF ASSESSMENT

The following section presents a brief outline of the existing environmental conditions in Bangladesh and then considers the potential social and environmental impacts upon each of the 4 sites under review. Information was gathered from both existing sources, including environmental and social impact assessments (and equivalent) undertaken for previous projects, and from interviews. Site visits were undertaken where interviews with local operating staff were carried out. It must be stressed that specialist environmental and social personnel were not amongst the staff at each site, and due to time constraints it was not possible to identify local environmental and social specialists for interview.

SITE SELECTION

A key factor in optimising a power project is site selection. For the purposes of this assignment three broad areas were selected for study. The first area is the north east of the country centred around Sylhet, one of the major gas producing areas. The principle here is that the power plant would be close to an existing source of fuel, namely the natural gas of the Sylhet fields. The second area is the centre of the country near Siranjganj, which is on the west bank of the Jamuna river close to the Jamuna Bridge. This is a central area with good communications via road, rail and river as well as proximity to connections with the national gas and electricity grids. The third area is located in the west, close to the border with West Bengal, India, at Bheramara. This area offers the advantage of being close to the potential market in India.

For the purposes of this study the environmental and social assessment has been focused around the sites of existing power plants. Already being linked to the national electricity grid, being close to a source of cooling water, and having the necessary road/rail infrastructure close by, these locations were the obvious starting point when searching for suitable sites. In addition, all but one of these sites was supplied directly or close to the existing gas grid.

ENVIRONMENTAL CONTEXT OF BANGLADESH

Topography

Most of Bangladesh is a vast, low lying alluvial plain with an elevation less than 30 metres above sea level, sloping gently to the south and southeast, formed from sediments deposited by two great river systems, the Ganges (Padma) and the Brahmaputra (Jamuna), which join in the south-central part of the country, and flow to the sea through a broad and complex delta system. A third, and much smaller drainage system, the Meghna, drains the northeast part of the country including Sylhet and the eastern part of Dhaka Division and the northern part of Brahmaputra division.

Gradients in general are low, and in many areas are barely perceptible. The only significant areas of elevation are in the Chittagong hill tracts to the southeast and close to the Indian borders in the east and northeast areas. There are thus very few areas where topography would significantly constrain construction of power plants, gas pipelines and transmission lines.

Geology

The surface geology of Bangladesh is dominated by generally poorly consolidated sediments deposited over the past 10,000 to 15,000 years (Holocene age). Bedrock is exposed only in the Chittagong hill tracts of the southeast and the Sylhet hills, in the northeast. The alluvial cover of Bangladesh obscures a complex tectonic zone that contains valuable mineral and petroleum potential, although it is entirely subsurface. The depth of the hydrocarbon reservoirs exploited for natural gas is generally in excess of 2,000 metres, and the strata are of Miocene age.

Soils

From the crop production viewpoint, Bangladesh soils can be grouped into 3 main categories (IUCN1993): floodplain, terrace and hill soils.

The floodplain soils mainly comprise permeable sandy loams and sandy clay loams. Drainage status varies widely from good to poor, depending on position in the landscape and groundwater levels. When used in embankments, these soils are commonly susceptible to water erosion, unless protected by vegetative cover.

Most soils in the Syhlet area have developed in recent sediments, including swamp deposits in the Sylhet depression, and modern alluvium - sands, silts and clays - on the floodplains of the Old Brahmaputra and middle Meghna Rivers.

Hill soils are found in the Sylhet Hills. Where the underlying rock is sandstone, sandy loams, loamy sands and loams predominate. Shales give rise to heavy silty loams to sandy clay loams that are relatively infertile. Cuttings in these soils for road construction have resulted in severe erosion.

Climate

The climate of Bangladesh is sub-tropical, with hot and humid weather during the summer months, and cooler, drier weather in the winter. The monsoon season is spread over the period from June to October, during which time humid air flowing over the country from the southwest results in torrential rainfall. Around 65-70 % of the average annual rainfall occurs during the monsoon, which typically begins on 01 June and may vary from 112 to 139 days. From Dhaka, mean annual rainfall increases northwards towards the Meghalaya Hills north of Sylhet, averaging around 2200 mm/yr at Bhairab and some 4600 mm/yr at Sylhet itself

Average annual rainfall varies considerably throughout the country from a maximum of around 5500mm in the extreme northeast to a minimum of around 1100mm in the extreme west. Most of the country experiences 1500-2500mm annual rainfall.

The high rainfall during the monsoon period means that in Bangladesh the construction period for pipelines is typically restricted to the months October – March.

Air Quality

Air quality in most rural locations in Bangladesh is good, since there is no major air polluting industrial installations. Traffic congestion is very common in all towns along most roads, resulting from inadequate road width, encroachment by shops etc, and in these congested areas, air pollutant levels are almost certainly high. Localized pollution (due to particulate emissions in particular) may occur in the neighborhood of brick kilns, many of which are fired by low-grade coal, and have chimneystacks of inadequate height to allow efficient dispersion of smoke.

