Canadian Natural Gas: Past, Present and ..... a New Model for Predicting the Future

Dave Russum, P.Geol.
Geo-Help Inc and AJM Petroleum Consultants
University of Calgary Presentation,
February 2004

www.geohelp.ab.ca
Presentation Format

- Canada’s Resources and Reserves
- Current Trends in Production and Drilling
- A new Resource Development Model
- Predicting the Future and what it may look like
- Questions and Feedback

• More info: www.geohelp.ab.ca
Some Definitions:

Gas: Combustible gas primarily methane

Gas Resources: The total quantity of gas without regard for whether it is technically, physically or economically producible

Gas Reserves: The portion of the known resources that can be technically, physically and economically produced with our current knowledge
Some Definitions Continued:

Conventional Gas: Gas in porous and permeable rock that typically flows without significant stimulation.

Unconventional Gas: Gas in low porosity/permeability rock or adhering to the matrix that requires significant technical intervention to liberate examples: Coalbed methane, Gas hydrates.
Canada’s Natural Gas Production (Bcf/d Adapted from CAPP Data)

17.4Bcf/d = 6.3Tcf/Yr = 46.6 million Average Calgary homes

Stats Can Feb 2004

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Production and Alberta Price
(AJM Data)
Canada’s Natural Gas Resources and Reserves
Resource Triangle

Conventional Reservoirs
- Obvious Traps
- Subtle Traps

Obvious Traps
- Heavy Oil
- Sour Gas
- Tar Sands
- CBM
- Oil Shale

Small Volumes
- High Quality
- Difficult to find
- Easy to develop

Subtle Traps
- Unconventional Reservoirs
- WCSB

WCSB
- Large Volumes
- Low Quality
- Easy to find
- Difficult to develop

Basin Maturity
- Better Technology
- (Higher prices)

Unconventional Reservoirs
- Small Volumes
- Low Quality
- Easy to find
- Difficult to develop

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Unconventional Resources

Coalbed Methane
- Gas trapped in coal (300+ Tcf?)

Gas Hydrates
- Gas trapped in ice crystals (>10,000 Tcf?)

Shale Gas
Tight Gas

- Know the resource exists
- Low quality, challenging to extract
- Lack technology or economic incentive to extract
- Price will determine rate of development

Included with conventional?
Canada’s Resources and Reserves (data adapted from CGPC 2001)

Ultimate Resources

> 15000 Tcf

Total Conventional + Unconventional
592 Tcf

Discovered
340 Tcf

Raw Gas
204 Tcf

Sales Gas

Remaining Unproduced
60 Tcf

Remaining Reserves

Rate of Conversion:
Accessibility Technology Price

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Canada’s Remaining Accessible, Proven, Marketable Gas Reserves
(Estimated December 2002)

59.7 Tcf
Alberta Remaining Reserves and R/P

Found more gas than produced only 3 years since 1982

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Reserve/Production Ratio

Reserve Life Index
Example 60Tcf Reserves/6Tcf Production per year = 10Years

Does not mean we will run out of gas in 10 years
- Time to produce current reserves at current rate
- Additions to Reserves or reduction in Production extends life
‘Orphaned’ Resources  (Skipper, 2001)
Understanding Remaining Gas Resources – Accessible and Economically Available

<table>
<thead>
<tr>
<th>Accessible</th>
<th>Accessible with restrictions</th>
<th>Inaccessible</th>
</tr>
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<tbody>
<tr>
<td>&lt;$6.00Cdn /mcf</td>
<td>Present</td>
<td>Future</td>
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<td>&gt;$6.00Cdn /mcf</td>
<td>Future</td>
<td>Future</td>
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</table>

Russum, CSEG Recorder, June 2003
Predicting future accessible resources

<table>
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<tr>
<th>Present</th>
<th>Post 2010</th>
<th>&gt;2025</th>
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<tr>
<td>Available now and future</td>
<td>Available post 2010</td>
<td>(Post 2025?)</td>
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Approximate distribution of known resources

