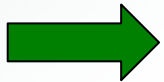
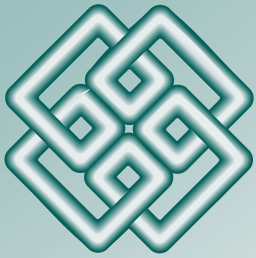


PTAC

Unconventional Gas Technology Roadmap Workshops

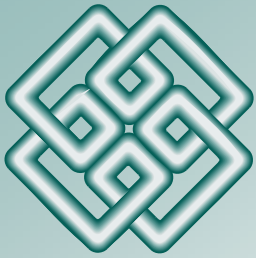
Shale Gas	October 14, 2005
CBM/NGC	October 17, 2005
Tight Gas	October 20, 2005
Gas Hydrates	October 25, 2005
Summary Session	November 4, 2005





Unconventional Gas Technology Roadmap Background

- Western Canada's gas production recently peaked at 6 TCF (16 BCF/day) and is not expected to grow significantly in the medium term
- In the long term, gas supply is forecast to decline to about 4 TCF by 2020. Added conventional supplies from the East Coast and MacKenzie delta may help maintain a national production level up to about 7 TCF per year, but without added reserves from other quarters, the long term position is clear; natural gas supply in Canada, and consequently our contribution to North American energy supply, and valuable exports, will decline in the next two decades unless new supplies from unconventional sources are developed and brought on stream.



Why a Roadmap?

Technology development holds the key to unlocking reserves, to improve recovery and reduce costs. The development of a “Technology Roadmap” similar to one published for the “oil sands” and “clean coal” industries, is a way to increase awareness of the opportunity offered by unconventional gas, and bring the future development opportunity under the review of a wide stakeholder base. In this way, the industry can gain consensus on the technical challenges, help legislators understand those challenges, and where necessary make an appropriate response to encourage further development of particular resources.

Unconventional Gas Technology Roadmap Workshop
October 20, 2005, 9:00 am – 4 pm,

Alberta Research Council, Calgary, Alberta

TIGHT GAS

The attached notes are from the breakout groups that discussed the technology development needs and opportunities in the future development of Tight Gas

Breakout Group Operations

There were two breakout groups in the morning, and each was asked to consider the Tight Gas needs under 5 categories:

- 1. Resource Definition**
- 2. Non-Environmental Challenges to development**
(not restricted to those with technology development needs)
- 3. Environmental Challenges to development**
(not restricted to those with technology development needs)
- 4. Current Technology used in each of 3 areas:**
 - Geosciences / Characterization/Modeling
 - Drilling / Completions and Stimulation
 - Lift Mechanisms and Surface Infrastructure
- 5. Future Technology Development Needs / Opportunities in:**
 - Geosciences / Characterization/Modeling
 - Drilling / Completions and Stimulation
 - Lift Mechanisms and Surface Infrastructure

After the feedback from the three breakout groups, individuals selected one of the three technology areas to review the morning work in more detail and add value as appropriate. There were only two pm groups, as there was insufficient interest to review the Lift Mechanisms... a second time

List of Attendees

Bill Kauffman	AERI Alberta Energy Research Institute
Tom Byrnes	Alberta Energy and Utilities Board
Dean Rokosh	Alberta Geological Survey
Haibo Haung	Alberta Research Council
Srdjan Borac	Anadarko Canada Corporation
Yunhon Yeung	Anadarko Petroleum Corporation
Bob Pearson	APA Petroleum Engineering Inc.
Allan Lau	BP Canada Energy Company
Florin Hategan	Burlington Resources Canada Ltd.
Joanne McNichol	
Padgett V. Eastman	Champion Technologies Ltd.
Juan Garcia	Fekete Associates Inc.
Rolf D. Wenzel	Ferus Gas Industries Inc.
Dave Flint	Forward Energy Group Inc.

