Shale Gas in Canada
An Overview

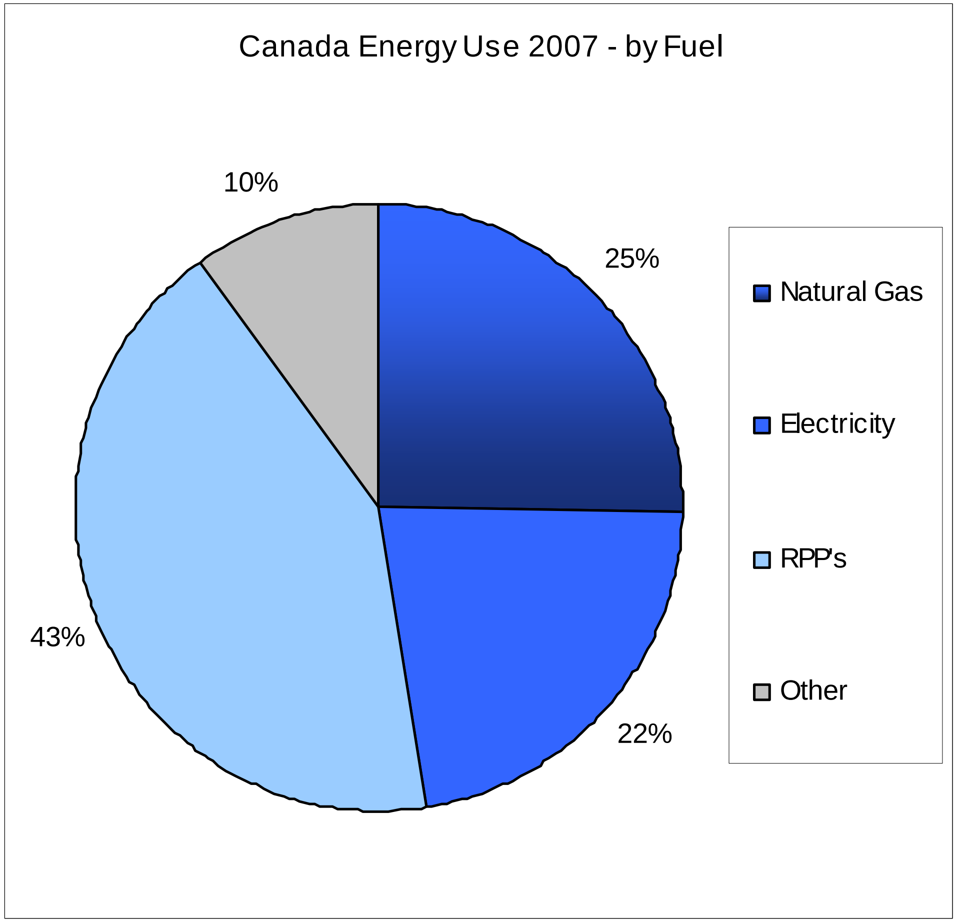
October 4, 2010

Canadian Society for Unconventional Gas

Canada's Natural Gas Use and Pipeline Network

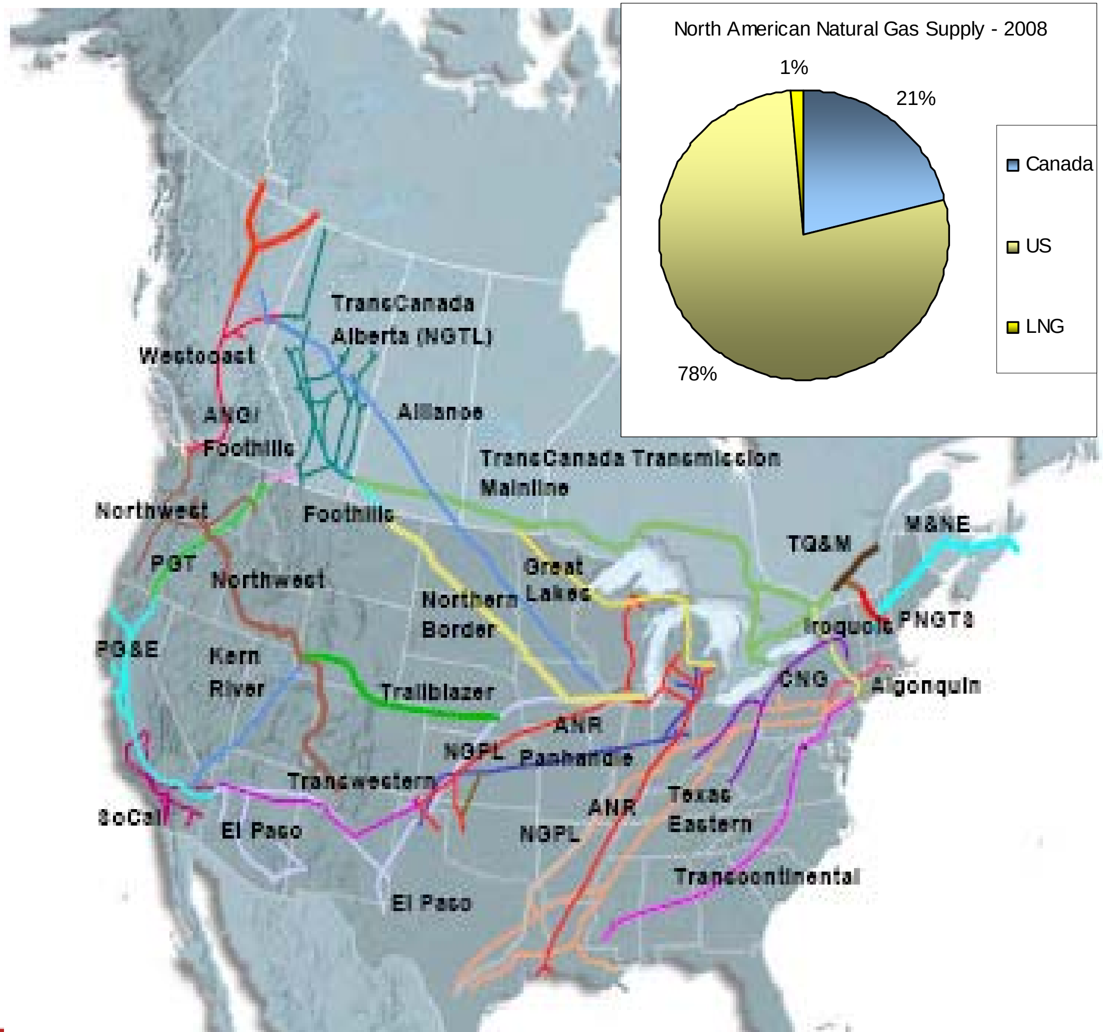
Natural Gas in Canada

- 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

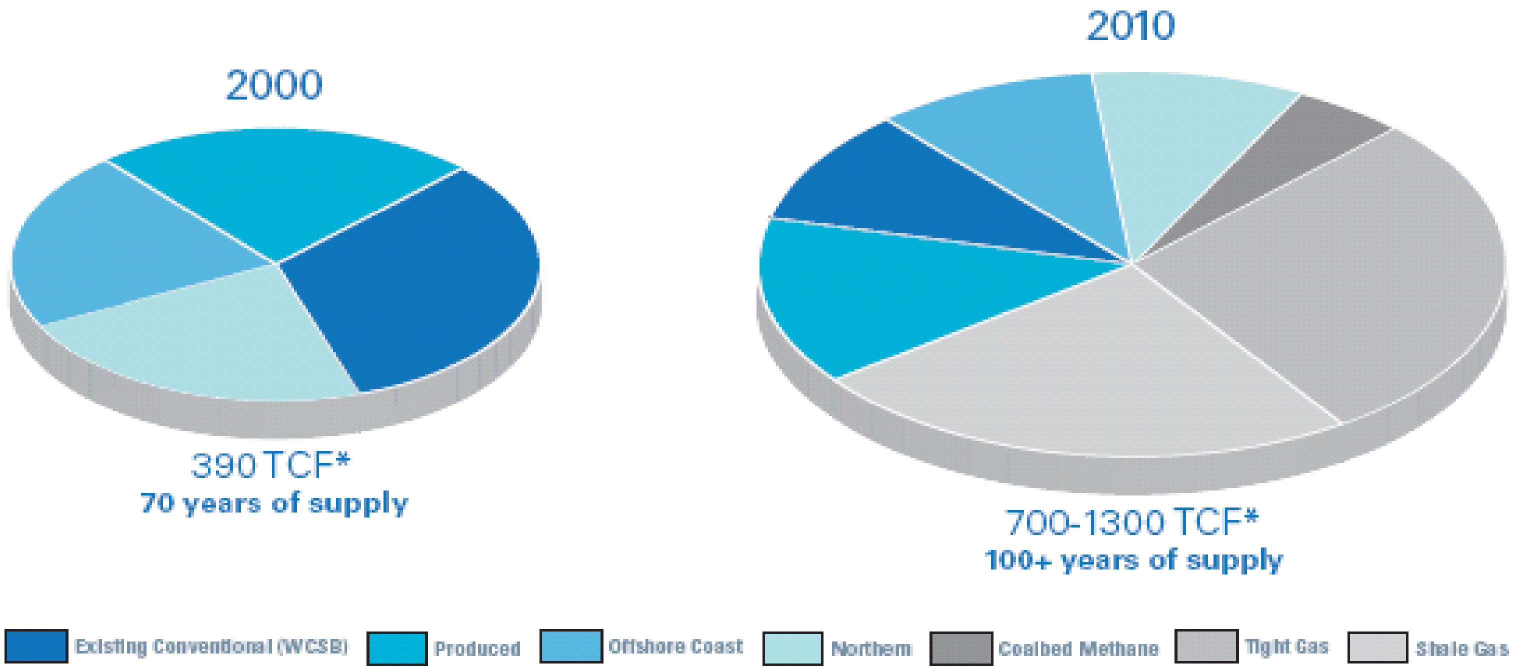
- Over 480,000 km of pipeline forms an interconnected North American pipeline network that provides reliable and safe delivery of natural gas.
- Backstopped by storage facilities that can hold 55 days of average daily North American natural gas consumption.
- Market supply:
  - 78% of supply from US
  - 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