<table>
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<tr>
<th>Present</th>
<th>Post 2010</th>
<th>&gt;2025</th>
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<tr>
<td>60Tcf Disc. + 55?Tcf Undisc.</td>
<td>32Tcf</td>
<td>1,000’sTcf</td>
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</table>
Canada’s Gas Production
Canada’s Natural Gas Production (Bcf/d Adapted from CAPP Data)

www.geohelp.ab.ca
Alberta
Where did Alberta’s Gas Go in 2002? (AEUB ST-3)

Total: 6025 Bcf
Sales: 4657 Bcf

USA
2654 Bcf
57%

Rest of Canada
1243 Bcf
27%

Alberta
760 Bcf
16%

Flared + Fuel

Injection

Shrinkage

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Alberta New Gas Drilling and Annual Gas Production (CAPP Data)

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Should be Bcf/Yr
<table>
<thead>
<tr>
<th></th>
<th>1992</th>
<th>2002</th>
<th>% Change</th>
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</thead>
<tbody>
<tr>
<td>Avg. IP of new wells</td>
<td>640mcf/d</td>
<td>250mcf/d</td>
<td>-61%</td>
</tr>
<tr>
<td>First year decline rate</td>
<td>29%</td>
<td>35%</td>
<td>+21%</td>
</tr>
<tr>
<td># of new gas wells</td>
<td>721</td>
<td>6923</td>
<td>+960%</td>
</tr>
<tr>
<td>Avg. new well depth</td>
<td>1151m</td>
<td>1100m</td>
<td>-4%</td>
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<tr>
<td>Total Producing Wells</td>
<td>29,800</td>
<td>70,000</td>
<td>+135%</td>
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<tr>
<td>Total Production</td>
<td>3.6Tcf/Yr</td>
<td>5.0Tcf/Yr</td>
<td>+39%</td>
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</table>
Canada’s Position in the world of Natural Gas
Canada Facts

- The 3rd largest producer of Natural Gas
- The 2nd largest exporter of Natural Gas
- 1% of the proven Natural Gas reserves in the World (18th place)
- The 3rd lowest R/P (9.8) after UK (6.2) and US (9.2).
  - Alberta’s R/P is 7-8, (25 in 1986)
- Highest COF&D of any Country in the World
World Gas Reserves (BP, 2001)

Total 5476 Tcf

- Middle East: 5% of Reserves, 30% of Production, 30% of Consumption
- Former Soviet Union
- North America: 5% of Reserves, 30% of Production, 30% of Consumption
- CANADA: 1%
- SE Asia
- Afr
- N. Am
- Eur
- S. Am

LNG could make gas a world commodity
North America

Reserves

-11%

1981: 365 Tcf
199
75.6
90.5
199

2001: 267 Tcf

Production

-47%

1981: 63 Bcf/d
52.6
7.2
2.8
16.6
53

2001: 73 Bcf/d
16.6
3.4

Consumption

1981: 61 Bcf/d
5.1
7
3.3
59.6

2001: 70 Bcf/d

USA
Canada
Mexico

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Comments

• Natural gas industry in North America has become a ‘just in time’ industry – very vulnerable to fluctuations in supply and demand.

• We need to recognise that we may be a significant producer today but there is no guarantee that this will continue.

• All levels of Industry and Government need to formulate a plan to ensure sustainability.
Resource Development Model (RDM)

Dave Russum
Geo-Help Inc
June 2003
Resource Development Model
- Intent

• A simple model to understand resource development
• Applicable to all non-renewable resources
• Applicable to renewable resources where production exceeds sustainable levels
• Relevant to a single project or to a total world assessment of a resource
• Provides some predictability to future trends
Resource Development Model (RDM) – 8 Stages

1. Discovery
2. Evaluation
3. Development
4. Growth
5. Peak
6. Decline
7. Reality
8. Abandonment

Knowing current stage of project can better predict future
Stage 1: **Discovery**

- Idea
- Exploration
- Recognition of the Resource
Stage 2: **Evaluation**

- Determination of the economic viability of the resource
- Decision to proceed
Stage 3: Development

• Bringing the resource into production
  – Finding the market
  – Developing the infrastructure
  – Creating ability to process the resource
Stage 4: **Growth**