List of Attendees (continued)

Bob Dixon	Forward Energy Group Inc.
Kirk Osadetz	Geological Survey of Canada
Emmanuelle Piron	IFP Technologies
Len Flint	Lenef Consulting Ltd.
Gary L. Horton	Mancal Energy Inc.
Jim Davidson	National Energy Board
Dave Quirk	Pinnacle Technologies (Canada) Inc.
Denis Gaudet	PTAC
Leah Lawrence	Real Data Analysis Inc.
John R. Kovacs	Schlumberger of Canada
Cris O'Brien	Shell Canada Limited
Terrence D. Lukie	Talisman Energy Inc.
Gerhard J. Pflug	TransCanada Pipelines Ltd.
John Van Ham	Van Ham Resources

AM - Breakout Group # 1

RESOURCE DEFINITION

Comments:

Tight gas shouldn't include desorption gas

NON- ENVIRO DEVELOPMENT CHALLENGES

- We know where it is – there is not a finding challenge
 - But do we know the quality (performance prediction)?
 - Correct reservoir characterization?
- Recovery is the challenge – getting it out of ground at decent rate
 - Rates, reserves and testing
- Regulatory issues
 - Why do need an AOF with EUB
 - Revisions to regulatory reporting on pressure (different reporting for tight gas)
 - Timing and types of submissions are issues (current timelines are limiting, type...)
 - Is uneconomic today because of time requirements on reporting
 - Currently prevents drilling of some wells
 - Need better data and so need reporting requirements
 - Improved disclosure on stimulation data
- Lack of flexible infrastructure where gas is in place
 - Revisit existing facilities with re-vamps for tight gas
- Current performance testing methodology has limited diagnostic capability
- Improved data collection technology
- Inadequate reservoir pressure testing methods and technology
- Low-cost, accurate and long-term testing technology
- Co-mingled of CBM and tight gas (data required)
- Low cost transmission of high-accuracy digital data from remote locations
- Gas well dewatering (downhole pumps)
- Real time bottom hole pressure data

ENVIRO-BASED DEVELOPMENT CHALLENGES

- Footprint environmentally or socially sensitive areas
 - Spacing requirements when can't pad drill (high well densities)
 - Number of compressors
 - Pipeline density
 - Permission to use temporary surface lines
- Access restrictions (slope stability)
 - Seasonal
 - Species at risk
 - Stakeholders
 - Land users (joint usage of roads and land)
- Requirement to use environmentally sensitive testing (limited flaring)
 - Costly with unintended results
- Fluid management and disposal
 - Drilling fluids
 - Fracturing fluids
- Fresh water supply in certain regions
 - Southern Alberta
- CO2 emissions
 - More energy intensive activities
- Cumulative impacts
 - From oil and gas and other industries

Overarching needs

- Service suppliers need to know size of the market
- R&D commitments from all (industry, service providers, government)
- Lower costs across the whole industry
- Workforce availability (can we get the right people and mentor them)
- Interdisciplinary integration

FUTURE TECH DEVELOPMENT OPPORTUNITIES

GEOSCIENCES / RESOURCE CHARACTERIZATION/ MODELLING

- Needs today
 - We have technology, it is just cost prohibitive
- Future technology needs
- Definition of net pay (what is contributing, is it shale gas, CBM, etc.)
- New logging tools
 - Direct measurement of permeability (proxies to permeability)
 - Effective porosity and gas saturation
 - Whole new suite of logging tools
- Core measurement procedures (new standards for testing tight gas core)
 - Irreducible water saturation
 - Wet ability and capillary pressures
 - Water sensitive component distribution
 - Direct measurement of permeability (proxies to permeability)
 - Effective porosity and gas saturation
- In-situ identification of micro-fractures
- New seismic processing

FUTURE TECH DEVELOPMENT OPPORTUNITIES

GEOSCIENCES / RESOURCE CHARACTERIZATION/ MODELLING

- Reservoir characterization (macro-scale)
 - Linking well and seismic data (may lose resolution)
 - Diagenesis distribution
 - Interdisciplinary integration (tools, training and management components)

- Modelling
 - Isn't a model for handling stacked intervals (geocellular scale)
 - Fully 3-D modelling that includes cross-well (fast, low cost, user friendly prediction model; handles hydraulically and naturally fractured reservoirs)
 - Stochastic modelling of fractures and permeability

- Resource Characterization
 - Determine drainage areas and shape to optimize spacing, well type and development
 - Predicting long-term deliverability and recovery
 - Understanding liquid mobilization, production and allocation
 - Understand continuity of beds

 - Economic data collection
 - Basic physics tied back to reservoir models
 - Analytical modelling tools