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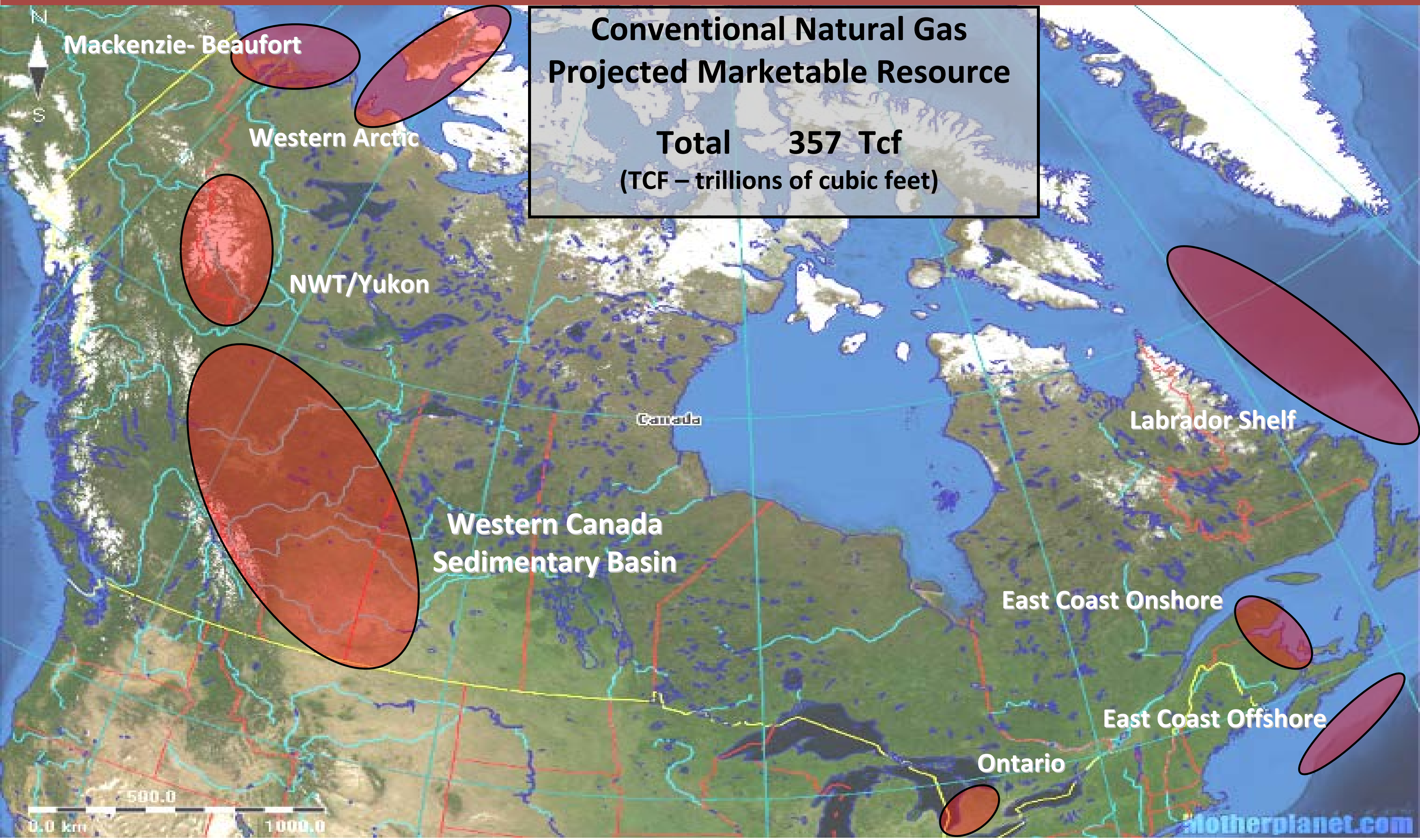
Summary

Canada's Marketable Natural Gas Resource Base (TCF)

Resource Type	TCF
Coalbed Methane	34 – 129
Tight Gas	215 – 476
Shale Gas	128 – 343
Sub-Total Unconventional	376 – 947
Conventional	357
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