In an unregulated environment:
- “Unbridled optimism” - Intense Competition
- Assumption of virtually unlimited future production
- Costs escalate
- Hasty investment decisions (herd mentality)
- High production to monetise resource
- Production accelerates beyond reasonable levels
Stage 5: Peak

- Generally not recognised until afterwards
- Very short lived in a deregulated environment (eg. Ladyfern – <1 month)
- Early (knowledgeable) investors and operators may quietly exit
Stage 6: **Decline**

- “Denial” - Companies, workers, politicians, regulators and consumers predict and expect continued growth in production
  - “Current decline is temporary”
- Future predictions disconnected with current reality (often based on old data)
- High Spending based on unrealistic expectations
- Costs to maintain production increase
- Opinions that all is not rosy are not welcome

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Stage 7: **Reality**

- Limitations of resource recognized
- Opportunities inadequate for large operators
- Remaining quality resources become cash cow
- Quotas or regulations applied to extend the life of resource
  - Generally too little to late
  - Vehemently opposed by impacted Industry
- Government invests in R&D
- (Incentives introduced to encourage exploration)
- Rate of decline slows
- Small, low cost operators pursue remaining resources
Stage 8: Abandonment

- Remaining resource is dispersed, low quality and expensive to extract.
- Production grinds to a halt
- Restoration often does not occur - creating the “ghost towns” that are common in former natural resource area.

Note: Resource not completely produced; not economically viable to extract what remains or a more viable alternative has been discovered.
Reserves - Actual and Forecast

Unbridled optimism

- Reserves
- Forecasts

Stages
1 Disc 2 Eval 3 Dev 4 Grow 5 Peak 6-Dec 7 Real 8 Aban

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Resource Development Model – WELSH COALFIELDS

1. Discovery (Pre 1850)
2. Evaluation (2 years?)
3. Development (1850’s)
4. Growth (1850-1880)
5. Peak (1890?)
6. Decline (1900-1970)
8. Abandonment (1980s)

Current Stage: 8
Stages

• Not consistent in length
• Stage may be skipped or take hundreds of years
• Will be some overlap of stages
• New technology or high prices may rejuvenate or extend an existing project/resource

Caution – external influences will mask stages (eg. Deregulation, legislation, access, abnormal prices etc)

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RDM and the Oil and Gas Industry

Dave Russum
Hubbert’s Peak

Hubbert (1949) showed that for a finite resource a plot of production vs. time would have a peak. The higher the peak, the sooner and sharper the decline.

Volume under curve = producible resource

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Hubbert’s Success and Failure

• In 1956 he correctly predicted the peak for US Oil production in 1970

• In 1974 he incorrectly predicted world oil production to peak in 1995
  – ‘Crying wolf’
  – ‘Experts’ can’t predict next month’s production
Why was Hubbert wrong?

• Hubbert was not wrong with the concept
• He was wrong with the timing because he miscalculated the potential resource (the volume under the curve)
• He did not take into account how, innovation, technology and higher price plus higher spending could increase the potential resource over time
Production Profiles

Accelerated Case: GPP, technology do not have time to evolve, total production lower. (Future more Predictable)
Ladyfern
(Data from AJM 2003 Report)

Ladyfern Gas Production

Current
Stage 7
(Reality)
Resource Development Model – Ladyfern

1. Discovery (3 years)
2. Evaluation (1 week?)
3. Development (6 months)
4. Growth (1.5 years)
5. Peak (1 day?)
6. Decline (1 day)
7. Reality (Present)
8. Abandonment

Current Stage: 7

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Why we need to do better than Hubbert

• If we could identify the RDM stage of a play, area, basin or the world it would help:
  – Identify upside or limitations of an area
  – Develop meaningful expectations for future production
  – Proactively identify supply problems
  – Provide more realistic planning for Governments and users of the product

• (Gas should be easier to predict than oil!)
Applying the RDM to Oil and Gas Industry

- Production alone is oversimplification
- Need to understand historical perspective

Plus:
- Would like to measure spending
- Number of wells acts as a proxy to spending
Texas Onshore gas production (1950 to Present)

Current Stage: 7 (Reality)

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Alberta gas production and gas wells (CAPP Data)

Current Stage: 6 (Decline) - Rapidly Moving to Reality

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## Texas Onshore vs. Alberta Statistics