- Clear definition of boundary between tight gas and desorption gas

FUTURE TECH DEVELOPMENT OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- Evaluation of all results in drilling, completion and stimulation
- Stimulation modelling
 - models are too simplistic today to predict fracture height and half length, effective dynamic fracture half length
 - Using pseudo-3-D model is inappropriate (leads to by-pass pay and poor drainage prediction, and ultimately over/under capitalization of the resource)
- Drilling and completion fluid selection (compatibility and effectiveness)
 - Tight gas sucks up the fluid and it leads to damage
- Manage pressure drilling and/or under balanced drilling (UBD)
- Cementing selection and procedures
 - Evaluation techniques for cement jobs
 - Reverse circulation cementing, cementing slim well completion
- Higher abandonment cost (perhaps)
- Technologies that add value
- Mapping application for complex wells and completions
 - (e.g. open hole with comingling, multilateral wells, and massive fracs)

FUTURE TECH DEVELOPMENT OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- Rig-site fluid monitoring tools
 - Data collection
- Real time data gathering while drilling and fracturing
 - Could also learn a lot with post-data
- Intermittent communication connection from remote locations
 - Improved reliability
 - Would enable analysis in Calgary (thus dealing with personnel shortage)
- Advanced service rigs or rig-less completions
- Improve snubbing
 - Need to develop balanced and under balanced completion technologies
 - Need liquid-less completion technologies (or non-damaging fluids, vaporizing fluids)
- Highly dependent on fracturing
- Fracture stimulation technologies for horizontal and multilaterals
- Slick water fracture applications and upgrades
 - Requires review (is an old technology)

- Decision matrix for drilling and completion
 - AI guided decision-making tool linked to public data

FUTURE TECH DEVELOPMENT OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

- Downhole compressors tech
- Compressors
 - Low intake pressures
 - Retro-fit
 - supply of compressors
- Downhole separation and disposal tech
- Better understanding of foaming agents (and getting the mixing energy downhole)
- Improved lift techniques for small volumes of water in gas
 - Improved measuring techniques
 - Surface instrumentation
 - Low-cost, low liquid rate, production logging tools
 - Improved higher capacity pumps (meaning deeper) powered by renewables
 - Energy storage for pumps
- Guide for selecting best lift mechanisms
- Retrofit pig launchers (techniques for finding stuck pigs)
- Improved gas hydrate management technology

FUTURE TECH DEVELOPMENT OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

- More available and user friendly tools for transient slug behaviour (slug behaviour in gathering systems)
 - Automation
 - Improved gathering system modelling
- Integrated gathering system modelling
 - Integrated and automated data
 - Populating data
- Downhole generator
 - Gas to generate electricity
- Low-rate, multi-phase meters (approved by regulators)
- Surface infrastructure issues have a lot to do with environmental issues

AM - Breakout Group # 2

RESOURCE DEFINITION

Comments:

- permeability is not material
- pervasive play-based definition may be more appropriate
- workable in context of information gathered today or can be obtained
- ... or should it be pool based ?
- operations perspective ... need for stimulation?
- why do we need a definition...think of how the definition will be used
- geological basis
- UGTR needsthe political/legislative audience needs some direction or basis ...our wider audience to promote the need for creative fiscal support
- permitting (*see “Challenges”*)
- natural fractures or not ?
- absence of water ?

NON- ENVIRO DEVELOPMENT CHALLENGES

- Distinctive regulations for tight gas that impact:
 - tests
 - comingling
 - hole size / well design
 - parcel size
- lack of infrastructure outside wcsb (including roads etc)
- risk .v. reward...but risks offset by lower capex
- gas price volatility ... what is the new “floor”
- impact of offshore LNG ... SNG
- basis for and future “demand destruction”
- impact of energy efficiency investments
- sweet spot definition
- land tenure system ex wcsb ...lack of contiguous blocks and scale
- comingling issues ... production regulations
- distinctive regulations for tight gas (testing of levels)
- Aboriginal issues / “sharing the opportunity”
- skilled labour ... human resources
- publicly funder R&D...the “UG-AOSTRA”

ENVIRO-BASED DEVELOPMENT CHALLENGES

- the footprint from “wells to furnace”
- protected areas
- noise –compression
- well density
- groundwater protection
- water and other fluids used in production
- CO₂ emissions ... life cycle ... p/l and compression...Kyoto impact

FUTURE TECH DEVELOPMENT OPPORTUNITIES

GEOSCIENCES / RESOURCE CHARACTERIZATION/ MODELLING

- finding “sweetspots” ...the geological properties of these resources poorly known
- better seismic techniques to find the resources
- logging methodology ...completion strategy
- how to find the most favourable economic targets
- reservoir simulation models to predict resource productivity...well spacing ... etc
- compression .v. shear wave interpretation ... have we “mined” the data sufficiently ?
- improved vertical seismic processing
- special formation evaluation by coring & analysis

