Mines and Minerals Development (Package # 07) Hydrocarbon Unit

Coal Sector Development Strategy (Final)

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PricewaterhouseCoopers Pvt. Ltd.

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Table of contents

Table of Abbreviations

Abbreviation	Full Form
ADB	Asian Development Bank
AEC	Asia Energy Corporation Pty. Ltd
AMD	Acid Mine Drainage
AOA	Articles of Association
BAPEX	Bangladesh Petroleum Exploration Company Ltd
BB	Bangladesh Bank
BCF	Billion Cubic Feet
BCMCL	Barapukuria Coal Mining Company Limited
BERC	Bangladesh Energy Regulatory Commission
BGFCL	Bangladesh Gas Fields Company Ltd
BGDCL	Bakhrabad Gas Distribution Company Ltd
BHP	Broken Hill Proprietary
BMD	Bureau of Mineral Development
BMEDC	Bangladesh Mineral Exploration and Development Corporation
BOGC	Bangladesh Oil and Gas Corporation
BOGMC	Bangladesh Oil, Gas and Mineral Corporation
BOI	Board of Investment
BPC	Bangladesh Petroleum Corporation
BPDP	Bangladesh Power Development Board
BPI	Bangladesh Petroleum Institute
Bt	Billion Tonnes
BTU	British Thermal Unit
BUET	Bangladesh University of Engineering and Technology
CBM	Coal Bed Methane
CDA	Chittagong Development Authority
CIDA	Canadian International Development Agency
CMC	Chinese National Machinery Import & Export Corporation
CNG	Compressed Natural Gas
CPEF	Coal Price Equalization Fund
CSDU	Coal Sector Development Unit
D.C.	Deputy Commissioner

EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMRD	Energy and Mineral Resources Division
ERD	Economic Relations Division
ERL	Eastern Refinery Limited
FDI	Foreign Direct Investment
FOB	Free On Board
FS	Feasibility Study
FY	Financial Year
GDP	Gross Domestic Product
GNI	Gross National Income
GoB	Government of Bangladesh
GSB	Geological Survey of Bangladesh
GSP	Geological Survey of Pakistan
GTCL	Gas Transmission Company Ltd
GW	Giga Watt
HCU	Hydrocarbon Unit
HHV	Higher Heating Value
ICP	Indonesian Coal Price
IED	Industry and Energy Division
ILO	International Labor Organization
IMCL	International Mining Consultants Limited
IMED	Implementation Monitoring and Evaluation Division
IMF	International Monetary Fund
IT	Information Technology
JGTDSL	Jalalabad Gas Transmission and Distribution System Limited
JICA	Japan International Cooperation Agency
JORC	Joint Ore Reserves Committee
JV	Joint Venture
KDA	Khulna Development Authority
KGCL	Karnaphuli Gas Company Ltd
KPI	Key Performance Indicator
kWh	Kilo Watt Hour
LDT	Lower Dupi Tila
LIBOR	London Interbank Offered Rate

LPGL	LPG Bottling Plant
LPI	Logistics Performance Index
LTCC	Longwall Top Coal Caving
M&P Contract	Management Production and Maintenance Service Contract
MGMCL	Maddhapara Granite Mining Company Ltd
MMDP	Mines and Minerals Development Project (Package #07)
MMMR	Ministry of Mines and Minerals Resource, Bangladesh
MMR, 1968	Mines and Minerals Rules
MOA	Memorandum of Association
Mt	Million Tonne
Mtoe	Million tonnes of oil equivalent
MTPA	Million Tonnes Per Annum
MTPY	Million Tonnes Per Year
MW	Mega Watt
NBR	National Board of Revenue
NE	North East
O&M	Operations and Maintenance
OH&S	Occupational Health & Safety
PAP	Project Affected People
PAYE	Pay As You Earn
PGCL	Paschimanchal Gas Company Ltd
PPE	Personal Protective Equipment
PPP	Public Private Partnership
PSC	Profit Sharing Contract
PSMP	Power System Master Plan, 2010
PSU	Public Sector Unit
R&R	Rehabilitation and Resettlement
RAJUK	Rajdhani Unnayan Kartripakkha
RPGCL	Rupantrito Prakritik Gas Company Ltd
SDF	Sustainable Development Framework
SE	South East
SGCL	Sundarban Gas Company Ltd
S&P	Standard and Poor's
SW	South West
SWGCL	South West Gas Company Ltd

TCF	Trillion Cubic Feet
TEFS	Techno-Economic Feasibility Study
TEPCO	Tokyo Electric Power Company
TGDTCL	Titas Gas Transmission & Distribution Company Ltd
UCG	Underground Coal Gasification
UDT	Upper Dupi Tila
UNDP	United Nations Development Programme
UNFC	United Nations Framework Classification
USC	Ultra super critical

1. Executive summary

1.1.1. This report "*Coal Sector Development Strategy*" is prepared as part of the Mines and Minerals Development Project (Package # 07) of Hydrocarbon Unit, Energy and Mineral Resources Division, Bangladesh.

1.1.2. The Terms of Reference of this report is "*To develop Coal Sector Development Strategy (including Peat) with appropriate enabling frameworks for the public sector and for private sector participation and institutional arrangements for the sector".*

1.1.3. To achieve development goals, energy security is essential. A challenge to this is the present over-reliance on natural gas which accounts for about 73% of the country's commercial energy supply even as the resources are depleting. The peak demand for electricity by 2030, as per the Power System Master Plan 2010 (JICA report) considering the Government Policy Scenario is estimated at 33,708 MW. In contrast, sustainable supply of natural gas is uncertain beyond 2030, highlighting the necessity to develop alternative sources of primary energy. Coal represents a key alternative for use in base load power plants.

1.1.4. Given this background, it's imperative to develop a holistic approach and strategy to develop the coal sector of Bangladesh with long term vision and in scientific manner to ensure resource conservation.

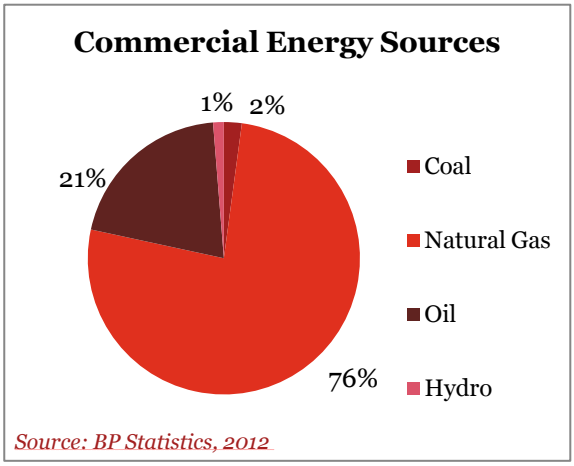
1.1.5. The development strategy will need to cover several dimensions which are discussed below.

1.1.6. **Coal resources and reserves**

- Coal resources in Bangladesh are identified in the north western part of the country and appear to have a geological linkage with the coal fields in the state of Assam and Raniganj area of West Bengal in India. Bangladesh has a total coal resource and reserve base of about 3.1 Billion Tonnes. Out of this total coal resources, around 13% (402.32 Mt) is under 'proved' category, around 27% (839.90) is under 'indicated' category and the balance about 60% (~1900 Mt) is under 'inferred' category.

1.1.7. **Demand and supply scenario of coal:**

- The primary energy consumption of Bangladesh is 24.3 Mtoe (2011) representing 0.2% of global primary energy consumption, against a global population share of about 2.4% (BP statistical review of World Energy, 2012). The energy mix of Bangladesh presents an uncommon picture for a non-oil rich nation.



Source: BP Statistics, 2012

- Natural gas is the dominant primary commercial energy source for Bangladesh with over three-fourths share, followed by oil at 21%. Coal, despite its significant resources in the country, hydroelectricity and other power sources together contribute barely 3% of total commercial energy use. There is a need to diversify the current energy mix for a variety of reasons viz., to extend the country's finite natural resources to last for longer period of time, to lower the carbon intensity, and to take advantage of cheaper energy sources (including through imports if required and available).

- The Bangladesh Government is committed on a policy to make electricity available to all by 2021 and is targeting 600kWh per capita. To address the power shortfall and meet the growing demand, the Government proposed initiatives to add about 11.8 GW generation capacities in next 5 years (2012-2016).

- With depleting Gas reserves and current known resources, Coal is major alternative energy fuel available in Bangladesh which can help in rapid growth and contribute to national economy by feeding power plants.

- Of the 33,708 MW power requirements by 2030 (PSMP, 2010), the Government of Bangladesh plans to generate 20,000 MW using coal both domestic and imported.

- Currently coal demand of Bangladesh is primarily from 2x125MW coal fired power plant at Barapukuria, brickfields and other industries. On other hand, Barapukuria Coal Mine operated by the Barapukuria Coal Mine Co. Ltd. (BCMCL) is the only coal mine of Country with annual capacity of 1 Mtpa.

- It is therefore, evident that actions must be initiated immediately for developing the coal deposits of the country, so that coal is available in adequate quantities before 2015 as an alternative commercial fuel for power generation.

1.1.8. Strategy for development of coal deposits

- Additional drilling is required to bring entire coal resource of around 3.1 Bt into 'proved' category.

- The detailed exploration and other studies along with the preparation of geological reports and other study reports of all the coal basins can be completed within a period of 3-4 years if executed without interruptions.

- The detailed exploration of the coal basins and other related studies should be funded by a State agency/ PSU so that the geological reports and other reports become the properties of BMD and GSB as well as government can fetch better returns on auctioning established reserves.

- The policies and strategy for development of coal mines should be framed keeping the following fundamental objectives in view to achieve the goal of sustainable development of the coal mining sector of the country.

    - Maximization of conservation of coal resources.

    - Attainment of highest level of safety in mines.

    - Minimization of environmental damage to mining areas.

1.1.9. Investment models and financial aspects:

- **Public sector investment:** Coal mining is a high risk capital intensive industry. Considering the risks involved in mining industry, Government may provide budgetary support in the form of equity or share capital to a public sector enterprise. The possibilities of getting financial assistance from multilateral funding agencies could also be explored.

- **Private sector investment:** There are several routes to invite private sector funds to invest in any sector few of which are foreign direct investment (FDI), joint venture (JV), public private partnership (PPP), and profit sharing contract (PSC). The private sector investment in mining sector in Bangladesh has been limited due to the inadequate geological information about mineralization in the country and enabling policy framework to ensure investment incentives to

private sector. For ensuring the confidence of investors in the coal sector, it would be important to ensure that the financial and physical (transmission and distribution infrastructure) capacity of BPDB is strengthened to enable it to purchase the contracted quantities of coal on time from Coal Bangla or any other government agency and make payments on time (considering that open market coal sales by private investor shall not be allowed and all products shall be sold to Government Agency as being done in Gas Sector). Involvement of the private sector could be through a public private partnership (PPP) arrangement under PSC specifically developed or designed for the coal sector model using the experience gained from the gas sector. Further, the selection of private partner should be done through a transparent international bidding process. The government may roll out fiscal incentives for the private sector.

1.1.10. Contractual issues

- Coal mining is a capital intensive industry with high associated risk, thus, it is preferable to undertake a separate and exclusive study to examine different models and modalities of financing to choose the best option for Bangladesh. Bangladesh should encourage the option of contract mining or joint development with experienced developers wherein the provisions are attractive for both parties (Bangladesh government and contractor/operator). Various types of contracts for mine development and operation prevalent in various countries are:
    - Cost-plus contract: The contractor is responsible for development and operations of the coal block. The owner (Government) would allow a fixed profit based on percent of operating cost or amount per ton or percent of capital cost etc.
    - Levelised price contract: In such contracts, the contractor is fully responsible for development and operations of the coal block and the price at which the coal is delivered is lump sum on per unit quantity delivered subject to escalation based on some pre-agreed formula (to accommodate change in cost structure due to inflation).
    - Profit sharing contract: The investor/contractor can be given due return on his investment for exploration and production of the coal, during mining operation and the profit coming out of coal production shall be shared between the partners as is done in hydrocarbon production sharing contract in Bangladesh.
- Taking into account the various types of coal contracts described above and the circumstances prevailing in Bangladesh as far as coal is concerned, a model coal PSC appropriate for attracting investment in the coal sector may be prepared. The contractor selection may be done by conducting international competitive bidding process.

1.1.11. Legal framework

- In Bangladesh, the principal laws enacted to regulate mineral sector were: the Mines Act, 1923 and the Mines and Minerals (Regulation and Development) Act, 1967 (E.P. Act II of 1968). While the Mines Act, 1923 was amended in year 2005, the Mines and Minerals (Regulation and Development) Act, 1967 was repealed in the year 1992 and was replaced by the Mines and Mineral Resources (Control and Development) Act, 1992 (Act No. 39 of 1992).
- The Mines and Minerals Rules, 1968 was framed under the Mines and Minerals (Regulation and Development) Act, 1967, through which the Government has delegated its authority to Bureau of Mineral Development (BMD) in the matters of regulating Exploration Licences, Mining Leases and Quarry Leases. The Mines and Minerals Rules, 1968, was subsequently amended in years 1989, 1995, 1999 and 2004. In 2012, Mines and Minerals Rules 1968 was repealed and replaced by Mines and Minerals Rules (2012). In the report on "Review of the existing Mining Act, Rules and Regulations and Recommendations", prepared by PwC, the provisions in existing Acts and Rules have been studied in detail and compared with the provisions of mining legislations of

India, Australia, Canada, South Africa and Indonesia and some of the guidelines of Sustainable Development Framework (SDF) to identify gaps.

- Recommendations: It is necessary for sustainable development that the current legislations are amended and wherever required, new legislations are enacted to address issues related to technical management; ownership of mineral resources, FDI, investment facilitation, royalty and taxation; Occupational Health & Safety (OH&S), fair wages, working conditions, etc.; social and environmental impacts of mining activities etc.

  Our recommendations broadly covers Amendments and additions in existing laws; Changes in licencing regime; Promulgation of new laws and authorities; Formulation of policies related to FDI, R&R.

1.1.12. Institutional aspects

- As per the constitution of People's Republic of Bangladesh, the ownership of its mineral wealth lies with people of the country. Thus, on behalf of people of Bangladesh, the mineral and mining sector is governed and controlled by the Ministry of Power, Energy and Mineral Resources (MoPEMR), GoB. The MoPEMR has got two major divisions: Power and; Energy and Mineral Resources.

- Energy and Mineral Resources Division (EMRD) is the arm of ministry responsible for development and exploitation of Mineral Oil, Gas, Coal, Hard Rock and other mineral resources of Bangladesh. EMRD manages the business through two main Corporations:

  - Petrobangla for Oil, Gas, Coal and Minerals; and

  - Bangladesh Petroleum Corporation (BPC) for petroleum products.

- Petrobangla has a number of subsidiary companies incorporated under the Companies Act, 1994. Operations of these companies are monitored and supervised by Petrobangla. The pre-operating, monitoring and regulatory functions to be performed by government like survey, exploration, administration and issuance of mining concessions or licences and mining leases and other regulatory measures are performed by different agencies formed under EMRD namely – GSB (survey and exploration); BMD (mining licences and leases); Department of Explosives (the safety during handling of explosives, gases, petroleum and other flammable liquids, combustible solids etc.).

- It has been observed that the present system and organizations dealing with mines and minerals may not achieve the objective of focused exploration and development of the mineral resources to serve the interests of the people of Bangladesh. Hence, establishment of some new institutions are being proposed. These are Coal Sector Development Unit (CSDU); National Mines and Minerals Council; The Ministry of Mines and Mineral Resources; Coal Bangla/Khani Bangla; Inspectorate of Mines and Minerals; Mines and Minerals Institute.

1.1.13. Human resources and management

- Skilled resources in Bangladesh mining sector are very limited. The proposed mines will need huge skilled labor force to work efficiently with costly mining machinery in a totally unknown and unfamiliar atmosphere deep underground. As setting up of a fully fledged educational institute may take time, for more skilled jobs like management of operations and planning, supervision of mines etc. GoB may consider setting up of Vocational training Institute. This institute will provide regular trainings to the people deployed in the mines and will also undertake skill development courses for new manpower deployed at mine at operational level.

- Institutes may consider tie-ups and exchange programs with renowned mining institutions to strengthen their curriculum and academic level. Setting up of new institute to offer education in disciplines like mining engineering, geology, mineral processing engineering etc. may be considered. The mining courses offered should integrate mining related IT education.

- Bilateral agreements for sharing of technology and knowledge with countries which are rich in mineral resources and have a well established mining industry shall be beneficial to Bangladesh.

- Contracts entered with the foreign developers and operators should have provisions of knowledge sharing and skill and technology transfer. Further, there may be provisions for compulsory employment of certain local manpower which will help in domestic capacity building.

- A coal training fund may be set up similar to the existing gas sector training fund financed by contributions from private investors in coal mining.

1.1.14. Coal sector infrastructure development

- The area comprising the discovered coal fields and potential coal basins in northwestern Bangladesh should be declared as the "Coal Zone". The Coal Zone has to be formed taking into consideration, the entire socio-economic structure in the region. A Coal Zone Study is to be undertaken. In order to ensure proper planning of the entire area with respect to the infrastructure requirements, a Coal Zone Study is to be undertaken by involving relevant authoritites.

- Coal Axis should be given due consideration to define a route for development of coal transportation system across the Bangladesh. Its viability (or otherwise) should be established through a techno-economic study by experts. Coal axis is to be used as principle region for locating the major coal fired power stations in Bangladesh such that they have the flexibility to use both local and imported coal.

- The infrastructural development for coal production and supply must ensure that the transportation cost is kept at minimum and maximum capacity utilization of the facilities. The river routes must be given top priority for coal transportation in addition to the improvement in road and railway modes.

1.1.15. Coal depletion and pricing policy

- To ensure the long term energy security of Bangladesh it is desirable that the limited reserves of coal are depleted in a planned manner over a long period of time with a vision of coal conservations and maximum exploitation. Therefore, there must be a depletion policy which specifies the period over which an existing reserve would be fully mined, say, for example, 30-50 years. It should be encouraged that power plants use imported coal. Emphasis may be given to develop peat as domestic fuel than coal to conserve coal for higher value usage. Further, techno-economic feasibility of blending peat with coal should be explored.

- Coal pricing policy may be revisited to represent a realistic scenario making the return to the investors reasonable keeping the coal price tolerable. Setting up of Coal Price Equalization Fund (CPEF) may be considered.

1.1.16. Land utilization and reclamation

- The mine plan and the PSC/mining contract, if there is one, must make it obligatory for the mine owners to reclaim and rehabilitate the mining area after mine closure as per the mine plan to the extent feasible. Adequate safeguards need to be built in to the lease documents (and the PSC) so that it can be enforced.

- A policy may be framed to deal with the rehabilitated land so that while fair play is assured to the lessee, the Government steps in to avoid windfall gains to the lessee by imposing a suitable tax.

1.1.17. Role of other available fuels like Peat

- Peat deposits occur in the marshy areas of the north-eastern, central and south western parts with a total reserve of more than 170 million tons. Calorific value of peat ranges from 6000 to 7000 BTU/lb (3334 to 3889 Kcal/Kg). Peat can be used as fuel for domestic purposes, brick manufacturing, boilers, etc. However, its exploitation has not yet started in Bangladesh.
- The following recommendations are made for role of other available fuels like peat:
    - Detailed surveys to confirm the reserves of peat from the category of resources be carried out.
    - Undertake studies to establish suitability of peat resources for power generation and also for domestic fuel.
    - Undertake detailed socioeconomic survey before extraction of peat, as peat fields are good paddy fields.
    - Undertake techno-economic feasibility studies for the areas with proven reserves.
    - Invite bids for setting up 25-50 MW (or of higher capacity) power stations near the peat fields to be awarded along with a mining lease for peat. The peat deposits may be divided into blocks if need be but ensuring that they are of a viable size to sustain a power station for 25-30 years.
    - Smaller deposits need not be divided into blocks and need not be linked to setting up power stations.
    - Encourage local entrepreneurs to set up units for producing briquettes from peat for domestic and other use and popularize it.
    - Conduct research for use of peat as a fertilizer and/or soil conditioner for agriculture and horticulture sector and also for fisheries and water treatment and/or purification.
    - Frame separate rules for leasing and land acquisition, lease or purchase specifically to suit peat mining operations in Bangladesh.

1.1.18. Recommendations and conclusion

Step	Aspect	Recommended Strategy
1	Legal framework and Institutional development	• It is necessary for sustainable development of the sector that the current legislations are amended and wherever required, new legislations are enacted as suggested in this report. • Strengthening of existing institutions and establishment of new institutions like National Mines and Minerals Council; Coal Bangla and Khani Bangla; Ministry of Mines and Mineral Resources; Coal Sector Development Institute; Inspectorate of Mines and Minerals; Mines and Minerals Institute
2	Depletion policy	• To ensure the long term energy security of Bangladesh it is desirable that the limited reserves of coal are depleted in a planned manner over a long period of time with a vision of coal conservations and maximum exploitation.

Step	Aspect	Recommended Strategy
		• There must be a depletion policy which specifies the period over which an existing reserve would be fully mined, say, for example, 30-50 years
3	Declaration of Coal Zone and Coal Axis	• Area comprising discovered coal fields and potential coal basins in northwestern Bangladesh may be declared as the Coal Zone • Carry out a techno-economic feasibility study for the purpose of assessing the viability of Coal Zone • Demarcate the Coal Zone into coal blocks for inviting bids for prospecting and (finally) leasing. • Promote Coal Axis to develop coal based power generation stations.
4	Decision on investment models and type of contract	• Government should provide budgetary support in the form of equity or share capital to a public sector enterprise. • The possibilities of getting financial assistance from multilateral funding agencies should be explored. • Taking into account the various types of coal contracts (Cost plus, levelised price, PSC) and the circumstances prevailing in Bangladesh, a model coal PSC appropriate for attracting investment in the sector may be prepared. • To encourage private investors for undertaking exploration of mineral resources with assurance for award of mining license to operate, in case of successful exploration. • In view of the need of specialized financing and development need of the coal sector, the tailored mode of investment in terms of PSC may be explored. However, the issue may be professionally examined further and any mode of financing that suits best for the country in the back ground of international financing market may be adopted expeditiously. Contractual issues should be settled with due diligence so that a win-win situation is created for all the involved parties.
5	Decision on commercial aspects	• Coal pricing policy may be revisited to represent a realistic scenario which provides reasonable return to the investors keeping the coal price tolerable. Setting up of Coal Price Equalization Fund (CPEF) may be considered to supply coal at uniform price to consumers from all coalfields. • To encourage private sector participation, the government may roll out incentives for the private sector in the form of tax holidays, waiver of local taxes, reduction in import duties on equipment etc.
6.	Pre-development activities in coal deposits	• Invitation of bids for exploration activities. • Detailed exploration and other studies along with the preparation of geological reports and other study reports of all the coal basins can be completed within a period of 3-4 years • Studies suggested in this report should be conducted expeditiously to establish feasibility of opencast mining. • For introduction of stowing in the mines, studies have to be initiated immediately on high priority basis for assessing availability of sand in Jamuna river/ other rivers and the annual rate of replenishment of sand in these rivers • Model bid documents and contract manuals for exploration, mine construction and for mine development and operation have to be

Step	Aspect	Recommended Strategy
		prepared expeditiously
7	Development of coal deposits	• Development of different mines should be phased to match with the availability of international contractors and development of internal organization to handle increased scale of operation • It is necessary to take decision on the pending applications (Phulbari and Khalashpir coalfield) at the earliest. • Invitation of bids
8.	Coal sector infrastructure Development	• This should be done in conjunction with the concept of coal zone. • Coal Axis should to be given due consideration to define a route for development of coal transportation system across the Bangladesh. Its viability (or otherwise) should be established through a techno-economic study by experts. • Coal axis is to be used as the sites for locating the major coal fired power stations in Bangladesh such that they have the flexibility to use both local and imported coal. • The infrastructural development for coal production and supply must ensure that the transportation cost is kept at minimum and to the best of capacity utilization of the facilities. The river routes mode of transport must be given top priority in addition to the improvement in road and railway modes.
8.	Peat development	• Undertake studies to establish suitability of peat resources for power generation and also for domestic fuel. • Conduct research for use of peat as a fertilizer and/or soil conditioner for agriculture and horticulture sector and also for fisheries and water treatment and/or purification. • Detailed surveys should be done to confirm the reserves of peat from the category of resources be carried out. • Undertake techno-economic feasibility studies for the areas with proven reserves. • Encourage local entrepreneurs to set up units for producing briquettes from peat for domestic and other use and popularize it. • Frame separate rules for leasing and land acquisition, lease or purchase specifically to suit peat mining operations in Bangladesh
9.	Human resources development	• Setting up of Vocational training Institute that will provide regular trainings to the people deployed in the mines and will also undertake skill development courses for new manpower deployed at mine at operational level • Academic courses in mining, geology and other related fields to be introduced at the college and university level. • As interim measures, bilateral agreements with minerals rich countries to be made to train Bangladeshi personnel in foreign coal mines.

