Challenges of Coalbed Natural Gas Development in Northwestern Bangladesh*

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Abstract

Scattered, isolated deposits of Permian high-volatile bituminous coal constitute a potential resource for the energy-deficient region west of the Jamuna (Brahmaputra) River. Five coalfields (Barapukuria, Dighipara, Jamalganj, Khalaspir, and Phulbari) have been delineated so far by remote geophysical surveys and subsequent exploratory drilling. Individual coal beds, as much as 47 m thick, have been reported at depths between 100 and 1200 m below surface level. Total coal resource estimates range from 2000 to 5000 Mt. Total gas-in-place estimates calculated by various indirect methods range from 31 to 60 Gm³ (1 to 2 Tcf).

To date, no comprehensive investigation to define discovered coal gas resources and establish commerciality for any of these prospective reservoirs has been attempted. General coal composition (proximate analysis), petrography, and thermal maturity (Ro) data are available for each coalfield. Other reservoir conditions that need to be quantified by exploratory drilling and core sampling include direct-gas-content measurements, gas composition and gas-storage-capacity analyses, as well as reservoir volume and density measurements.

In-situ permeability and hydrologic tests of prospective reservoirs are also needed to evaluate the production potential of the coal gas prospects. Studies of the Barakapuria coal deposit, in conjunction with development of the first underground coal mine in the region, indicate that hydrologic conditions within the basin may be problematic for dewatering reservoirs to initiate gas production. Hydrogeology of the Jamalganj deposit may be more favorable for reservoir dewatering.

Comprehensive desktop studies of the five coalfields that consider gas content information from analogous areas would provide a basis for ranking the coal-gas potential of each prospective basin. Then, a site-specific exploratory drilling program could be designed to evaluate the gas-resource potential of the most likely prospect.
Challenges of Coalbed Natural Gas Development in Northwestern Bangladesh

Ricky T. Hildebrand
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Unconventional Reservoir Services
Outline

- Introduction
- Coal and CBNG in Bangladesh
  - Deep wells
  - Barapukuria
  - Phulbari
  - Khalaspir
  - Dighipara
  - Jamalganj
- Challenges of CBNG Development
  - Reservoir Parameters, Gas Content
  - Geologic and Hydrologic Conditions
  - Market and Infrastructure
- Conclusions
Bangladesh Energy Supply and Demand

- Current Remaining Gas Reserves (2009) = 18.8 Tscf (532 Gm3)
- Domestic Demand Growth Rate = 7%/yr (Case B)

Data from Hydrocarbon Unit, 2009, Guidelines for exploration and development strategy for Bangladesh: Bangladesh Energy & Mineral Resources Division Report, 18 p.
CBNG — A Potential Energy Resource

- a.k.a. CBM, CSM, CSG, CMM
- Continuous accumulation
- CH$_4$ is most abundant gas
- Reservoir is source rock
- Primarily sorbed gas
- Typically water saturated

$1 < \phi_s < 5 \text{ vol}\% \quad k_a > 0.1 \text{ mD}$
Index map of Bangladesh showing geologic provinces, tectonic plates, and regional cross sections (modified from Curiale and others, 2002)
Location of Gondwana basins and general stratigraphy, northwestern Bangladesh (modified from Uddin and Islam, 1992; Elahi, 1995; Frielingsdorf and others, 2008; and Islam and Hayashi, 2008)
## Coal in Bangladesh

<table>
<thead>
<tr>
<th>Coalfield (District)</th>
<th>Year of Discovery</th>
<th>Known Area (km²) [Planimeter¹]</th>
<th>Aggregate Coal Thickness (m)</th>
<th>Number of Coal Beds or Zones</th>
<th>Depth of Coal (m)</th>
<th>Coal Rank</th>
<th>In-situ Coal Resources (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barapukuria² (Dinajpur)</td>
<td>1985</td>
<td>5.16 [7.2]</td>
<td>21.63–74.31</td>
<td>7</td>
<td>118–518</td>
<td>HVB Bituminous</td>
<td>377</td>
</tr>
<tr>
<td>Phulbari³ (Dinajpur)</td>
<td>1997⁴</td>
<td>[12.4]</td>
<td>15–70</td>
<td>3</td>
<td>120–240</td>
<td>HVB to HVA Bituminous</td>
<td>572</td>
</tr>
<tr>
<td>Khalaspir⁵ (Rangpur)</td>
<td>1989</td>
<td>12.26 [12.2]</td>
<td>23.21–59.10</td>
<td>8</td>
<td>257.2–482.9</td>
<td>HVA to LV Bituminous</td>
<td>685</td>
</tr>
<tr>
<td>Dighipara⁶ (Dinajpur)</td>
<td>1995</td>
<td>5 [NA]</td>
<td>61.38 (Avg.)</td>
<td>6</td>
<td>323–408</td>
<td>HV Bituminous</td>
<td>600</td>
</tr>
<tr>
<td>Jamalganj⁷ (Joypurhat)</td>
<td>1962</td>
<td>6.8–41⁸ [24.5]</td>
<td>18.59–99.49</td>
<td>7</td>
<td>640–1,158</td>
<td>HVB to HVA Bituminous</td>
<td>1,053 (11.7 km² area)</td>
</tr>
</tbody>
</table>