FUTURE TECH DEVELOPMENT OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- research into design and interpretation of tests
- drilling fluids and any negative formation damage ...
these reservoirs less forgiving than conventional
- hole stability and wash-outs
- fracture fluid and proppant design
- fracture mapping ...where and why ?... the use of
tilt meters and borehole imagers
- directional drilling ... including horizontal drilling ...orientation...bit life
- how to find the natural fractures
- drilling and completion efficiency
- controlled application of under-balanced drilling
- re-fracturing .v. effectiveness of compression
- field optimization

FUTURE TECH DEVELOPMENT OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

- gas production in the presence of liquids, such as retrograde condensate
- there may also be water from other layers
- gathering system design for low pressure production
- reduced cost of facilities and compression
- reduce pad size
- placing fracs in deviated wells

PM - Breakout Group # 1

Reassessment of Geosciences / Characterization / Modelling

FUTURE TECH DEVELOPMENT OPPORTUNITIES

GEOSCIENCES / RESOURCE CHARACTERIZATION/ MODELLING

Needs today

- We have technology, it is just cost prohibitive

Overarching

- Identification of plays and areas (knowledge need)
 - Geological proxies (using screening criteria like depth, porosity and permeability)
 - Criteria are function of price over time
 - Knowledge of natural limitations
 - Important characteristics reflected in criteria
- Hierarchy of technology needs and linkages between technologies
- Unconventional gas, AOSTRA-type or GRI entity
- How to integrate data of different types, scales, etc. is key area of research

Future technology needs

- Definition of net pay (what is contributing, is it shale gas, CBM, etc.)
 - Tight gas definition in Canada encompasses US definition of tight gas
 - Are there technology needs to define tight gas? In mixed environments it is complex to answer this question.
 - Need for petroleum systems models of different tight gas resource types.

FUTURE TECH DEVELOPMENT OPPORTUNITIES

GEOSCIENCES / RESOURCE CHARACTERIZATION/ MODELLING

- New logging tools
 - Direct measurement of permeability (proxies to permeability)
 - Effective porosity and gas saturation
 - Whole new suite of logging tools
 - Improvement of log suite interpretation (so don't rely on core analyses as much)
 - New slim hole downhole pressure measuring device for low perm rock
- Core measurement procedures (new standards for testing tight gas core)
 - Irreducible water saturation
 - Wettability and capillary pressures
 - Water sensitive component distribution
 - Direct measurement of permeability (proxies to permeability)
 - Effective porosity and gas saturation
- Improved evaluation procedures for well test analysis
- In-situ identification of micro-fractures
 - Correlation of FMI and core results
 - Calibration of measurement tools with the rock (integration technology)
 - New seismic processing
 - on both vertical and horizontal basis
 - Improved seismic to improve resolution of geologic model
 - Capturing both compression and shear wave data to describe reservoir heterogeneities and fluid content, rock mechanical properties for fracture design

FUTURE TECH DEVELOPMENT OPPORTUNITIES

GEOSCIENCES / RESOURCE CHARACTERIZATION/ MODELLING

- Reservoir characterization (macro-scale)
 - Linking well and seismic data (may lose resolution)
 - Rock to well to seismic to reservoir integration (don't necessarily need new technology, rather need to re-integrate existing technology)
 - How to integrate data of different types, scales, etc. is one of key areas of research
 - Diagenesis distribution
 - Interdisciplinary integration (tools, training and management components)
- Modelling
 - Isn't a model for handling stacked intervals (geocellular scale)
 - Fully 3-D modelling that includes cross-flow (fast, low cost, user friendly prediction model; handles hydraulically and naturally fractured reservoirs)
 - Stochastic modelling of fractures and permeability
 - Ability to model heterogeneity at reservoir-scale
 - Distinguish between clastic reservoirs versus carbonates
 - Better reservoir model source codes that are physically correct rather than historically matched

FUTURE TECH DEVELOPMENT OPPORTUNITIES

GEOSCIENCES / RESOURCE CHARACTERIZATION/ MODELLING

- Resource Characterization
 - Determine drainage areas and shape to optimize spacing, well type and development
 - Predicting long-term deliverability and recovery
 - Understanding liquid mobilization, production and allocation
 - Understand continuity of beds
 - Understanding the depositional environment and diagenetic history
 - Better geological models to feed back into geophysics (seismic) and reservoir models
 - Characterize naturally fractured reservoirs
 - In deviated and horizontal wells
 - Tools more measuring pressure in reservoir (continuous fibre-optic pressure monitoring tool)
 - Economic data collection
 - Basic physics tied back to reservoir models
 - Analytical modelling tools
- Clear definition of boundary between tight gas and desorption gas