<table>
<thead>
<tr>
<th></th>
<th>Texas</th>
<th>Alberta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (sq. miles)</td>
<td>269,000</td>
<td>255,000</td>
</tr>
<tr>
<td>Cum Production</td>
<td>319Tcf</td>
<td>109Tcf</td>
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<tr>
<td>Peak Production Year</td>
<td>1971 (9.5Tcf)</td>
<td>2000 (5.1Tcf)</td>
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<tr>
<td></td>
<td>R/P = 15</td>
<td>R/P = 8</td>
</tr>
<tr>
<td>Remaining Reserves Peak Year</td>
<td>1971 (122Tcf)</td>
<td>1982 (65Tcf)</td>
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<tr>
<td></td>
<td>R/P = 15</td>
<td>R/P = 28</td>
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<tr>
<td>2002 Remaining Reserves</td>
<td>43Tcf</td>
<td>40Tcf</td>
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<tr>
<td>2002 Production</td>
<td>5.6Tcf</td>
<td>4.8Tcf</td>
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<tr>
<td></td>
<td>R/P = 7.7</td>
<td>R/P = 8.3</td>
</tr>
<tr>
<td>2002 Gas wells</td>
<td>65,686</td>
<td>70,000</td>
</tr>
</tbody>
</table>

**Alberta is not as rich in natural gas as Texas!**
Resource Development Model
– Alberta Gas

1. Discovery (1880’s)
2. Evaluation (20 years?)
3. Development (1910-1950)
5. Peak (2001)
6. Decline (2001- Present)
7. Reality
8. Abandonment

Current Stage: 6

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Improving the Model

- Technology, regulations, new concepts, ease of access, maturity of area all impact
- Lumping/splitting of data will tend to mask results
- Need to place activity in historic context
Example of a formation/area in decline (Data from AJM 2003 Study)

Kaybob Mississippian

Prd-cg-Day Avg GAS Mcf
Well Count

Current Stage 6 (Decline)
Example of a formation/area still growing (Data from AJM 2003 Study)

Current Stage 4 (Growth)
Implications of trends

• Can plot trends on a pool, play, area, basin or worldwide basis

• Immature trends (low well counts and low productivity) still difficult to predict future (Look at well density?)

• Mature trends the decline in existing productivity is likely to be greater than any new additions

**Note:** Does not mean there are no opportunities left to be found but investment must be made with caution
# Canada’s Hydrocarbon Stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>1 Disc</th>
<th>2 Eval</th>
<th>3 Dev</th>
<th>4 Grow</th>
<th>5 Peak</th>
<th>6 Dec</th>
<th>7 Real</th>
<th>8 Abn</th>
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<td>Gas Hydrates</td>
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<td>Tar sands</td>
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</table>

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Problem

• General trends can be identified from regional data but may be masking some very important underlying trends and opportunities

• How do we efficiently dig down through the data in real time?
Solution

• AJM Petroleum Consultants have developed a web based Resource Potential Model - enables a Basin to be analysed in much greater detail

• Model incorporates:
  – Decline analysis at the well level
  – Geo-statistical analysis of production
  – Full-cycle economic analysis
  – Geological and engineering expertise
  – Up-to-date data

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AJM Petroleum Consultants
RPM Analysis

• WCSB divided into 16 geographic areas for gas (13 for oil) based on regional geological parameters.

• Each area is divided into 14 stratigraphic groups based on similar producing formations.

• Provides 224 discrete sets of data that can be individually assessed or grouped.
RPM: 16 Geographic Gas Areas

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Results – Central Foothills

Central Foothills Gas Production

- Production Mcf/d
- U Cret
- U Col
- Colorado
- U Mann
- M Mann
- L Mann
- Jur
- Tri
- Miss
- U Dev
## RPM Results – Central Foothills (AJM 2003 Study)

