Western Canada Tight Gas Resource Characterization Project

Deep Basin Tight Gas
Resource Characterization, Assessment and Future Supply

CSUG Canadian Society for Unconventional Gas

March 2008

Forward ENERGY GROUP INC.

Western Canada Tight Gas Resource Characterization Project

Natural Resources Canada - GSC

Devon Canada Corporation
Husky Oil Operations Ltd.
Imperial Oil Limited
Petrel Robertson Consulting Ltd.
Talisman Energy Inc.
TransCanada Pipelines Limited

NEB, CGPC, BCMEMPR, EUB, Sask IR, ARI, USGS, EIA

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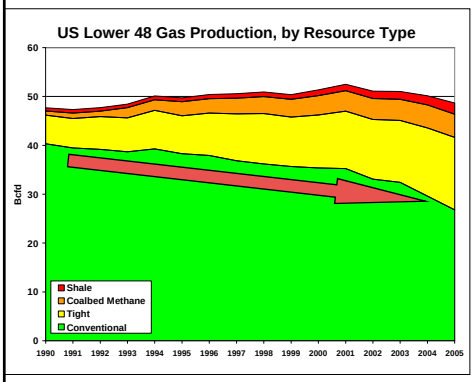
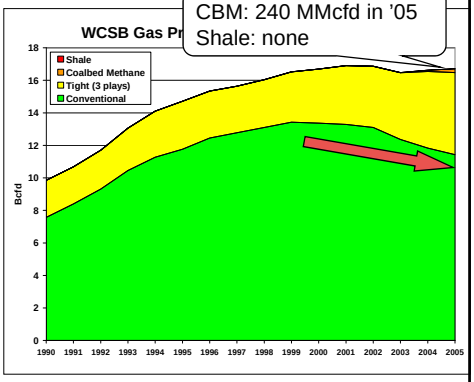
Gas Production Profiles





CBM: 240 MMcfd in '05
Shale: none

US Lower 48

- Conventional gas in decline
- Tight gas in lower 48 over 30% of 2005 total
- CBM and shale gas significant

Western Canada

- CBM growing rapidly
- Tight gas not reported
  - estimate over 30% of 2005 total
- Conventional gas in decline

Better understanding of tight gas is important

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Project Objectives

1. Communicate clearly the tight gas opportunity by establishing a **workable definition** for tight gas accepted by stakeholders
2. **Characterize** the tight gas opportunities into play types and analyze their supply trends
3. **Estimate** remaining tight gas resource potential and model its future conversion into supply.
4. Summarize resource and **supply potential** and **identify technology** and opportunities to maximize development of tight gas in Western Canada.

Distinguish tight gas from conventional gas

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Different Resource Models

CONVENTIONAL	CONTINUOUS
1. Discrete gas pools in ocean of water-saturated reservoir	1. Pervasive gas saturated accumulations
2. Only high quality reservoir accumulates gas in place	2. Very large gas in place in reservoir of all qualities
3. Discovery is uncertain, recovery is certain	3. Discovery is certain, recovery is uncertain
4. Discovery process is efficient	4. Recovery is inefficient but improves with technology
5. R&D to increase success	5. R&D to improve recovery and characterization
6. Remaining resource, in small undiscovered pools, is small	6. Remaining resource in lower quality reservoirs is large
7. Historical view of WCSB remaining resources	7. Alternative view of WCSB remaining resources
"Glass is mostly empty"	*"Glass is mostly full"*

Very different outlook for future supply

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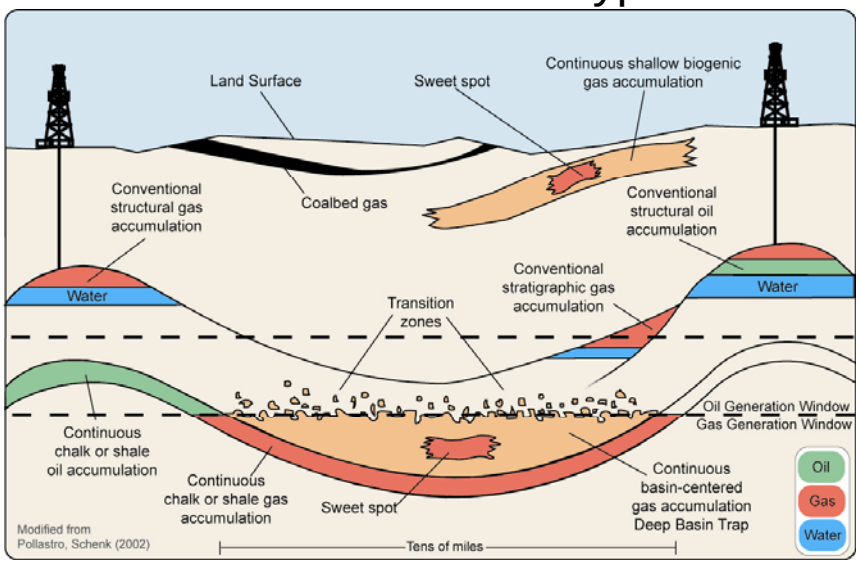
Gas Accumulation Types