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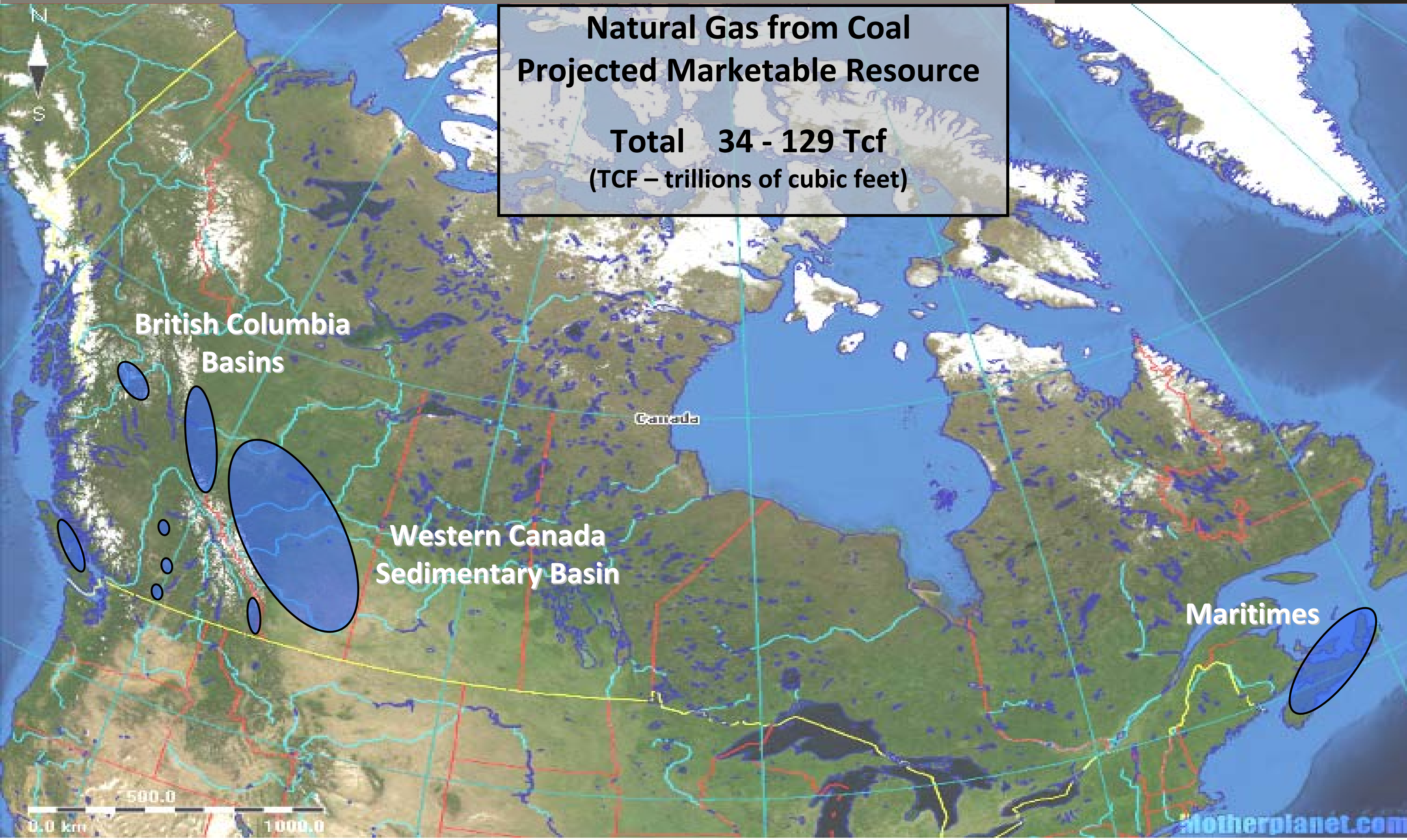
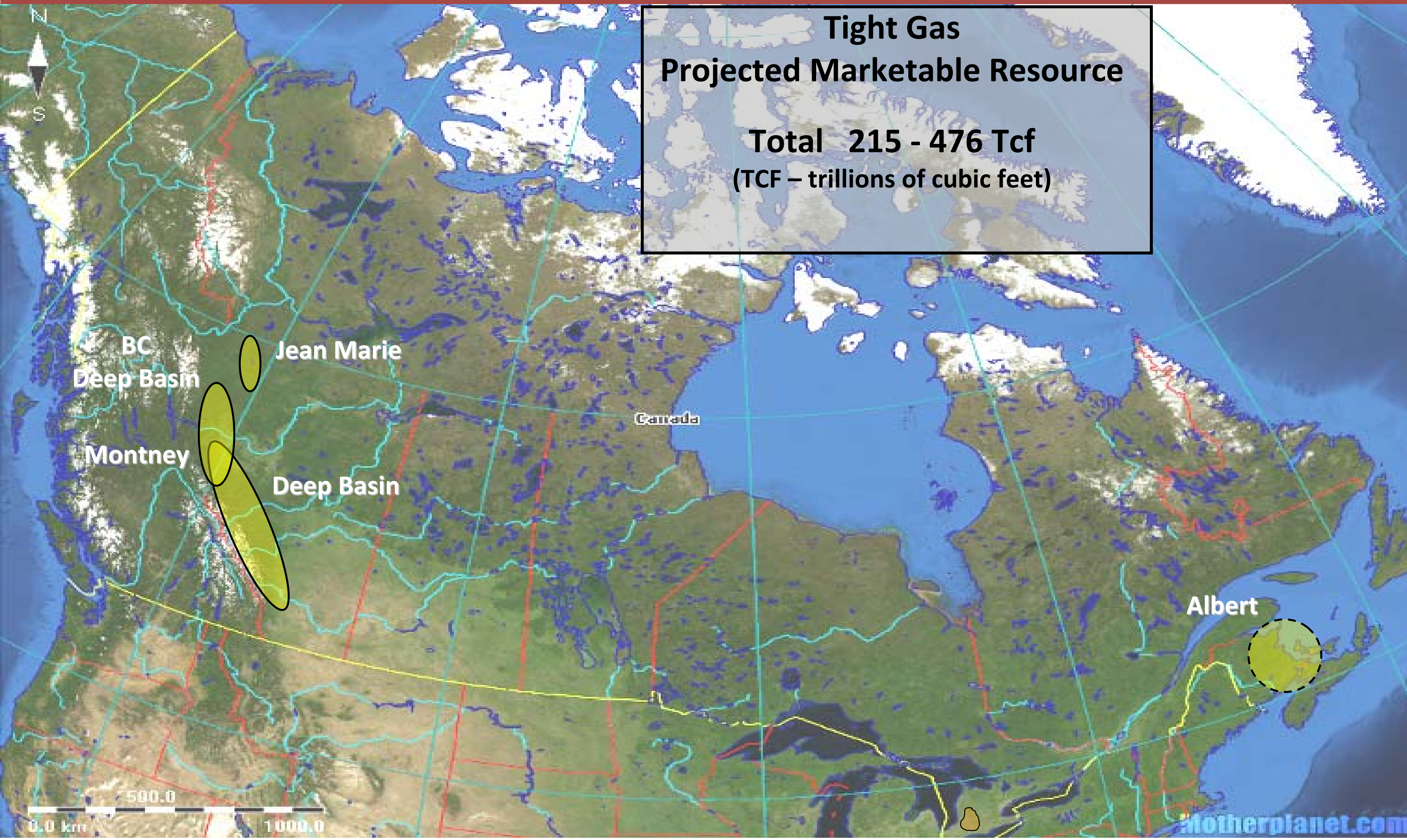
Canada's Natural Gas Resource Base



