Status of Unconventional Gas in North America

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AJM Petroleum Consultants

CSUG/PTAC –
7th Annual Unconventional Gas Symposium
November 8th 2005
Predictions:

2002 – Predicted Alberta’s and probably Canada’s natural gas production had peaked. (Published: CSPG Reservoir, January 2003)


2005 - …………………
..... And a Challenge

We are all experts in the field of natural gas so.....

Take out your business card and write the answer to the following question on the back:

**What will the AECO spot price in $’s CDN per GJ be on the 1st November 2006?**
- The price was $9.98 CDN per GJ on 1\textsuperscript{st} November 2005

Drop your card in the container at the entrance.

I will report back at the next Conference and award a prize to the person closest to the correct answer.
Presentation Format

- What is unconventional gas?
- Current production in North America
- Resources and reserves
- What unconventional opportunities should we consider?
- Issues
- The need for more research and a comprehensive energy plan
Unconventional Gas Reservoirs

• ‘Any methane not trapped in a porous, permeable, buoyancy driven system”
• Characteristics – extremely variable – (often)
  – Methane not freely dispersed
  – Low or heterogeneous permeability
  – Source rock and reservoir closely related
  – Large, low concentration resources
  – Unusual pressure regimes
• ‘More Challenging to extract’
• In many cases a poorer quality of conventional gas
Current Gas Production in North America
North American Gas Production

North American Peak Production?

U.S. Peak

Cdn Total

U.S. Total

U.S. CBM

U.S. Other

U.S. ‘Conventional’

Source BP, 2005 and Others
The Gap between US Gas Production and Consumption (BP, 2005)

12+Bcf/d Canadian imports, LNG
Prices began to rise in North America when Alberta production growth failed to meet demand.
Canada’s Natural Gas Production
(Bcf/d Adapted from CAPP Data)

Production Growth controlled by pipeline capacity

E Canada
Rest WCSB
Alberta

Peak?

Record Prices
Record Activity
Production Flat to Declining
Not Sustainable
Contribution of Unconventional Gas Production, WCSB, December 2004

33% of Production, 50% of Current Activity?

Source: PetroCube 2005
In North America:

Approximately 22Bcf/d of current gas production is “Unconventional Gas”

Unconventional gas production may outstrip conventional production within 5 years

(Which is why North America has the most expensive natural gas production in the World)
The Difference Between Resources and Reserves
Canada’s Resources and Reserves Natural Gas

(Conventional data adapted from CGPC 2001)

?10,000 Tcf

Ultimate Resources

Total Conventional + Unconventional

592 Tcf

Discovered

>1,000 Tcf

340 Tcf

Raw Gas

204 Tcf

Sales Gas

Remaining Reserves

Unproduced

55 Tcf

(>95% WCSB)

Rate of Conversion:

Accessibility Technology

Price Motivation
Understanding Remaining Gas Resources
– Accessible and Economically Available

<table>
<thead>
<tr>
<th>Available at current prices</th>
<th>Accessible</th>
<th>Accessible with restrictions</th>
<th>Inaccessible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presently Available Resources (Reserves)</td>
<td>Future Available Resources</td>
<td>Available at higher prices or New Technology</td>
<td>Future Available Resources</td>
</tr>
</tbody>
</table>

Can apply this approach to Conventional and Unconventional Resources

Source: Russum, CSEG Recorder, June 2003
# Understanding Remaining Gas Resources

- Accessible and Economically Available

<table>
<thead>
<tr>
<th></th>
<th>Accessible</th>
<th>Accessible with restrictions</th>
<th>Inaccessible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available at current prices</td>
<td>55Tcf</td>
<td>50Tcf? Resources</td>
<td>20Tcf? Resources</td>
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<tr>
<td></td>
<td>Discovered Reserves, 20Tcf? Undiscovered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available at higher prices or by New Technology</td>
<td>50Tcf? Resources</td>
<td>100Tcf? Resources</td>
<td>10000Tcf??? Resources</td>
</tr>
</tbody>
</table>

Will be updating these numbers with the CGPC

Much of amber and red resources are unconventional – the Challenge

Source: Russum, 2005
Distribution of Rock in the Western Canada Sedimentary Basin (WCSB)

1,800,000km³

- Shales 38%
- Carbonates 28%
- Sands 8%
- Coal <1%
- Evaporites 4%
- Shallow mixed lithology 22%

500,000km³

(Too shallow for thermogenic gas generation)

Conventional Porous ~6% → Conventional Productive 1%?