Low permeability reservoirs contain GIP only in pervasive gas saturated regimes

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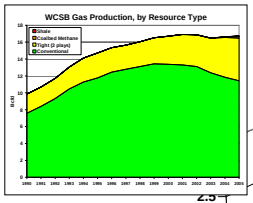
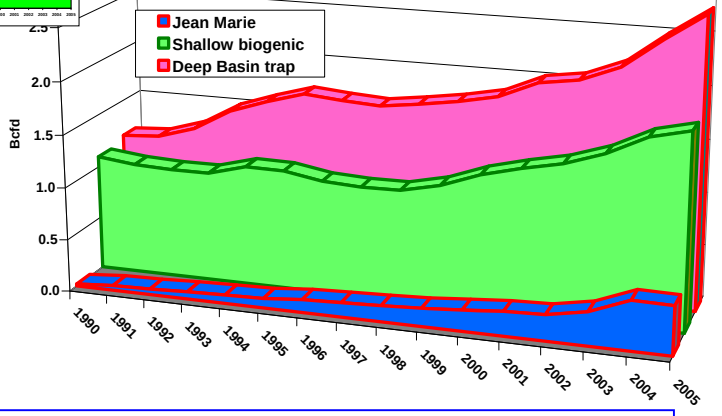
WCSB Tight Gas Regions



Production by Tight Gas Region



Recent growth in all three major tight gas regions

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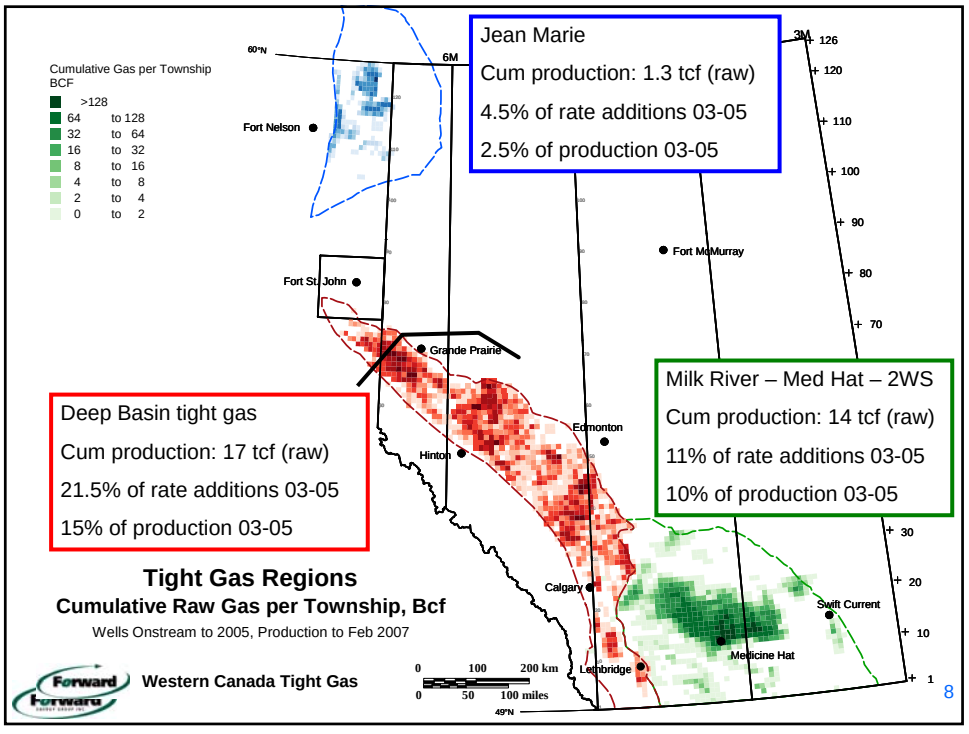

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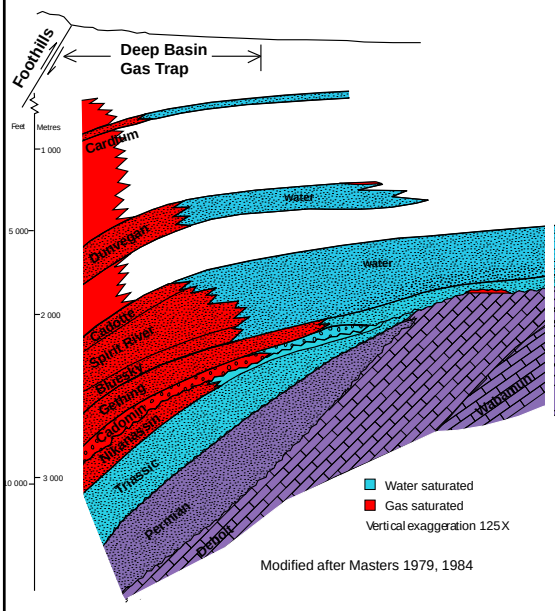
Deep Basin Trap Schematic Section