No information is available on the emissions from gas processing facilities in Bangladesh, but is likely that concentrations of NO_x, CO and particulates is locally elevated in the close vicinity of existing gas plants.

Ambient Noise

In most areas, ambient noise levels are very low. Higher localized noise levels occur in most centers of population, particularly in market areas that tend to be congested with traffic and house a wide range of commercial operations, many of which generate high noise levels.

Surface Water

Bangladesh has a high density of rivers. The river system that flows through Bangladesh comprises the third largest source of fresh water discharge to the world's oceans although nearly all of Bangladesh's

rivers originate outside the country. Although an immense quantity of surface water flows through Bangladesh, the flow is seasonal and the availability of surface water during the critical months of December through March becomes very limited.

The countryside is heavily dissected by river channels converging on the main river systems of the Padma (Ganges), the Jamuna and the Meghna. Owing to the very gentle topography, river channels meander and follow a winding course towards their confluence with these main rivers that are themselves braided and meandering. The presence of numerous drainage channels is a significant impediment to development; for example it is only in 1998 that a road bridge has been completed across the Jamuna river. Prior to that there was no road link between the western and the eastern halves of the country.

The river systems in Bangladesh play a vital role as transport routes. Water transport is still considered an important feature of many rural areas, and both permanent and seasonal watercourses are used for navigation.

The low gradients and low-lying nature of the floodplains which cover much of the country, coupled with high and intense rainfall during the monsoon season, congested drainage and high flows in the major rivers, result in major flooding. Approximately 60% of the land area is flooded to a depth of 1 m or more at the peak of the monsoon. In addition to damage to private property, public infrastructure, and loss of life, flooding results in considerable damage to crops, either through inundation itself, or burial under silt and sand deposited from the floodwaters.

Groundwater

A shallow (<10 mbgl) water table is ubiquitous in Bangladesh and the alluvium and Tertiary strata represent a valuable aquifer supporting large-scale abstraction by shallow tubewells (there are estimated to be more than 600,000 of these in Bangladesh) for potable consumption and for irrigation. In the low-lying areas of Sylhet and Dhaka divisions the depth to groundwater is generally less than 5 m. Although shallow, the water table is likely to be well below the installation depth for transmission pipelines.

In addition to the shallow tubewells (those where the water level is within the suction limit of a surface-mounted pump), there are approximately 30,000 deep tubewells in Bangladesh abstracting water from deeper levels within the Tertiary sediments. The aquifers are generally within 200 –250 metres of the surface, whereas the petroleum reservoirs are usually more than 1,500 metres below the surface, and there is generally no natural connection between the two (there are some surface seeps of oil at several places in Bangladesh).

Under natural conditions the groundwater level fluctuates seasonally. The levels are lowest in late April or early May, and rise during the rainy season. In general, dry season use of ground water is extensive. Under the very gentle topographic gradients prevailing in Bangladesh, the rate of lateral movement of groundwater is likely to be slow.

The general quality of shallow groundwater is good, with a low total dissolved solid content. Recently the problem of arsenic contamination of groundwater has come to light, although the problem so far appears to be confined to the southwestern part of the country.

Forestry

Forested areas in Bangladesh are sparsely distributed across the country. Officially, the Department of Forestry reports, forests account for about 13% of the total land area. In actuality forests comprise only 8 % and are located mostly in the Chittagong Hill Tracts, the Sundarbans and the Madhurpur Tract.

Population

Approximately 80% of the population of Bangladesh lives in rural areas. The rural population density is high, particularly in the Dhaka division where the average is more than 1000 persons per square kilometre. In Sylhet division the density is amongst the lowest in the country although even here the

average is about 500 persons per square kilometre. In the western region the density of population is moderate, averaging about 750 persons per square kilometre. Route selection for pipelines and transmission lines will inevitably require careful planning to avoid areas of higher population density.

Settlements are normally located on natural ground that lies about 1-3m above the surrounding land surface, but in many places, individual houses have been constructed on elevated platforms of excavated soil, whose surface is just above annual flood level.

Agriculture

About 67% of rural households have agriculture as the main source of income, of which about 44% derive this from farming, and 23% from supplying agricultural labour (GOB 1994). Agriculture accounts for about 66% of employment in the country as a whole, and contributes 35% to GDP. Although the proportion of the population engaged in agriculture is decreasing, for the foreseeable future this sector will continue to be the largest single source of employment (GOB 1995).

Agriculture is centred on crop production, and for most farmers is at or near to subsistence level. Livestock raising is ancillary, with most cattle (mainly oxen, with a relatively small proportion of buffaloes) being kept in small numbers for draught purposes. Large numbers of goats, and much smaller numbers of sheep are evident in most areas (GOB 1992). Livestock, and particularly cattle, are partially stall-fed on crop residues or grass collected from the fields, but grazing on fallow fields and uncultivated land such as roadside borrow areas and the road margins themselves is very common.