Step	Aspect	Recommended Strategy
10.	Land utilization and Reclamation	• The mine plan and the PSC/mining contract, if there is one, must make it obligatory for the mine owners to reclaim and rehabilitate the mining area after mine closure as per the mine plan to the extent feasible. Adequate safeguards need to be built in to the lease documents (and the PSC) so that it can be enforced. • A policy may be framed to deal with the rehabilitated land so that while fair play is assured to the lessee, the Government steps in to avoid windfall gains to the lessee by imposing a suitable tax.

2. Introduction

2.1. Context

2.1.1. Bangladesh is one of the world's most densely populated countries with a modest per capita income (USD 700, IMF 2012). The country has posted a consistent growth of around 6% for the past several years (IMF, 2007-12) and a robust export growth of 17% (2006-10, ADB Outlook 2011) despite the global recession. Country has moderate external debt (22.6% of GNI, 2011) and the second best credit rating in the region (BB- for long-term debt, S&P 2012).

2.1.2. Despite several challenges in near term, long term growth prospects looks bright. The Government's vision document charts a growth rate 10% by 2017 (Vision 2021). In the year 2013-14, GDP growth is expected to go up to 6% (ADB) supported by revival of exports and improving industrial performance.

2.1.3. The country's continued economic stability and growth will depend inter alia on its ability to upgrade public infrastructure, in particular, the energy sector, transport and urban development.

2.1.4. The primary energy consumption in Bangladesh is 24.3 Mtoe (2011) represents 0.2% of global primary energy consumption, against a global population share of about 2.4% (BP statistical review of World Energy, 2012). Similarly, the per capita power generation is low at 236 kWh (BPDB 2009-10) and electricity access covers only 60% of the population (BPDB 2012-13). This is low even in comparison with other South Asian countries.

2.1.5. A challenge to achieving these goals is the present over-reliance on natural gas which accounts for about 73% of the country's commercial energy supply even as the resources are depleting. The peak demand for electricity by 2030, as per the Power System Master Plan 2010 (JICA report) considering the Government Policy Scenario is estimated at 33,708 MW. In contrast, sustainable supply of natural gas is uncertain beyond 2030, highlighting the necessity to develop alternative sources of primary energy. Coal represents a key alternative for use in base load power plants. The total coal production currently is about 3,000 tonnes per day from the Barapukuria coal mine in Dinajpur that primarily feeds two local 125 MW power plants.

2.1.6. To develop its energy sector, Bangladesh has formulated policies to attract private and foreign investment inter alia in the oil, gas and coal sectors and in power generation. The Government has committed to develop power sector and adopted policy to provide access to electricity to all by 2021 and is targeting 600kWh per capita.

2.1.7. To implement this policy and achieve various objectives, Government wishes to develop Coal Sector to exploit alternate energy sources. While Coal Policy is being drafted by Government of Bangladesh, it is necessary to have a defined strategy and road map to achieve sector development objectives for coal sector in scientific manner to meet future demand and reduce reliance on natural gas.

2.2. Terms of Reference

2.2.1. The Terms of Reference of this report is *"To develop Coal Sector Development Strategy (including Peat) with appropriate enabling frameworks for the public sector and for private sector participation and institutional arrangements for the sector"*.

3. Coal reserves of Bangladesh

3.1. Geology

3.1.1. Bangladesh occupies a major part of the Ganges - Brahmaputra basin adjoining Indian State of West Bengal in the west and Tripura in the east.

3.1.2. Geological evolution of Bangladesh is related to the uplift of the Himalayan Mountain range and outbuilding of deltaic landmass by major river systems originating in the uplifted Himalayas.

3.1.3. This geology is mostly characterized by the rapid subsidence and filling of a basin in which a huge thickness of deltaic sediments were deposited as a mega-delta out built and progressed towards the south.

3.1.4. Only the eastern part of Bangladesh has been uplifted into hilly landform incorporating itself into the frontal belt of Indo-Burma range lying to the east. All the above has been the result of the Indian plate colliding with the Asian plate as explained by the universally accepted theory of plate tectonics.

3.1.5. The geology of Bangladesh has been discussed below under the following heads:

i. Tectonic framework,

ii. Stratigraphy and

iii. Economic Geology

3.2. Tectonic Framework

3.2.1. Tectonic framework refers to the basic structural frame on which Bangladesh stands. Bangladesh is divided into two major tectonic units: Stable Precambrian Platform in the northwest and Geosynclinal basin in the southeast.

3.2.2. A third unit, a narrow northeast-southwest trending zone called the Hinge Zone separates the above two units almost through the middle of the country.

3.2.3. The stable Precambrian platform occupies Rajshahi, Bogra, Rangpur and Dinajpur areas and is characterized by limited to moderate thickness of sedimentary rocks above a Precambrian igneous and metamorphic basement.

3.2.4. This unit is geologically stable in relative terms and has not been affected by fold movement. Some fault bounded graben basins occur within the Precambrian Basement. These basins contain coal bearing rock units of the Permian Period (286 to 245 million years ago), the oldest sedimentary rock found in Bangladesh.

3.2.5. The Precambrian platform is divided into a northern Rangpur Saddle with a very shallow Precambrian basement (130 to 1,000m) and a southern Bogra Shelf with a basement at moderate depth (1 to 6 km). Sedimentary layers in the Bogra shelf dip very gently towards the southeast until it reaches the hinge zone when the dip suddenly increases to 15 to 20 degrees and the sedimentary units plunge to a great depth into the deep geosynclinal basin in the southeast.

3.2.6. The geosynclinal basin in the southeast is characterized by high thickness (maximum of about 20 km near the basin centre) of clastic sedimentary rocks, mostly sandstone and shale of Tertiary age. It occupies areas of greater Dhaka, Faridpur, Noakhali, Sylhet, Comilla, Chittagong and the Bay of Bengal.

The hinge zone is a 25-km wide northeast-southwest zone that separates the Precambrian platform in the northwest from the geosynclinal basin to the southeast.

3.3. Stratigraphy

Stratigraphy of the Precambrian Platforms in the Northwestern Bangladesh

3.3.1. Stratigraphic subdivision of the rock sequences in Bangladesh is as follows:

- **The Precambrian platform in north-western Bangladesh:** The Precambrian basement is composed mainly of granite, granodiorite and gneiss. The basement occurs at a shallowest depth of 130 m below the surface in the Rangpur.

- **Permian:** The oldest sedimentary unit in Bangladesh is the Gondwana group of Permian age, resting unconformably on the Precambrian crystalline basement. The Gondwana group is composed of hard sandstone with some coal and shale layers. The Group is about 1000m thick and is found in fault bounded graben basins.

- **Jurassic-Cretaceous:** Above the Gondwana group of sediments lies a sequence of volcanic basaltic rock layers of Jurassic age called Rajmahal Trap formation. The unit is about 500m thick. The Rajmahal trap is overlain by the Shibganj Trapwash formation, a relatively thin cover of the weathered product of volcanic rocks consisting of red ferruginous sandstone and mudstone of cretaceous age.

- **Early Tertiary:** The next upward sequence of rocks is named the Jaintia group, which belongs to the Palaeocene and Eocene age. The Jaintia group is divided into three units, from bottom upward, the Tura formation, Sylhet Limestone formation and Kopili Shale. The Tura formation is of Eocene age with average thickness of 250m. The Sylhet Limestone formation is the most extensively developed unit in the subsurface of northwestern Bangladesh and is a marker horizon in the seismic section. The overlying Kopili formation is composed of dark grey to black fossiliferous shale with a few limestone beds. The unit has a thickness of 40 to 90m.

- **Late Tertiary:** The Barail group, 150 to 200m thick and consisting of sandstone, shale and siltstone with occasional carbonaceous layers. This is overlain by the Surma group (and often called the Jamalganj formation), about 400m thick, and consist of deltaic sandstone, shale and siltstone.

- **Pleistocene:** The Surma Group is overlain by the Dupi Tila formation of the Pliocene-Pleistocene age, composed of medium to coarse-grained sandstone, and having a thickness of about 270m. The overlying Dihing formation is pebbly sand to occasional gravel deposits, having a thickness of about 150m. All the above are covered by about 100m of soft sandy, silty and clayey sediments of Bengal Alluvium of Recent age.

Stratigraphy of the Geosynclinal basin in South-Eastern Bangladesh

3.3.2. The stratigraphy of the geosynclinal basin to the southeast is characterised by an enormous thickness of sedimentary succession (upto about 20 km), mostly Tertiary in age. Rocks older than Oligocene have not been encountered in the outcrop in the geosyncline basin.

- **Late Tertiary:** The Oligocene is represented by the Barail group, named after the Barail Range in India. The Barail group is composed of alternating sandstone, shale, siltstone and occasional carbonaceous rich layers. In Bangladesh most of the Barail group is very deeply buried, although

about 350m of the upper part of the Barail is exposed on a small strip of land in jaintiapur, on the northern Sylhet border with India.

- **Miocene-Pliocene:** The Surma group of the Miocene-Pliocene age overlies the Barail group with an unconformity. The Surma group has a thickness of about 3,500m to 4,500m and is composed of monotonous alternating sandstone, shale, siltstone and some conglomerate.

  The Surma group is divided into two formations, a lower more sandy Bhuban formation and an upper more argillaceous (clayey) Bokabil formation. The Surma group forms the backbone of the eastern hilly areas of Bangladesh including those of Sylhet and Chittagong hills where it is extensively exposed.

  The Surma group is overlain by the sand dominating Tipam group of the Pliocene-Pleistocene age. The Group is subdivided, from bottom upward, into the Tipam Sandstone formation, Girujan Clay formation and Dupi Tila formation. The Tipam Sandstone formation, about 1,200m to 2,500m thick, is dominantly composed of medium grained sandstone frequently cross bedded, with little shale and this indicates deposition under a river environment.

  The overlying Girujan Clay formation is a shale unit with a thickness of 100 to 1,000m. The Dupi Tila Sandstone formation is 2,000 to 3,000m thick and is composed of medium to coarse loosely compacted cross-bedded sandstone, occasionally pebbly. The above is covered with about 100m of sandy, silty and clayey sediment of Bengal Alluvium of Recent age.

3.4. Economic Geology

3.4.1. Occurrence of economic deposits of petroleum and mineral resources in Bangladesh has been constrained by the geological parameters especially by the tectonic-structural setting and stratigraphy. For example, the large deposits of bituminous coal are restricted to northwestern Bangladesh in Dinajpur and Rangpur districts, because of the occurrence of Permian rocks in graben basins within the Precambrian platform.

3.4.2. On the other hand the large natural gas reserves are located in eastern Bangladesh because folded structures are formed which trapped the gas in thick Mio-Pliocene sandstone reservoirs. Bangladesh has so far discovered significant amounts of economic mineral resources including natural gas, coal and peat, limestone, crystalline hard rocks, heavy minerals, kaolinite and glass sand. Each of these resources is associated with specific geological settings.

3.4.3. During the middle Eocene time northwestern Bangladesh was covered with a shallow open marine condition and the Sylhet Limestone formation was formed during that time. Limestone is thus confined to areas where the Sylhet limestone formation occurs. This formation is found in the subsurface in the Bogra-Rajshahi area and found on the surface in the Lalghat-Bhangerhat areas of northern Sylhet. Recently the Geological Survey of Bangladesh has reported the existence of large economically exploitable deposits of limestone in the Joypurhat area of northwestern Bangladesh.

3.4.4. Rich deposits of glass sand are found in many areas, mainly in the eastern part of the country. The occurrence of glass sand depends on the process of concentrating quartz in sand by washing away impurities. The glass sand deposits are found as pockets or lenses of quartz rich sand within the Dupi Tila formation, itself a sand-dominating unit.

3.5. History of Coal Exploration

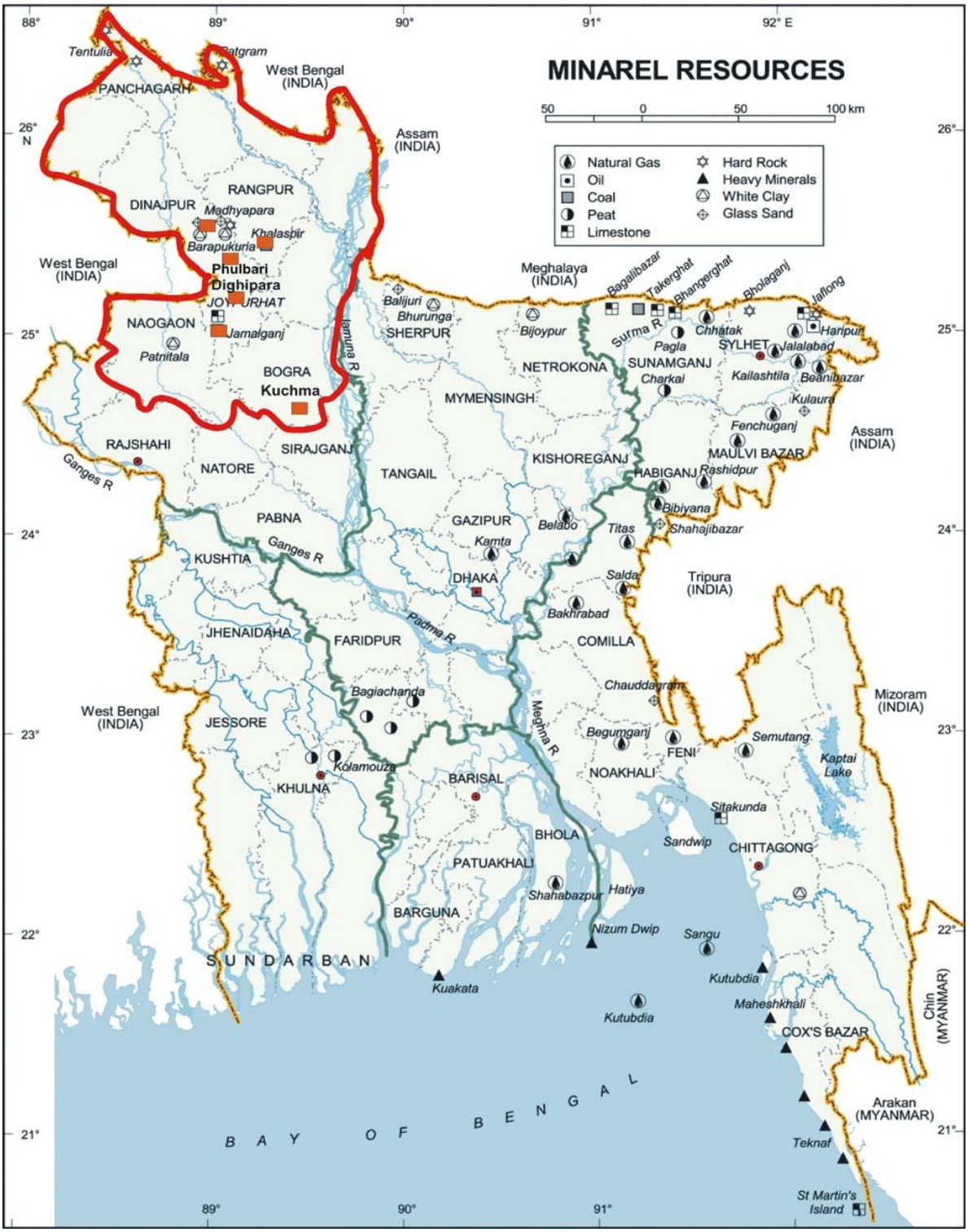
3.5.1. Standard Vacuum Oil Company while drilling for oil in northern Bangladesh discovered coal in the Kuchma area in Bogra district in 1959. Following the discovery of a thick bituminous coal seam at Kuchma near Bogra, a UN-PAK Mineral Survey Project was initiated in 1961 with the aim to locate coal deposits by deep drilling. Ten boreholes were drilled and necessary geophysical surveys were

undertaken resulting in discovery of seven coal seams in the Jamalganj area near the border of Naogaon and Bogra district.

3.5.2. Later Geological Survey of Bangladesh (GSB) undertook aero-magnetic and gravity survey followed by drilling campaign in the North Western Bangladesh and discovered Coal deposits in Barapukuria (1985) and Dighipara (1995) in Dinajpur district and Khalashpir (1989) in Rangpur district. Phulbari Coal deposit in Dinajpur district was discovered by Broken Hill Proprietary (BHP) during 1994- 1997. In 1998 BHP assigned their rights to Asia Energy Corporation (Bangladesh) Pty. Ltd (AEC).

3.5.3. The locations of the coal fields and other mineral resources of Bangladesh have been marked in the map below. It can be noted that all identified coal fields are located in the north western part of the country and have a geological linkage with the coal fields in the Assam and Raniganj area of State of West Bengal in India.

3.5.4. With the limited information on geophysical seismic survey, it may be optimistic to expect coal at a shallower depth in Bangladesh. The coal fields are characterized by thick sedimentary overburden heavily affected by underground aquifers in the coal bearing areas.



Source: Infrastructure Investment Facilitation Company

Figure 1: Coal and Mineral Deposits in Bangladesh

3.6. Resources and Reserves of Coal Fields

3.6.1. Estimated resource and reserves in the identified five coalfields of Bangladesh as per UNFC system is as follows:

Sl. No.	Coal Basin	Depth of Coal Field (in m)	Total Coal Resources and Reserves (Mt)
1.	Barapukuria	118-509	346.71+ (43-64)*
2.	Phulbari	150-250	572.00
3.	Khalashpir	228-510	523.49
4.	Jamalganj	640-1158	1053.90
5.	Dighipara	323-408	600.00
Grand Total			3139.10-3160.10

*Resources of VI Seam in second syncline area towards SW of main basin, after Wardell Armstrong.
Source: Report on Mineral Resource Assessment Report, PwC

Table 1: Field wise position of coal resources and reserves in Bangladesh

4. Overview of energy sector of Bangladesh

4.1. Introduction

4.1.1. Country's industrialization and economic growth depends on availability of commercial energy. Coal is one of the main sources of commercial energy for several countries accounting for about 30% of commercial energy consumption globally.

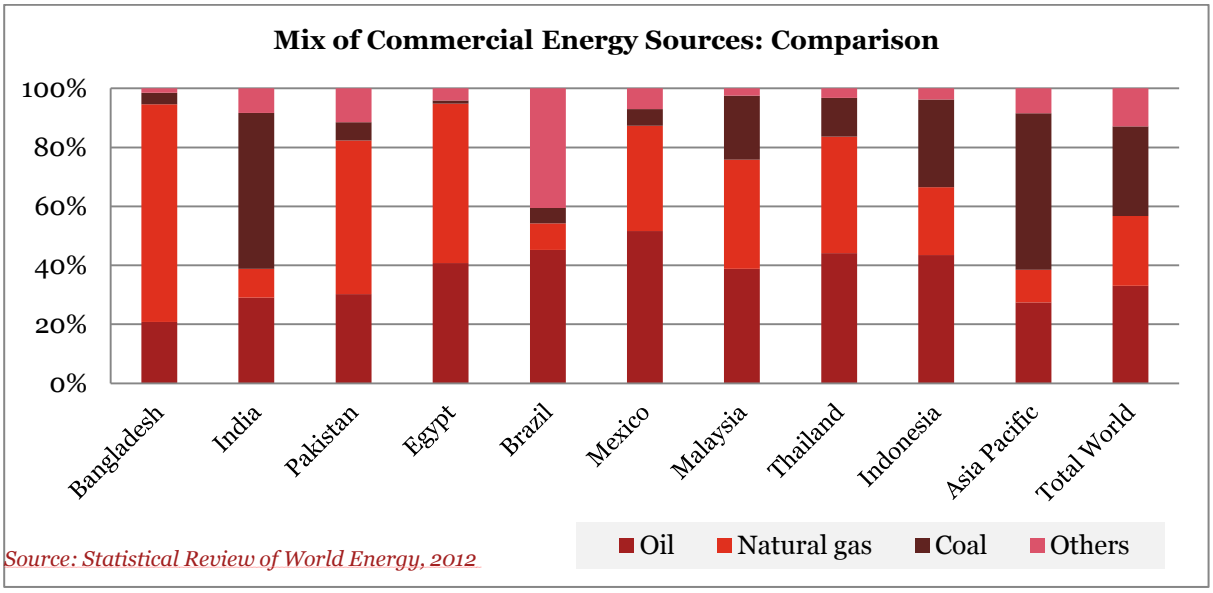
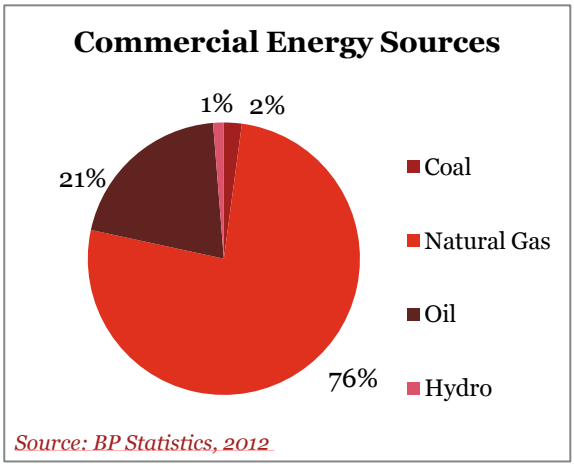


Figure 2: Comparison of Mix of Commercial Energy Sources

4.1.2. The primary energy consumption in Bangladesh is 24.3 Mtoe (2011) representing 0.2% of global primary energy consumption, against a global population share of about 2.4% (BP statistical review of World Energy, 2012).

4.1.3. The energy mix of Bangladesh presents an uncommon picture for a non-oil rich nation. Natural gas is the dominant primary commercial energy source for Bangladesh with over three-fourths share, followed by oil at 21%. Coal, despite its significant reserves in the country, hydroelectricity and other power sources together contribute barely 3% of total commercial energy use.



4.1.4. The commercial energy mix of Bangladesh could significantly change in the coming years. The level of commercial energy use and per capita consumption will substantially change as the country grows and diversify the reliance on energy sources. The share of non-commercial sources of energy (largely wood, agricultural residue) is 60% and about 4/5th of the population depends on it. As this population moves to commercial energy sources we would see a more diverse mix of sources including renewable energy.

4.1.5. Considering this, it is imperative to diversify current energy mix to prolong life of country's finite natural resources, to lower the carbon intensity, and to take advantage of cheaper energy sources (including through imports if required and available). As there are no immediate substitutes to use of petro-products to drive the transport sector, conservation efforts also in effect bring future energy security for the country.

4.2. Power Demand Analysis

4.2.1. Bangladesh's per capita electrical energy consumption is amongst the lowest in the world, and third lowest in Asia. As per the latest data available, Bangladesh's annual per capita electricity consumption was only 252 kilowatt hours (kWh), compared to India and Pakistan which had consumption rates of 571 kWh and 449 kWh respectively.

4.2.2. The figure illustrates the comparison of per capita electric power consumption among the other South Asian and East Asian countries.

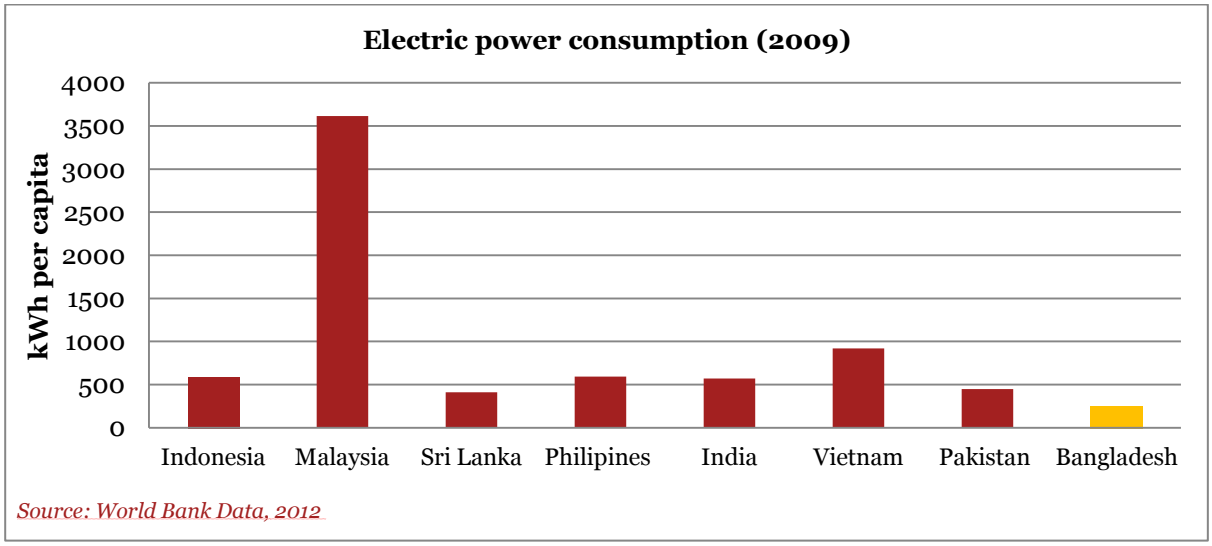


Figure 3: Per capita electric power consumption among the other South Asian and East Asian countries

4.2.3. In FY 2010-11, total installed power generation capacity stood at 7264 MW (Bangladesh Economic Review 2011). Of this the share of public sector (including REB) was 4027 MW and that of private sector was 3237 MW. This is less as compared to the estimated power demand of 2012 (7518 MW: PSMP 2010).