Modified after Masters 1979, 1984

- Pervasive gas downdip
- Water saturated porosity updip and in underlying and overlying formations
- Transition zone location varies by formation
- Foothills is western limit
- Conventional buoyancy traps in aquifers
- Tight gas sands downdip with sweet spots
- 8 stratigraphic intervals, 13 plays evaluated
- Stacked plays
- Thickness is typical only of northern Deep Basin
- Stippled zones are not continuous reservoir and only about 1/3 sandstone
- Drilling targeted to underlying Triassic and Paleozoic plays

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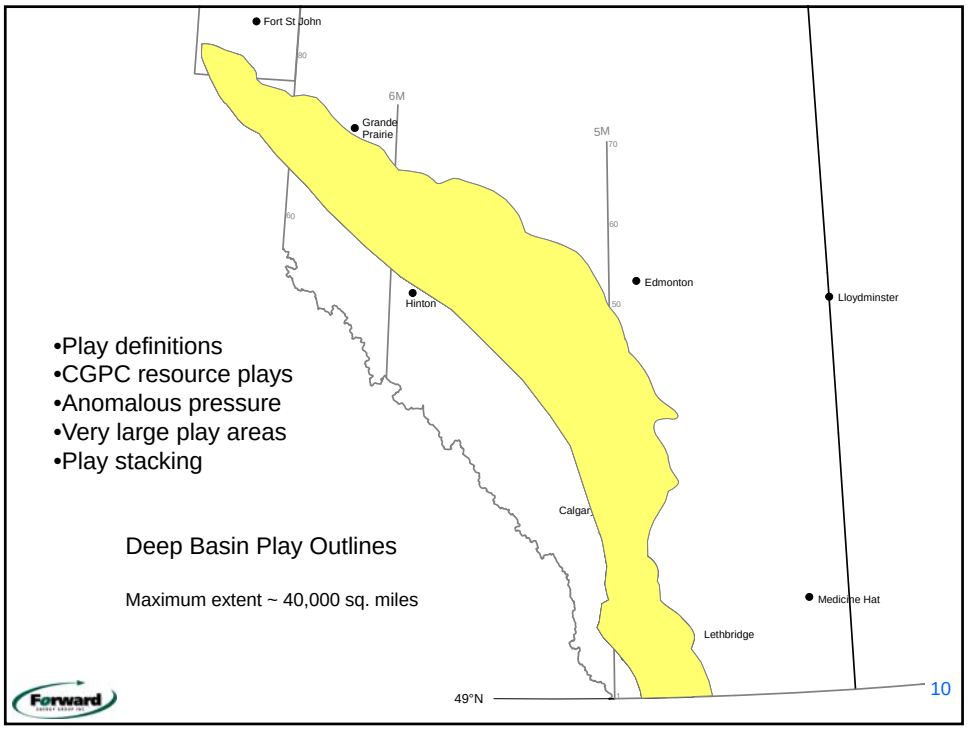

- Play definitions
- CGPC resource plays
- Anomalous pressure
- Very large play areas
- Play stacking

Deep Basin Play Outlines

Maximum extent ~ 40,000 sq. miles

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Resource Assessment

- Discovery process models: “Law of diminishing returns”
  - Discrete pools in play where discovery history exists - CGPC
- GIP: “Dream the Big Dream”
  - Subsurface volumetric study from petrophysics and mapping
  - John Master’s 1984 estimate of 1500 Tcf GIP for Mannville in the Deep Basin trap
- Cellular methods:
  - Extrapolate resources to undrilled areas based on well recovery, success rate and well spacing from drilled and evaluated areas
  - Developed by USGS and Advanced Resources International (ARI) for unconventional gas resource estimates for US EIA

Resources = (Area * Success / Spacing) * EUR/well

Area:	Undeveloped area
Success :	% of Undeveloped area EUR > cutoff
Spacing:	Average drainage area of wells
EUR/well:	Average EUR for successful well

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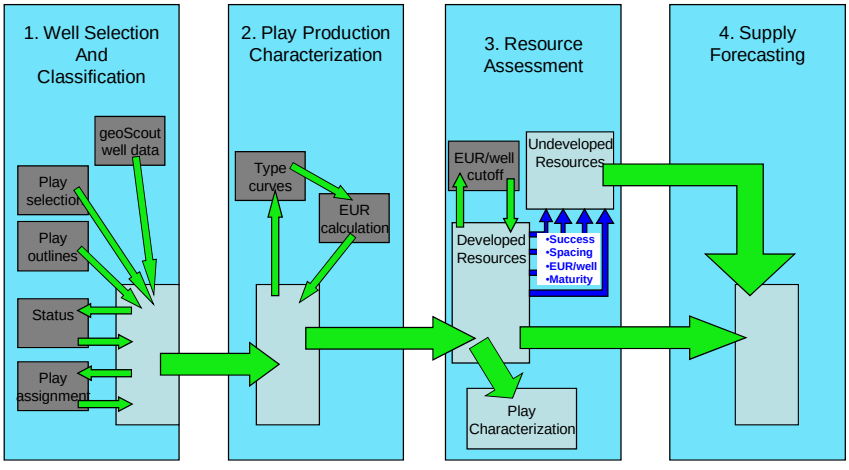
Tight Gas Resource Assessment Process



Developed and adapted processes, database and software to assess undeveloped resources for Deep Basin plays

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Database and Processes

All wells drilled in Deep Basin play area: 67,000 in 90,000 events

- 39,000 wells evaluate Deep Basin intervals in play areas
- 10,000 wells contain 11,000 gas-producing events from fourteen Deep Basin plays to year-end 2005
- Although 43% of Deep Basin producers occur in commingled pools, we were able to assign 35% to pure Deep Basin plays

Value-added data per well

- Producing play, EUR, penetration, status, surface loss, section . . .

