Shale Gas in Canada
An Overview

October 4, 2010

Canadian Society for Unconventional Gas
Canada’s Natural Gas Use and Pipeline Network
• First Canadian well drilled in 1889

• Canada is the world’s third largest gas producer and exporter

• Gas provides 25% of Canada’s total energy demand and is the largest energy source in the residential, commercial and industrial sectors
  • 48% residential
  • 45% commercial
  • 32% industrial
  • <1% transportation

• Growing volumes used to generate power
• Export revenues between $15-30 billion/year
A Reliable Supply Network

- Over 480,000 km of pipeline forms an interconnected North American pipeline network that provides reliable and safe delivery of natural gas.

- Backstopped by storage facilities that can hold 55 days of average daily North American natural gas consumption.

- Market supply:
  - 78% of supply from US
  - 21% from Canada
  - 2% LNG.
Canada’s Natural Gas Resources
Canada’s Natural Gas Resource Base

Marketable Gas Resource has Grown Significantly and Rapidly

2009 Produced: 5.6 TCF
Gross Exports: 3.3 TCF
Imports: 0.7 TCF
Domestic Consumption: 3.0 TCF

Note: 1 Tcf of gas = water and space heat for 10 million homes for a year
## Canada’s Marketable Natural Gas Resource Base (TCF)

<table>
<thead>
<tr>
<th>Resource Type</th>
<th>TCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coalbed Methane</td>
<td>34 – 129</td>
</tr>
<tr>
<td>Tight Gas</td>
<td>215 – 476</td>
</tr>
<tr>
<td>Shale Gas</td>
<td>128 – 343</td>
</tr>
<tr>
<td>Sub-Total Unconventional</td>
<td>376 – 947</td>
</tr>
<tr>
<td>Conventional</td>
<td>357</td>
</tr>
</tbody>
</table>

**Total Resource Base***  
733 - 1304

*Note: CSUG does not yet include natural gas hydrates in Canada’s resource base. Although hydrates have vast potential, research is at an early stage and it is difficult to anticipate whether the resource will be commercially developed.
Canada’s Natural Gas Resource Base

Conventional Natural Gas Projected Marketable Resource

Total 357 Tcf
(TCF – trillions of cubic feet)

July 14, 2010
Canada’s Natural Gas Resource Base

Natural Gas from Coal
Projected Marketable Resource

Total 34 - 129 Tcf
(TCF – trillions of cubic feet)
Canada’s Natural Gas Resource Base

Tight Gas
Projected Marketable Resource
Total 215 - 476 Tcf
(TCF – trillions of cubic feet)
Canada’s Natural Gas Resource Base

Shale Gas
Projected Marketable Resource
Total 128 - 343 Tcf
(TCF – trillions of cubic feet)

July 14, 2010
Supply is Robust

- North America has a 100 year natural gas resource
- Unconventional gas, particularly shale gas and tight gas, will be a major contributor to Canadian markets
- Supply robustness assured by:
  - Geographic diversity
  - Conventional natural gas production
  - Expanded tight gas production in established areas
  - New shale and tight gas regions
  - LNG import capabilities
  - Extensive transportation and distribution network across Canada
  - Import and export connections with US Lower 48
  - Strategically located gas storage facilities
Shale Gas
Unconventional Gas Enabling Technologies

Technology has unlocked unconventional gas potential

• Fit-for-purpose rigs
• Long reach horizontal drilling
• Multi-stage hydraulic fracturing
  • Slickwater technology
  • Microseismic analysis
• Multi-well drilling pads
• Manufacturing style approach to all operations (gas factories)
Unconventional Gas Enabling Technologies

- Pad wells, horizontal drilling, multi-stage fracturing
  - Lighter environmental footprint
  - “Manufacturing” approach
  - Economies of scale
Unconventional Gas Enabling Technologies

• Microseismic monitoring
  • Used in many places to improve understanding of fracturing operation
  • Allows monitoring lateral and vertical extent and nature of fracs
    • Vertical extent of frac typically 100-200 m
    • Lateral extent typically 200-500 m
  • Assists in continuous improvement of fracking practices

• Sophisticated and complex production testing can aid in understanding of reservoir productivity and appropriate staging of fracs
What Makes a Good Shale Gas Play?