Canada's Natural Gas Resource Base



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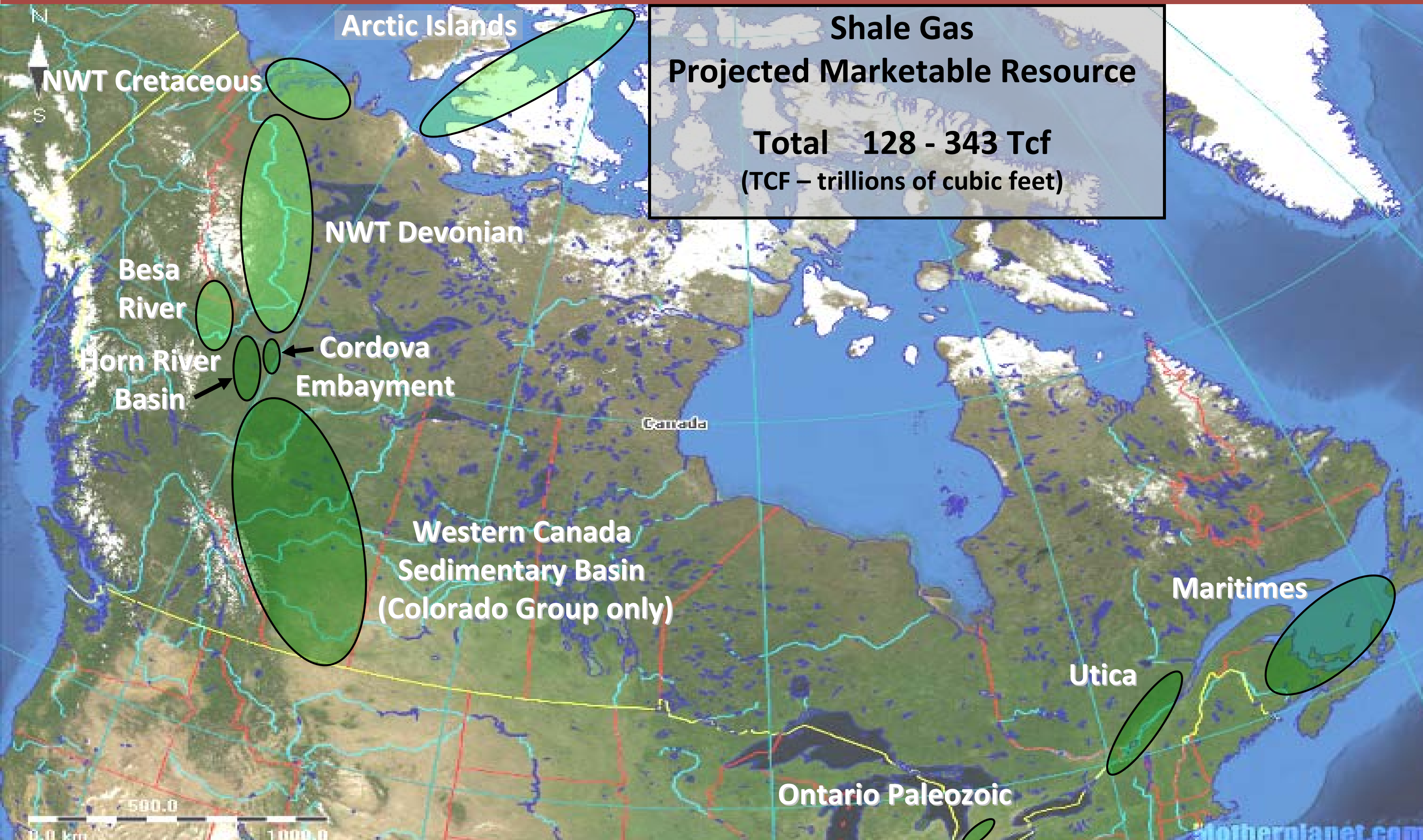
Canada's Natural Gas Resource Base