### Area Summary

<table>
<thead>
<tr>
<th>Stratigraphic Group</th>
<th>Number of Evaluated Wells</th>
<th>Chance of Success</th>
<th>Resources Sales Volume (MMcfe)</th>
<th>Finding &amp; Development Costs ($/Mcfe)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Unrisked</td>
<td>Risked</td>
</tr>
<tr>
<td>Upper Colorado</td>
<td>50</td>
<td>47%</td>
<td>2,270</td>
<td>1,067</td>
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<tr>
<td>Colorado</td>
<td>69</td>
<td>68%</td>
<td>3,678</td>
<td>2,501</td>
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<tr>
<td>Upper Mannville</td>
<td>13</td>
<td>39%</td>
<td>936</td>
<td>365</td>
</tr>
<tr>
<td>Middle Mannville</td>
<td>8</td>
<td>59%</td>
<td>3,649</td>
<td>2,153</td>
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<tr>
<td>Lower Mannville</td>
<td>8</td>
<td>48%</td>
<td>3,938</td>
<td>1,890</td>
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<td>Upper Triassic</td>
<td>6</td>
<td>50%</td>
<td>6,678</td>
<td>3,339</td>
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<tr>
<td>Mississippian</td>
<td>96</td>
<td>61%</td>
<td>7,381</td>
<td>4,502</td>
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<tr>
<td>Upper Devonian</td>
<td>28</td>
<td>59%</td>
<td>13,626</td>
<td>8,040</td>
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</table>
Results Continued – Central Foothills (AJM 2003 Study)

Financial Indicators (Before Tax)

<table>
<thead>
<tr>
<th>Stratigraphic Group</th>
<th>Number of Evaluated Wells</th>
<th>Chance of Success</th>
<th>Average Netback ($/Mcf)</th>
<th>Break-Even Gas Price, $/Mcf</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>@ $4.00/Mcf</td>
<td>Unrisked</td>
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<td>Upper Colorado</td>
<td>50</td>
<td>47%</td>
<td>2.50</td>
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<td>Colorado</td>
<td>69</td>
<td>68%</td>
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<td>39%</td>
<td>2.44</td>
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<td>2.46</td>
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<td>Lower Mannville</td>
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<td>48%</td>
<td>2.46</td>
<td>2.26</td>
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<td>6</td>
<td>50%</td>
<td>2.10</td>
<td>2.32</td>
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<td>Mississippian</td>
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<td>61%</td>
<td>2.20</td>
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<td>28</td>
<td>59%</td>
<td>2.02</td>
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## Example of Play Area Stages
### WCSB

<table>
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<th>Play Area 3</th>
<th>Play Area 224</th>
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</tr>
<tr>
<td><strong>3</strong> Dev</td>
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<td><strong>4</strong> Grow</td>
<td><strong>5</strong> Peak</td>
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<tr>
<td></td>
<td></td>
<td><strong>6</strong> Dec</td>
<td><strong>7</strong> Real</td>
</tr>
<tr>
<td><strong>8</strong> Abn</td>
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</table>

Relate play stages to recent activity, production and economics to gain more accurate understanding of future potential.

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RDM (Resource Development Model) and RPM (Resource Potential Model)

- RDM is not a panacea but provides some useful information at all scale

- Incorporating a well count acts as a proxy for spending (activity level) – provides insights into trends particularly as approach peak production

- Combining with a product like AJM’s RPM creates an exceptionally powerful tool
Future Direction

• Merge the RDM and RPM data to confirm the peak BUT also the timing and extent of the decline and whether we will eventually reach a plateau of sustainable production.
Predicting future trends
Natural Gas In Canada – Where are we going?

**SUPPLY:**
- Exploration
- Remaining Reserves

**DEMAND:**
- Production
- Exports

---

- **100Tcf** (39 Years)
- **60Tcf** (9 Years)
- **7Bcf/d**
- **17Bcf/d**

---

**FUTURE?**
- Kyoto?
- El Nino?
- NAFTA?
- OPEC?
- LNG?
- Politics?
- Terrorism?
- N.Am Economy?

**Prices**

---

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Canadian Gas Supply
NEB Forecast 1999 (Bcf/Yr)

Production increase: 43%
Canadian Gas Supply
NEB Forecast 2003 (Bcf/Yr)

Production Increase: 20%

Note: includes some LNG imports by 2008
Canadian Gas Supply
NEB Forecast 2003 (Bcf/Yr)