- Many variables
- Small changes can have big impact

**Below-Ground Factors**
- Organic content, maturity
- Rock quality (perm, porosity)
- High Pressure (11 kpa/m)
- Thickness
- Frac-ability, brittleness,
- Depth, development costs

**Above-Ground Factors**
- Access to large mineral tracts
- Fiscal burdens (royalties, taxes)
- Regulatory environment
- Gathering & processing costs
- Transportation costs, distance to market

Steady improvement in reservoir understanding and surface logistics combined with technology refinements lead to reduced costs and increased production rates (Horn River and Montney examples on next slide).
Industry Addressing Competitiveness Challenge

Continuous cost and performance improvements

Well Cost Evolution ($C)
Montney – Cost Per Frac Interval

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost ($MM/Frac stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1.50</td>
</tr>
<tr>
<td>2007</td>
<td>0.95</td>
</tr>
<tr>
<td>2008</td>
<td>0.79</td>
</tr>
<tr>
<td>2009</td>
<td>0.65</td>
</tr>
<tr>
<td>2010F</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Horn River – Cost Per Frac Interval

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost ($MM/Frac stage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>2.0</td>
</tr>
<tr>
<td>2009</td>
<td>1.0</td>
</tr>
<tr>
<td>2010F</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Well Performance Evolution
Montney – Production Rate (Per Well)

<table>
<thead>
<tr>
<th>Year</th>
<th>Production Rate (MMcfe/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>2.1</td>
</tr>
<tr>
<td>2007</td>
<td>3.9</td>
</tr>
<tr>
<td>2008*</td>
<td>3.7</td>
</tr>
<tr>
<td>2009</td>
<td>4.7</td>
</tr>
<tr>
<td>2010F</td>
<td>5.3</td>
</tr>
</tbody>
</table>

*Decrease due to stepping out of core region

Horn River – Production Rate (Per Well)

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<td>9.1</td>
</tr>
<tr>
<td>2010F</td>
<td>11.7</td>
</tr>
</tbody>
</table>

Source: Encana
Regulatory and Environmental Considerations for Shale Gas
Shale Gas Activity

Development is very complex in terms of technology, equipment, and execution

• All work is part of a regulated process:
  - Consultation
  - Application Submission
  - Approvals with conditions
  - Rules for implementation and monitoring
  - Reclamation/remediation

• Experienced people and proper equipment ensure safety

• Drilling, completion, and pipeline tie ins require intense activity

• Low activity on a well pad once production is underway
Multi-well Pad Drilling Activity at Horn River

January 2010
Production Facilities

Horn River Pad site - Sept 2009
Regulatory Overview

- Shale gas activity primarily provincially regulated
- Each aspect of shale gas activity is regulated in each jurisdiction
  - Drilling and pre-drilling activities
  - Completions/fracing → water supply, disposal
  - Production → pipelines, facilities
  - Resource management → well spacing / densities, buffers
  - Abandonment and reclamation
- Although regulations differ in various jurisdictions primary functions of health, safety, and environmental protection are always addressed
- Stage of development dictates need for and type of regulation
Shale Gas Drilling

• Typical technology: horizontal drilling following a period of evaluation and testing using vertical wells
  • Length & depth of horizontal varies by play
  • Multiple wells on one pad
• Significantly reduced footprint compared to vertical well development
• Drilling is regulated in all jurisdictions, mainly through well licensing process
  • Consultation / notification provisions
  • Surface land access (road, wellsite)
  • Location / depth details required
  • Well construction techniques specified – casing, cementing
  • Protection of usable groundwater is KEY
  • Isolation of expected gas producing zones is important
Water Considerations
• Well casing and cementing techniques are used to isolate the producing formation from all formations above.
• Cement is pumped between the casing and the formation, and between the two casing strings.
• Casing and cement layer(s) provide isolation for any potential aquifer(s).
• Production casing and cement provide isolation for producing zones.
• Well cementing and casing techniques are used in all oil and gas wells.
• Hydraulic fracturing operations are not permitted to compromise the integrity of well construction.

Source: Canadian Natural Gas
Shale Gas Completions / Fracing

• More than a million hydraulic fracturing operations in North America during the past 50 years

• Many approaches to hydraulic fracturing for shales. Fraccing procedures are often basin specific, and although some methods use no water, water based fracs are typical today

• Typical technology
  • High pressure, high volume, multi-stage water-based fracs
  • Frac fluid returns (flowback) captured at wellsite and/or nearby facility
• Water supply is an important factor and is regulated in all jurisdictions
  • Identification of source is required and viability is reviewed
  • Licensing (water withdrawals) may be required
  • Volumes monitored

• Industry is working aggressively to reduce water use. Where practical, strategies include
  • Use of brackish or salt water for some or all of the supply necessary for fraccing operations
  • Recycling of portion of frac fluid that is produced after the fraccing operation
  • Fluid alternatives

• Development brings economies of scale to water management and encourages innovation