4.2.4. The electricity industry suffers from a range of challenges viz., high peak-to-average demand, supply rationing, high network losses, dependence on Government subsidies, poor quality of supply, and under-served rural areas.

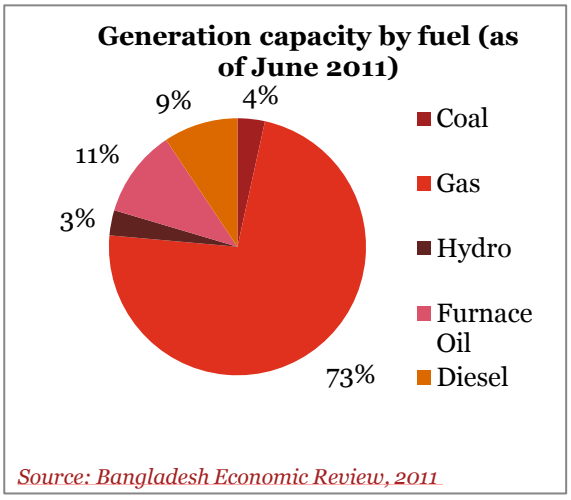


Figure 4: Generation Capacity by fuel - Bangladesh

4.2.5. Energy security has become an important consideration for many developing economies with rising costs of fuels and strong competition for acquisition of thermal coal assets, even as new reserves have been added. This has prompted many countries (such as Australia, Indonesia, India) to relook at their mining policies, laws, regulations, taxation, and other industry practices.

4.2.6. The Bangladesh Government is committed on a policy to make electricity available to all by 2021 and is targeting 600kWh per capita. To address the power shortfall and meet the growing demand, the Government proposed initiatives to add about 11.8 GW in next 5 years (2012-2016). The figure below shows the annual generation capacity addition for the medium term.

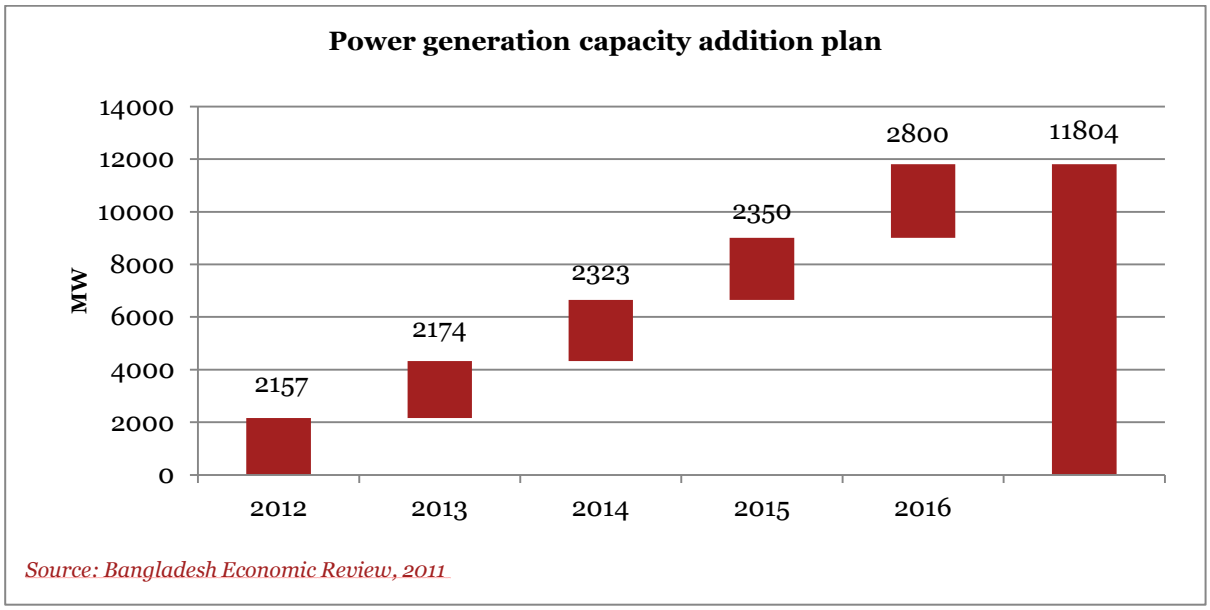


Figure 5: Power capacity addition plan - Bangladesh

4.2.7. As discussed above, the major source of electricity generation in Bangladesh is natural gas. As a result, the gas fields are increasingly taking a lot of pressure in terms of production, and consequently depleting at a faster rate.

4.2.8. Till now, 23 gas fields have been discovered in the country with an estimated recoverable proven and probable reserve of 20.61 TCF. Of this, as of June 2011, 9.79 TCF gas has already been produced while only 10.82 TCF is remaining (Bangladesh Economic Survey, 2011).

4.2.9. Bangladesh produced 709 BCF of natural gas in 2010-11 (Bangladesh Economic Survey, 2011). Considering the current production level, the Reserves to Production ratio (R/P) of natural gas in the country is about 13-14 years. Though BP Statistics (2012) has pegged R/P ratio at 18 years.

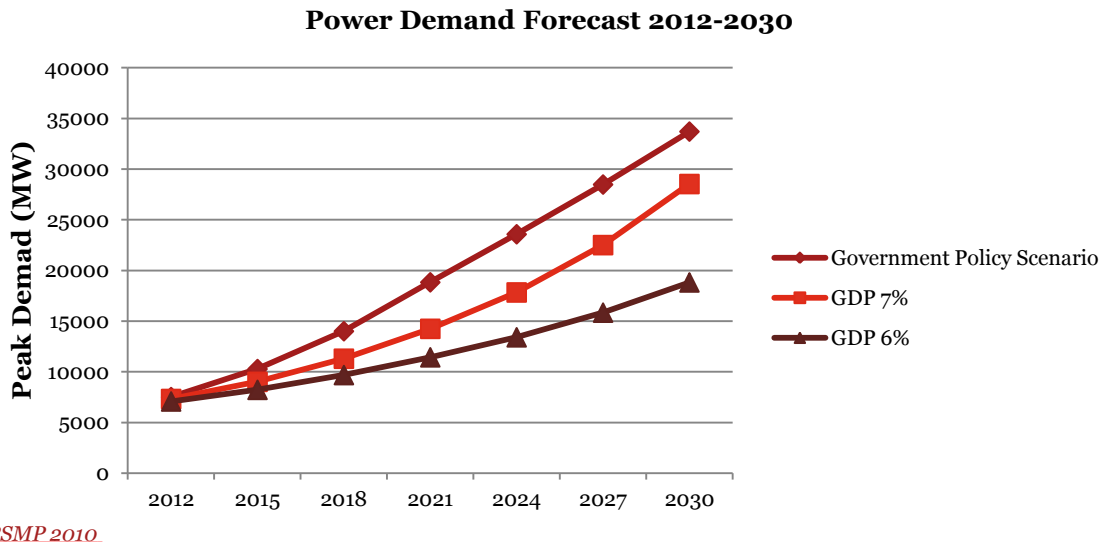
4.2.10. Further, the gas demand and supply forecast by various agencies reveals that indigenous natural gas would be in short supply from the year 2015 and by the year 2025, gas supply shortage would become significantly large. The pressure is aggravated since alternate indigenous source of commercial energy is not developed in country like coal, peat etc.

4.2.11. While the need to find more gas reserve cannot be undermined, it is equally important that other energy sources (like coal and peat) that are available in the country be utilized in order to bear a greater share in the total energy mix of the country.

4.2.12. Recent shortage of gas that caused a curtailment of electricity generation prompted the Government to conduct a study through Japan International Cooperation Agency (JICA) that concentrated on developing the coal sector in Bangladesh.

4.2.13. The Tokyo Electric Power Company (TEPCO), on behalf of JICA prepared "The Study for Master Plan on Coal Power Development in the People's Republic of Bangladesh" and created the Power System Master Plan 2010 (PSMP 2010) in February 2011.

4.2.14. Building on the PSMP 2006, the PSMP 2010 estimated the power requirements in the country for various scenarios. These scenarios and the Power Demand forecasts are illustrated below.



PSMP 2010

Figure 6: Power Demand Forecast 2012-2030

Power Demand forecast (Government Policy Scenario)

4.2.15. The table below gives the power demand forecast in the Government Policy Scenario

Year	Peak Demand [MW]	Generation [GWh]
2010	6,454	33,922
2011	6,765	35,557
2012	7,518	39,515
2013	8,349	43,882
2014	9,268	48,713
2015	10,283	54,047
2016	11,405	59,945
2017	12,644	66,457
2018	14,014	73,658
2019	15,527	81,610
2020	17,304	90,950
2021	18,838	99,838
2022	20,443	109,239
2023	21,993	118,485
2024	23,581	128,073

Year	Peak Demand [MW]	Generation [GWh]
2025	25,199	137,965
2026	26,838	148,114
2027	28,487	158,462
2028	30,134	168,943
2029	31,873	180,089
2030	33,708	191,933

Source: PSMP 2010

Table 2: Power Demand forecast (Government Policy Scenario)

4.2.16. With the current known resources, major alternative energy fuel available in Bangladesh is coal. Coal has the potential to contribute to the national economy by way of supplying energy for power generation, as well as for heat applications in industries.

4.2.17. It is therefore, evident that actions must be initiated immediately for developing the coal deposits of the country, so that coal is available in adequate quantities before 2015 as an alternative commercial fuel for power generation.

4.3. Coal demand-supply analysis

Coal Demand

4.3.1. Since the PSMP 2010 is the only document that details out the planning for the future coal fired power stations in the country, this report has based its projections of coal demand for power generation on the PSMP 2010.

4.3.2. Of the 33,708 MW power requirements by 2030, the Government of Bangladesh plans to generate 20,000 MW using coal both domestic and imported.

4.3.3. The new coal fired power stations planned (i.e. excluding the presently operating 250 MW at (Barapukuria) are as follows:

Coal Fired Power Generation Projects Planned by BPDB (upto 2030)		
Domestic Coal Based:		
K-D-P[1]	6x1000 MW USC	6,000 MW
K-D-P	8x 600 MW USC	4,800 MW
	Sub-total (local)	**10,800 MW**
Imported Coal Based:		
Rampal, Khulna	Khulna 1300 MW Coal based TPSC Project	660x2=1320 MW
Anawara, Chittagong	Chittagong 1300 MW Coal based TPSC Project	660 x2=1320 MW
Mosheshkhali, Cox's bazar	Mosheshkhali 5320 Coal based	1000 x4 =4000 MW

[1] K-D-P = Khalashpir-Dighipara-Phulbari

Coal Fired Power Generation Projects Planned by BPDB (upto 2030)		
	TPSC Project	660x2=1320 MW
Chittagong	Chittagong	282.67
Labonchora, Khulna	Labonchora, Khulna	282.67
Maowa, Munshiganj	Maowa, Munshiganj	522
Chittagong	Chittagong	619
	Sub-total (imported)	**9,666 MW**
Total new generation using coal (approx)		**20,500 MW**

Table 3: Coal Fired Power Generation Projects Planned by BPDB (upto 2030)

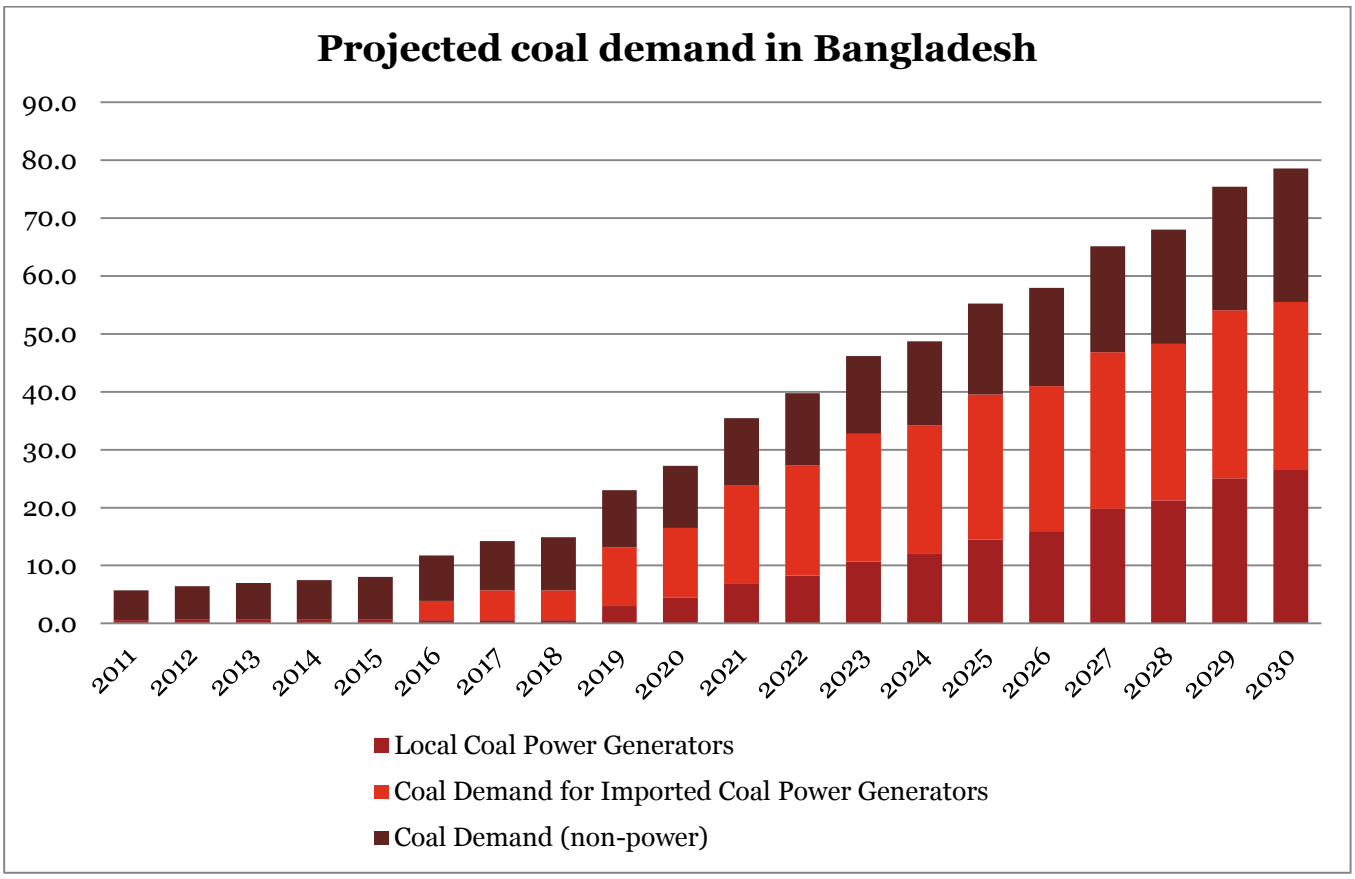
Source: Power Division, MoPEMR

4.3.4. Coal quality tests conducted during preparation of PSMP 2010 suggests that Barapukuria coal has a higher heating value (HHV) of 7,100 kcal/kg. Compared to this, imported coal is assessed to have an HHV of 5,100 kcal/kg. On this basis, IIFC estimated the representative coal consumptions for using two types of coals as follows:

- 2.4 MTPY per 1000 MW for domestic coal
- 3.0 MTPY per 1000 MW for imported coal

4.3.5. Considering this, IIFC estimated that by year 2030, domestic coal requirement for power generation purposes will be 26.5 MTPA, while imported coal requirement will be about 29 MTPA. Further, it is estimated that by 2030, brick fields and other uses shall require about 19.7 MTPA coal. The demand for coal for uses other than power generation has been assumed to be about 5.76 MTPY, rising at 10% per annum from a base of 3.2 MTPY in the year 2006. Coal consumption for other uses is conservatively estimated to grow at 8% per year from the year 2014.

4.3.6. The chart below shows the projected coal demand in Bangladesh till 2030.



Source: IIFC analysis

Figure 7 Projected Coal Demand in Bangladesh

Coal Supply

4.3.7. At present, coal demand in Bangladesh is mainly from the 2x125MW coal fired power plants at Barapukuria, brickfields and other industries. The mine operated by the Barapukuria Coal Mine Co. Ltd. (BCMCL) which was developed jointly by Petrobangla and CMC of China (agreement concluded in 1994).

4.3.8. The table below lists the coal production results for the years 2006-2010. Coal is supplied for the two neighboring 125 MW Barapukuria Thermal Power Plants. The mine also supplies coal for brick making and other industrial users. At present, the mine has an annual production capacity of about one million tonnes.

FY	Planned coal production (t)	Coal production achieved (t)
2006	500,000	362,470
2007	770,000	348,200
2008	970,000	611,674
2009	1,020,000	904,659
2010	930,000	709,155
2011	560,000	

Source: EMRD

Table 4 Coal production figures at Barapukuria Coal mine

Note: It may be noted that the mine has never achieved the planned production which has been often below the rated capacity except in 2009.

4.3.9. The coal fields of the north-western part of the country have a good potential to contribute significantly to the energy security and hence, national economy.

4.3.10. As discussed above, by 2030, Bangladesh would need a total of 78 MT of coal annually. Domestic coal supply alone would be insufficient to meet this demand. The PSMP identified four scenarios; wherein Bangladesh can satisfy its power demand:

1. **Fuel Diversification Scenario:**

   To satisfy power demand projected under the government policy scenario, fuel diversification is promoted multifariously and considerable effort is required to attain domestic and import coal scenarios.

2. **Domestic Coal Promotion Scenario:**

   Based on scenario (1), the risk of the unsuccessful development of import coal procurement will be considered. To make up for this shortage, oil consumption will be increased. (Oil: 6% to 15%)

3. **Import Coal Promotion Scenario:**

   Based on scenario (1), the risk of the unsuccessful development of domestic coal development will be considered. To make up for this shortage, oil consumption will be increased. (Oil: 6% to 28%)

4. **Gas Promotion Scenario:**

   Based on scenario (1), the risk of the unsuccessful development of both import and domestic coal development is considered. To make up for this shortage, gas production will be increased. (Gas: 23% to 54%)

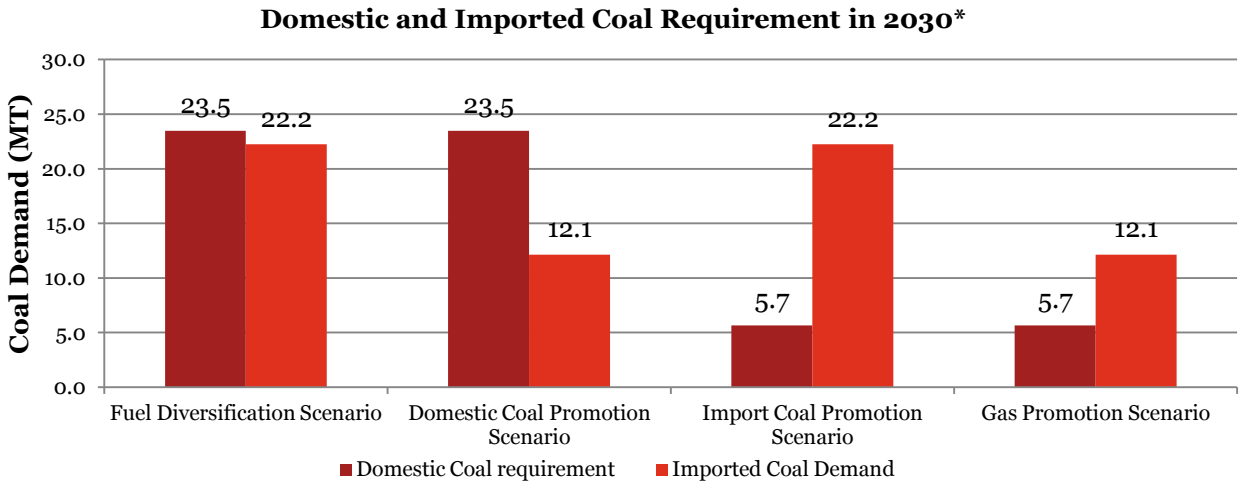
4.3.11. The table below shows the Fuel-wise composition at each scenario:

Scenario	Domestic Coal	Imported Coal	Gas	Oil	Nuclear	RE/Border
Fuel Diversification	29%	22%	23%	6%	10%	10%
Domestic Coal Promotion	29%	12%	23%	15%	10%	10%
Import Coal Promotion	7%	22%	23%	28%	10%	10%
Gas Promotion	7%	12%	54%	6%	10%	10%

Source: Power Sector Master Plan 2010

Table 5: Fuel wise composition at each scenario

4.3.12. The graphs below shows the domestic coal and imported coal requirement for power sector in each scenario in 2030: (Assuming that the total power demand of 33,708 MW in 2030 is met in each scenario)



*Domestic Coal Requirement is calculated based on the representative coal consumption of 2.4 MTPY per 1000 MW and Imported Coal Requirement is calculated based on the representative coal consumption of 3.0 MTPY per 1000 MW (Refer to 4.3.4 for basis of Assumptions)

Figure 8: Domestic and Imported Coal Requirement in 2030

4.3.13. In 2030, in case of Fuel Diversification Scenario/Domestic Coal Scenario the domestic coal requirement is expected to be 23.5 MTPA and even in the case of Import Coal Promotion Scenario/ Gas Promotion Scenario the domestic coal requirement is expected to be 5.7 MTPA.

4.3.14. Given current domestic coal production capacity of 1 MTPA, the demand supply gap stands at 22.5 MTPA in Fuel Diversification Scenario/Domestic Coal Scenario and 4.7 MTPA in Import Coal Promotion Scenario/ Gas Promotion Scenario.

4.3.15. Thus, it is imperative in all the scenarios that a coal sector master plan be prepared for the country to meet the rising demand of coal from power as well as other sectors and promote coal production.

4.3.16. Given this, subsequent chapters discussed strategy to develop domestic resources.

5. Development of coal deposits

5.1. Strategy for mining of coal deposits

Strategy for mining of coal deposits in Bangladesh encompasses various issues as follows:

5.1.1. Policy issues

- Integrated energy policy of Bangladesh and develop integrated plan for harnessing potential of all energy sources– share of coal based energy in total energy mix.
- Depletion policy for indigenous resources of energy minerals
- Policy for acquisition of coal assets abroad
- Viability gap funding for sand stowing and other measures for safety and conservation of coal.

5.1.2. Technical issues

- Phased exploration programme.
- Assessment of Geo-mining and hydro-geological conditions of the coal basins.
- Safety and conservation imperatives – feasibility of sand stowing.
- Environmental and social issues.
- Production potentiality of each coal basin considering the above issues.
- Technical Feasibility of blending peat with indigenous coal

5.1.3. Commercial issues

- Phased demand for indigenous and imported coal.
- Comparative viability of indigenous coal and imported coal in terms cost per kCal (or per unit energy).
- Commercial Feasibility of blending peat with indigenous coal
- Funding options for coal mining projects.

5.1.4. Infrastructural and other issues

- Development of roads and railway network for new coal basins and also development of port handling facilities for import of coal.
- Power supply arrangement from two different sources for each coal basin (for safety of mines and miners).
- Global availability of qualified exploration agencies and laboratory facilities for coal testing etc.
- Global availability of reliable mine construction and operation contractors.
- Availability of indigenous manpower for exploration and mine operation

5.2. Status for exploration

5.2.1. The resource base indicating status of exploration of different coal basins of Bangladesh are summarized below:

Sl. No.	Coal Basin	Coal Resources and Reserves (Mt)				Remarks
		Proved	Indicated	Inferred	Total	
1.	Barapukuria	114.32	211.33	21.06+ (43-64)*	346.71+ (43-64)*	*Resources of VI Seam in second syncline area towards SW of main basin, after Wardell Armstrong.
2.	Phulbari	288.00	226.00	58.00	572.00	
3.	Khalashpir	-	297.57	225.92	523.49	
4.	Jamalganj	-	-	1053.90	1053.90	
5.	Dighipara	-	105.00	495.00	600.00	
	Grand Total	402.32 (12.82%)	839.90 (26.76%)	1896.88-1917.88 (60.42%)	3139.10-3160.10 (100%)	Percentages calculated on the total figure of 3139.10

Source: Report on Mineral Resource Assessment, PwC

Table 6: Summary of coal resources of Bangladesh

5.2.2. It may be seen from the above table that out of the total coal resources, around 13% is under 'proved' category, around 27% is under 'indicated' category and the balance about 60% is under 'inferred' category. Thus there is need for taking up an accelerated programme for detailed exploration for bringing the resources of all the known coal basins into 'proved' category.