Shale Gas
Projected Marketable Resource

Total 128 - 343 Tcf
(TCF – trillions of cubic feet)

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

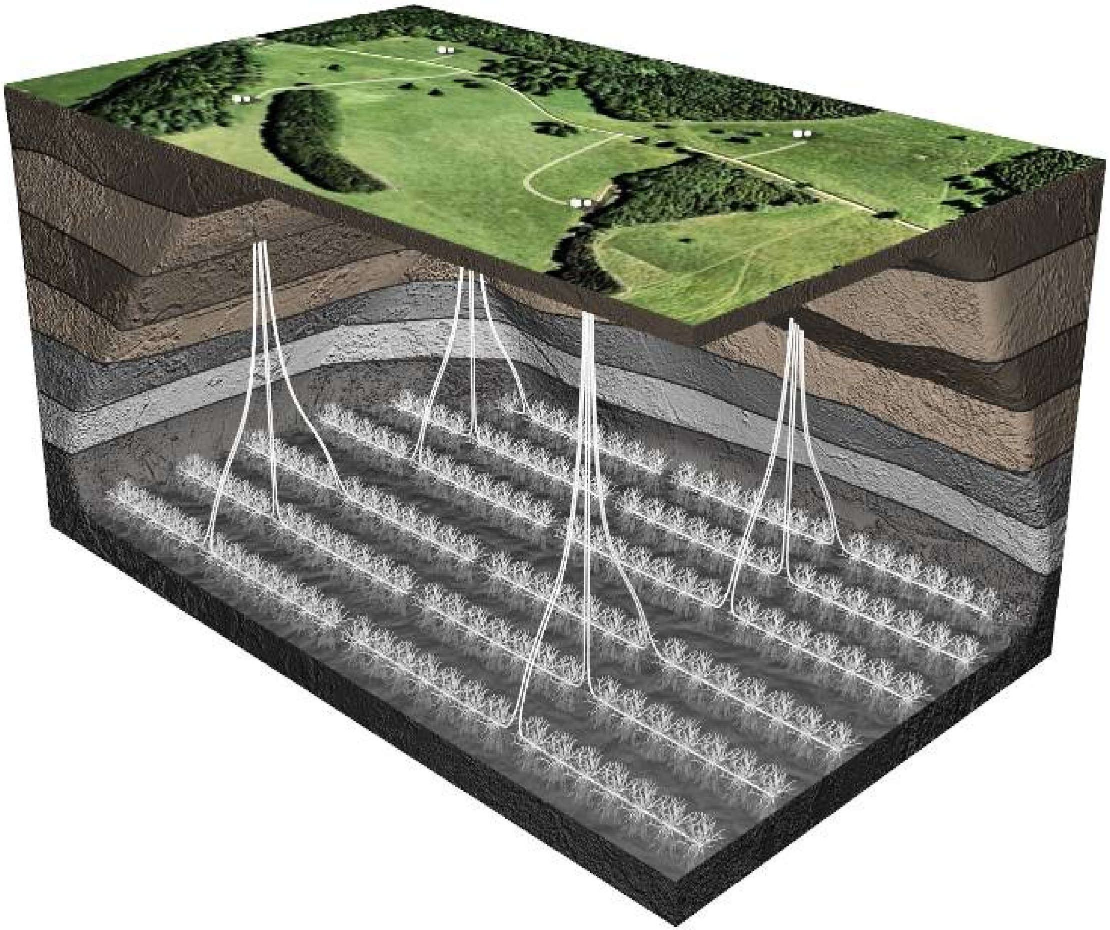
Unconventional Gas Enabling Technologies