Source: Russum, 2005
Distribution of Rock in the WCSB

**CONVENTIONAL**
- Tight/Fractured Gas (Deep Basin)
- Biogenic Gas (Milk River, Med Hat)
- Shale Gas
- CBM
- Coal <1%
- Carbonates 28%
- Evaporites 4%
- Shale 38%

**UNCONVENTIONAL**
- Tight/Fractured Gas (eg. Jean Marie)
- Shale Gas
- UNCONVENTIONAL Potential 94%
- Tight Gas?
- Shallow mixed lithology 22%
- Sands 8%
- @1cu.ft/ton = 5000Tcf Gas
What Unconventional Opportunities Should we be Considering?
Unconventional Gas - Types

- Shallow Gas
  - Biogenic in clastic reservoirs
  - Ultra shallow gas
- ‘Tight’ Gas
  - In clastic and carbonate reservoirs
- Deep Basin Gas (Basin Centred Gas)
- Coalbed Methane (CBM)
  - Also called Natural Gas from Coal (NGC)
- Shale Gas
- Gas Hydrates
  - in molecular structure of ice
- Inorganic Methane(?)
- Continuously (Currently) Generated Methane
# Unconventional Gas – Resources and Status

(*From various sources*)

<table>
<thead>
<tr>
<th>Resource in USA*</th>
<th>Status USA</th>
<th>Resource in Canada*</th>
<th>Status Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shallow Biogenic Gas</strong></td>
<td>20Tcf</td>
<td>On-going Production</td>
<td>40Tcf</td>
</tr>
<tr>
<td><strong>Tight Gas (&lt;0.1md)</strong></td>
<td>&gt;700Tcf</td>
<td>Opportunity?</td>
<td>600Tcf</td>
</tr>
<tr>
<td><strong>Deep Basin/BCG</strong></td>
<td>1949Tcf</td>
<td>Production since 1970’s</td>
<td>400-700Tcf</td>
</tr>
<tr>
<td><strong>Coalbed Methane</strong></td>
<td>749Tcf</td>
<td>Production since 1970’s</td>
<td>400-700Tcf</td>
</tr>
<tr>
<td><strong>Shale Gas</strong></td>
<td>600Tcf</td>
<td>Production since 1827</td>
<td>100-900Tcf?</td>
</tr>
<tr>
<td><strong>Gas Hydrates</strong></td>
<td>1000Tcf?</td>
<td>Experimental Research</td>
<td>5000Tcf?</td>
</tr>
<tr>
<td><strong>Continuously Generated Methane</strong></td>
<td>3Bcf/d?</td>
<td>Pilot Projects</td>
<td>400Mmcf/d?</td>
</tr>
</tbody>
</table>
# Unconventional Gas – Issues

(Scale 1-5, where 1=Good, 5=Bad)

<table>
<thead>
<tr>
<th>Resource in Canada*</th>
<th>Status Canada</th>
<th>Timing</th>
<th>Environmental</th>
<th>Cost</th>
<th>Score</th>
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</thead>
<tbody>
<tr>
<td>Shallow Biogenic Gas</td>
<td>Production since 1905</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Tight Gas (&lt;0.1md)</td>
<td>?</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Deep Basin/BCG</td>
<td>Production since 1976</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Coalbed Methane</td>
<td>Production since 2002</td>
<td>1 - 4</td>
<td>2 - 5</td>
<td>2 - 4</td>
<td>5 - 14</td>
</tr>
<tr>
<td>Shale Gas</td>
<td>Experimental activity</td>
<td>3</td>
<td>3</td>
<td>3+</td>
<td>9+</td>
</tr>
<tr>
<td>Gas Hydrates</td>
<td>Experimental Research</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Inorganic Methane</td>
<td>?</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Continuously Generated Methane</td>
<td>Pilot Projects</td>
<td>2</td>
<td>-2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Liquefied Natural Gas</td>
<td>Start-up 2008</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>
Coalbed Methane
Horseshoe Canyon Current Productivity  (AJM Database, production to June 2005)
Horseshoe Canyon Production (AJM, 2005)

- Coal depth: 200-300m
- Median = 79mcf/d

Map: Belly River TVD
## WCSB Coalbed Methane

<table>
<thead>
<tr>
<th>Coalbed</th>
<th>Resource Potential</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ardley Coal WC Alberta</td>
<td>Low/Moderate</td>
<td>Limited activity, freshwater issues</td>
</tr>
<tr>
<td>Horseshoe Canyon Coal</td>
<td>High</td>
<td>Focus of current activity, readily accessible, dry gas</td>
</tr>
<tr>
<td>Mannville Coal WC Alberta</td>
<td>Very High</td>
<td>Requires de-watering – moving to commercial phase e.g. Trident/Nexen, Corbett Creek</td>
</tr>
<tr>
<td>Mannville Coal NE BC</td>
<td>Moderate?</td>
<td>Experimental activity, - 7 permits granted, confidential results</td>
</tr>
<tr>
<td>Kootenay Coal SE BC</td>
<td>Moderate</td>
<td>Experimental, Encana, Devon. Coal continuity and environmental challenges</td>
</tr>
</tbody>
</table>
Shale Gas
What is Shale Gas?