EUR calculation

- By play for producing zones based on play type curve and R/P
- Trends, distributions, mapping, cutoffs, production forecasting, etc

Query and analysis processes and software

- Success rate per well or section by play with variable EUR cutoff, trends, Deep Basin and other plays, play maturity
- Historical well spacing per section by play, area tested by spacing
- Resource estimate model, scenarios

Processes that work for Deep Basin plays

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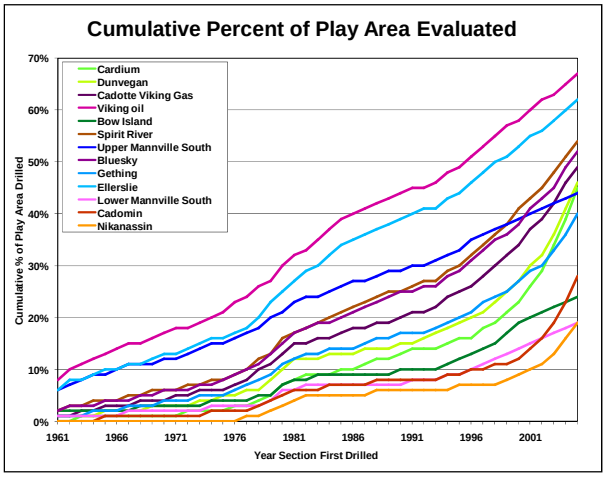
Maturity Varies by Play



- Evaluated area varies from 18% to 67%
- Uncertainty increases for less mature plays
- Most wells have modern log suites
- Many wells drilled since the Deep Basin trap concept was described in 1970s

- Accelerating activity, particularly in northern plays, since 1992
- Drilled area of Cadomin play has tripled in last 10 years

Increasing activity targeted to Deep Basin tight gas

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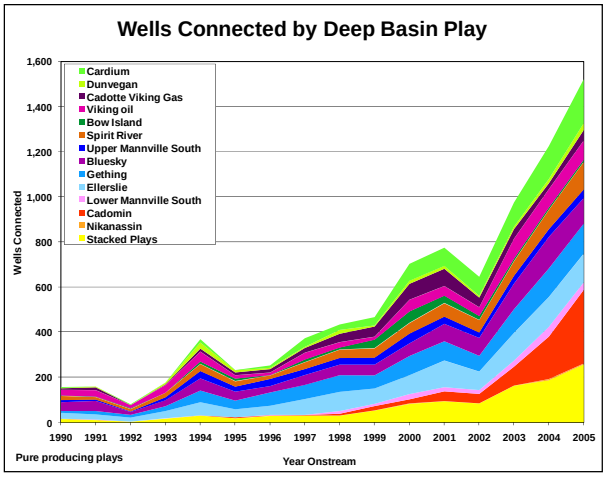
Gas Well Connections



- Total annual connections growing rapidly
- 28% growth rate from 2002 to 2006
- Cadomin, stacked plays and Cardium plays lead connection growth
- Declining connections in some plays: Cadotte and Bow Island

- Stacked play wells : segregated production from different plays or commingled production from two or more plays
- Stacked play wells average 13% of total connections

63% of all Deep Basin connections since 1998

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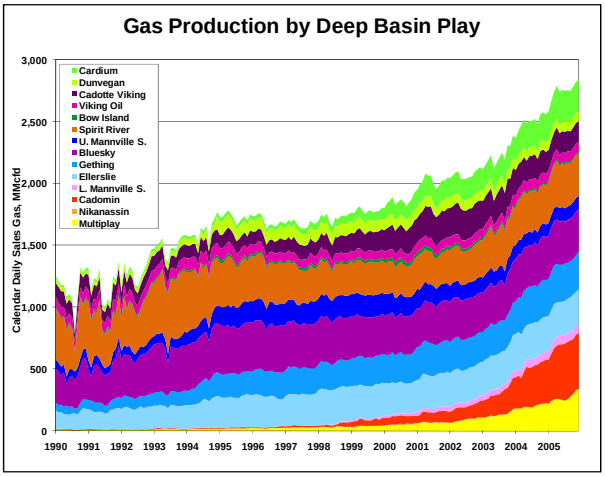
Gas Production