5.2.3. The total additional drilling required to bring the entire resource of around 3.1 Bt into 'proved' category has been tentatively assessed to be 1.84 lakh meters. This estimate is based on a broad order of magnitude study and the actual meters of additional drilling may vary depending upon structural complexities of the coal basins. Basin-wise break-up of the above additional drilling required is as under:

Coalfield	Area (km^2)	Drilling required (m)	Additional Holes required
Barapukuria	3.68	2800	11
Phulbari	23.00	23,450	80
Khalashphir	10.00	24,600	62
Jamalganj	11.70	83,900	83
Dighipara	15.00	49,350	116
Grand		**1,84,100**	**352**

Total	

Table 7: Break up of additional drilling required

5.2.4. As geological reports of the coal basins are pre-requisite for preparation of techno-economic feasibility reports on the basis of which investment decisions will be taken, the detailed exploration of these deposits need to be expedited. The following strategies for detailed exploration are recommended:

- Multiple drilling rigs for high speed drilling are to be deployed as actual time available for field drilling work will be restricted to dry season only.
- One fourth of the boreholes may be of non-coring type. However, all boreholes (coring and non-coring) are to be geophysically logged.
- Exploration contract should not be combined with mining and construction contracts. Preferably, different exploration contractors may be selected for different basins. This is to ensure smooth implementation of exploration program and ensure maximum returns to Government during mining stage given government can get better deal if reserves are established.
- Exploration contracts to include the following in its scope:
    - High speed drilling, geophysical logging, surface surveying and contouring, analysis of coal cores from accredited laboratories etc.
    - Physico-mechanical studies of coal and rock strata (@ 1 borehole/ km^2).
    - Preparation of geological reports complete with plans etc.
    - Hydro-geological study and report.
    - Gas content of seams and CBM potentiality study and report.
    - Baseline environmental study (for all seasons) and report.
    - On-site training of geologists, geophysicists, hydro-geologists, drilling engineers, drill operators and mechanics of Bangladesh.
- Geological Survey of Bangladesh (GSB) should be entrusted with responsibility of monitoring exploration for identifying new deposits of coal, peat, hard rock and other minerals in the country and vetting of draft geological reports to be submitted by exploration contractors.
- To win investor confidence and attract more investors, a national repository of all geological information should be created with one agency. Thus, GSB shall be responsible for maintaining a Data Repository of all Geological Data for all the minerals including coal, hard rock etc. However, BMD shall be owner and custodian of all data and reports pertaining to mining and minerals sector including but not limited to geology data and information, quality and chemical analysis data, land records of mineral bearing area, leasing and licensing related information, regulatory filings etc. in respect of the mineral inventory of Bangladesh. Thus, BMD shall maintain a central data repository of mineral sector.
- Measures to be taken for capacity building of BMD and GSB personnel to equip them adequately to deal with technical capability to monitor and review exploration work as well as commercially to deal with contract management and contractual issues.

5.2.5. Above mentioned steps to facilitate development of coal fields, the detailed exploration and other studies along with the preparation of geological reports and other study reports of all the coal basins

can be completed within a period of 3-4 years since the time work commence if wok is taken continuously without any interruption.

5.2.6. The detailed exploration of the coal basins and other related studies should be preferably funded by a State agency/ PSU so that the geological reports and other reports become the properties of BMD and GSB. These reports will have to be procured by the prospective mine developer before submitting their bid documents for exploitation of respective deposits.

5.2.7. Alternately, private investors may be invited to invest in exploration but given the high risk nature of the exploration activities, many private investors may not be keen. Further, private investors may need surety of getting mining license to operate and sufficient incentives and mechanisms to recover investment made on exploration including open market sale of coal. In case it is funded by Private Sector, all the geological data and information generated shall be sole property of Government and should be handed over to BMD and GSB. If Government decides to auction mineral resources, prospective bidders can purchase this information from Government which will also help them placing competitive bids.

5.3. Strategy for Exploitation

5.3.1. Gross geological coal resource of Bangladesh is estimated at about 3.13 Bt. The recoverable reserve will depend on a host of factors like structure of the deposits, hydrogeology of the basins, method of mining to be followed, cost of mining etc. and can only be firmed up after preparation of techno-economic feasibility reports for all the coal basins.

5.3.2. However, at the present stage, recoverable coal reserves of Bangladesh may be taken at around 1 Bt by assuming an overall recovery of 30% of geological resource. This would mean a per capita recoverable coal reserve of around 6.3 tonne only with the present population base.

5.3.3. The coal basins of Bangladesh are characterized by the occurrence of multiple seams some of which are thick/very thick, presence of highly water bearing unconsolidated Upper Dupi Tila horizon above the coal seams, presence of large number of faults, high depth of seams, susceptibility of some of the coal seams to spontaneous heating etc.

5.3.4. Also, the land surface over the coal deposits is highly fertile and supports a large agrarian population whose interests must be protected by the companies engaged in coal mining.

5.3.5. Thus, policies and strategy for development of coal mines should be framed keeping the following fundamental objectives in view to achieve the goal of sustainable development of the coal mining sector of the country.

- Maximization of conservation of coal resources.
- Attainment of highest level of safety in mines.
- Minimization of environmental damage to mining areas.

5.3.6. Total coal production from all the five identified coal basins of Bangladesh can be firmed up after preparation of detailed Feasibility Reports for these basins. The status of exploration and planning together with reserves, rated mine capacity, depth of the lowest coal seam etc. of each basin are summarized below:

Coal basin	Area (sq.km)	Depth range of lowest workable Seam (m)	Status of exploration	Status of planning	Geological reserve (Mt)	Extractable Reserve (Mt)	Rated Capacity as per FR (Mty)	Remarks
Barapukuria	6.68	110-540	Mostly explored	TEFS available for VI &V seams only	346.71	84.02	1.0	VI seam in central part of mine is being worked by multi-slice longwall mining with caving. LTCC method is proposed to be adopted in 2nd Slice. Southern part of the seam requires further exploration and planning. Further studies are needed to establish the feasibility of opencast mining in a portion of northern part of VI seam.
Phulbari	23	243-318	Mostly explored	Life of mine Plan and EIA reports available	572	475	15.0	Planning done for opencast mining. However, several studies need to be done before commencement of mining. Also, severe environmental damage and social strife expected due to opencast mining in the area.
Khalashpir	10	293-500	More drilling needed	TEFS available	523.49	120	4.0 (rated capacity) 2.0 (for initial 7 yrs)	TEFS proposes Multi-slice longwall mining with caving using artificial iron matting but provision for stowing has also been kept in case of problem with caving. Also, one Room & Pillar district with Continuous Miner has been suggested. For the rated capacity of 4.0 Mty, 4 nos of longwall panels, 1 no. Room & Pillar district and 7-10 development headings with road headers have been proposed in the TEFS. Some studies have also been suggested to firm up mining system. While the TEFS is prepared, further exploration is required to be

Coal basin	Area (sq.km)	Depth range of lowest workable Seam (m)	Status of exploration	Status of planning	Geological reserve (Mt)	Extractable Reserve (Mt)	Rated Capacity as per FR (Mty)	Remarks
								conducted to establish technical parameters fully.
Jamalganj	11.7	903-1126	Yet to be explored in detail.	TEFS not done yet.	1053.9 (tentative)	Not estimated	No study/ planning done yet	Deposit lying at very high depth and unexplored. Detailed exploration and other studies including gas content studies to be taken up. Mining will be difficult and will require special expertise. Economic viability of conventional mining in medium term is doubtful.
Dighipara	15.0	396-455	Yet to be explored in detail.	TEFS not done yet	600.0 (tentative)	Not estimated	No study/planning done yet.	Detailed exploration need to be taken up on priority. There is possibility of getting additional coal bearing area. Mining appears to be feasible in this basin.

Table 8: Summary of status of exploration and planning of different coal basins of Bangladesh

5.3.7. The major factors that would influence the strategy of mining the coal deposits of Bangladesh are:

- Technical and environmental feasibility of opencast mining in Phulbari mine and in part of Barapukuria mine.
- Necessity of adopting stowing method in some deposits and long term availability of sand in the vicinity of such deposits.
- Suitability of coal deposits for application of caving method.

Opencast Mining

5.3.8. Application of opencast mining method will help conservation of coal resources of Bangladesh by increasing extraction ratio. However, several studies are required to be taken up to establish the technical feasibility of opencast mining which are as follows:

- Hydro-geological studies to ascertain the impacts of large scale dewatering of UDT aquifer through borewell pumps to be installed around the opencast excavation. It is apprehended that such dewatering of UDT aquifer in Phulbari opencast mine may increase the ground water flow in the adjacent Barapukuria underground mine. Also, the possibility of ground subsidence due to lowering of the ground water level has to be studied to ascertain the safe distance of opencast workings so that important structures in the vicinity are not affected.
- Slope stability studies for the internal and external spoil dumps and for the highwall slopes of the mine have to be taken up considering water saturated strata of unconsolidated UDT and LDT horizons to ascertain safe slope angles for different slope heights.
- Ground bearing capacities of UDT and LDT strata to ascertain that the ground will support movement of Heavy Earth Moving Machineries to be deployed for excavation in the mine, particularly during rainy seasons.
- The other important factor that must be considered and studies be conducted before adopting opencast mining method is impact of such mining on environment and local people. Mining should not be done at the cost of creating social strife in the area. However, underground mining with caving will also impact the local people in much the same way as in opencast mining, due to surface subsidence caused by extraction of multiple seams having average aggregate thicknesses varying from around 30 m to 60 m in different coal basins of Bangladesh.

Underground Mining with Sand Stowing

5.3.9. The coal basins of Bangladesh are characterized by the presence of multiple seams some of which are thick/extra thick and by the presence of highly water bearing and thick Upper Dupi Tila aquifer bed belonging to Pliocene age above the coal horizons belonging to Godwana formation.

5.3.10. Presently, the thick VI seam is being worked in Barapukuria mine by multi-slice (inclined slicing) longwall mining with caving. Stowing method has not been selected in this mine due to non-availability of stowing material in the vicinity and high cost of stowing.

5.3.11. However, after extraction of the first slice, there has been considerable surface subsidence, occurrence of fire in panels and problems arising out of high make of water. These problems are expected to be more pronounced with mining of subsequent slices by caving. Also, the upper seams in Barapukuria must have been damaged making these unsuitable for mining.

5.3.12. Adoption of stowing method for extraction of multi-seam deposits and thick seams would result in safer mining, much reduced surface subsidence and higher extraction ratio and conservation of coal.

However, for adopting stowing method in the mines of Bangladesh, several constraints are to be surmounted. The major issues to be resolved are as follows:

- Availability of stowing material of right quality has to be ensured. Jamuna river located around 60 Km from the coal basins appears to be the only possible source of sand but the volume of available sand in the river bed and the rate of replenishment of sand in the river need to be assessed. The volume of sand that would be available on regular basis over a long period may be the deciding factor for maximum coal production capacity from underground mines/seams where application of stowing method is essential. In case of shortage of sand, possibility of using alternate stowing material have to be explored for working these mines/seams.
- Powered supports have to be specially designed to accommodate stowing pipes and to have rear support extensions etc. Suppliers of such supports have to be located. Therefore, studies have to be initiated on priority basis for assessing availability of sand on a sustained basis from Jamuna river and for selecting method of excavation and mode of transport of the sand to the identified coal mining areas. Also, a preliminary survey for possible manufacturers of the special types of powered supports to be deployed in stowing faces has to be taken up.
- Besides the above, site specific studies are also required to ascertain the impact of shrinkage of packing material in the goaf as the number of slices/seams extracted by stowing increases, on the un-worked upper slices/seams, time required for settlement of movement caused by such shrinkage and the cumulative impact of such shrinkages on the UDT aquifer and on surface subsidence.

Underground Mining with Caving

5.3.13. For maximum recovery of resources by underground mining with caving, it is necessary to start extraction from topmost seam to be followed by the next lower seam and so on.

5.3.14. Suitability of a coal deposit for its extraction with caving will depend on the thickness of parting between UDT horizon and topmost workable coal seam, strength of rocks in this parting, number of workable coal seams and their thicknesses, cumulative thickness of extraction planned, presence of surface features which cannot be relocated, number of land losers, homesteads etc. needed to be rehabilitated, propensity of the coal seams to spontaneous combustion etc.

5.3.15. Therefore, site specific studies are to be taken up for each of the coal basins to predict, inter alia, the following:

- Increase in thickness of caved zone and water permeable fractured zone with the increase in cumulative thickness of seams extracted,
- Make of water in underground workings of each seam/slice of seam,
- Support resistance required in the longwall faces/depillaring areas in each seam, and
- Maximum area and depth of surface subsidence after extraction of all seams in the mine.

A decision on suitability of adopting caving method in a deposit can be taken on the basis of the outcome of the above studies.

5.3.16. At present, none of the studies recommended above for determining suitability of a deposit for opencast mining or for adopting stowing /caving system in underground mining have been taken up.

5.3.17. Therefore, specific recommendation regarding mining system to be adopted in different coal basins of Bangladesh cannot be made at this stage. However, an indicative projection of coal mining systems and strategies to be followed in each of the coal basins are outlined below.

Barapukuria

5.3.18. Presently, VI seam (average thickness 36 m) is being worked in the central part of Barapukuria mine by multi-slice longwall mining with caving. The first slice of 3 m height has already been extracted and the second slice of 6 m height is proposed to be extracted below the first slice goaf by Longwall Top Coal Caving method.

5.3.19. In the absence of scientific studies, uncertainties exist regarding behavior of the strata and support density required, ingress of water etc. in the second and subsequent slices. To ensure safer and sustainable mining, feasibility of working VI seam in ascending order with stowing staring from bottom of the seam, should be examined

5.3.20. This will also prevent further damage of the upper seams. The thicknesses of individual slices and coal partings to be kept between the slices can be determined during detailed planning.

5.3.21. The southern sector of seam VI has to be explored further. After preparation of the geological report, Techno-economic Feasibility Report should be prepared considering both stowing and caving methods for extraction of VI seam so that a proper selection of mining system can be made by BCMCL.

5.3.22. In the northern part, there is potentiality of opencast mining of VI seam. However, studies need to be taken up to ascertain the stability of internal spoil dump and highwall slopes, competence of thick unconsolidated UDT and LDT formations to support movement of heavy earth moving equipment and to ascertain the impact of large scale dewatering of aquifer in the surrounding area.

5.3.23. If the results of these studies establish technical feasibility of opencast mining, then opencast mining should be done in this sector after depletion of extractable underground reserves of VI seam of central and southern sectors.

5.3.24. This approach will allow maximum extension of opencast mining towards the dip side (as the existing shafts will not be required to be protected), thus enhancing recovery of VI seam reserves of the north sector.

5.3.25. The residual void of this opencast excavation has to be filled up by re-handling the surface overburden dumps to de-sterilize the land occupied by these dumps and to restore land surface of the excavated area as far as practicable.

5.3.26. If, however, opencast mining is not considered to be technically feasible in the northern part of VI seam, then the area may be worked by mechanized Bord and Pillar mining adopting partial extraction with stowing, to the extent possible without jeopardizing mine safety.

Khalashpir

5.3.27. Techno–Economic Feasibility Study (TEFS) has been carried out for Khalashpir deposit. The TEFS has proposed to work the multi-seam deposit by a combination of mechanized longwall and mechanized Room and Pillar systems of mining with caving starting from the topmost seam.

5.3.28. Thick seams have been proposed to be worked in multiple slices in descending order using artificial iron mesh mattings. However, provision for adopting stowing has also been kept in the report so that the system can be operationalised in case of any difficulty with the caving system. A rated production of 4.0 Mtpa has been envisaged from four longwall faces, one Room and Pillar district and 7-10 development faces.

5.3.29. The studies recommended for adopting caving method under UDT formation have to be carried out for the geo-mining condition of Khalashpir mine and the mine design parameters have to be firmed up.

5.3.30. After extraction of the topmost seam by caving, the goaved out areas are expected to be filled with water; hence adequate precautions need to be taken during extraction of lower seams by caving below the waterlogged goaves of upper seams.

5.3.31. The present TEFS does not mention the rated production that will be achieved if extraction with stowing is done. Therefore, likely production and corresponding sand requirement need to be estimated, if stowing system is adopted eventually. TEFS of Khalashpir mine mentions the recoverable reserve of the mine as 120 Mt. However, the basis of estimation of recoverable reserve has not been given in the TEFS, neither the details of design loss and mining loss of coal in seams I,II and IV which are proposed to be mined have been indicated.

5.3.32. Also, additional exploration is to be carried out expeditiously in Khalashpir for firming up geological report of the deposit. The geology of the Khalashpir coal mine having an area of 7.5 sq.km has been deciphered based on 18 boreholes. This gives a borehole density of 2.4 boreholes/sq.km for the upper seams (up to seam IV) and further less for the lower seams. This borehole density is considered highly inadequate for a structurally complex deposit having 8 coal zones with seams showing tendency of erratic merging and splitting. Further, the existing boreholes provide incomplete data as the seams in most of the boreholes have not been analysed. Therefore, mine planning has to be done afresh after formulation of firm geological report.

Phulbari

5.3.33. The TEFS of Phulbari deposit suggests an opencast mining with a rated capacity of 16 Mtpa of ROM coal at an average stripping ratio of 7.5 m^3/t. Out of the total geological reserves of 573 Mt, the recoverable reserve will be 475 Mt of ROM coal.

5.3.34. The total overburden volume has been estimated at 3554 M cum., about 80% of which are Tertiary sands, silts and gravel and balance 20% are Permian rocks. Initial depth of the box-cut excavation will be around 200 m and the maximum mine depth will be 330 m. For most part of the mine, the depth will vary within a range of 200-250 m.

5.3.35. OB will be excavated by large hydraulic shovels (500-700t) and 230 T haul trucks. Coal will be mined by hydraulic excavators (200-400t) and 90T-190T haul trucks. Highwall mining from quarry bed to extract part of reserves blocked below Phulbari village has also been suggested in the TEFS. The overall slopes of highwall benches have been kept at 20^o in Tertiary strata and 40^o in Permian rock.

5.3.36. To prevent water from Dupi Tila aquifer entering the mine, ground water pumping of about 6000 Million liters per day has been envisaged in the project by a series of borehole pumps installed around the mine excavation.

5.3.37. Out of total 3554 M.cum of OB excavated, 1028 Million cum will be kept in 120m high external dump covering an area of 13 sq. km. and a quarry residual void with a depth of 250 m will be left at the end of quarrying operation. This void will be filled with water eventually.

5.3.38. About 6500 ha of land will have to be acquired for the project involving relocation of 40,000 people in 9160 households (2005 data). In addition some households may have to be relocated for realignment of road and rail corridors. Population displacement has not been anticipated in relocation sites but some 'host community' households and businesses may require relocation.

5.3.39. The major areas of concern in implementation of opencast mine at Phulbari are as follows:

- Stability of internal spoil dump slope in the north and of highwall slopes on east west and south sides, having heights of 250 m to over 300 m, particularly during the pronounced rains in Bangladesh.

- Competence of Tertiary strata comprising sand, silt and gravels to support movement of heavy equipment like large shovels (500t-700t) and 230T dumpers even in dry season
- Impact of extensive dewatering of UDT aquifer in the make of water in adjoining Barapukuria mine and in the stability of structures in the vicinity.
- Possible resistance of local people /PAPs towards the relocation and rehabilitation programme.

5.3.40. If proper solutions to the above technical problems can be obtained after appropriate studies and if the PAPs can be motivated to accept the rehabilitation package, opencast mining at Phulbari should be implemented even with high initial depth, long gestation period and high cost of mining for the conservation of coal and safer mining.

5.3.41. However, the residual void at the end of opencast mining has to be filled up by re-handling the external spoil dump. This will desterilize the land surface occupied by the dump, convert the residual void to land surface and fully re-establish the ground water regime.

5.3.42. The additional cost of this final mine closure activity will have to be built up through appropriate provisions in the operating cost of the mine during productive life of the mine.

5.3.43. In case, after the studies, opencast mining is not found technically feasible at Phulbari, then underground mining method in conjunction with stowing has to be adopted for exploitation of the deposit and fresh TEFS report has to be prepared.

Dighipara

5.3.44. Regional exploration in this basin (by 4 boreholes) has proved existence of seven coal horizons, out of which the topmost four horizons appear (named I, II, III and IV) occurring at depths varying from 323.09m to 444.79m appear to be consistent.

5.3.45. These four coal horizons are separated by thin partings varying from 2.29m to 8.32m (usually 3m-5m). Seams I and II are the thickest and are having average thicknesses of 15.94 m and 34.92 m respectively followed by Seam IV (4.74m) and Seam III (3.73 m).

5.3.46. Depth of Dupi Tila formation in the area ranges from 3.66m - 8.23m at the top to 189.58m -327.95 m at the bottom. The parting between Dupi Tila and Gondwana formation varies from 0- 122.24 m as observed in the four boreholes. However, the thicknesses of parting between the base of water bearing Upper Dupi Tila formation and Gondwana are not available.

5.3.47. The coal seams occur in the uppermost part of the Gondwanas and the topmost seam (seam I) lies within 0 – 47.66m from the upper surface of Gondwana rock as observed in the four boreholes done. The reserves in an area of 15 sq. km of the basin have been tentatively estimated at 600 MT.

5.3.48. The basin appears to be promising and therefore, detailed exploration must be taken up with top priority in the 15 sq. km. area and also, geophysical survey should be conducted simultaneously to firm up the area of the coal basin which may extend beyond 15 sq. km. area presently envisaged.

5.3.49. After preparation of geological and hydro-geological reports of the deposit and after conducting the studies recommended for determining suitability of the deposit for adopting caving /stowing system of underground mining, the appropriate method of working should be frozen. Thereafter, the optimal rated capacity for the deposit has to be arrived at by carrying out techno-economic feasibility study.

5.3.50. However, considering possible occurrence of multiple seams and thick seams below water bearing Dupi Tila formation and presence of large agrarian population on the surface, adoption of mechanized longwall method with stowing appears to be ideally suitable for the deposit provided, adequate stowing material and appropriate powered supports are available.

5.3.51. Otherwise, an appropriate mining method with caving will have to be designed based on the geology of the deposit and other data, for its optimal extraction.

Jamalganj

5.3.52. This deposit has been explored in 11.7 sq. km area by 11 boreholes (about 1 borehole/sq.km). Thus, detailed exploration is necessary for firming up the geology of the basin. Also, geophysical studies have to be carried out to demarcate the delineation of the basin area.

5.3.53. Altogether 7 coal horizons (named as seam I to seam VII in descending order) have been identified in the basin at depths varying from 641.2m to 1124.1 m. The total estimated geological reserve is 1053.9 MT, 90% of which are occurring in seams III, IV, VI and VII. Dupi Tila formation is around 42.7 m thick in the area and occurs between depths of 59.5m to 102.2 m.

5.3.54. Mining of this deep seated deposit is likely to face problems of high temperature (estimated at 53 oC at 1000m depth), rock bursts, high gas emission etc. apart from the problems of mining thick seams.

5.3.55. Method of mining can be firmed up after detailed geological data, gas content data of the coal seams and physico-mechanical properties of the rocks are available. The gestation period of the mine will also be high.

5.3.56. A tentative estimate of gas-in-place in the drainage area of a single well with well spacing of 60 acres (24.24 ha) for combined III/IV seam considering borehole data of EDH-11 (13.24 m of low ash coal and 12.64 m of high ash coal) as representative of the coal field, a coal density of 1.4 t/m^3 and a gas content of 4 m^3/t, 5m^3/t, 6m^3/t and 7m^3/t as given in the Technical Report (1995) of British Geological Survey is reproduced below.

Gas content	Gas-in-place (Million cu.m) from one well (60 acre spacing)
4m^3/tonne	35.23
5m^3/tonne	44.06
6m^3/tonne	52.88
7m^3/tonne	61.69

Table 9: Tentative estimate of gas-in-place in the drainage area

5.3.57. A recovery factor of 50% over 15 years was considered in the above study for calculating the value of recovered gas and was found to be yielding higher revenues (at the same gas price) compared to some of the contemporary US CBM fields.

5.3.58. After detailed exploration and gas content study, a techno-economic feasibility report for CBM extraction from Jamalganj basin must be carried out. If CBM extraction is found feasible, the same may be implemented first in the basin and coal mining in the basin can follow CBM extraction.

5.4. Recommendations

5.4.1. Peak coal production capacity of Bangladesh will depend on the following:

- The number of basins that can be worked at a time and phasing of their construction and development
- Contributions from opencast operation, if any

- Number of underground mines and number of extraction panels with caving and with stowing and also number of development headings being driven, in these mines.
- Method of mining and type of mechanization adopted in each mine

5.4.2. It may be noted that Bangladesh have very limited mining experience and expertise. Thus, the number of coal mines that can be operated at a time in Bangladesh may be limited by the global availability of experienced mine construction and M&P contractors, availability of indigenous manpower for management, supervision and workmen trained in mining operation and also on availability of fund.