### Coal Occurrence (District)

<table>
<thead>
<tr>
<th>Year Drilled</th>
<th>Total Depth (m) [Fm]</th>
<th>Aggregate Coal Thickness (m)</th>
<th>Number of Coal Beds</th>
<th>Depth of Coal Range (m)</th>
<th>Coal Rank</th>
<th>In-situ Coal Resources (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuchma-1⁴,⁸ (Bogra)</td>
<td>2,875 [L. Gondwana]</td>
<td>52</td>
<td>5</td>
<td>2,380–2,876</td>
<td>Bituminous</td>
<td>ND</td>
</tr>
<tr>
<td>Bogra-1⁸ (Bogra)</td>
<td>3,816 [Precambrian]</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Coal seams encountered</td>
<td>ND</td>
</tr>
<tr>
<td>Singra-1X⁹ (Natore)</td>
<td>4,100 [L. Gondwana]</td>
<td>100</td>
<td>20</td>
<td>2,900-4,100</td>
<td>Bituminous</td>
<td>ND</td>
</tr>
</tbody>
</table>

¹ Area of available map measured by planimeter
² Islam and Hayashi, 2008
³ GCM Resources plc (Asia Energy plc), 2005
⁴ Akhtar, 2000
⁵ Islam and others, 1992
⁶ Ghose, 2009
⁷ Imam and others, 2002
⁸ Ball and others, 1983
⁹ Elahi, 1995; Frielingsdorfe and others, 2008

NA – Not Available
ND – Not Determined
Map and cross section of the Barapukuria basin (modified from Islam, 2009)
Maps showing total coal thickness and depth of cover in the Phulbari basin (GCM Resources, 2005)
Map showing proved and probable areas of coal in the Khalaspir basin, and general cross section (modified from Hasan and Kamaluddin, 1990; and Islam and others, 1992)
Location map of the Dighipara basin
(Ghose, 2009; Google Earth, 2010)
Location map of the Jamalganj basin (modified from Imam and others, 2002)
## CBNG Reservoir Parameters

<table>
<thead>
<tr>
<th>Coalfield</th>
<th>Maturity ($R_o$)</th>
<th>Aggregate Coal Thickness (m)</th>
<th>Depth of Burial (m)</th>
<th>Estimated Gas Content (m$^3$/t) ‡</th>
<th>Coal Resources (billion tonnes)</th>
<th>Permeability (mD)</th>
<th>Potential OGIP (Gm$^3$)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Value</strong>¹</td>
<td>&gt;0.7</td>
<td>&gt;30</td>
<td>152–1,524*</td>
<td>6–7</td>
<td>&gt;1</td>
<td>&gt;1.5</td>
<td>—</td>
</tr>
<tr>
<td><strong>Barapukuria</strong>²</td>
<td>0.55–0.84</td>
<td>21.63–74.31</td>
<td>118–518</td>
<td>6.51–12.68</td>
<td>0.377</td>
<td>9.8–137.8</td>
<td>3.6–5.1</td>
</tr>
<tr>
<td><strong>Phulbari</strong>³</td>
<td>0.82</td>
<td>15–70</td>
<td>120–240</td>
<td>9.6</td>
<td>0.572</td>
<td>ND</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Khalaspir</strong>⁴</td>
<td>0.79–0.94</td>
<td>23.21–59.10</td>
<td>257–483</td>
<td>9.6</td>
<td>0.685</td>
<td>ND</td>
<td>6.6</td>
</tr>
<tr>
<td><strong>Dighipara</strong>⁵</td>
<td>0.7–1.1</td>
<td>61.38 (Avg.)</td>
<td>323–408</td>
<td>9.6</td>
<td>0.6</td>
<td>ND</td>
<td>5.8</td>
</tr>
<tr>
<td><strong>Jamalganj</strong>¹</td>
<td>0.66–0.84</td>
<td>18.59–99.49</td>
<td>640–1,158</td>
<td>10.7–12.8</td>
<td>1.053</td>
<td>ND</td>
<td>12.3</td>
</tr>
<tr>
<td>**Jharia (India)**⁶</td>
<td>0.84–1.46</td>
<td>75–110</td>
<td>300–1,200</td>
<td>9.8–21.7</td>
<td>12.3†</td>
<td>0.03–3.0</td>
<td>85</td>
</tr>
<tr>
<td>**Bokaro (India)**⁷</td>
<td>0.95–1.06</td>
<td>70–140</td>
<td>300–1,500</td>
<td>15.8–17.0</td>
<td>3.2†</td>
<td>ND</td>
<td>45</td>
</tr>
<tr>
<td><strong>U.S. Projects</strong>¹⁸</td>
<td>0.7–1.2</td>
<td>7.6–30.5</td>
<td>150–1,000+</td>
<td>7.8–18.7</td>
<td>2.6–7.7</td>
<td>1–100</td>
<td>22.9–49.8</td>
</tr>
</tbody>
</table>