PM - Breakout Group # 2

Reassessment of Drilling / Completions / Stimulation & Lift Mechanisms & Surface Infrastructure

FUTURE TECH DEVELOPMENT OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- research into design and interpretation of well tests and PTA

(put in first section...Geosciences/Reservoir
Characterization/Modeling)

FUTURE TECH DEVELOPMENT OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- Evaluation of all results ...better “data mining”
- Stimulation modelling
 - Models are too simplistic today to predict fracture height and half length, effective dynamic fracture half length
 - Using pseudo-3-D model is inappropriate (leads to by-pass pay and poor drainage prediction, and ultimately over/under capitalization of the resource)
- Fracture fluid and proppant selection/design
- Drilling and completion fluid selection (compatibility and effectiveness)
these reservoirs are less forgiving than conventional
- Drilling and completion efficiency supply chain management
 - Tight gas sucks up the fluid and it leads to damage
- Manage pressure drilling and/or under balanced drilling (UBD)
- Well bore integrity
 - Cementing selection and procedures
 - Hole stability and wash outs
 - Evaluation techniques for cement jobs
 - Reverse circulation cementing, cementing slim well completion
- Higher abandonment cost (perhaps)

FUTURE TECH DEVELOPMENT OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- Technologies that better match the “economic envelope”
- Mapping application for complex wells and completions (e.g. open hole with comingling, multilateral wells, and massive fracs)
- Rig-site fluid monitoring tools
 - Data collection
- Real time data gathering while drilling and fracturing
 - Could also learn a lot with post-data
- Intermittent communication connection from remote locations
 - Improved reliability
 - Would enable analysis in Calgary (thus dealing with personnel shortage)
- Advanced service rigs or rig-less completions
- Improve snubbing
- Need to develop balanced and under balanced completion technologies
- Need liquid-less completion technologies (or non-damaging fluids, vaporizing fluids)
- Highly dependent on fracturing...fracture mapping ...where and why ?... the use of tilt meters and borehole imagers

FUTURE TECH DEVELOPMENT OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- Fracture stimulation technologies for horizontal and multilaterals
- Slick water fracture applications and upgrades
- Requires review (is an old technology)
- Decision matrix for drilling and completion
- AI guided decision-making tool linked to public data
- Placing fracs in deviated wells, including optimum number of fracs
- How to find the natural fractures
 - seismic processing sweetspot ID
 - accurate fluid loss measurements while drilling
 - logging techniques, including LWD
 - improved PTA techniques (over use of radial composite model)
 - other techniques for finding fractures
- Directional drilling including horizontal drilling
 - bit life
- Optimizing re-fracturing frequency and design
- Evaluate versus effectiveness of compression
 - evaluate shape of IPR close to AOF
- Field optimization

FUTURE TECH DEVELOPMENT OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

- Gathering system design for low pressure production; reduced cost of facilities and compression
- Downhole compressors tech
- Compressors
 - Low intake pressures
 - Retro-fit
 - supply of compressors
- Downhole separation and disposal tech
- Better understanding of foaming agents (and getting the mixing energy downhole)
- Improved lift techniques for small volumes of water
- Improved measuring techniques for small volumes of water
 - Surface instrumentation
 - Low-cost, low liquid rate, production logging tools
- Improved higher capacity pumps (meaning deeper) powered by renewables
- Energy storage for pumps
- Guide for selecting best lift mechanisms
- Retrofit pig launchers (techniques for finding stuck pigs)
- Improved gas hydrate management technology

FUTURE TECH DEVELOPMENT OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

- More available and user friendly tools for transient slug behaviour (slug behaviour in gathering systems)
 - Automation
 - Improved gathering system modelling
- Integrated gathering system modelling
 - Integrated and automated data
 - Populating data
- Downhole generator
 - Gas to generate electricity
- Low-rate, multi-phase meters (approved by regulators)
- Surface infrastructure issues have a lot to do with environmental issues
- Gas production in the presence of liquids, such as retrograde condensate there may also be water from other layers
- Liquid removal
 - water
 - condensates
 - fracturing fluids
 - drilling / completion fluids
- Improved safety procedures