5.4.3. Therefore, the development of different mines should be phased to match with the availability of international contractors (interested in Bangladesh) and development of internal organization to handle increased scale of operation.

5.4.4. Contribution from opencast operation will depend on feasibility of opencast mining to be determined based on the studies suggested in this report.

5.4.5. If opencast mining turns out to be technically and environmentally feasible, the contribution from opencast mines will largely be dependent upon the actual progress of rehabilitation of PAPs and calendar plan of mine operation. Thus, the studies suggested in this report have to be taken up and completed expeditiously.

5.4.6. Number of caving and stowing panels in a mine will be determined during detailed mine planning on the basis of availability of sand for stowing and geo-mining condition of the seam being extracted.

5.4.7. Planning should be done for optimal production from a mine and accordingly, the number of panels to be extracted at a time in a mine should be fixed at the planning stage. Site specific studies for each mine have to be taken up to predict strata behavior, support resistance required, make of water, maximum subsidence etc, as the cumulative thickness of seams extracted by caving/stowing increases. Mine planning with caving is to be done on the basis of results of these studies.

5.4.8. Viewing broadly, two scenarios that may emerge in Bangladesh are:

Scenario I - Opencast mining will not be technically or environmentally feasible.

- Thus, entire coal production of Bangladesh will be from underground mines. However, out of the five basins, contribution of coal production from the deep seated (640 m – 1124 m deep) Jamalganj deposit may not be available in the near future.
- The contribution from the remaining four deposits will depend on the number of stowing and caving faces as discussed above.

Scenario II - Opencast mining will be technically and environmentally feasible.

- In such case, contribution from Phulbari mine itself will be substantial (16 Mtpa as per TEFS). In addition to this, production from the three underground mines may also be available. Also, the possibility of utilizing the Dupi Tila sand excavated in Phulbari opencast mine as stowing material after processing, can also be examined.
- In addition to the coal production, production of CBM may also be available from Jamalganj deposit, if techno-economic study establishes feasibility of CBM extraction.

5.4.9. For introduction of stowing in the mines of Bangladesh, studies have to be initiated immediately on high priority basis for assessing availability of sand in Jamuna river/ other rivers and the annual rate of replenishment of sand in these rivers.

5.4.10. Simultaneously, manufacturers of the special types of powered supports that are required to be deployed in longwall stowing faces have to be identified.

5.4.11. If adequate sand becomes available and manufacturers of suitable powered supports are identified, a Project Report for sand gathering from river bed and its transportation to the mines has to be prepared and approved.

5.4.12. Also, suitable bid documents and contract manuals be prepared for selecting contractors for sand gathering and for construction and operation of sand transportation system.

5.4.13. Model bid documents and contract manuals for exploration, mine construction and for mine development and operation have to be prepared expeditiously. Exploration contracts must include the provisions suggested in this report. Mine operation contracts must include clauses for recovery guarantee and safety guarantee etc.

5.4.14. Further, to seek participation of global players, the contract documents has to be prepared in line with global standards and on principle of equitability so that the it have enough incentives for a global player to invest in Bangladesh.

5.4.15. If the CBM is found viable in Jamalganj or any other coalfield, it is necessary to develop model bid document and contract manual to invite parties for CBM well development and operation. Here also, clauses for recovery guarantee should be included along with appropriate provisions for resource conservation.

5.4.16. Administrative framework and internal organization of coal mining sector of Bangladesh need to be greatly strengthened to manage the increased scale of operation in exploration, coal mining and new technology areas like CBM extraction.

5.4.17. Further, one dedicated contract management cell need to be established within the umbrella of ministry or relevant executing agency. This organization need to have sufficient number of qualified manpower to manage the bid process for selection of contractors and developers. This organization would need capabilities in various areas some of which are commercial, mineral exploration, mine planning, finance, policy and regulator, legal etc.

5.4.18. It is therefore necessary to develop trained manpower at all levels. While class room trainings may be imparted in the training institutes of the country, arrangement for on the job training have to be made in other countries practicing similar technologies that are contemplated to be used in Bangladesh.

6. Investment Models and Financial Aspects in the Coal Sector

6.1. Public Sector Investment

6.1.1. Coal mining is a capital intensive industry and entails high risks. Currently the data and information including study reports available for various coal fields related to mining and socio-economic aspects is not sufficient to assess associated risks and cost implications.

6.1.2. In this context, it is important to recognize that the data/information obtained at the feasibility stage do not necessarily reflect the actual conditions as has been observed during mining at Barapukuria.

6.1.3. For example, water inrush has been manifold higher than anticipated in case of Barapukuria coal mine which may also happen in case of other coal deposits. This is even more likely due to many faults that have been identified in and around the coal beds in the area.

6.1.4. As such, to arrive at a reasonable estimate of the investment needed, more data is required to make informed decisions, especially with respect to the method of mining. This strongly suggests the need for undertaking detailed techno-economic and financial feasibility studies for the coal basins.

6.1.5. It is a fact that open pit mining will enable extracting more than 90 percent of the coal deposits (in case of large mines) as against 60-70 percent or less in case of underground operations. To understand the implications, the investment needs for both the options need to be compared along with the level of production needed for ensuring economic operation of the mines.

6.1.6. Moreover, due to risky nature, it is not easy to mobilize the required funds for steady development of the mining and mineral sector. However, for mineral resources especially oil, gas, and coal in the case of Bangladesh, exploitation has to be carried out even under such conditions to best serve the national interests.

6.1.7. In past, it has been observed that the conventional FDI is not always appropriate to meet the exploration and feasibility stage requirements or, even if it does, the terms and conditions may be such that prospective investors may not be interested unless the mining rights are guaranteed and minimum returns are assured. Given this, coal sector deserves require special considerations from Government to facilitate development.

6.1.8. In the economies where mineral resources are nationalized like India, government or government owned agencies are investing on exploration which is one of the most risky component of mining.

6.1.9. There is no denying of the fact that coal is a strategic commodity for Bangladesh. With limited or no possibilities for export, not many foreign investors may be interested in investing in the coal sector in Bangladesh.

6.1.10. Given the investment scenario described above, the primary, if not only, source of funding could gravitate towards the public sector, which means a combination of budgetary support in the form of equity or share capital to a public sector enterprise which in turn would be able to borrow from financial institutions which may insist on a sovereign guarantee for the loans.

6.1.11. The possibilities of getting financial assistance from multilateral funding agencies like the Asian Development Bank and/or the World Bank could also be explored. It may be noted that such assistance is usually routed through the Government or its agencies.

6.2. Private sector investment (domestic and foreign)

6.2.1. As discussed above, considering the uncertainties and risks involved, it is possible that not many private sector investors may be interested in investing resources in coal sector of Bangladesh.

6.2.2. Coface, an international Credit Management services company, has rated Bangladesh as "C"[2] in the overall country rating and "D"[3] in business climate rating. These ratings indicate that the business environment of Bangladesh is difficult and needs further improvement.

6.2.3. Thus, it is necessary for Bangladesh to strengthen the economy, make it more investor friendly and market its investment potential to enable the country to attract favorable responses from international investors for the coal mining sector. This may be done by formulating business friendly policies and conducting road shows and investor meets. All this would require preparation in terms of internal capacity building, developing model documents for inviting investment and project implementation support agreement etc.

6.2.4. There are several routes to invite funds to invest in any sector such as foreign direct investment (FDI), joint venture (JV), public private partnership (PPP), and profit sharing contract (PSC).

6.2.5. Depending on the financial analysis with special reference to mining techniques and marketing opportunities for coal, an investor (domestic or foreign) is likely to agree to finance only on equitable terms of project implementation and sufficient government support to secure investment and earn returns.

FDI policy

6.2.6. Till date foreign participation in mineral sector in terms of funding of projects has been limited due to the inadequate geological information about mineralization in the country and local challenges. Though notably the only operating coal mine in country is being operated by foreign company but the payments are guaranteed. While some foreign companies acquired/granted mining license, they are not able to operationalize the mine due to various reasons.

6.2.7. The scenario in the gas sector in Bangladesh is entirely different, wherein exploration and development of natural gas resources has been phenomenal in the last few decades. There has been a reasonably good participation by foreign oil and gas companies since the 1950s and this sector has reached maturity so far as the IOCs are concerned. However, the mining sector is lagging behind in this respect.

6.2.8. Given past experience, Foreign Direct Investment (FDI) in coal mining needs to be tailored in such a manner that the investment is made by the expatriate company as the developer of the coal deposit and the product is sold to Bangladesh for cost recovery and a reasonable profit based on the opportunity cost of capital for similar investments elsewhere.

Payment/guarantee

6.2.9. For any investor, the prime issue would be marketing the coal at prices which would fetch assured returns at acceptable rates. If the coal can be sold only in the domestic market, which is the likely

[2] "The business environment is difficult. Corporate financial information is often unavailable and when available often unreliable. Debt collection is unpredictable. The institutional framework has many troublesome weaknesses. Intercompany transactions run major risks in a difficult environment."

[3] "*The business environment is very difficult. Corporate financial information is rarely available and when available usually unreliable. The legal system makes debt collection very unpredictable. The institutional framework has very serious weaknesses. Intercompany transactions can thus be very difficult to manage in the highly risky environment.*"

scenario in Bangladesh, then its concern would be the capacity of Bangladesh agencies to pay for the produced coal in order to earn a reasonable return on their investment.

6.2.10. Since coal in Bangladesh is destined to be used domestically, the prospective investors would be interested to ensure a viable and mature domestic market for coal. As the maximum use of coal will be for power generation, BPDB is expected to be its major buyer.

6.2.11. For ensuring the confidence of investors in the coal sector, it would be important to ensure that the financial and physical (transmission and distribution infrastructure) capacity of BPDB is strengthened to enable it to purchase the contracted quantities of coal on time from Coal Bangla[4] or any other government agency and make payments on time.

6.2.12. This would enable Coal Bangla or any other government agency to give guarantees, if required, to buy all the coal and make timely payments. The investors may also opt for entering into a joint venture with Coal Bangla or any other government agency to minimize the risk and facilitate operations within the country.

6.2.13. In case of joint ventures with the public sector, preference should be given to those foreign enterprises that are state owned in their respective countries.

6.2.14. While the investment in the form of JV or PPP is invited, on one side government should facilitate implementation of project and provide market for coal sales and on the other side, sufficient guarantees should be sought so as to bind investor for implementation of project in serious manner.

Ownership of resources

6.2.15. As per the provisions of Constitution, mineral resources of Bangladesh are assets of the state and owned by people of Bangladesh, giving ownership of this resource to foreign company in lieu of only royalty payment may not be in the best interest of the country. This is because any above normal profits earned by foreign shareholders may be remitted out of country. Thus M&P contracts allowing good returns to operators to recover investment should be explored wherein government remains owner of the resources.

6.2.16. Variation of a PSC may also be explored which would meet the expectations of all parties to the contract. However, the basic fact of the coal being used entirely within Bangladesh should be the guiding principle to conserve the resource for future.

Bidding for Coal Blocks

6.2.17. The coal zone[5] as proposed in this report comprises of Dinajpur and Rangpur districts and parts of Bogra and Naogaon districts of Rajshahi Division. On notifying the coal zone the Government or the GSB would be required to fence off the 5 (five) coal fields already discovered and also the prospective area where GSB has plans for taking up drilling in the future for coal exploration.

6.2.18. Thereafter, the entire coal zone may be divided into blocks (like the gas blocks in the gas sector). These blocks (green fields) may then be awarded through competitive bidding for prospecting/exploration license and mining lease under a Profit Sharing Contract (PSC). The prospective bidders should be provided with a draft of the PSC along with other relevant documents to facilitate taking a decision to participate in the bidding process.

6.2.19. This requires developing model bid documents and PSC. Further it is necessary to identify coordinating agency to conduct bidding. Once the coordinating agency is identified, as mentioned in earlier sections,

[4] Coal Bangla is a proposed new institution to be formed on the lines of Petrobangla. Additional details are provided in section 11

[5] Refer to section 12 for additional details

suitable capacity building exercise need to be taken up to equip this agency for managing the bid process, contracts and oversee development of coal assets.

Phulbari and Khalashpir coal fields

6.2.20. The status of the two coal fields namely Phulbari and Khalashpir is still uncertain. Exploration licenses for these fields were granted in the past to two mining companies following which the companies carried out some field work and submitted reports along with applications to the relevant department of the Government for obtaining a mining lease.

6.2.21. A decision on the application for a lease or cancellation of the earlier license/lease is awaited. A decision to either cancel the earlier licenses or to further proceed with these two firms or go in for fresh bidding for a PSC needs to be taken. The legal issues involved may be examined by the agencies concerned. These coal fields may be awarded under a PSC through competitive bidding process.

6.2.22. In case the Government decides to continue with the existing companies, i.e., Hosaf and a Chinese consortium for Khalashpir Coal Field and AEC Pty. Bd. Ltd. for Phulbari Coal Field, then these companies should be informed of the further action required of them before a mining lease is granted under a PSC (or otherwise). On the other hand, if Government decides to terminate the existing licenses, then a fresh bidding process would be required to be initiated. To summarize, it is necessary to take decision on the pending applications at the earliest so that further action to expand domestic coal production capacity may be taken.

Existing Coal Fields Tendering Phases

6.2.23. The two coal fields, namely, Jamalganj coal field and Dighipara coal field, are at a stage where bidding for inviting investors could be initiated. As more geological and techno-economic feasibility studies are needed to firm up estimates of the cost for developing these mines, these fields may be awarded to the prospective investors through competitive bidding under a PSC for the coal produced. Though it shall be noted that Jamalganj coalfield has potential to set up CBM and UCG project and thus action may be taken considering recommendations related to CBM and UCG sectors.

6.2.24. The investors will bear all the risks involved and their share of coal will depend upon the risks involved. The PSC will be the basis of mining operations and marketing of the coal from these mines.

6.2.25. The law and general guidelines for doing or starting a business in Bangladesh are also applicable to mining ventures. Since mining is a new developing field there are no sector specific guidelines as yet in the existing procedure. The BOI could frame the necessary guidelines to facilitate investors interested in the coal mining sector.

6.3. Recommendations

6.3.1. Considering the risks involved in mining industry, Government may provide budgetary support in the form of equity or share capital to a public sector enterprise.

6.3.2. The possibilities of getting financial assistance from multilateral funding agencies like the Asian Development Bank and/or the World Bank could also be explored. It may be noted that such assistance is usually routed through the Government or its agencies.

6.3.3. Involvement of the private sector could be through a public private partnership (PPP) arrangement under a PSC specifically developed and designed for the coal sector using the experience gained from the gas sector. Private investors may be invited to invest in exploration but given the high risk nature of the exploration activities, many private investors may not be keen. Thus, private investors may be provided with assurance of getting mining license to operate on successful exploration and sufficient incentives and mechanisms to recover investment made on exploration.

6.3.4. The government should roll out incentives for the private sector in the form of tax holidays, waiver of local taxes, reduction in import duties on equipment etc.

6.3.5. It is necessary to take decision on the pending applications at the earliest so that further action to expand domestic coal production capacity may be taken.

6.3.6. **International competitive bidding**

- Investment in the coal mining sector may be attracted from the private sector through a transparent bidding and evaluation process.
- Create a strong and professionally capable techno-commercial team to oversee the bidding processes, review the proposals and conduct negotiations for the coal sector. Depending on the target source for financing, different strategies may be needed in each case.
- Demarcate the Coal Zone into coal blocks for inviting bids for prospecting and (finally) leasing.
- Bids for Jamalganj and Dighipara may be sought separately since these fields have been discovered by the GSB. Further, Jamalganj can be explored for alternate technologies for recovery like CBM and UCG given this coalfield is at high depth making it unviable with conventional technology.

7. Contractual Issues

- As discussed earlier, some of the key reasons for lower level of domestic and foreign interests in the coal mining have been low level of data availability which makes it difficult to evaluate the assets and perception of poor growth prospects, given the absence of markets (consumers) other than brick making.

- Coal mining is a capital intensive industry with number of uncertainties involved. Therefore, it is preferable to undertake a separate and exclusive study to examine different models and modalities of financing so that the best option could be chosen by the Government to proceed with the development of coal and other mineral resources without sacrificing national interests in the process.

- Bangladesh should encourage the option of contract mining or joint development with experienced developers wherein the provisions are attractive for both parties (Bangladesh government and contractor/operator). Adequate returns on investment to contractor/operator need to be ensured to invite more participants which in turn may provide better technological access as well as result in more competitive cost of production. Thus, while selecting an investor for coal development, the terms of agreement should be such that the investor gets an adequate return on his investments while owner of mines (Bangladesh Government or its agency) gets its due share without compromising any benefit that it may reasonably lay claim to as the sole owner of the resource. The long term agreements with the mine developers thus should create a win-win situation.

7.1. Types of Contracts for mine development and operations

Cost-Plus contract

7.1.1. In cost-plus contract, the contractor is responsible for development and operations of the coal block. The owner would allow a fixed profit based on percent of operating cost or amount per ton or percent of capital cost etc.

7.1.2. The profit to the contractor is assured while owner actively oversees the operations to ensure that the determinants of cost are tightly controlled.

7.1.3. In this type of contracts, the coal is obtained by Owner on the cost of mining and not linked with the market price and thus value of the coal lies with owner which can be unlocked by selling in the market.

Levelised price contract

7.1.4. In such contracts, the contractor is fully responsible for development and operations of the coal block and the price at which the coal is delivered is lump sum on per unit quantity delivered subject to escalation based on some pre-agreed formula (to accommodate change in cost structure due to inflation). In such condition, irrespective of actual cost of mining, owner pay fixed mining service fee to contractor. Since, the fee payable by owner is not linked to cost; owner is insulated to any adverse impact on cost. Further, owner may not need to monitor cost of operations. However, the owner should keep the oversight to check the compliance with rules and regulations.

7.1.5. In these contracts, contractor have incentive to reduce cost as same increases its profit margin but given all the unforeseen mining risks lies with contractor (which may result in increased cost), many international contractors may be less interested as enough data is not available for the coal fields of Bangladesh to establish detailed techno-economic viability.

Profit Sharing Contract (PSC)

7.1.6. As private investment in the coal fields in Bangladesh is fraught with risks, some model for inviting financing for production may be developed taking a cue from the Model Production Sharing Contract for the gas sector.

7.1.7. A PSC is a modality through which coal exploration and development could be implemented keeping the interests of contractor and the country in view. The issue to be addressed would be sharing the costs and risks involved in exploration. The ideal situation for Bangladesh would be if the foreign company is prepared, at least initially, to write off the expenditure on exploration in the event the results of the exploration/prospecting are negative.

7.1.8. If the results are positive, then the PSC should be designed in such a way that the cost of exploration is factored into the PSC and the investor is given enough incentives for incurring expenditure on carrying out detailed techno–economic feasibility studies and then take it forward to finance mine development and mining with or without the participation of international financing institutions.

7.1.9. In the process, the investor/contractor shall be given due return on his investment for exploration and production of the coal, during mining operation and the profit coming out of coal production shall be shared between the partners.

7.1.10. Further, given the coal bearing area are populated, PSC's may also include government support provisions in dealing with the local population and land related issues

7.1.11. Although PSC is yet to be popularized in the coal industry, successful negotiation of such options between the host country and the coal contractor could open a new horizon in the exploration and development of coal mines, both locally and internationally.

7.2. Key provisions in contract

7.2.1. **Allocation of risks and responsibilities:** The risks and responsibilities should be judiciously allocated such that each party is able to perform its obligations effectively and efficiently. It is suggested that key officials like Mines Manager, Safety officer, Ventilation officer, Training Officer etc. should be from owners' side while Operator/Contractor will be responsible for all the day to day activities to be performed for operations and development of mines. It should be noted that all day to day works, medium term and long term planning, recruitment etc. done by Operator should have the prior approval of mine owners. Manager and safety officer (deployed by owner) should have authority to stop deployment of people in mine or part thereof and to instruct Operator to take up protective works/repair works etc. for ensuring safety in mines.

7.2.2. **Performance Guarantee provisions:** Herein, the contractor provide security to the owner/purchaser in the form of Bank Guarantee, Earnest money deposit or any other financial instrument in lieu of performance of its obligations under the agreement involving meeting production targets and other agreed KPIs. Similarly, the owner/purchaser provides security to contractor in acceptable form to ensure timely payment for the services rendered and also secure payment defaults. In case of default by any party, other party may encash the security in accordance with the provisions of the agreement.

7.2.3. **Penal provisions:** The contract document should specify the penalty imposed on any party who fails in performance of its obligations due to reasons other than other parties' fault and/or force majeure event. Some examples of such provisions are liquidated damages; Take or Pay and Serve or Provide. In Take or Pay and Serve or Provide, if purchaser offtakes coal less than the agreed quantity then it is under obligation to pay for the quantity not offtaken. Similarly, if contractor fails to supply agreed quantity from designated mine then it is under obligation to supply coal from any other source.

7.2.4. **Performance Measurement:** The contract should clearly specify the performance parameters and measurement system like type, size and quality of coal to be produced, delivery points, process of measurement of progress of work etc. It should also specify any other KPIs to be met by either party like minimum availability of equipment, safety performance etc. Given this, contract should specify the adjustments to be made to payments due for non performance or below expected performance.

7.2.5. **Payment provisions:** Contract should provide for consignment cycle, payment mode and cycle of payment for the undisputed invoices. This ensures that contractor receive payment for the work completed in time. Any delay in payment may attract interest.

7.2.6. **Other provisions:** Other key provisions of the agreement deals with insurance, force majeure conditions, dispute resolution mechanism, suspension and termination terms, recourse on termination etc.

7.3. Procedure for selecting contractor

7.3.1. The contractor selection may be done by conducting international competitive bidding process wherein international and domestic companies can participate individually or by forming consortiums. Some of the key benefits of conducting the bid process are as follows:

- A competitive bid process can be a risk mitigation or a price discovery mechanism.
- Encourages use of new technology, scale, and modern mining methods.
- Unbundling of competitively bid rates and earn-out mechanism.
- More interest can be attracted
- Possibly opportunity to get access to better technology at cheaper rates

7.3.2. Qualifying requirements in bidding process: Some of the key issues from our past experience in contractor selection are mentioned below:

- Stricter technical capability requirement limits competition. This gives rise to need to plan in pre-sales effort to ensure more credible specialist bidders. The country/asset specific issues are required to be given due consideration before conducting any bid process.
- More permissive technical qualifying criteria will attract new operators that are more competitive but with lesser technical capabilities. This will demand stricter risk assignment and bidder familiarization.
- Allowing consortium provides opportunity to combine strengths and meet qualifying requirements. But this demand specific contract provisions to tie-in parties for the needed duration.

7.4. Recommendations

7.4.1. Taking into account the various types of coal contracts described above and the circumstances prevailing in Bangladesh as far as coal is concerned, a model coal PSC appropriate for attracting investment in the coal sector may be prepared.

7.4.2. Such PSC will be approved by the Cabinet and will form the basis for all contracts to be awarded to private investors in the coal sector. The Model Coal PSC will be based upon the proven Model Gas Production Sharing Contract in Bangladesh, allowing for the differences between the two fuels and their end uses.

8. Legal framework

8.1. Introduction

8.1.1. In Bangladesh, the principal laws enacted to regulate mineral sector were: the Mines Act, 1923 and the Mines and Minerals (Regulation and Development) Act, 1967 (E.P. Act II of 1968).

8.1.2. While the Mines Act, 1923 was amended in year 2005, the Mines and Minerals (Regulation and Development) Act, 1967 was repealed in the year 1992 and was replaced by the Mines and Mineral Resources (Control and Development) Act, 1992 (Act No. 39 of 1992).

8.1.3. The Mines and Minerals Rules, 1968 was framed under the Mines and Minerals (Regulation and Development) Act, 1967, through which the Government has delegated its authority to Bureau of Mineral Development (BMD) in the matters of regulating Exploration Licences, Mining Leases and Quarry Leases. The Mines and Minerals Rules, 1968, was subsequently amended in years 1989, 1995, 1999 and 2004. In 2012, Mines and Minerals Rules 1968 was repealed and replaced by Mines and Minerals Rules 2012 which broadly have provisions similar to Mines and Minerals Rules 2012.

8.1.4. In the report on "Review of the existing Mining Act, Rules and Regulations and Recommendations", prepared earlier by Consultants, the provisions in existing Acts and Rules have been studied in detail and compared with the provisions of mining legislations of India, Australia, Canada, South Africa and Indonesia and some of the guidelines of Sustainable Development Framework (SDF) to identify gaps.