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



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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 typically100-200 m
    - Lateral extent typically 200-500 m
  - Assists in continuous improvement of fraccing 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**

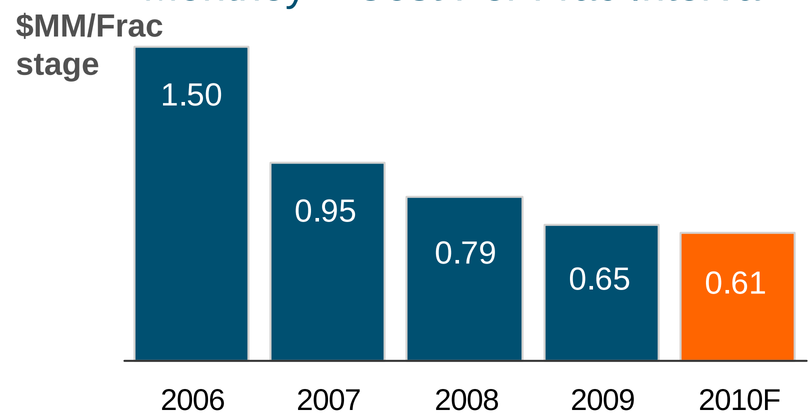
Below-Ground Factors	Above-Ground Factors
• Organic content, maturity • Rock quality (perm, porosity) • High Pressure (11 kpa/m) • Thickness • Frac-ability, brittleness, • Depth, development costs	• Access to large mineral tracts • Fiscal burdens (royalties, taxes) • Regulatory environment • Gathering & 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).

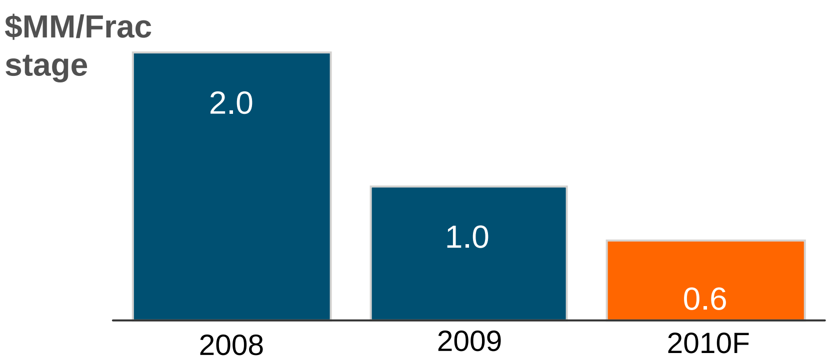
Continuous cost and performance improvements

Well Cost Evolution ($C)

Montney – Cost Per Frac Interval

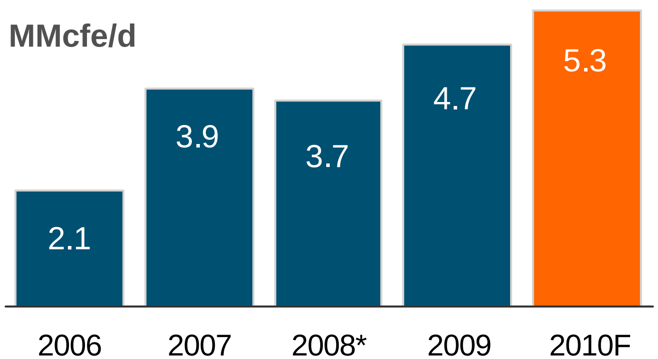


Horn River – Cost Per Frac Interval



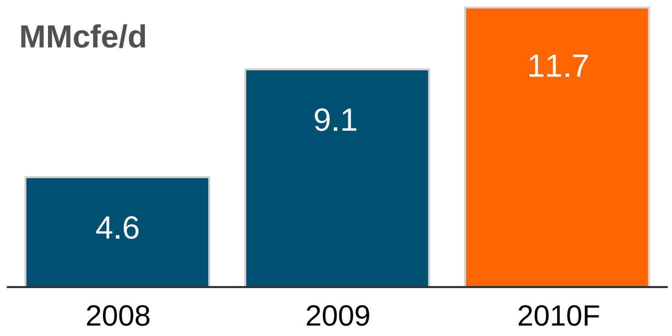
Well Performance Evolution

Montney – Production Rate (Per Well)



*Decrease due to stepping out of core region

Horn River – Production Rate (Per Well)