- Total production grew by over 1 Bcf/d since 1998
- 6% growth rate from 1998 to 2006
- Cadomin, Multiplay and Cardium plays lead production growth
- Declining production in some plays: Cadotte, Upper Mannville South and Bow Island

- Multiplay: commingled production from two or more plays where the primary producing zone cannot be distinguished
- Commingling regulations will result in far more Multiplay producers in future

2005 Deep Basin production: 1 Tcf per year

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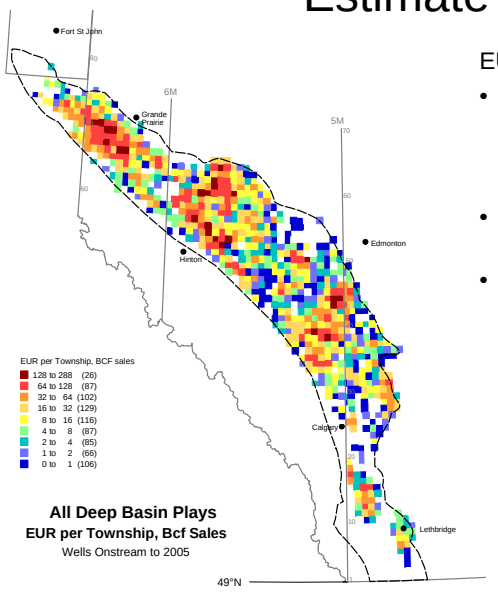
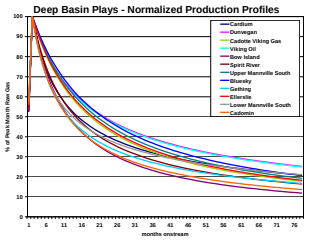
Estimate EUR



EUR : Estimated Ultimate Recovery

- Calculate EUR using normalized production profile by play, current rate, producing time and cumulative production
- Normalized production profiles vary in shape between plays
- All profiles are hyperbolic with high initial decline rates



Almost 22 Tcf connected by 2005 in Deep Basin plays

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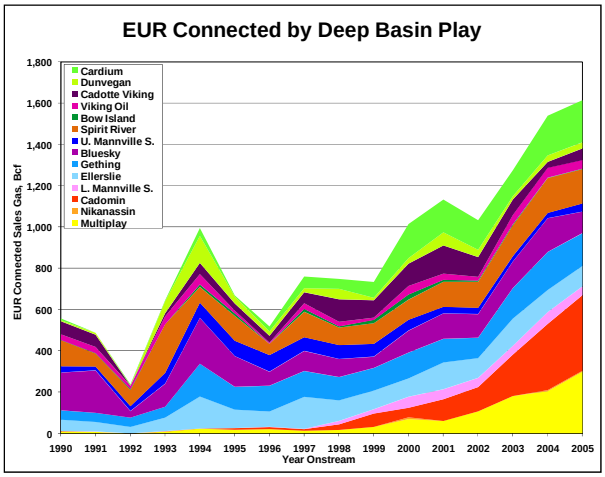
EUR Connected



- EUR connected growing
- Growth rate not as rapid as wells connected
- Cadomin, Multiplay and Cardium plays lead EUR connected growth
- Declining EUR connected in some plays: Cadotte, Upper Mannville South and Bow Island

- Multiplay: commingled production from two or more plays where the primary producing zone cannot be distinguished with publically available data
- Commingling regulations will result in far more Multiplay producers in future

Deep Basin EUR connected exceeds production

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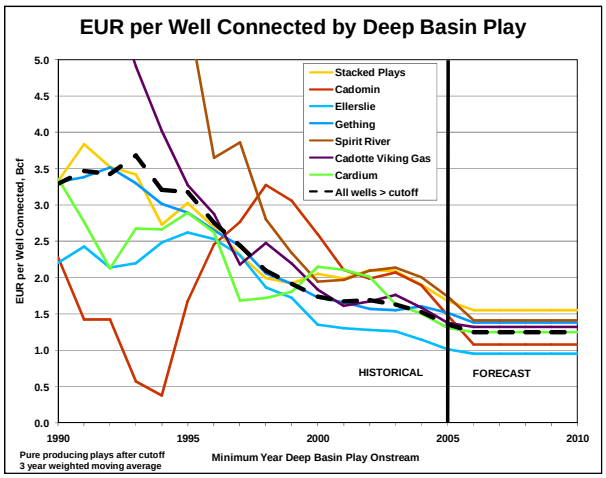
EUR per Well



- EUR per well decreased rapidly – from few high EUR wells to many lower EUR wells connected recently
- Decrease since 2000 has been relatively low – we believe improved technology is offsetting the decline trend
- Stacked play wells have slightly higher EUR per well than average

- EUR per well used in forecast is estimated from recently-connected wells
- Assume technology will maintain future average EUR per well constant