8.1.5. The various aspects of the mining life cycle, governed by these legislations, reviewed are as follows:

- Revision and updating of Acts, Rules and Regulations related to Mineral Sector;
- Licensing and Leasing Types and Process;
- Health and Safety Management;
- Management of Mineral Resource Information;
- Classification and reporting of Mineral Resources and Types;
- Conservation of Mineral Resources during Mining, Extraction and End-use;
- Labour employment, Workers Compensation and Welfare Legislations;
- Domestic and Foreign Investment in Mineral Sector;
- Taxation and Royalties; Socio-economic Benefit Optimization;
- Environmental Management;
- Mine Closure and Post-mining Transition.

8.1.6. Based on the study, suitable recommendations are made for further amendments and changes to be brought in the in the existing legal framework governing mineral sector of Bangladesh.

8.2. Way forward

8.2.1. It was observed that it is necessary for sustainable development of the sector that the current legislations are amended and wherever required, new legislations are enacted to address following:

- The issues related to technical management, viz. mineral resource classification and reporting, mineral inventory accounting, mining methods, mineral conservation, etc;
- The matters pertaining to Occupational Health & Safety (OH&S), fair wages, working conditions, etc;
- The social and community impacts of mining activities and need of responsible mining and inclusive growth; and
- The mining specific environmental management with stress on land and water resources in Bangladesh.
- Ownership of mineral resources, FDI, investment facilitation, royalty and taxation etc.
- Regulations to govern mine operations

Government should thus take appropriate steps to implement recommendations made in report on "Review of the existing Mining Act, Rules and Regulations and Recommendations".

9. Institutional Aspects

- Minerals and Mining sector is of very high importance to Bangladesh given that indigenous natural gas constitutes 90% of the sources of fuel supply for power generation, fertilizer production and other major industries.
- At the same time, the presence of about 3.1 billion tons of coal have caused the Government to give special attention to development of Coal Sector to ensure harnessing alternate source of energy and diversify energy portfolio.
- As per the constitution of Republic of Bangladesh, the ownership of its mineral wealth lies with people of country. Thus, on behalf of people of Bangladesh, the mineral and mining sector is controlled and governed by the Ministry of Power, Energy and Mineral Resources (MoPEMR), GoB.
- Presently, Prime Minster holds the charge of this ministry and is being assisted by an Adviser and a State Minster.
- The MoPEMR has got two major divisions:
    a) Power Division
    b) Energy and Mineral Resources Division
- Energy and Mineral Resources Division and Power Division were created to cater to the need for more specialized intervention in energy (including mineral resources) and power sector. The two divisions are administratively headed by Secretaries.

9.1. Administrative Structure for the Minerals Sector

9.1.1. Through Cabinet Division Notification No. CD-4/1/94-Rules/23(100), dated the 25th March, 1998, the Energy and Mineral Resources Division and Power Division was created under the Ministry of Power, Energy and Mineral Resources (MoPEMR) to meet the need for more specialized intervention in the power and energy sectors.

9.1.2. The Energy and Mineral Resources Division is entrusted with the responsibilities of formulating all policies related to Natural Gas, Liquid Petroleum and Mineral Resources and related policies and administrative control over Petrobangla, Bangladesh Petroleum Corporation, Geological Survey of Bangladesh, Bureau of Mineral Development, Department of Explosives, Bangladesh Petroleum Institute and the Hydrocarbon Unit.

9.1.3. Energy and Mineral Resources Division through Petrobangla and its Companies is carrying out the exploration and development of gas, oil and coal and other minerals to meet the growing energy demand of the country. The Energy and Mineral Resources Division with the support of Petrobangla finalizes Production Sharing Contract with IOC's.

9.1.4. Natural Gas is most important indigenous source of commercial energy in Bangladesh currently accounting for 73% of the commercial energy of the country. To meet the total demand for commercial energy, Bangladesh imports annually about 1.3 million metric tonnes of crude oil.

9.1.5. In addition to this, another 3.6 million metric tons (approx) of refined petroleum products are imported per annum. Eastern Refinery Limited (ERL), a subsidiary company of the Bangladesh Petroleum Corporation (BPC), is capable of processing 1.3 million metric tonnes of crude oil per year.

9.1.6. To significantly reduce dependency on imported fuel and environmental pollution and to save foreign currency, the use of CNG vehicles was introduced in 1997. The number of CNG refueling stations is 565 and 162 conversion workshops have already been set-up in the country.

9.1.7. Besides natural gas, Bangladesh has significant coal reserves. Coal reserves of about 3.1 billion tonnes comprising of 5 deposits at depths between 118-1158 meters have been discovered so far in the north-western part of Bangladesh.

9.1.8. Possibilities and prospects of extraction of coal bed methane (CBM) need to be explored from these coal deposits. The Government is actively reviewing the law to be made applicable for exploration and production of coal bed methane. So far, coal is being mined only from the Barapukuria coal field.

9.2. Functions of different energy sector entities

9.2.1. The following chart depicts the governance structure for mineral sector in Bangladesh.

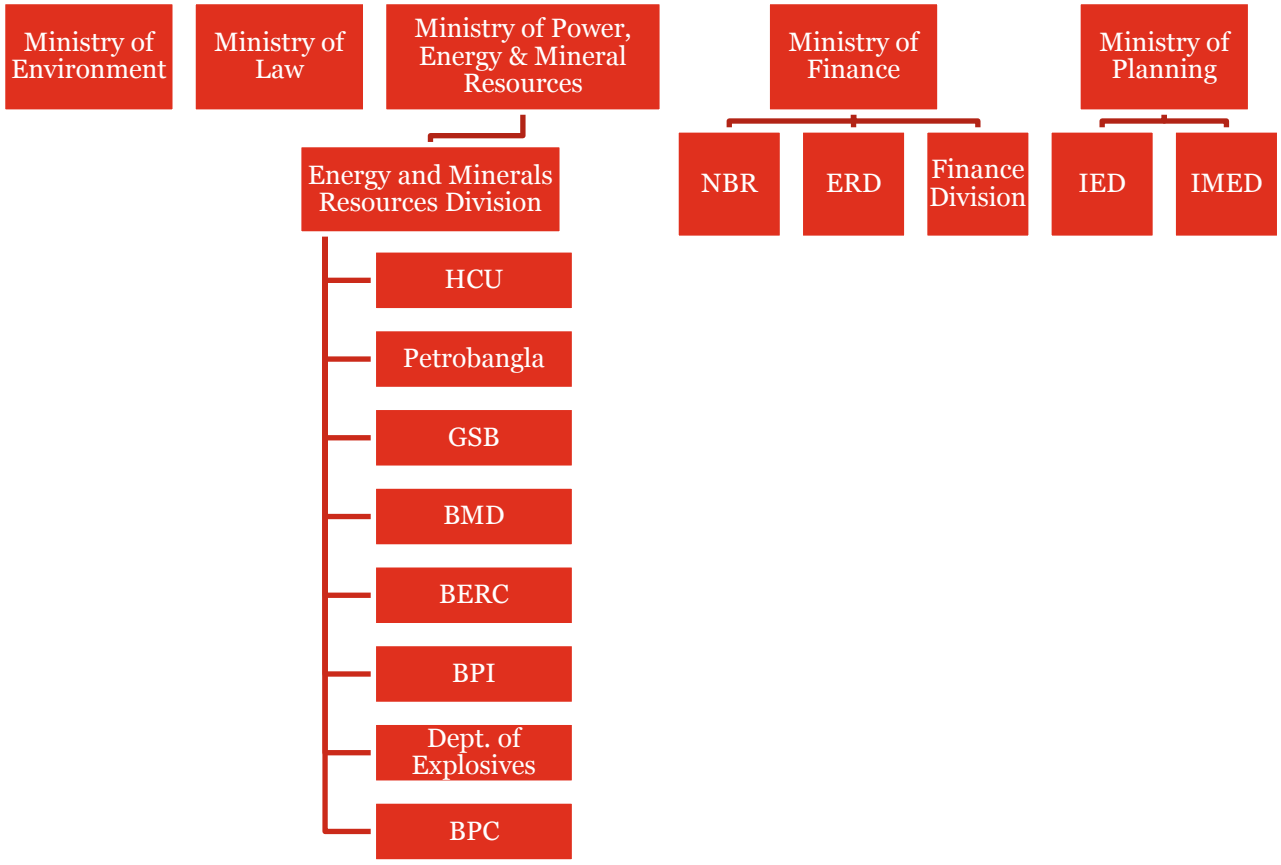


Figure 9: Governance structure for mineral sector in Bangladesh.

Hydrocarbon Unit (HCU)

9.2.2. In order to develop the Energy Sector and provide technical advice to the Energy and Mineral Resources Division, the Hydrocarbon Unit started functioning as a 'Technical Assistance' project financed under a grant of the Royal Norwegian Government in July 1999 and continued up to June 2005.

9.2.3. Later, phase-II of the project started again under a Norwegian grant administered by the Asian Development Bank. This phase will be continued up to December 2013. Meanwhile, the Hydrocarbon Unit was given a permanent status on the 28th May, 2008. The functions of the HCU include:

- Gas reserves,
- Undiscovered gas resources,
- Gas production & assessment of consumption at regular intervals.
- Data management on the oil and gas sector.
- Overview of and observations on Production Sharing Contract activities.
- Internal and regional gas market analyses.
- Formulation of exploration and depletion policy.
- Working as the technical arm of the ministry.
- To provide opinion on development of oil, gas and mineral resources of the country in line with the Government's directions.

Petrobangla

9.2.4. Bangladesh Oil, Gas and Mineral Corporation (BOGMC) was created through the Presidential order # 27 on March 26, 1972. The minerals operations of the corporation were segregated and vested in a new organization, i.e., the Bangladesh Mineral Development Corporation (BMDC), on the 27th September, 1972, through PO # 120.

9.2.5. The reconstituted Bangladesh Oil & Gas Corporation (BOGC) was short named Petrobangla through ordinance # 15 of the 22nd August, 1974. On the 13th November, 1976, through ordinance #88, the importation, refining and marketing of crude and petroleum products was vested with the newly formed Bangladesh Petroleum Corporation (BPC).

9.2.6. BOGC and BMEDC were merged into a single entity, Bangladesh Oil, Gas & Mineral Corporation (BOGMC), by Ordinance # 21 of the 11th April, 1985.

9.2.7. In a partial modification of the Ordinance by Law 11 of February 1989, the corporation was short named Petrobangla and given the authority to hold the shares of the companies dealing in oil, gas & coal, minerals exploration and development.

9.2.8. The companies under Petrobangla is shown below:

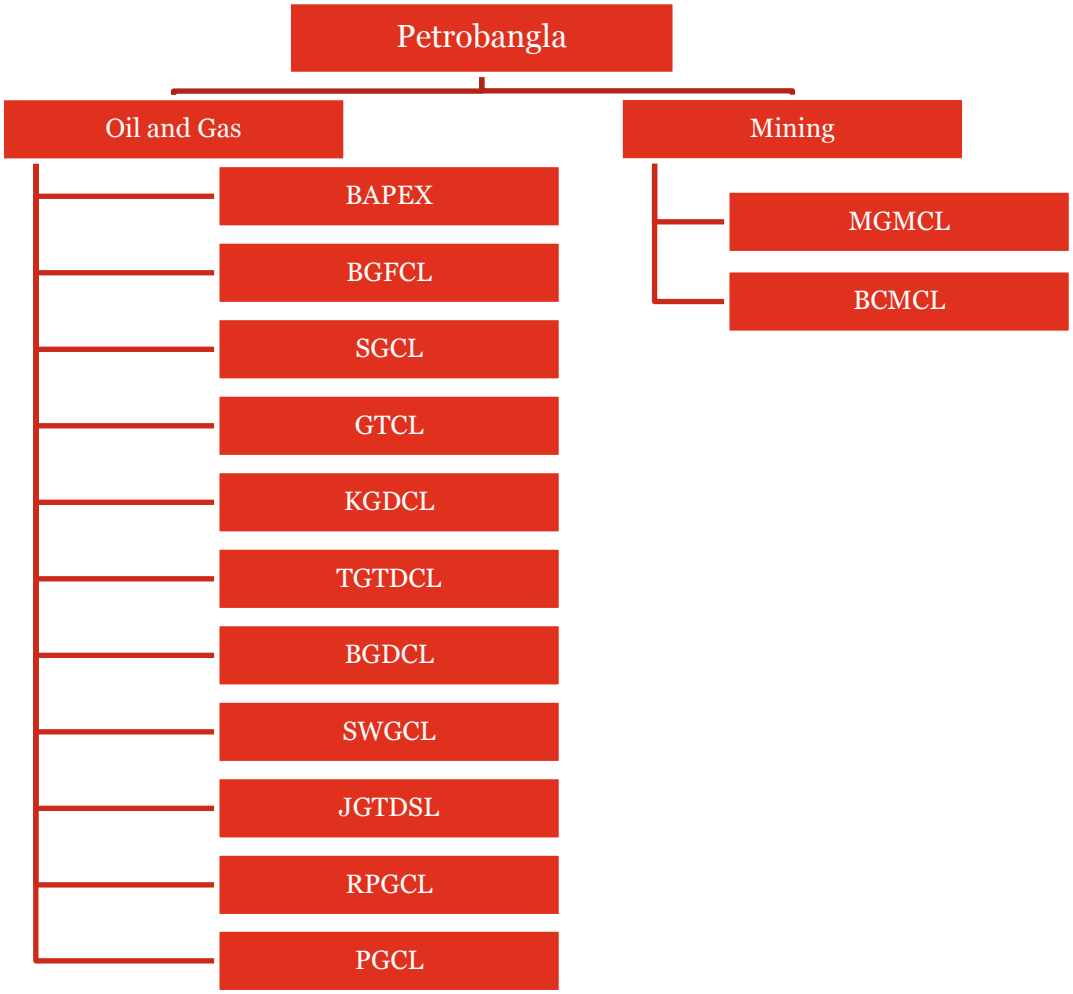


Figure 10: Companies under PetroBangla

Geological Survey of Bangladesh

9.2.9. The Geological Survey of Bangladesh (GSB) is a scientific research-based Government organization under the Ministry of Power, Energy and Mineral Resources of the Government of the People's Republic of Bangladesh.

9.2.10. It started functioning immediately after the liberation of the nation in 1971. The main achievement of the Geological Survey of Bangladesh is to discover low sulphur high quality bituminous coal at Barapukuria, Dighipara in Dinajpur and Khalashpir in Rangpur at shallow depths, hard rock at Maddyapara in Dinajpur and glass sand, white clay, peat and gravel deposits in various locations in the country.

9.2.11. The functions of GSB are as follows:

- To investigate in detail such areas as are indicated by geological mapping to be favorable for accumulation of industrial rocks, mineral fuel, ground water and other natural resources.
- To investigate in detail and conduct extensive geophysical, test drilling and geochemical operation in order to evaluate the known mineral deposits.
- To conduct stratigraphy studies to identify, correlate and determine the sequence of rock units in support of mapping and exploration programmes including age determination by fossils and other geo-chronological methods.

- To carry out geological investigations in connection with various civil engineering construction, water resources management, land use, geo-environmental studies, environmental hazards and urban geological mapping.
- To carry out marine geological and geophysical investigation and geo-morphological studies of river basins and the delta regions.
- To undertake systematic sampling of mineral fuels and ground water resources and to carry out mineralogical and chemical analyses of the samples.
- To advise public and private organizations in all matters connected with geology and resources of the earth.
- To conduct research in various fields of geology.
- Delineation of affected areas and find out source and origin of arsenic and other toxic elements in ground water.

Bureau of Mineral Development (BMD)

9.2.12. The Bureau of Mineral Development (BMD) functions under the Energy and Mineral Resources Division of the Ministry of Power, Energy and Mineral Resources.

9.2.13. It was established in 1962 under the Industries and Minerals Division of the then provincial Government which was under the Ministry of Industries and Natural Resources of the Central Government.

9.2.14. BMD does the overall management and grants exploration licenses, mining leases and quarry leases for all minerals (except oil and gas) available in the country according to the Mines and Minerals Rules, 1968 which has been amended coming into force the Mines and Mineral Resources (Control and Development) Act, 1992 (Act No. 39 of 1992).

9.2.15. The functions of this office are:

- Maintaining records of the areas bearing economic minerals.
- Receiving applications for licenses and leases and processing them for approval/rejection.
- Granting licenses/ leases to interested parties for exploration, mining or quarry purposes.
- Maintenance of records for licenses and leases granted.
- Inspection of progress in respect of licenses and leases and observance of rules and regulations, etc., by the parties.
- Initiating appropriate action against a party who fails to adhere to the rules and regulations governing licenses or leases as prescribed by the Government.
- Maintenance of records of mineral products in the country and their utilization and export, if any.
- Recommending framing new laws, rules and regulations in respect of minerals and amendments thereof.
- Fixing royalty, rent, levies, etc., on minerals exploited and their realization.

- To collect royalty and other revenues, as provided under the rules, from exploration licenses, mining leases and quarry leases for different minerals.

Bangladesh Energy Regulatory Commission (BERC)

9.2.16. The Commission was established through an Act entitled Bangladesh Energy Regulatory Commission Act, 2003, to create an atmosphere conducive to private investment in the generation, transmission and distribution of electricity, developing gas resources and petroleum products, to ensure transparency in the management, operation and the fixing of tariffs in these sectors; to protect consumers' interest and to bring about a competitive market in the Country.

Bangladesh Petroleum Institute (BPI)

9.2.17. In order to conduct research and development activities, including producing skilled manpower in related fields, and to ensure professional administration and management in the oil, gas and mineral sectors, the Bangladesh Petroleum Institute (BPI) has been established under the Bangladesh Petroleum Institute (BPI) Act, 2004.

9.2.18. The BPI works has the following functions:

- Impart training to the professionals and technicians engaged in the petroleum sector of the country.
- Undertake advanced studies/research on hydrocarbon prospects and development.
- Establish a computerized data processing/information centre and perform subsequent operational activities.
- Provide technical support services to the organizations engaged in activities related to petroleum.

Department of Explosives

9.2.19. The Department of Explosives is an attached department of the Ministry of Power, Energy and Mineral Resources.

9.2.20. Its primary function is to ensure the safety of human life, national property and environment through effective administration and enforcement of the Acts and Rules during manufacture, processing, refining, transport/transmission, import, storage, use, handling etc. of commercial explosives, compressed gases, natural gases, gas cylinders, gas containers and petroleum and other flammable liquids, combustible solids including calcium carbide and oxidizing substances.

Bangladesh Petroleum Corporation (BPC)

9.2.21. The Bangladesh Petroleum Corporation was established by Ordinance No. LXXXVIII of 1976. It began to function from 1977 with 3 (three) Oil Marketing Companies, 2 (two) Blending Plants, 1 (one) LPG Bottling Plant (LPGL) and a refinery (ERL) as its subsidiaries. Its main functions are import of crude oil, refining and marketing of petroleum products.

9.3. New Institutions

9.3.1. It has been observed that the present system and organizations dealing with mines and minerals cannot achieve the objective of exploring and developing the mineral resources to serve the interests of the people of Bangladesh given limited mandate and also lake of capabilities. Hence, establishment of some new institutions are being proposed.

National Mines and Minerals Council

9.3.2. The first change proposed shall be made at the apex level. A new National Mines and Mineral Council is being suggested to lead the mines and minerals sector in Bangladesh.

9.3.3. This apex body will be the supreme body for approving the plans and strategy for development of the mines and minerals sector in the country. The Council will meet at least twice in a year and after taking stocks of the issues shall direct the actions to be taken by concerned authorities for the sector.

9.3.4. The council will be headed by the Prime Minister and the Ministers of Finance Ministry, Law Ministry, Forest and Environment Ministry, Ministry of Communication, Ministry of IT, Ministry of Power and Chairman of the Parliamentary Standing Committee for Mining and Mineral Resources, shall be the members of the council. The Secretary, Ministry of Mines and Mineral resources shall work as the Member secretary.

The Ministry of Mines and Mineral Resources

9.3.5. The Ministry of Mines and Mineral Resources shall be a new ministry with two divisions one being the Gas and the other shall be Mines and Minerals. The Coal Sector Development Unit will be under the Secretary, Mines and Minerals Division.

9.3.6. The Ministry of Mines and Minerals Resource shall have the following set up:

1. **Corporate affairs Division:**

   To deal with Coal Mining companies, other mining companies, Bangladesh Petroleum corporations, Gas companies.

2. **Energy and Mineral Resources Division**

   To deal with Department of Mining and Minerals, which will work for the following:

   - Exploration licenses
   - Mining lease and related issues, (strengthening of present BMD)
   - Exploration through GSB
   - Mining and Minerals Institute
   - Inspectorate of Mines and Explosives Department.

Corporate Bodies (Coal Bangla & Khani Bangla)

9.3.7. Two new corporate bodies are being suggested one to look after the development of coal sector and the other for the development of other minerals including hard rock, lime stone, ordinary stone and gravels, etc.

9.3.8. All these institutions shall be modernized to handle the state of the art technology as needed for expeditious development of mining and minerals sector in Bangladesh.

9.3.9. While dealing with the existing affairs of the mining and minerals sector the attention of the new ministry shall also encompass the affairs in sand mining, along the river routes to ensure scientific extraction of sand from the riverbed keeping in view the river morphology, river erosion and the environmental issues, the stone collections, the clay mining, the glass sand mining as well as beach sand mining for commercial purposes.

9.3.10. A detailed study for the organization, scope of activities, manpower requirement with specific job description and qualifications etc shall be initiated to move forward with the proposal.

Coal Sector Development Unit

9.3.11. The reforms to be carried out for the development of the coal sector needs to be implemented by a specialized unit called the coal sector development unit under the new Ministry of Mines and Minerals Resource (MMMR).

9.3.12. This Unit shall be key coordinating unit between different ministries to ensure development of coal sector by integrating the work plans and budgets of all the ministries linked like The Ministry of Mines and Minerals, Environment Ministry, Ministries related to Infrastructure and other related aspects.

9.4. Recommendations

9.4.1. The following new institutions need to be established for the development of the coal sector.

- Coal Sector Development Unit (CSDU)
- National Mines and Minerals Council
- The Ministry of Mines and Mineral Resources
- Coal Bangla and Khani Bangla
- Inspectorate of Mines and Minerals
- Mines and Minerals Institute

10. Human Resources and Management

10.1. Vocational Training Institutes

10.1.1. In recent time, mining technology has developed significantly and industry is highly technology oriented. Since Mining Industry is in nascent stage in Bangladesh, skilled resources in the mining sector are very limited. Compounded with the fact that larger chunk of Bangladesh coal deposits are deep seated and can be mined by underground mining or other specialized technologies requiring higher degree of skills.

10.1.2. The proposed mines will need huge skilled labor force to work efficiently with costly mining machinery in a totally unknown and unfamiliar atmosphere deep underground. The skilled workforce required shall include officers, planners, operators, technicians, electricians, mechanics etc.

10.1.3. While setting up of a fully fledged educational institute may take time and which is likely to produce engineers for more skilled jobs like management of operations and planning, supervision of mines etc., Government of Bangladesh may consider setting up of Vocational training Institute. This institute will provide regular trainings to the people deployed in the mines and will also undertake skill development courses for new manpower deployed at mine at operational level.

10.1.4. These training institutes must be equipped with both trainers and equipment to produce trained manpower in the various disciplines or trades of international standards since they would be handling state of the art mining machinery.

10.1.5. Given the current status of mining industry and indigenous technical manpower, suitable tie-ups should be considered with renowned mining institutes globally to build this Vocational Training Institute.

10.2. Introducing Mines and Minerals related subjects in the Engineering Institutions and Universities

10.2.1. We understand that some private universities in Bangladesh have introduced mining and geology courses for graduation level students. These institutes may also consider tie-ups and exchange programs with renowned mining institutions to strengthen their curriculum and academic level.

10.2.2. Further, in the event of higher requirements of engineering graduates, setting up of new institute to offer education in disciplines like mining engineering, geology, mineral processing engineering etc. may be considered.

10.2.3. The Bangladesh University for Engineering and Technology (BUET) has a department which has some relevance to the subject but needs a thorough review. While undertaking a revision of the syllabi it must be kept in mind that mining is a multidisciplinary activity and that apart from mining engineers, mechanical and/or mining machinery engineers, electrical and civil engineers are also required.

10.2.4. Further, in recent times, technology has progressed at faster pace and significantly high IT applications are used in mining industry for planning, production monitoring, supervision, maintenance, stores and inventory, office work etc. Thus the mining courses offered should integrate mining related IT education with the course to be offered.

10.3. Bilateral agreements with mineral rich countries for Mining Professionals

10.3.1. Bilateral agreements for sharing of technology and knowledge with countries which are rich in mineral resources and have a well established mining industry shall be beneficial to Bangladesh. This will also help in fulfilling immediate training needs of Bangladesh manpower. Further, short term deployment to mines of neighboring countries may help in developing hands on experience. Self sufficiency in trained power is as desirable a goal as self sufficiency in energy.