Rice is the dominant crop in most areas and more than 80% of the country's cultivable land is under paddy cultivation for at least part of the year. There are two crops per year wherever land and water conditions are suitable, and in some areas where it is marginal, at least a single crop of rice is grown, since it forms the staple food for the population. Wheat and jute are also very important, and each occupy about 5% of the cultivable land. Oilseeds (mainly brassicas and sesame), sugarcane, pulses, vegetables and spices are also significant crops. Tea is grown in "tea gardens" in the Sylhet Hills.

Rental of land is relatively uncommon, and when available costs around Tk 1500-2000/bigha/year (approximately Tk11,100-14,800/ha/yr). More commonly, land is mortgaged out for an indefinite period to provide a cash sum. Mortgage prices vary considerably, depending on productivity and local pressure on land. In most areas, mortgages are for around Tk 8,000-12,000/bigha (approximately Tk59,000-89,000/ha), although this can be much higher on very productive land.

Annex 3: Power Grid System of Bangladesh

Appendix A
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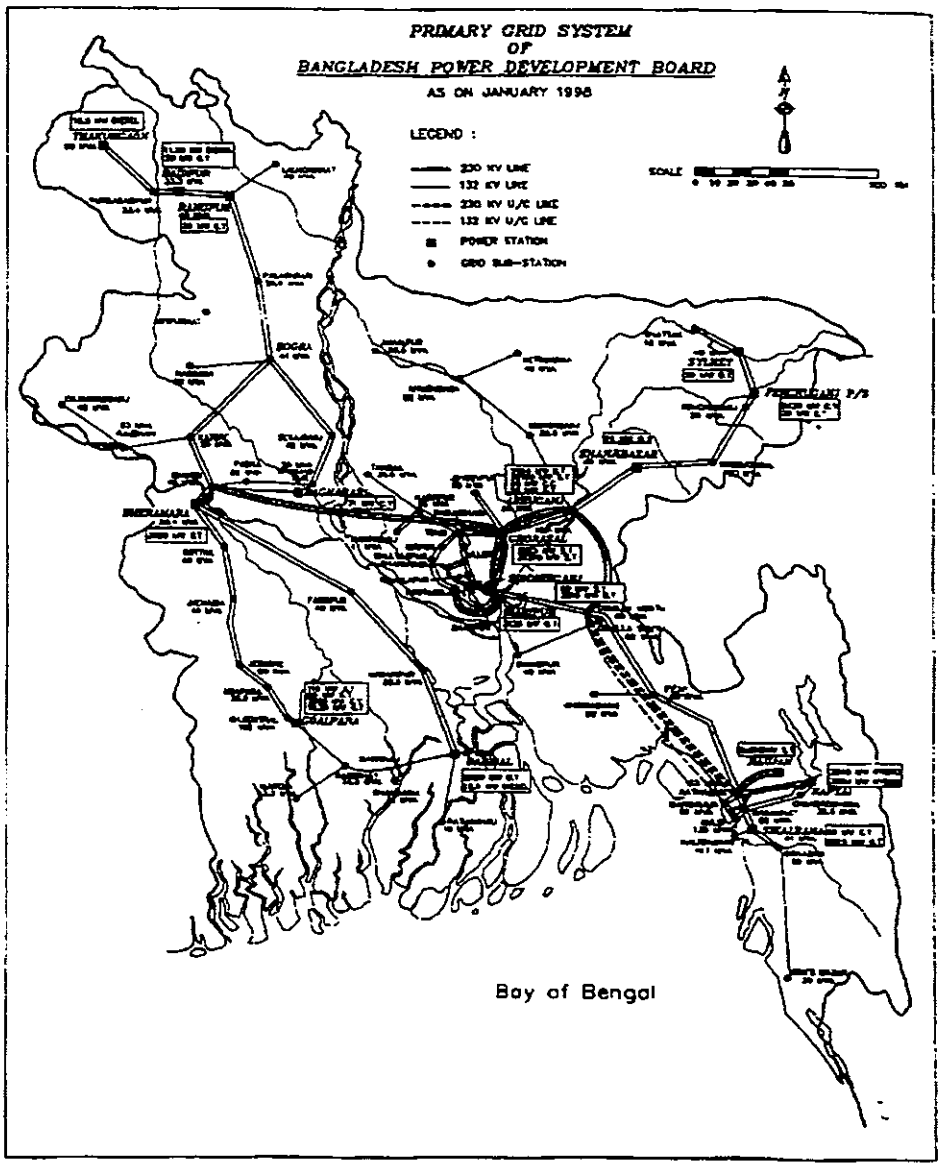

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