Trend driven by price and pursuit of marginal EUR

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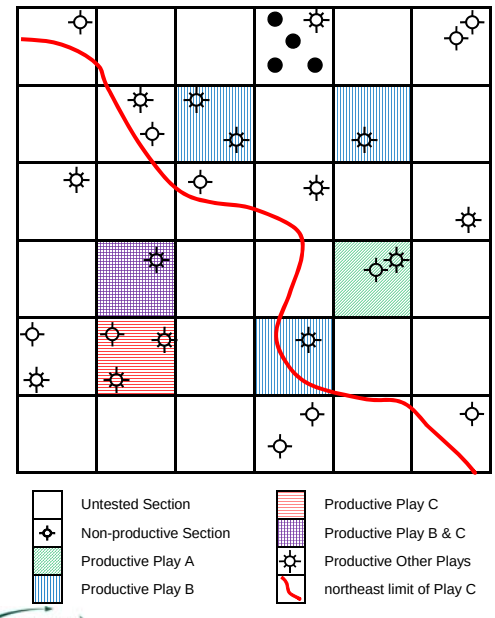
Section Success Map Schematic



Schematic Scenario
1 township : 36 sections, 36 square miles
Play C only in southwest portion (17 sq miles)
29 wells evaluate all Deep Basin plays

Drilling Success

Nonproductive wells	11/29=38%
Productive from any Deep Basin play with EUR > cutoff	8/29=28%
Productive from other plays	10/29=34%

Maturity

19 sections undrilled in Deep Basin plays	
17 sections test Plays A & B	17/36=47%
5 sections test Play C area	5/17=29%

Section Success: <u>any</u> Deep Basin play

Nonproductive sections	5/17=29%
Productive from any Deep Basin play with EUR > cutoff	6/17=35%
Productive from other plays	6/17=35%
Stacked Deep Basin plays	1/17= 6%

Section Success: <u>each</u> Deep Basin play

Play A:	1/17= 6%
Play B:	4/17= 24%
Play C:	2/5 = 40%

Average Section Spacing

Play A	640 acres: 1@640 ac.
Play B	560 acres: 3@640 ac.; 1@320 ac.
Play C	480 acres: 1@640 ac.; 1@320 ac.

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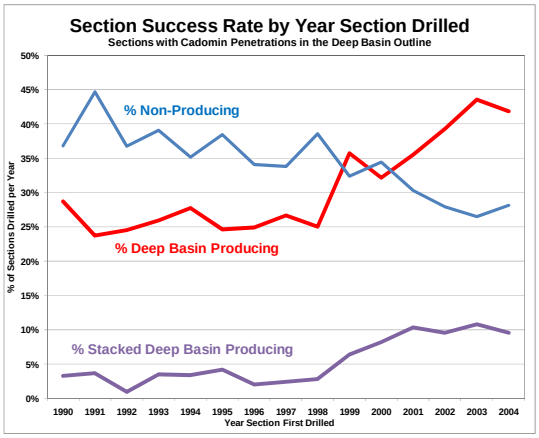
Section success for any Deep Basin play



- Historical success in any Deep Basin play: 25% of sections testing Cadomin
- Recent success in any Deep Basin play: 38%
- Sections with stacked producers increasing
- Failure rate declining but still high: 30%

- All sections where one or more wells penetrate Cadomin or deeper
- Success: Section where at least one well producing from any Deep Basin play has an EUR greater than a minimum play EUR (commonly 0.25 Bcf)
- Stacked play success sections produce from two or more Deep Basin plays

Section success rates: too low for random drilling!

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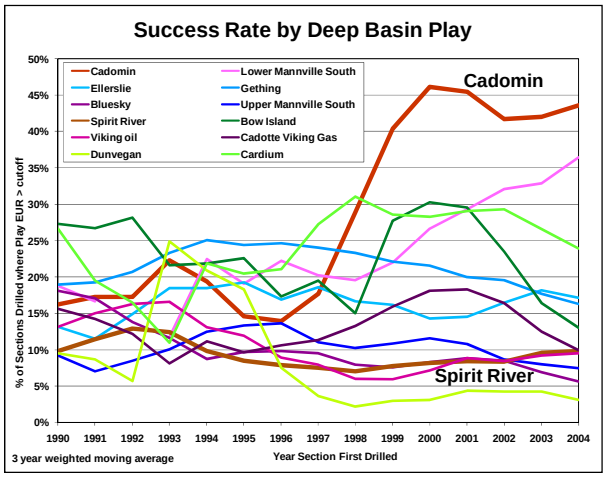
Section success for each Deep Basin play



- Historical total success rates for individual plays are low relative to US tight gas plays
- Annual success rates have been fairly consistent through time
- Recent trend in the Cadomin is exception
- Recent success in any Deep Basin play: 38% of sections testing Cadomin

- Success: Section where at least one well drilled to the play has an EUR greater than a minimum EUR (commonly 0.25 Bcf)
- Multiplay success sections have been allocated to pure plays

Low success rates: discovery is uncertain!