10.4. Contractual Obligations of the Coal Development Contractors for Human Resource Development

10.4.1. Currently the only operating coal mine of Bangladesh is being operated through Contract Mining. Further, it is expected that in some form the contract miners either as O&M contractor or M&P contractor will be engaged atleast for some coalfields. These contractors are expected to source skilled manpower and technology from outside Bangladesh given same is not available in the country.

10.4.2. Thus, the contracts entered with the foreign developers and operators should have provisions of knowledge sharing and skill and technology transfer at all times during the contract. Further, there may be provisions for compulsory employment of certain local manpower which will help in domestic capacity building.

10.4.3. It should be noted that all the knowledge transfer and skill development exercise must be done in the local language or the language which can be understood by the domestic people.

10.5. Recommendations

10.5.1. A coal training fund may be set up similar to the existing gas sector training fund financed by contributions from private investors in coal mining. The fund could be used for upgrading the syllabi of training colleges and institutes and providing the equipment needed to impart training in modern mining techniques.

11. Coal Sector Infrastructure Development

11.1. Coal Zone

11.1.1. As discussed earlier, coal resources of Bangladesh are concentrated in the north-western part of Bangladesh and other potential coal bearing areas are also expected to be in vicinity of existing coal bearing area.

11.1.2. Thus, to take up coal exploration and development on priority basis, the area comprising the discovered coal fields and potential coal basins in northwestern Bangladesh should be declared as the "Coal Zone". The map below shows the existing coal bearing areas discovered by GSB and the potential Coal Zone. The GoB in consultation with GSB may increase, reduce and revise the boundary line of this map as necessary.

Figure 11 Existing and Potential Coal Zone

Source: Draft Coal Policy, Energy and Mineral Resources Division, Ministry of Power, Energy and Mineral Resources, Government of The People's Republic of Bangladesh, version 5.1, 31 May 2006" prepared by IIFC

11.1.3. The benefits of declaring Coal Zone are as follows:

- Once the area is delineated, it may be provided special status to have focused development of the coal fields and related infrastructure on priority basis to ensure offtake of coal and delivery to consumers.
- It is known that the coal bearing area of Bangladesh is highly fertile agricultural land. Further, the area is densely populated and to enable development of coal resources in the area, special provisions may be required for land acquisition and Rehabilitation and Resettlement of affected people. In such scenario, declaration of Coal Zone can allow implementation of special provisions for coal sector development in the area.

11.1.4. For e.g. while in India there is no specific delineation of coal zone, the Coal Bearing Area Acquisition and Development Act provides government coal companies to acquire coal bearing land on priority basis over other users of land at appropriate compensation. This is necessary for development of coal sector which plays a significant role in development of country and energy security. This may be supported by the fact that while other users can utilize non coal bearing land and may be relocated, mining can be done only at places where minerals exists.

11.1.5. The Coal Zone has to be formed taking into consideration, the entire socio-economic structure in the region, such as:

- Physical infrastructure e.g. railways, roads, power transmission, ports, waterways, water reservoir
- Social infrastructure like towns, schools, health facilities, industries,
- Agricultural land use patterns
- Water bodies, underground aquifer movements etc.
- Bio-diversity of the proposed zone

11.1.6. In order to ensure proper planning of the entire area with respect to the infrastructure requirements, a Coal Zone Study is to be undertaken. The study is to be carried out with a long term vision, by the relevant authorities. The study is to be supported by:

- The BMD for overall planning of the coal developments
- GSB for delineating the potential coal basins
- Power Division for power generation, evacuation and use
- Bangladesh Railway for rail connections
- Roads and Highways for the road network
- Bangladesh Inland Water Transport Authority (BIWTA) for river ports and waterways
- Urban and town planners
- Ministry of Agriculture for irrigation and land use
- Ministry of Water Resources for aquifer structure effects and water reservoir

- Department of Environment for environmental impact assessment
- Silt industry specialists for the collection and movement of silt for stowage and land reclamation
- Ministry of land and others as needed

11.1.7. Once the Coal Zone is identified and delineated, GoB may consider setting up Coal Zone Development Authority to develop master plan for coal zone development and coordinate with various stakeholders.

11.2. Coal Axis and transportation of coal

11.2.1. For making mining projects successful, it is important to have supporting infrastructure for transport of man and material.

11.2.2. The concept of coal axis is to define a route for development of coal transportation system across the Bangladesh. It is known that the river Jamuna passes through Bangladesh and traverse north-south across country. The river is all season river with flat bed and hence, suitable for inland transportation. Further, the known coal deposits are located in close proximity of the river system and thus provide opportunity to use river way for coal transportation reducing requirements of capital investment as well as land requirement.

11.2.3. The Coal Axis should be centered around the coal mines, stock yard and the river routes meant for riparian vessels loaded with coal for the power stations and other bulk consumers.

11.2.4. Coal from the local mines could be stored at one or two suitable central locations (coal hubs) along the river Jamuna (Brahmaputra) which could be connected to the coal mines by heavy duty conveyor belt systems (or, ropeways or any other suitable system to be identified based on techno-economic studies). Coal stockyards with facilities of international standards for storing and handling coal can be set up for transporting coal to power stations by inland water transport vessels. However, initially scientific studies should be carried out to identify coal characteristics like incubation period; moisture absorption etc. to ensure that coal quality does not deteriorate or coal is not lost during storage period.

11.2.5. With the view of better utilization of coal and reduction in coal transport requirement, setting up of domestic coal power plants along the Coal Axis may be considered. The probable such centers are Chandpur, Sirajgonj or Phulcharighat, Bahadurabad, Goalondo or Shatnol.

11.2.6. Thus, under the concept of a Coal Axis, all the mines are proposed to be connected to the coal stock yards to be set up at two or three points along the western bank of river Jamuna. These points will be navigable throughout the year by inland vessels and have adequate mechanized loading and unloading facilities.

11.2.7. It is known that the country receives about 1.4 billion tonnes of silt annually which can be used for stowing in underground mines and land reclamation. Thus, these points can also receive bulk sand cargo, obtained from dredging of river(s), for transportation to sites for stowing and land reclamation. Considering the movement of coal as well as sand, cargo can be available both ways which will help in economical operations. However, the techno-economic viability and cost effectiveness need to be established along with addressing other operational issues.

11.2.8. Coal for brick burning and other uses should be transported by the existing network of roads and river ways. The roads along the coal axis would have to be upgraded and maintained accordingly.

11.2.9. While it may not be possible to relocate or change the sites already chosen for the coal based power stations but in future coal fired power plants sites should be identified considering location of coal mines and transportation routes.

11.2.10. The success of the concept of a coal axis depends crucially on dovetailing the coal transport network with the location of coal fired power stations. Thus, success of this concept entirely depend upon integrated energy sector planning covering coal mining, power plant development, transportation network etc. and techno-economic feasibility study of various options.

Coal Center for imported coal

11.2.11. Power Sector Master Plan 2010 prepared by JICA suggests that import of coal shall be necessary for meeting the energy demand of the country. A linked study to PSMP envisaged establishment of coal centers for imported coal with facilities to handle cargo ships carrying 30,000 tonnes of coal.

11.2.12. These proposed coal centers, one in Chittagong and another in Mongla, are located near southern coastal region and will be far from the power plants located in land. These can supply coal to the power plants through a secondary transportation system using inland vessels. For example, the power plants as of now will not receive direct delivery of coal from the ships to the power stations but would have to resort to inland river transportation.

11.2.13. While these coal centers may be appropriate for short term needs to handle imported coal, but considering the mid-term and long-term prospects for handling coal, the location of these sites for the power plants may need to be revisited to reduce overall transportation efforts and costs.

Concept of energy security through swing supply to coal fired stations

11.2.14. The presentation by Power Division, Ministry of Power, Energy and Mineral Resources on “Future Coal Requirement in Bangladesh Power Sector” November 19, 2011 elaborates the type, number and capacities of the new coal fired power stations to be installed in the country till the year 2030.

11.2.15. The plan envisages constructing three coal centers in Chittagong, having coal fired generation in the northern region as well as the central region. A 2 x 660 MW station is planned at Khulna which will have flexibility to consume both domestic as well as imported coal.

11.2.16. The locations of the proposed power plants have been shown in the figure below.

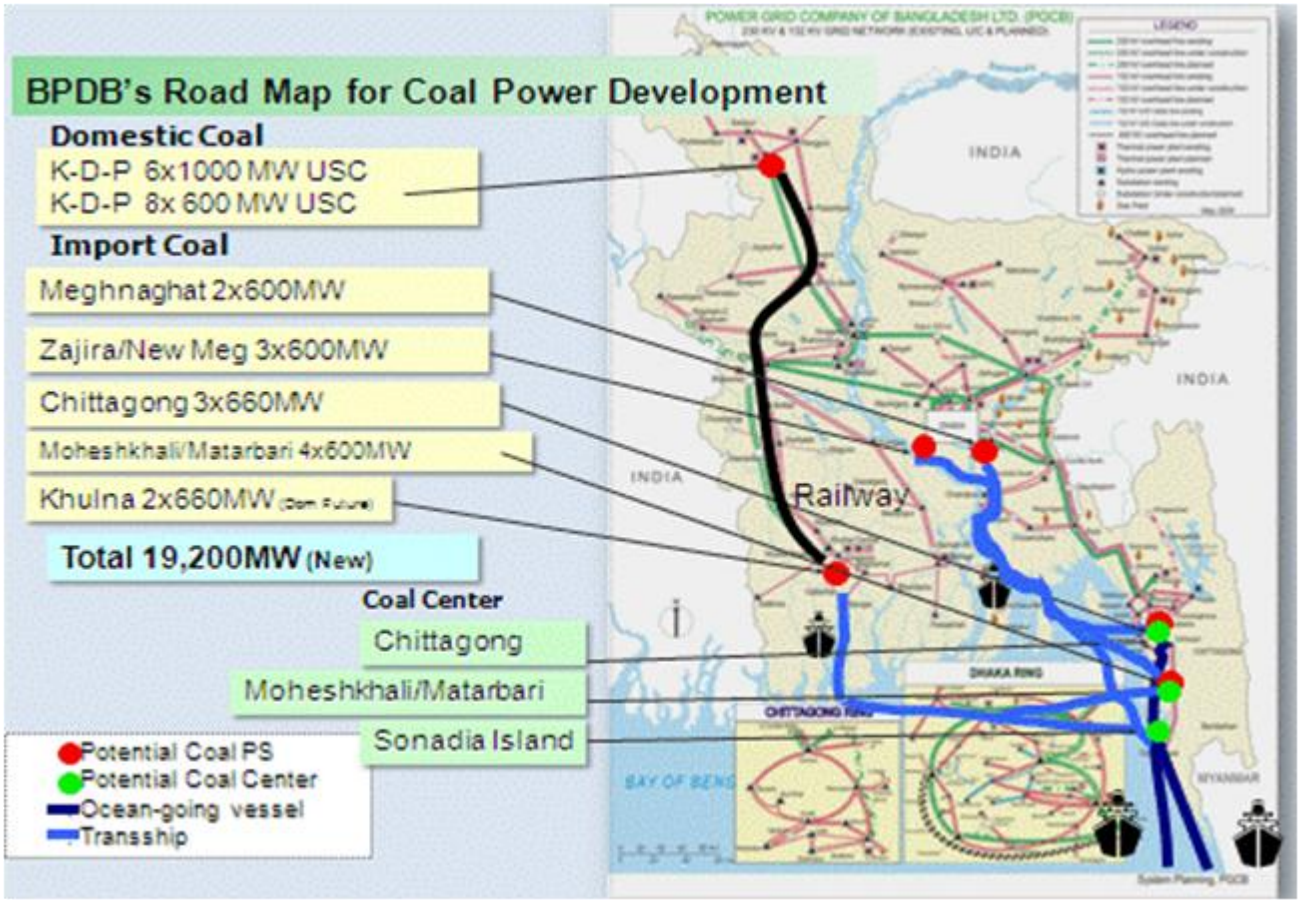


Figure 12: Location of proposed power plants

Source: Presentation on "Future coal requirement in Bangladesh Power Sector" by Power Division, MoPEMR

11.2.17. The coal mining capacity of the country can be ramped up in future but the timeframe required is still uncertain. Thus, it is imperative to set up power plants which can switch from one source of coal to other (import to domestic etc.).

11.2.18. The coal axis is to be used as the sites for locating the major coal fired power stations in Bangladesh such that they have the flexibility to use both local and imported coal.

11.2.19. This requires that the power stations be sited alongside the major rivers in northern Bangladesh to Chittagong along the coal axis, as illustrated in the figure below. A coal center for handling domestic coal would be needed near the BKDP coal region.

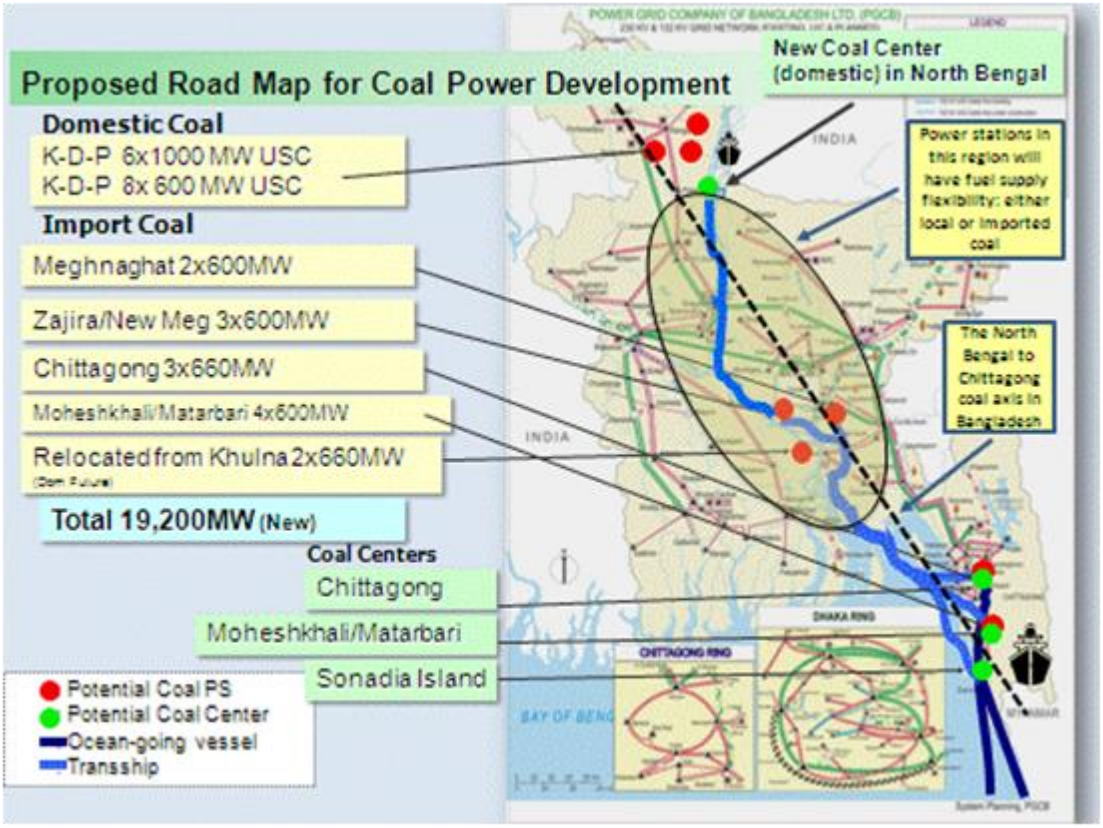


Figure 13: Proposed road map for coal power development

Source: IIFC

11.2.20. It is thus desirable that the boiler design(s) chosen for power stations in Bangladesh are suitable for local coal types and the imported coal should be similar in characteristics.

11.2.21. The advantage of the coal axis concept is that the coal fired power stations located in the central regions (circled) along the Jamuna-Padma-Meghna river banks can have flexibility of fuel supply – either from domestic sources or from imported sources. This will have immense benefits in fuel supply security for the power stations as they will be able to use either local coal or imported coal.

11.3. Inland transport infrastructure for coal

11.3.1. The problems and prospects of coal transportation in Bangladesh are mixed. It is advantageous because the country is crisscrossed by at least two major river systems namely Ganges and Brahmaputra which make the river transportation system a very attractive option for bulk cargo handling and movement. But the disadvantage is that the country lacks railways and roads of international standards to handle millions of tonnes of coal.

11.3.2. The sites have been selected obviously to offset the transportation costs in terms of coal unloading from sea going vessels and then transshipment to the power plants. These points of coal based power plants would only be negotiable with the rail or high ways from the domestic mines though river routes remains navigable throughout the year in some other points which could be potential power plant sites.

Figure 14: Rail Map of Bangladesh

Source: www.mapsofworld.com

11.3.3. Barapukuria and Phulbari coal fields are located near Phulbari Railway Station and are adjacent to a broad gauge railway line that connects Khulna from Parbatipur (railway junction station). The port city of Chittagong is accessible to the mine site through a meter gauge railway line that crosses the Jamuna Multi-purpose Bridge.

11.3.4. The rail corridor from the coal belt to Khulna Port has strategic importance and should be completed on priority. If international market conditions for coal become unfavorable for any reason the power stations could shift to indigenous coal using the railway line.

11.3.5. The existing railway lines would need up gradation if it is to handle the bulk transportation of coal from these mines. A detailed study is required to determine level of up gradation to cater to the need of the power stations based on domestic coal.

Figure 15 Road network map of Bangladesh

Source: www.mapsofworld.com

11.3.6. Both Barapukuria and Phulbari coal fields are connected to Khulna and Chittagong by a national highway. If needed, coal can also be transported by the network of roads available in the country, provided these are upgraded to carry the heavy duty dumpers generally deployed for transporting coal. However, it may be noted that the road transportation over long distance may not be economically viable option given higher cost of coal transport and thus in-land water ways may be better suited for the purpose.

11.4. Recommendations

11.4.1. The concept of a Coal Axis is to be given due consideration and its viability (or otherwise) be established through a techno-economic study by experts. If it is found to be viable it should adopted as

the model for the integrated development of the coal sector and the coal based power sector in Bangladesh.

11.4.2. Carry out a techno-economic feasibility study for the purpose of assessing the viability of Coal Zone by appointing Independent Agency.

11.4.3. The Coal Zone can be developed as a major power producing block based on mine mouth coal fired power generation. Accordingly, direct transmission lines can be constructed from this zone to different load centers of the country.

11.4.4. The coal axis in the country along the Jamuna-Padma-Meghna river may be used for locating coal fired power stations. The rivers will provide the cooling water necessary for the power stations but care has to be taken not to increase the temperature beyond what is ecologically acceptable (too high a temperature may affect river based life species like fish).

11.4.5. The coal related infrastructure is to be developed by GoB with assistance from development partners or private sector on a long-term business plan and appropriate fee can be charged to users of facilities.

11.4.6. As a general rule, power stations based in the interior of the country and located near coal mines should use indigenous coal and those near the ports should use imported coal. However, given that at present there is much uncertainty in the coal mining sector the concept of flexibility of coal supply from either local sources or imported sources needs to be adopted for power sector planning.

11.4.7. Studies need to be carried out to understand the transportation of coal and silt for the coal fired stations. Integrated thinking is necessary for the coal and silt handling.

12. Coal Depletion and Pricing Policy

- To ensure the long term energy security of Bangladesh it is desirable that the limited reserves of coal are depleted in a planned manner over a long period of time with a vision of coal conservations and maximum exploitation. In other words, there must be a depletion policy which specifies the period over which an existing reserve would be fully mined, say, for example, 30-50 years.

- A corollary to this is supplementing or filling the gap between supply, which is based on the depletion policy, and demand with imported coal or other substitutes (e.g. peat).

- Even in the power stations located inland in the coal belt to the northwest of the country, part of the coal needed to generate power at the rated capacity should be met through imported coal. Power plants located at the ports should be run entirely on imported coal unless the international market for coal makes it difficult to do so at a particular time.

- Coal needed for industries and as domestic fuel should be met from either domestic coal mines or from imported coal depending on the convenience and preference of the user circumscribed by the distribution network. Emphasis may be given to develop peat as domestic fuel than coal to conserve coal for higher value usage.

12.1. Blending with Peat

12.1.1. Bangladesh has large deposits of peat. So far not much use has been made of this energy resource. Some countries (e.g., Ireland, Finland and Russia) use peat reserves for generating power stations ranging in size from 20MW-40MW (Ireland) to 1020 MW (Shatura in Russia). Others range from 154 MW to 300 MW.

12.1.2. It is not known whether blending peat with coal to generate power is techno-economically feasible. However, this possibility may be explored. If found feasible, the power station(s) could be located near the source of peat and coal transported to the site as the cost of transporting coal would be cheaper in terms of cost per gigacalorie transported though the final decision can be taken only after overall techno-economic study as economics will also depends on the feasible blending ratio of coal and peat for power generation which will determine the quantum to be moved and transportation cost.

12.1.3. Besides, peat could be an independent fuel for other uses, mainly small industries and domestic. This would reduce the demand for coal.

12.2. Coal Pricing Policy

12.2.1. In the age of globalization, the general view is that pricing is best left to market forces. However, a problem arises if there is a substantial difference between the cost of production, which could vary widely from mine to mine, and the landed cost of imported coal.

12.2.2. If imported coal is more expensive, then domestic producers may get a windfall by increasing their price to match the price of imported coal. If the cost of domestic coal is substantially higher then it faces competition from imported coal except where the cost of inland transportation and distribution bridges the gap to a considerable extent.

12.2.3. The prices of coal per gigacalorie (or any other criteria to factor in differences in the quality of coal) for each mine should be determined on a cost plus formula which provides for a reasonable post tax (if any) return on net worth.

12.2.4. Since a substantial part of the domestic coal would be used for generating power and for other industrial uses it is desirable that the price of coal per gigacalorie is uniform throughout the country. The means to achieve this is to set up a Coal Price Equalization Fund.

12.3. Coal Price Equalization Fund (CPEF)

12.2.5. The pithead coal prices and the landed cost of imported coal and the quantities of each are taken and a weighted average arrived at every quarter.

12.2.6. The mines whose “determined” prices are below the weighted average price (WAP) would sell at the WAP and deposit the excess in the Coal Price Equalization Fund (CPEF) and those whose prices are above the CPEF would also sell at the WAP and be reimbursed the shortfall in receipts from the CPEF.

12.2.7. For reasons like variations in the quantities produced vis-a vis the targets or rated capacities, it is likely that for a particular quarter the receipts and payments or cash-flow may not balance out. The CPEF should have a corpus to deal with surpluses and deficits. In the long run, a well designed and administered system would prove to be useful.

13. Land Utilization and Reclamation

- All mining activities (underground and opencast) cause some damage to the land surface in the mining area. In earlier days the land surface affected by mining activities was left as it was at the end of the mine's life.

- The current Acts and Rules does not explicitly mandates the mining companies to restore and reclaim the land to minimize the adverse effects of mining. In many countries, regulatory framework requires afforestation of stockpiles and filling up the pits with the backfilling of removed overburden and afforest. For e.g. in India, miners need to have a progressive mine closure plan which need to be implemented. This plan provides for land reclamation, back filling and forestation measures.

- Most of the countries in the world involved in mining operations have enacted legislation making it mandatory to reclaim or rehabilitate the land affected by mining and rendering the land usable in future. Mining activities in many part of world has seen resistance and people were no longer willing to accept the loss of fertile farmland and their home.

- A new strategy is therefore required, beyond mere afforestation of stockpiles and filling up pits with water. Given the major impact on the landscape, representatives of various institutions and organizations had their own ideas about reclamation of mined out areas and its reuse.

- It was not until the 1980s that the Mining Act emphasized the need for careful handling of the land and better standards for reclamation in the public interest. The current thinking is that, as far as possible, mined out areas must be restored or rehabilitated to render them useful again.

- The nature of the reclamation would depend greatly on the local conditions and would be a mix of back filling, conversion to water bodies, afforestation, etc. Land which can be back filled could be put to urban (domestic) or industrial use since it would be in the vicinity of the townships which were established during mining activities.

- In case of underground mines the effects on the surface are dependent on the methods of mining deployed for mineral extraction, thickness of the mineral body, its depth from the surface, etc. Nearly all underground excavations are associated with some sort of subsidence (depression of land on the surface). The amount of depression on the surface depends on the size of the excavation underground and the geophysical conditions of the ground above the mineralized zone.

- If the land surface is used for agriculture or for homesteads, then as a pre-cautionary measure appropriate mine excavation designs should be worked out in order to minimize the effect of subsidence.

- The most effective way of minimizing the effect of subsidence is by stowing, a process by which the mined area is filled up with sand slurry from the surface. Normally sand is dredged out from a nearby river bed and pumped in to the mine. If the economics is favorable, then stowing is the best solution to prevent subsidence.

- Subsidence can also be reduced to some extent by using appropriate designs for underground excavations. For example, in case of room and pillar method, increase in pillar size is likely to take more weight of the strata above and consequently reduce subsidence.