Available for Export

Domestic Consumption Increase: 47%

Note: includes some LNG imports by 2008
Future Marketable Gas Unconventional (Bcf/Yr)

Assume:
1Bcf/d by 2009
(10,000 Wells?)
2.2Bcf/d 2016

Dave Russum, 2003
Future Marketable Gas
East Coast (Bcf/Yr)

www.geohelp.ab.ca

Dave Russum, 2003
Future Marketable Gas Territories (Bcf/Yr)

MacKenzie Pipeline
1 to 1.8 Bcf/d

Dave Russum, 2003
Future Marketable Gas Saskatchewan (Bcf/Yr)

Assume 3% Growth/Yr

Dave Russum, 2003
Future Marketable Gas
British Columbia (Bcf/Yr)

Assume 3% Growth/Yr

Dave Russum, 2003
Future Marketable Gas Alberta (Bcf/Yr)

3% Decline to 2005
5% Decline after

NEB Case

Dave Russum, 2003

www.geohelp.ab.ca
Future Marketable Gas Prediction (Bcf/Yr)

$\text{UnConv}$  
$\text{E Coast}$  
$\text{Territories}$  
$\text{Sask}$  
$\text{BC}$  
$\text{Alberta}$

Export to US  
Rest of Canada  
Alberta Demand

Dave Russum, 2003

www.geohelp.ab.ca
How Important is Natural Gas to Alberta? - Exports 2001

- Gas and Gas Liquids: $23.00 Billion
- Crude Petroleum: $12.61 Billion
- Petrochemicals: $3.75 Billion
- Livestock/Red Meat: $3.08 Billion
- Forest Products: $2.87 Billion
- Electronic Products: $2.61 Billion
- Crops: $2.12 Billion
- Metals & Machinery: $2.06 Billion
- Refined Petroleum Products: $0.63 Billion
- Transportation Equipment: $0.60 Billion
- Coal: $0.39 Billion

Total Exports: $56.9 Billion

*Includes Telecom Equipment
Source: Statistics Canada
Is there anything left to find?

YES!

(CGPC Estimate 246 T Cf
Undiscovered Conventional gas in Canada
+ huge volumes of Unconventional Gas)

Will take research, money and patience
to be successful

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Exploration

All Western Canada Exploration Statistics:

• 1992: 1570 Wells 50% Success Rate
• 2003: 4696 Wells 83% Success Rate

• How many Exploration wells did these top producers drill in 2003?
  – BP, Chevron-Texaco, Imperial, Nexen, Shell, Suncor.

• Answer: 29 (0.6% of all exploration)
## Exploration Strategy - Risk and Reward Profile

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<th>RISK</th>
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<th>Medium</th>
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<td>VULTURE</td>
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- **TIGER**: High Reward
- **RARE (Eureka)**: Rare Reward
- **GRIZZLY, WOLF**: Medium Reward
- **DINOSAUR**: Low Reward
- **HAWK**, **VULTURE**: Low Reward

Most Recent ‘Exploration’

Dave Russum, 2002
Challenges to R&D and Exploration

- **Poor results** – WCSB Maturity, high COF&D., low IP, high decline
- **M&A activity** – Focus on short-term
- **Capital directed to mega projects** – tar sands
- **Domestic exploration competing with international opportunities**
- **Growth in energy trusts** – liquidating assets
- **Few ‘mid-cap’ companies or active majors**
- **Difficult to raise capital for long term exploration**

Result: Few active domestic exploration groups, even less research = less ‘real’ exploration and less progress on a serious problem
Reversing the Trends

• Cannot happen overnight!
• Requires Industry and Government Commitment
• Research
• Cooperation
• Incentives and Regulations?
• Skilled people
• Innovation
• Training
The Choice:

AN ENERGY PLAN
More and better R&D and Exploration

VS.
A decline in gas production with implications for the North American energy picture
Summary

• Canada is not running out of gas resources
• We are rapidly depleting our accessible, cheap, natural gas reserves
• We must slow this trend by either finding more or exporting less
• Expanded LNG transport could make gas a world commodity – bypassing expensive Canadian gas?
Welcome your feedback

Contact Dave Russum

More Information:

www.geohelp.ab.ca
www.ajma.net

Thank You