‡ Gas content reported on a dry, ash-free basis if known

*Typical depth range of productive CBNG reservoirs (Murray, 1996; Nolde and Spears, 1998)

†India coal resources from Chandra, K., 1997, Alternative hydrocarbon resources in the next millenium: Geohorizons (Society of Petroleum Geophysicists), 18 p.

¹ Imam and others, 2002
² Islam and Hayashi, 2008
³ Asia Energy plc (GCM Resources plc), 2005
⁴ Islam and others, 1992
⁵ Ghose, 2009
⁶ Laxminarayana and Crosdale, 2002; Peters, 2000; Verma, 2005
⁷ Laxminarayana and Crosdale, 2002; Pophare and others, 2008; Verma, 2005
⁸ Jenkins and Boyer, 2008
Coal Depth Range and Coal Resources (Million Tonnes) for Coal Occurrences in Bangladesh
Determination of Gas Content

- Direct Measurement
  - Lost gas
  - Measured gas
  - Residual gas

- Indirect Measurement
  - Analogy
  - Empirical formula
  - Adsorption Isotherm

Gas Storage Capacity (Isotherm)

- Methane Storage Capacity: 450 scf/ton
- Initial Gas Content: 355 scf/ton
- Critical Desorption Pressure: 632 psia
- Initial Reservoir Pressure: 1,620 psia
- Abandonment Gas Content: 125 scf/ton
- Abandonment Pressure: 100 psia

Gas Recovery Factor: \((230/355) \times 100 = 64.8\%\) scf/ton
Geologic and Hydrologic Conditions

- Depositional environment (facies, organic source and preservation)
- Diagenetic history (thermal maturity)
- Structure (folds, faults), topography
- Alteration (igneous intrusion, mineralization)
- Character of aquifers (dimensions, lithology, permeability, pressure)

![Geologic and Hydrologic Conditions Diagram]

- Regional Aquifer
- TQ
- P
- pC
- Fracture conduit
- Reservoir leakage
- Potential Target

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CBNG — Markets and Infrastructure

Natural Gas for Domestic and Industrial Use

Gas-fired Combustion Turbine Generators

Natural Gas Fertilizer Factory, Fenchuganj

Gas Pipeline

Power Transmission Lines

(www.un.org)

(www.freefoto.com)

(www.adb.org)

(www.bjc.gov.bd)

(GNU Photo)
Conclusions

- **CBNG Resource Small Compared to Conventional Gas**
  - 34 Gm$^3$ potential OGIP vs. 532 Gm$^3$ remaining reserves
  - Total known coal area 80 km$^2$
  - Deep coal beds (>2,000 m BSL) problematic

- **Jamalganj Most Likely CBNG Prospect**
  - Best geologic and hydrologic setting
  - Reservoir parameters favorable for exploration
  - Sampling program needed to determine gas content

- **Frontier Area with Potential Undiscovered Resources**
  - Known Gondwana basins still untested for coal
  - Uncertain CBNG potential in coal-bearing areas
  - Infrastructure underdeveloped in region
Thank You for Your Attention

For additional information, please contact:

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References Cited


References Cited (continued)