• Water disposal and handling is regulated in all jurisdictions
• Frac fluids are typically >99% water and proppant (natural or synthetic sand)
• Some additives are used to improve the ability of the water to:
  • increase viscosity (improves the fluid’s capacity to carry sand grains long distances)
  • mitigate reaction of water with some clay minerals
  • reduce surface tension and improve fluid flow characteristics
  • eliminate bacteria which can produce hydrogen sulfide and various compounds that can cause corrosion or inhibit gas flow in the reservoir
## Typical Frac Fluid Additives

<table>
<thead>
<tr>
<th>Type</th>
<th>Source</th>
<th>Pros/Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gellants or gelling agents:</strong> increase viscosity, proppant suspension and provide lubrication.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guar Gum (most common gellant in use)</td>
<td>Guar bean, grown in India and Pakistan. Used as a food additive.</td>
<td>Creates a natural polymer chain. Can be refined multiple times to improve its qualities such as methanol tolerance, decreased hydration time, and increased viscosity.</td>
</tr>
<tr>
<td>Polyacrylamide</td>
<td>Chemically produced long-chain molecule, known as a polymer. Commonly used in water treatment as a flocculent, or for products such as soft contact lenses.</td>
<td>Used to make water slippery for slickwater fracturing.</td>
</tr>
<tr>
<td><strong>Crosslinkers:</strong> used in small quantities to join polymers in a three-dimensional shape.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boron, zirconium, titanium, or iron</td>
<td>Naturally occurring elements, mined at various locations.</td>
<td>Increases the viscosity of the liquid by linking the polymers.</td>
</tr>
<tr>
<td><strong>Clay Control:</strong> used in water sensitive formations to prevent clays from swelling.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>Potash, used in the preparation of many types of fertilizer, KCl is also used occasionally as a table salt substitute.</td>
<td>Reduces damage to reservoirs by inhibiting the reaction of certain clay minerals with water.</td>
</tr>
<tr>
<td><strong>Breakers:</strong> Breaks the polymer chain created by the gelling agent.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxidizers</td>
<td>Manufactured substances that release oxygen</td>
<td>Reduces viscosity of polymers and allows the fluid to flow back to surface.</td>
</tr>
<tr>
<td>Enzymes</td>
<td>A naturally occurring agricultural by-product</td>
<td>Consumes Guar Gum polymers.</td>
</tr>
<tr>
<td><strong>Surfactants:</strong> lower the surface tension on the fracturing fluid.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow back additives</td>
<td>Akin to soap, these additives enhance the ability of water to flow back to surface following treatment.</td>
<td>Allows easier flow back of the fluid after the treatment is complete.</td>
</tr>
<tr>
<td><strong>Biocides:</strong> Prevent the introduction of sulphate reducing bacteria into wells.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural and manufactured biocides</td>
<td>Can be derived from bacteria or plants, or prepared from chemicals.</td>
<td>Prevents introduction of bacteria that can produce hydrogen sulphide (H₂S) or other corrosive or fouling chemicals or substances in the reservoir. Pumped in small quantities.</td>
</tr>
<tr>
<td><strong>Energizers:</strong> gases used to energize (or foam) fluids for fracturing treatments.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>Common element found in the atmosphere. Carbon Dioxide can exist as a liquid, gas or solid, (known as 'dry ice').</td>
<td>Odourless and non-toxic. Improves the recovery of fluid, while reducing the potential of formation damage. Carbon Dioxide is moderately soluble in water and highly soluble in oil, particularly under pressure.</td>
</tr>
<tr>
<td>Nitrogen (N₂)</td>
<td>A naturally occurring element, nitrogen is stored, transported and pumped as a cryogenic liquid, then heated and injected into the wellbore as a gas.</td>
<td>Improves recovery of stimulation or well fluids.</td>
</tr>
</tbody>
</table>
• Additives used in frac fluids are regulated through a variety of federal programs, Acts, and regulations, mainly under Environment Canada and Health Canada
  • Canadian Environmental Protection Act (CEPA)
  • Chemicals Management Plan
  • New Substances Program
  • Transportation of Dangerous Goods
  • Workplace Hazardous Materials Information System
  • Material Safety Data Sheet requirements
• These requirements govern the use, handling, storage, transportation, labeling, disposal, and worker training and certification requirements
• Labeling must identify potential hazards and appropriate response
Summary

• Canadian markets have assurance of a robust natural gas supply
• Unconventional resource development, including shale gas development occurs within a strong regulatory environment
  • Regulatory requirements and operator best practices focus on protection of the environment and water resources, and on minimizing the impact of resource development on communities and stakeholders
• Industry is working aggressively to address water use
• Hydraulic fracturing operations are governed first by requirements that operations do not compromise well construction, and secondly, by federal regulatory oversight related to additives used in fracturing fluids
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