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

Shale Gas Frac Operations

Horn River – Jan 2010

Production Facilities

Horn River Pad site - Sept 2009

Regulatory Overview

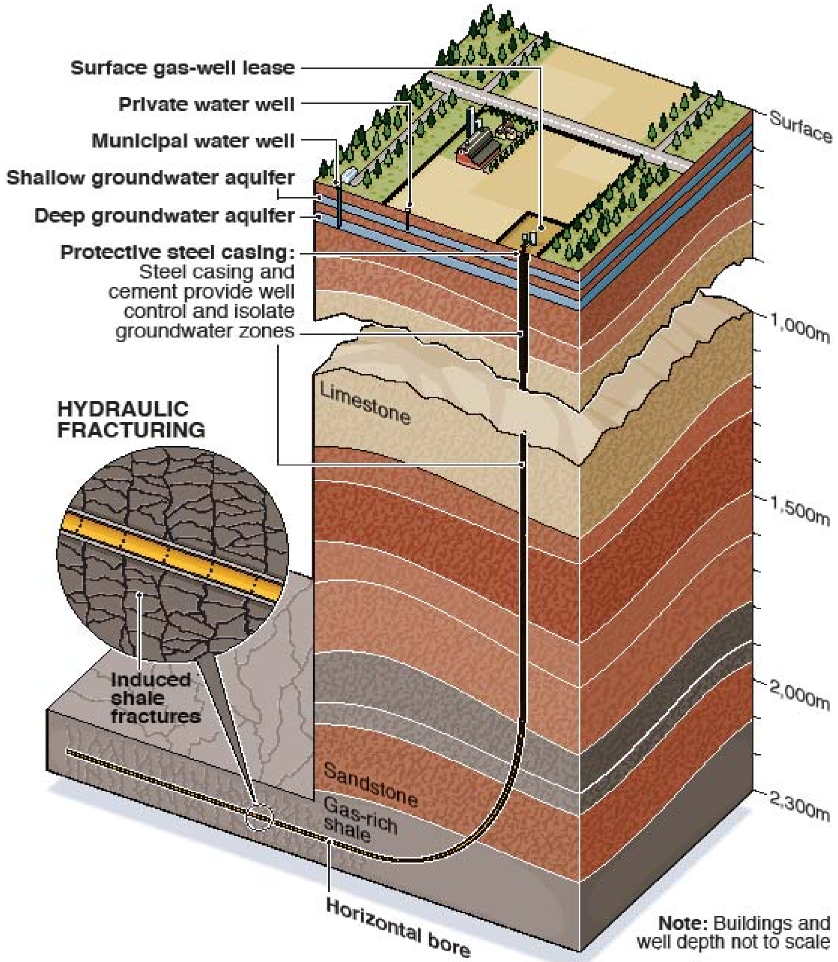
- Shale gas activity primarily provincially regulated
- Each aspect of shale gas activity is regulated in each jurisdiction
  - Drilling and pre-drilling activities
  - Completions/fracing → water supply, disposal
  - Production → pipelines, facilities
  - Resource management → well spacing / densities, 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

Groundwater Protection: Well Construction



Source: Canadian Natural Gas

- 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

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

Shale Gas Completions / Fracing – cont’d

- 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

Shale Gas Completions / Fracing – cont'd

- 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

Type	Source	Pros/Cons
Gellants or gelling agents: increase viscosity, proppant suspension and provide lubrication.		
Guar Gum (most common gellant in use)	Guar bean, grown in India and Pakistan. Used as a food additive.	Creates a natural polymer chain. Can be refined multiple times to improve its qualities such as methanol tolerance, decreased hydration time, and increased viscosity.
Polyacrylamide	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.	Used to make water slippery for slickwater fracturing.
Crosslinkers : used in small quantities to join polymers in a three-dimensional shape.		
Boron, zirconium, titanium, or iron	Naturally occurring elements, mined at various locations.	Increases the viscosity of the liquid by linking the polymers.
Clay Control: used in water sensitive formations to prevent clays from swelling.		
Potassium Chloride	Potash, used in the preparation of many types of fertilizer, KCl is also used occasionally as a table salt substitute.	Reduces damage to reservoirs by inhibiting the reaction of certain clay minerals with water.
Breakers: Breaks the polymer chain created by the gelling agent.		
Oxidizers	Manufactured substances that release oxygen	Reduces viscosity of polymers and allows the fluid to flow back to surface
Enzymes	A naturally occurring agricultural by-product	Consumes Guar Gum polymers.
Surfactants: lower the surface tension on the fracturing fluid.		
Flow back additives	Akin to soap, these additives enhance the ability of water to flow back to surface following treatment.	Allows easier flow back of the fluid after the treatment is complete.
Biocides: Prevent the introduction of sulphate reducing bacteria into wells.		
Natural and manufactured biocides	Can be derived from bacteria or plants, or prepared from chemicals.	Prevents introduction of bacteria that can produce hydrogen sulphide (H_2S) or other corrosive or fouling chemicals or substances in the reservoir. Pumped in small quantities.
Energizers: gases used to energize (or foam) fluids for fracturing treatments.		
Carbon Dioxide (CO_2)	Common element found in the atmosphere. Carbon Dioxide can exist as a liquid, gas or solid, (known as 'dry ice').	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.
Nitrogen (N_2)	A naturally occurring element, nitrogen is stored, transported and pumped as a cryogenic liquid, then heated and injected into the wellbore as a gas.	Improves recovery of stimulation or well fluids.

Shale Gas Completions / Fracing – cont'd

- 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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