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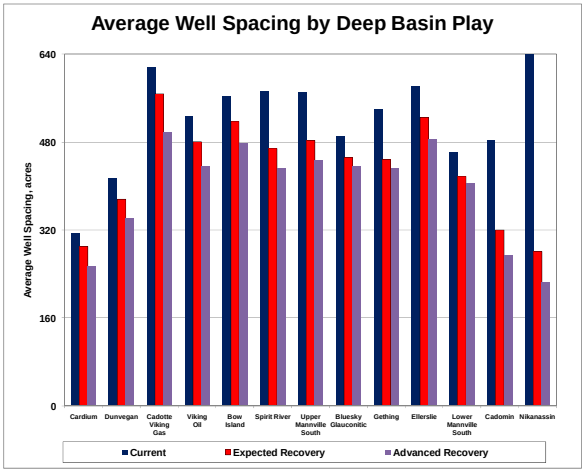
Well Spacing



- Most plays are currently drilled at 640 acres with minor downspacing
- Exceptions are Cardium, Dunvegan, Lower Mannville South and Cadomin
- Expected Recovery and Advanced Recovery scenarios envision incremental decreases in well spacing

- Contrasts with US tight gas plays where well spacing is 26 to 160 acres
- Are Deep Basin operators satisfied with current recovery of GIP?

Scenarios assume incremental downspacing

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Resource Estimation Scenarios

- Continuing Trends scenario
  - Undeveloped area will experience the historical success rate and well spacing but a lower mean EUR than recent drills
- Expected Recovery scenario
  - Incremental improvements: success rate is higher and well spacing is reduced resulting in more successful wells
- Advanced Recovery scenario
  - Significant improvements: success rate is higher, particularly for immature plays, and the trend to downspacing is extended
- EUR per well remains constant in all scenarios
  - Technology identifies and recovers same EUR from progressively lower quality reservoir
- Success rate increases and drainage area decreases
  - Lower quality reservoir will be recognized and completed as successfully productive
  - Reservoir characterization identifies downspacing opportunities

Technology improvement assumed in all scenarios

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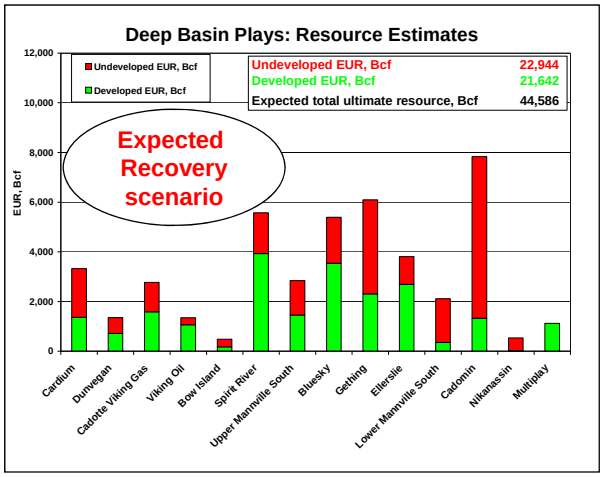
Deep Basin Resource Estimates



- 22 Tcf resource developed to 2005
- Under the Expected Recovery scenario: 23 Tcf undeveloped resource, to be connected from 2006
- Cadomin (6.5 Tcf) and Gething (3.8 Tcf) largest portions of undeveloped resource

- Continuing Trends scenario estimate: 16 Tcf
- Advanced Recovery scenario estimate: 30 Tcf

45 Tcf ultimate resource

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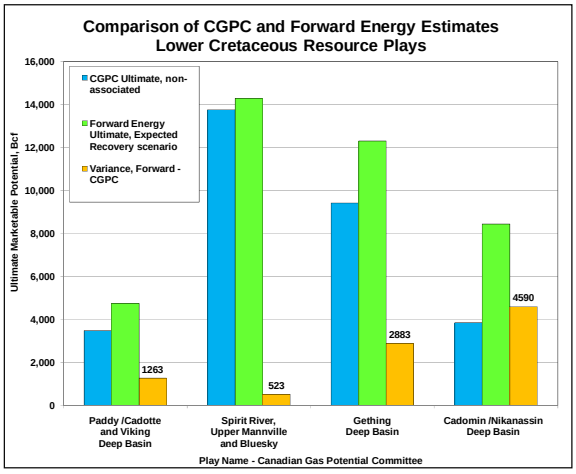
Comparison to CGPC Ultimate



- Forward Energy ultimate (Expected Recovery) is 39.8 Tcf vs. 30.5 Tcf for CGPC ultimate non-associated
- Cadomin/Nikanassin and Gething account for >80% of increase
- Significant drilling activity and reserves reporting post-dates the year-end 2003 reserves used in CGPC study

- CGPC ultimate marketable was factored to non-associated gas
- Forward Energy ultimate includes developed EUR allocated from Multiplay

30% increase in ultimate marketable resource

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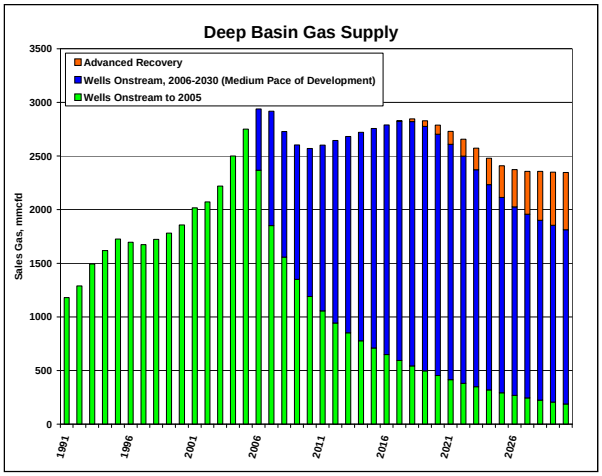
Gas Supply