- The long wall mining method with caving which is being practiced in Barapukuria Coal Mine in Bangladesh has provided for barrier pillars between the long wall panels. Had the size of these barrier pillars been nearly doubled, the present depression of land on the surface would probably have been

less. But this would have reduced the quantity of coal mined and thus render coal extraction uneconomic.

13.1. Reclamation of land damaged/left unused due to mining activities

13.1.1. In case of underground mining, the magnitude of surface subsidence will depend primarily on whether extraction of coal has been done with stowing or by caving, other factors remaining the same. In Bangladesh, the aggregate thickness of coal seams varies from 30m to 60m or more. If the seams are extracted by caving method, the magnitude of subsidence will be very high to the tune of 10m to more than 20m. It will be difficult to fill a subsidence trough of such magnitude because of dearth of filling material. In all probability, such trough will remain perpetually filled by ground water flowing from surrounding undisturbed ground (as ground water table is high) and also by rain water during monsoon. Thus, only limited options of post-mining land use are available.

13.1.2. In case of extraction of coal with stowing, the magnitude of surface subsidence will be limited and there is possibility of bringing back the subsided land to productive use with some effort of filling the land after completion of mining.

13.1.3. In case of opencast mining, reclamation of mine out land has to be done progressively with mining, starting usually from 5th or 6th year of excavation after sufficient coal has been extracted from the lowest seam and quarry floor exposed. It is usual that a large volume of waste dump is taken outside the pit area and stacked as external spoil dump, thereby sterilizing considerable land area. In case of high stripping ratio opencast mines as in Bangladesh, such external dump area may be very high. Further, during the end of opencast operation, a residual void is always created with depth equal to the depth of final cut. This residual void eventually gets filled with water. If the whole or part of the external spoil dump is rehandled after the productive life of the opencast mine, to fill the residual void, a great amount of land area can be de-sterilized and at the same time, volume of the ugly and dangerous residual void can be reduced. However, this will involve great expenditure which has to be loaded in the cost of opencast mining during productive life of mine.

13.1.4. The general sequence of extraction and reclamation would have to be planned in the following manner.

1. The top soil stripped/excavated need to be stacked, stored separately and maintained for 4-5 years until the coal from the bottom seam of the pit has been extracted and backfilling is possible.

2. The overburden of the other strata containing sand, shale, rocks etc. should also preferably be stacked separately and should be used for backfilling at the earliest possible opportunity.

3. After the coal seam has been mined out, the pit formed in the process would then be filled up with rocks, sand, clay, shale preferably restoring the sequence in which they existed before.

4. Refilling the top soil should be carried out at last to complete the reclamation process.

5. The refilled open pit mine area can be put to use for agriculture, providing irrigation, afforestation, if possible.

13.2. Land Reclamation Strategy

13.2.1. Proven land reclamation methods should be prescribed in the mining plan giving legal sanctity, if needed. This is to ensure that mine owners/operators take into consideration the cost of reclamation of land in their techno-economic feasibility studies.

13.2.2. The designated agency of the Government should monitor land reclamation by mine owners when the period of lease comes to an end or is otherwise terminated. The Government needs to formulate guidelines for mine closure. The cost of such mine closure operation need to be built-up through yearly contribution of a calculated amount from the revenue account of a mine (during its productive life) in an escrow fund, to be established by the Government of Bangladesh solely for the purpose of funding post-mining closure operations. The mine owner can utilize this accumulated fund for undertaking closure operations as per guideline. If, however, the mine owner is unable to take up the closure operation, the Government/Government agency can employ operators to complete the mine closure operation by utilizing this fund.

13.2.3. It may not be possible to fully restore the land to its original condition but whatever is possible must be done. In fact, it is unlikely that the land can be fully restored since a large volume of coal has been extracted and burnt for which it would be difficult to find enough material to fill.

13.3. Provisions for Land Reclamation

13.3.1. The lessee shall complete the work of land reclamation and its rehabilitation prior to abandoning the mining area. The lessee shall bear the complete cost of reclamation and rehabilitation to restore the conditions as far as practicable to its initial status. The time interval from the initial occurrence of damage to the reclamation stage should be as little as possible.

13.3.2. A problem arises in cases where a mining lease is terminated for violation of conditions or otherwise but mineable coal is still there in the mine and the mining lease is given to another party to continue mining coal.

13.3.3. For such cases a separate policy may be required which is enforced by appropriate rules. The mine plan for both the original lessee and the subsequent lessee should allow for this contingency.

13.3.4. Further, mine closer and reclamation policy should mandated for creation of separate mine closure fund by lessee with government which can be utilized by government for mine closure in case lessee does not do it as per approved plan and to the satisfaction of government.

13.4. Ownership of Reclaimed Land

13.4.1. Ownership of reclaimed land may be a tricky issue to deal with depending upon the ownership of land at the time of abandonment of mining activities. The lessee will argue (and rightly) that he has paid for the land by way of compensation at the time of being granted the mining lease for a specific area and has also spent on reclamation and rehabilitation. Thus, no other person can claim the land. He should be free to use the land as he likes, subject to any land use plan notified by the Government under law. Though after completion of mining activities, he may not have useful value for the land.

13.4.2. There are difficulties in giving the land back to the original owners. The questions like terms on which land can be given back (if given) and how can he be given back the land free if he has been adequately compensated for it under law, arise.

13.4.3. Also, the situation arises after a period of several decades by which time the original owner may be dead and his legal heirs may have moved to other places. Some owners may have taken the compensation and moved away to other places and occupations.

13.4.4. Thus, it may be a good idea and also workable if the lessee is allowed to dispose of the land within the laws relating to land use but the government put a tax on the sale price. This could be a win - win situation for both the lessee and the government as the custodian of public interest. The lessee has the attraction of being able to cash in on the appreciated value of the land and hence be more than willing to invest in reclamation and the government also collects revenue (capital gains tax). Alternately, law

itself may be framed to handover land to government or original land owners at certain fixed compensation to lessee (who have acquired the land).

13.5. Recommendations

13.5.1. The mine plan and the PSC/mining contract, if there is one, must make it obligatory for the mine owners to reclaim and rehabilitate the mining area after mine closure as per the mine plan to the extent feasible. Adequate safeguards need to be built in to the lease documents (and the PSC) so that it can be enforced.

13.5.2. A policy may be framed to deal with the rehabilitated land so that while fair play is assured to the lessee, the Government steps in to avoid windfall gains to the lessee by imposing a suitable tax.

14. Peat

14.1. Peat Resources in Bangladesh

14.1.1. Peat forms when plant material, usually in marshy areas, is inhibited from decaying fully by acidic and anaerobic conditions. It is composed mainly of marshland vegetation: trees, grasses, fungi, as well as other types of organic remains, such as insects and animal remains.

14.1.2. Peat deposits occur in the marshy areas of the north-eastern, central and south western parts with a total reserve of more than 170 million tons. Calorific value of peat ranges from 6000 to 7000 BTU/lb (3334 to 3889 Kcal/Kg).

14.1.3. Peat can be used as fuel for domestic purposes, brick manufacturing, boilers, etc. However, its exploitation has not yet started in Bangladesh. The table below gives an overview of the deposits of peat and their locations in Bangladesh.

Deposits	Depth (m)	Thickness (m)	Area (Sq. km)	Reserve (Mt)	Carbon content (%)	Ash content (%)	Moisture content (%)	Volatile matter (%)
Bagiachanda	0.4	0.6-3.3	500	150	24	16.63	17.1	42.30
Kolamouza	0.04-2.5	0.2-4	25	8	29.2	24.80	13.70	42.30
Maulvi Bazar	0-1.3	1.6	9.6	3	17.83	36.07	15.52	30.58
Chalan Beel	05-4.76	3.35-7.65	-	6.2	14.80	46.13	8.63	54.13
Charkai	0-0.8	0.13-2.6	11	3	18.32	17.6	27.77	
Pagla				13.2	16.37	25.9	37.7	43.3

Source Asian Mining Year Book (Seventh Edition), 2001

Table 10: Peat deposits and Quality

14.1.4. **Assessment reports of peat deposits:** In the report on Mineral Resources Assessment (submitted as part of this MMDP Project), peat resources have also been reassessed. On the basis of the available information, 38 Mt of dry peat resource has been classified as measured resource (UNFC code 331) and 95 Mt of dry peat resource has been classified as reconnaissance resource (UNFC code 334).

14.2. A Historical Perspective

14.2.1. In 1957, the then Geological Survey of Pakistan (GSP) discovered peat in greater Khulna & Faridpur districts during exploration work covering an area of 500 sq. km. In 1979-80, the then BMEDC in collaboration with the Geological Survey of Bangladesh (GSB) carried out a Feasibility Study on peat deposits in Kola Mouza, Khulna.

14.2.2. The study advocated using peat for domestic and brick-burning purposes. In 1983-84, a survey & investigation sponsored by UNDP confirmed that a reserve of 400 million tonnes of peat exists in various parts of Bangladesh. In 1986, Petrobangla conducted a detailed study on peat with the assistance of CIDA in Madaripur, Khulna and Gopalganj region.

14.2.3. The objectives of the study on peat were:

- Installation of a 10 MW pilot power plant using Khulna peat.
- Installation of two 25 MW commercial units using Madaripur peat.

- It was confirmed during the study that the cost of peat fuel is Tk. 0.81 per kilowatt hour (1986-basis) as compared to Tk. 1.51/kwh for furnace oil when used for power generation.
- Briquetting of peat for use in industry & for domestic purposes was also successful

14.2.4. Again in April 1992, with the approval of the Government of Bangladesh, Petrobangla undertook a project in Madaripur in the style of "Peat Development & Demonstration Project" to run a demonstration scheme for 3-years with production of 300, 4000 & 2,200 tonnes of peat/briquette in the 1st, 2nd & 3rd year respectively.

14.2.5. A site covering an area of 15.00 acres at Barabahadarpur Mouza of Kendua Union under Madaripur Sadar Thana was selected where peat thickness varies from 1.7m. to 4.25m. and the thickness of the overburden varies from 0.25m to 1.35m for extraction of peat.

14.2.6. The site was about 15 km south-west of Madaripur town & is connected by a 7 km. waterway from the mine site to Mostafapur and 8 km road from Mostafapur to Madaripur town. The objectives of the project were as follows:-

- To introduce peat as a fuel for domestic use and for brick burning.
- To establish a market for peat as a fuel for use in local areas.
- To observe the effects of the project on the environment.
- To determine the possibility of making briquettes to be used as fuel.
- To provide employment opportunities for the local unemployed low income group people.
- To determine viability of peat mines from the financial as well as socio-economic point of view.

14.2.7. Removal of overburden and extraction of peat was carried out manually using local labor and local equipment. Overburden & peat were stacked separately at the mine site. Peat drying was also carried out at the site.

14.2.8. Till June 1994, about 1800 tonnes of wet peat was extracted. A briquetting machine with a production capacity of 100 briquettes of size 8"x 4" x 2" per hour was installed at Gathmajee area near Mostafapur which was well-connected with Madaripur town by road & river. The machine was made locally for the first time in Bangladesh.

14.2.9. Till the 15th November, 1995; 55,500 briquettes were produced. The weight of the briquettes was about 55.5 tonnes in wet condition. On drying (moisture free) it was about 18.5 tonnes (33.33% of wet or mined peat). About 46 tonnes of peat was distributed among brickfields, workshops, houses in Madaripur town to demonstrate the use of peat. The results were encouraging. It was established that peat could be used in brickfields & other commercial & domestic sectors. As per assessment done in 1994-95, cost of production of peat/briquettes was roughly Tk. 2000/- per tonne which was considered high. A small quantity of peat was sold at Taka 750/- per ton to promote its use in the locality.

14.2.10. A local private sector firm in association with an expatriate institution is conducting a feasibility study in Madaripur area to confirm the reserve, depth and quality of peat. It is envisaged that subject to positive results from the feasibility study, peat mining may be undertaken by the same entrepreneurs to harvest enough peat for running a 50 MW power station in the vicinity of the peat fields.

14.3. Prospects for Peat utilization

14.3.1. The Electricity Supply Board of Ireland has been using peat-fired boilers for electricity generation for many years but the plant sizes have been small (20 MW to 40 MW). However, Russia and Finland have set up power stations with capacities from 154 MW to 1020 MW.

14.3.2. Peat is produced in two forms—sod and milled. Sod peat is burned on chain-grate stokers in boilers of up to 20 MW capacities; milled peat is fired as pulverized fuel in boilers of up to 40 MW capacities.

Peat mining methods

14.3.3. Peat mining is a relatively simple process of open pit mining. Peat deposits are usually found in marshy land. The overburden is first removed and the water is pumped out to dry out the area.

14.3.4. Once the peat field is dry then the peat is extracted either manually or by mechanical excavators. When the peat is exposed it is then cut either manually or by using a harvester.

14.3.5. If the peat is amenable to solidify itself then it is allowed to remain in the field for some time after which the peat is transported to the stack yard. If the peat is likely to become powdery, then it is collected as a powder and taken to the peat stack yard. Peat is then classified as sod peat or milled peat.

14.3.6. There are mainly two issues that arise in peat mining:

1. Finding a suitable site nearby for "storing" the overburden which is likely to be of used once the peat deposit has been mined out to restore the mined out area to the extent possible. Not being very deep it may be possible to get sand and/or silt from nearby rivers to make up for any shortfall.

2. Disposal of the water pumped out of the peat mine. If agricultural land is not far away, then it may be used for irrigation. With treatment, it may be also supplied to households (both general and those of mine workers involved in mining the peat and power station workers, if there is a peat fired power station). Any surplus would have to be disposed of in nearby streams/rivers.

14.4. Uses of Peat

14.4.1. Peat is a low calorific value fuel. But it can be used to generate electricity. In many countries, including some developed countries, peat is being used for electricity generation and district heating purposes.

14.4.2. Peat is also converted to briquettes and put to domestic use. Besides peat being used as a fuel, many countries use peat as fertilizers and soil conditioners as well. This use of peat would have to be established by soil scientists after analyzing the soil in the vicinity of the deposit, testing of peat quality and experimenting with peat.

14.4.3. If successful, the Agriculture Department could take up extension programmes to promote its use.

14.4.4. The lessee could also find alternate uses for peat like cooking fuel by households. Briquetting and specially designed cook stoves suitable for peat may be developed. This would reduce pressure on nature by reducing the demand for fuel wood.

14.5. Strategy for Developing Peat Fields in Bangladesh

14.5.1. Since Bangladesh has reasonable peat reserves at shallow depths and the accessibility to the peat reserves are good, peat may be considered as an additional source of fuel, after gas and coal, for the power sector. If peat proves to be acceptable in terms of harvesting without excessive damage to the environment then peat mining projects could definitely prove to be a boon for the country.

14.5.2. Given the need to step up generation of power and the overall shortage of primary energy, peat fired power plants could meet at least part of the deficit, especially in the southern region where peat deposits are high.

14.5.3. The peat fields may be divided into blocks and then the blocks may be awarded (or auctioned) to private entrepreneurs for mining for whatever use they can find a market for. The strategy should be to invite bids for peat mining and power generation as an integrated project. Further, successful bidder may be allowed to sell peat to other users to improve the viability of the investment.

14.5.4. Though an integrated mining cum power generating project would, perhaps, be the most attractive option, peat mining may be undertaken as an independent activity if an entrepreneur so desires. The bidding process should be open to both types of investors. It would be up to the lease holder of the peat mine to find buyers for the peat. He may enter into long term supply contracts with power stations, brick makers, industries, etc.

14.5.5. As the peat fields are in the wet lands and the rate of silt deposits is higher compared to the places upstream of the river, peat fields shall lend themselves to reclamation soon after the peat has been mined out.

14.5.6. Therefore, unlike open pit mining of other minerals like coal, peat fields are likely to be more amenable to open pit strip mining thereby digging in one place, harvesting the peat and then filling up the pit with the over burden from the next strip. Though overall viability need to be established after taking up appropriate technical studies.

14.5.7. A feasibility study should be carried out which must incorporate the environmental and social aspects very carefully to establish the techno-economically feasible of peat mining in Bangladesh.

14.5.8. As the peat fields are spread over a large area in the country, it would be advantageous to have small lease areas given to several companies to operate the peat fields which would be monitored and subjected to the regulatory measures under separate rules made for the purpose by the appropriate department/agency of the Government.

14.5.9. As is natural with most mineral deposits the distribution is not uniform. Some deposits may be very large and could supply the mineral for decades. Others may not last long if mined at a high rate.

14.5.10. Peat is a low calorific value fuel and hence very large quantities would be required to serve a purpose compared with coal or petroleum products. For investments to be viable and be attractive to a prospective entrepreneur it is essential that the sufficient resources are awarded to lessee so that he can continue to mine at an economical rate for a long period (say, 25-30 years).

14.5.11. Hence the policy should be to auction or allot large deposits to those who propose to use a substantial part of the mined peat for generating power. For smaller deposits, this may not be insisted upon and the lessee may sell the peat to wide range of users, including domestic households, restaurants, etc.

14.5.12. The special circumstances that are associated with peat deposits, i.e. shallow occurrence below fertile agricultural land can be taken advantage of by not fully buying off or acquiring the land but taking it on a temporary or short term lease from the owner and compensating him for loss of income until the land is restored and returned to him.

14.6. Environmental Impact and its Mitigation

Environmental Impact

14.6.1. Peat fields of Bangladesh are characterized by high yield agricultural land. When mining is taken up there would be environmental impacts like:

- The peat field will be dry due to dewatering which will lower the water table which in turn would drain water from the adjacent or nearby agricultural land making it difficult to grow paddy.
- Peat mining may affect agricultural activities and there could be a reduction in agricultural output.
- Water pollution, dust, noise and vibration.
- Carbon dioxide emission due its burning in power plants set up nearby to use the peat.

Mitigation

14.6.2. Since peat fields are small in size, the environmental disruption will not be severe nor is it likely to continue for long. It may be possible to keep the adverse effects to a minimum and the affected persons may be compensated adequately for the period their normal life (mainly farming) is disrupted.

14.6.3. To a great extent the land may be restored to its original state by measures like filling with silt diverted or pumped from nearby rivers. If soil scientists find it suitable, some of the peat could be used to improve the soil at the time of restoration.

Social Impact

14.6.4. Peat reserves being at shallow depths and mining operations being on a smaller scale and area, the social and environmental impacts of peat mining are likely to be less severe as compared to coal mining, whether it is open pit or underground mining.

14.6.5. Peat mining and processing is labour intensive and, hence, is likely to provide more employment. Separate ameliorative measures may be prescribed for peat mines both for environmental and social impacts after a careful study since there is very little experience and information on the likely impact on communities in the vicinity of the peat mines once mining is taken up on a commercial scale.

14.7. Recommendations

14.7.7. Detailed surveys to confirm the reserves of peat from the category of resources be carried out.

14.7.8. Undertake studies to establish suitability of peat resources for power generation and also for domestic fuel.

14.7.9. As peat fields are good paddy fields, an integrated detailed socioeconomic survey before extraction/ mining of the peat should be undertaken.

14.7.10. Undertake techno-economic feasibility studies for the areas with proven reserves.

14.7.11. Invite bids for setting up 25-50 MW (or of higher capacity) power stations near the peat fields to be awarded along with a mining lease for peat. The peat deposits may be divided into blocks if need be but ensuring that they are of a viable size to sustain a power station for 25-30 years.

14.7.12. Smaller deposits need not be divided into blocks and need not be linked to setting up power stations.

14.7.13. Encourage local entrepreneurs to set up units for producing briquettes from peat for domestic and other use and popularize it.

14.7.14. Conduct research for use of peat as a fertilizer and/or soil conditioner for agriculture and horticulture sector and also for fisheries and water treatment and/or purification.

14.7.15. Frame separate rules for leasing and land acquisition, lease or purchase specifically to suit peat mining operations in Bangladesh.

15. Recommendations and Conclusion

Step	Aspect	Recommended Strategy
1	Legal framework and Institutional development	• It is necessary for sustainable development of the sector that the current legislations are amended and wherever required, new legislations are enacted as suggested in this report. • Strengthening of existing institutions and establishment of new institutions like National Mines and Minerals Council; Coal Bangla and Khani Bangla; Ministry of Mines and Mineral Resources; Coal Sector Development Institute; Inspectorate of Mines and Minerals; Mines and Minerals Institute
2	Depletion policy	• To ensure the long term energy security of Bangladesh it is desirable that the limited reserves of coal are depleted in a planned manner over a long period of time with a vision of coal conservations and maximum exploitation. • There must be a depletion policy which specifies the period over which an existing reserve would be fully mined, say, for example, 30-50 years
3	Declaration of Coal Zone	• Area comprising discovered coal fields and potential coal basins in northwestern Bangladesh may be declared as the Coal Zone • Carry out a techno-economic feasibility study for the purpose of assessing the viability of Coal Zone • Demarcate the Coal Zone into coal blocks for inviting bids for prospecting and (finally) leasing.
4	Decision on investment models and type of contract	• Government should provide budgetary support in the form of equity or share capital to a public sector enterprise. • The possibilities of getting financial assistance from multilateral funding agencies should be explored. • Taking into account the various types of coal contracts (Cost plus, levelised price, PSC) and the circumstances prevailing in Bangladesh, a model coal PSC appropriate for attracting investment in the sector may be prepared. • To encourage private investors for undertaking exploration of mineral resources with assurance for award of mining license to operate, in case of successful exploration. • In view of the need of specialized financing and development need of the coal sector, the tailored mode of investment in terms of PSC may be explored. However, the issue may be professionally examined further and any mode of financing that suits best for the country in the back ground of international financing market may be adopted expeditiously. Contractual issues should be settled with due diligence so that a win-win situation is created for all the involved parties.
5	Decision on commercial aspects	• Coal pricing policy may be revisited to represent a realistic scenario which provides reasonable return to the investors keeping the coal price tolerable. Setting up of Coal Price Equalization Fund (CPEF) may be considered to supply coal at uniform price to consumers from all coalfields. • To encourage private sector participation, the government may roll out

Step	Aspect	Recommended Strategy
		incentives for the private sector in the form of tax holidays, waiver of local taxes, reduction in import duties on equipment etc.
6.	Pre-development activities in coal deposits	• Invitation of bids for exploration activities. • Detailed exploration and other studies along with the preparation of geological reports and other study reports of all the coal basins can be completed within a period of 3-4 years • Studies suggested in this report should be conducted expeditiously to establish feasibility of opencast mining. • For introduction of stowing in the mines, studies have to be initiated immediately on high priority basis for assessing availability of sand in Jamuna river/ other rivers and the annual rate of replenishment of sand in these rivers • Model bid documents and contract manuals for exploration, mine construction and for mine development and operation have to be prepared expeditiously
7	Development of coal deposits	• Development of different mines should be phased to match with the availability of international contractors and development of internal organization to handle increased scale of operation • It is necessary to take decision on the pending applications (Phulbari and Khalashpir coalfield) at the earliest. • Invitation of bids
8.	Coal sector infrastructure Development	• This should be done in conjunction with the concept of coal zone. • Coal Axis should to be given due consideration to define a route for development of coal transportation system across the Bangladesh. Its viability (or otherwise) should be established through a techno-economic study by experts. • Coal axis is to be used as the sites for locating the major coal fired power stations in Bangladesh such that they have the flexibility to use both local and imported coal. • The infrastructural development for coal production and supply must ensure that the transportation cost is kept at minimum and to the best of capacity utilization of the facilities. The river routes mode of transport must be given top priority in addition to the improvement in road and railway modes.
8.	Peat development	• Undertake studies to establish suitability of peat resources for power generation and also for domestic fuel. • Undertake detailed socioeconomic survey as peat fields are good paddy fields. • Conduct research for use of peat as a fertilizer and/or soil conditioner for agriculture and horticulture sector and also for fisheries and water treatment and/or purification. • Detailed surveys should be done to confirm the reserves of peat from the category of resources be carried out. • Undertake techno-economic feasibility studies for the areas with proven reserves. • Encourage local entrepreneurs to set up units for producing briquettes

Step	Aspect	Recommended Strategy
		from peat for domestic and other use and popularize it. • Frame separate rules for leasing and land acquisition, lease or purchase specifically to suit peat mining operations in Bangladesh
9.	Human resources development	• Setting up of Vocational training Institute that will provide regular trainings to the people deployed in the mines and will also undertake skill development courses for new manpower deployed at mine at operational level • Academic courses in mining, geology and other related fields to be introduced at the college and university level. • As interim measures, bilateral agreements with minerals rich countries to be made to train Bangladeshi personnel in foreign coal mines.
10.	Land utilization and Reclamation	• The mine plan and the PSC/mining contract, if there is one, must make it obligatory for the mine owners to reclaim and rehabilitate the mining area after mine closure as per the mine plan to the extent feasible. Adequate safeguards need to be built in to the lease documents (and the PSC) so that it can be enforced. • A policy may be framed to deal with the rehabilitated land so that while fair play is assured to the lessee, the Government steps in to avoid windfall gains to the lessee by imposing a suitable tax.