- **Grain Size, Matrix Permeability**
  - High
  - Low

- **Organic Content**
  - Low
  - High

- **Conventional Gas**
- **Unconventional Gas**
- **Shale Gas**
- **C.B.M. (Coal Bed Methane)**

Free Gas in Fractures and Adsorbed to Organics
Typical US Gas Productive Shales (Curtis, 2002)

Major producing Shales:
Mississippian: Barnett Shale (Fort Worth Basin).
Cretaceous: Lewis Shale (San Juan Basin)

Criteria:
Total Organic Carbon (TOC): Min >1%, Prefer >3.5%
Thermal maturity: Vitrinite reflectance Min >0.4%, Prefer >1%
Shale thickness: >10m
Gas content: Free gas + adsorbed gas >1.2cc/g. (>40scf/ton)
Natural permeability: Fractured (or ability to fracture)
Shale Gas potential in the WCSB

- Cretaceous
  - Colorado (Second White Specks)
  - Upper Mannville (Clearwater, Wilrich)
- Jurassic
  - Fernie
- Mississippian
  - Exshaw/Bakken, Besa River
- Devonian
  - Besa River
  - Fort Simpson
  - Muskwa
  - Duvernay
Geometry of WCSB

Surface

Minimum depth for thermogenic gas generation

Free Gas

GAS WINDOW

Adsorbed Gas

5000m

W

E

0m

Basement
Thickness of Shale in WCSB (Metres)

Source: PetroCube, 2005
Shale in WCSB (% of Sedimentary rock)

Source: PetroCube, 2005
## Comparison of Devonian shales, NEBC
(adapted from CBM Solutions, 2005)

<table>
<thead>
<tr>
<th></th>
<th>Avg. Thickness (meters)</th>
<th>Avg. TOC (%)</th>
<th>Avg. Gas Capacity (cc/g)</th>
<th>Thermal Maturity</th>
<th>Natural Fractures?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exshaw</strong></td>
<td>5 - 10</td>
<td>5%</td>
<td>1.3</td>
<td>Mature</td>
<td>Selective</td>
</tr>
<tr>
<td><strong>Besa River</strong></td>
<td>450 - 500</td>
<td>4.3%</td>
<td>0.8</td>
<td>Mature</td>
<td>Selective</td>
</tr>
<tr>
<td><strong>Fort Simpson</strong></td>
<td>475 - 525</td>
<td>0.4%</td>
<td>0.3</td>
<td>Mature</td>
<td>Selective</td>
</tr>
<tr>
<td><strong>Muskwa</strong></td>
<td>15 - 25</td>
<td>3.1%</td>
<td>0.7</td>
<td>Mature</td>
<td>Selective</td>
</tr>
</tbody>
</table>
Challenges for Unconventional Gas Production
Unconventional Gas - Producibility

• Low productivity (low decline rates?)
• Low recovery factors (opportunity)
• Require greater drilling density
• Increased infrastructure and surface impact
• Environmental issues – NIMBY, BANANA, NOPE, NITU
• Technologically challenging to produce:
  – Area and resource specific solutions
  – Low risk once specific solutions identified
• Relatively high development and operating costs
The Future of Natural Gas in Canada.....
The Issues

• Natural gas price is currently at record high levels
• What will high prices do to long term demand?
  – Expansion of tar sands and gas-fired power generation in Ontario - growth areas for natural gas?
  – Plastics, fertilizer and methanol - victims of high price
• Who is doing the exploration and research to sustain gas production?
• Canada’s obligations to NAFTA if gas production declining?
• Canada’s obligations to Kyoto if gas replaced by coal?
• How fast might LNG imports to North America grow?
• What happens to the Canadian gas industry if LNG is cheaper than domestic gas?
• What happens to the Canadian economy if our energy is more expensive than the rest of the world?
Conclusions

• North America’s gas demand will far outstrip conventional North American supply

• Unconventional gas is already a significant contributor but we need to expand that effort many times over

• Governments must take a lead in encouraging research and development of all energy resources along with education on the need for substantial conservation

• A Canadian Energy Plan that recognizes the problems and develops realistic solutions is vital to the future economic well-being of Canada (Alberta Government and Industry should take lead in this process)
A Prediction……

A supply disruption (real or perceived) or weather related demand increase will spike natural gas price to >$20 CDN per GJ in the next 12 months

Dave Russum (1st Sept 2005)
Thank you (Don’t forget to drop off your business card with gas prediction)

More Information?

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