- 10,000 wells onstream produced 14 Tcf to 2005; remaining EUR of 7 Tcf produced by 2030
- At a medium development pace, Deep Basin peak output (2.9 Bcfd) reached in 2006; long term rate stabilizes near 2.8 Bcfd
- Rate of supply constrained by finite volume of undeveloped resource (23 Tcf)

- With Advanced Recovery, technological advances improve success rates, increase down spacing and maintain EUR/well metrics over the longer term
- Most Advanced Recovery volume (7 Tcf) developed and produced after 2030

Expected Recovery will not sustain Deep Basin rates

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Tight Gas Play Comparison
Deep Basin and US Rocky Mountain region

	Deep Basin	US Rockies Tight Gas
Plays	13	13
Production, 2005	2.7 Bcfd	5.6 Bcfd
Play areas	Very large 3,500-21,500 sq miles	Small 1,000-6,500 sq miles
Play success rate	Low 5%-25%	High 73% to 96%
Well Spacing, future	220 - 500 acres	26 -160 acres
EUR per section, Bcf	Modest 0.5 to 3.4 Bcf	Large 2.2 – 50 Bcf
Undeveloped Resources	22.9 Tcf	67.1 Tcf
Reservoir interval	10's of feet	100's of feet
Play area % drilled	Higher %	Lower %
Sand/shale ratio	Low	High

Sources: Forward Energy, EIA AEO2007 supply model inputs

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Conclusions

Deep Basin plays differ from "pure" Continuous model

- Low success rates, singly or stacked
  - Discovery remains uncertain and requires management
- EUR per well has been decreasing
  - Rather than recovery per well increasing with advancing technology, recent high prices made lower reserve prospects economic
- Low frequency of downspacing
  - Operators appear satisfied current spacing will optimize GIP recovery
- Cadomin, Cardium and Lower Mannville South plays appear to behave more like Continuous model

Ultimate Resources +30% from CGPC estimates

- Undeveloped resource estimates range from 16 Tcf to 30 Tcf

Future Supply

- Expected Recovery of 23 Tcf will be connected, reach peak rate before 2020 and will be mostly consumed by 2030
- Increased supply from an Advanced Recovery scenario will require focused industry and government-supported R&D into technology to reduce risk and increase recovery

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Recommendations

Tight Gas Definition

- Adopt for reporting production, reserves and resource estimates

Other WCSB Tight Gas Plays

- Characterize and estimate resources for other tight gas plays

Deep Basin Plays

- Play boundary mapping, include Jurassic and Triassic plays

E&P Strategies

- Single play strategies: target to maximize single zone success rate
  - Infill offsetting producing low permeability wells
  - Extend reservoir trends from producing wells
  - Explore offsetting non-producing show, lead or bypassed pay wells
  - Optimize drilling and completion for single zone recovery (horizontal)
- Stacked play strategies: maximize resource density (GIP)
  - Target areas where plays stack to increase resource density
  - Optimize drilling and completion for multiple producing zones
  - Stack secondary plays with a primary play with higher success rate

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Recommendations

Technology

- Exploration and Reservoir Characterization
  - Play boundary and resource mapping
  - Better identification of gas in place (petrophysics and seismic)
  - Studies and models for reservoir and flow geometry and reservoir quality
  - Enhanced permeability identification, including fracture identification
- Drilling and Completion
  - Fracturing fluids and proppants
  - Geosteering and horizontal well applications
  - Multi leg stimulation and flow assessment
- Production
  - Low cost / low pressure gathering system infrastructure

Regulatory

- Commingling - Facilitated in northern portion of Deep Basin; may require similar regulations to south
- Multiple zone rights and land tenure
  - Separate ownership of zone rights requires agreements that deter and delay commingled development of stacked zones
- Downspacing – Correlative rights and bureaucratic approval processes delay drilling, slowing development pace

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Next Steps Forward

Deep Basin plays

- Update type curves and EUR for wells drilled to year-end 2007
- Scoping analysis for single play and stacked play strategies
  - e.g. Mapping total EUR per section, EUR and rate-added trends, tested wells
- Detailed characteristics by play and area and technology
  - e.g. Compare Cadomin horizontals to verticals in same area
- Competitor Analysis and Peer Benchmarking
  - e.g. Drilling, completion, connection and well performance, success rate
  - Value analysis: With these results, is anyone making money?
- Value-added technology data: completions, fracs, horz. length
- Alternate resource estimates and supply forecasts for Deep Basin

Tight gas play characterization: other WCSB plays

Tight gas play characterization: other basins

Focus on specific questions

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