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.

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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.

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Unconventional Gas Technology Roadmap Workshop
October 17, 2005, 9:00 am – 4 pm,

NEB Hearing Rooms, Calgary, Alberta

COAL BED METHANE
(NATURAL GAS from COAL)

The attached notes are from the breakout groups that discussed the technology development needs and opportunities in the future development of Coal bed Methane

List of Attendees

Dean Rokosh	Alberta Geological Survey
Andrew Beaton	Alberta Geological Survey
Brandy Jeary	Alberta Research Council
Jeff Sinclair	Alberta Research Council
Yunhon Yeung	Anadarko Petroleum Corporation
Alain Kahil	Apache Canada Ltd.
Tim Leshchyshyn	BJ Services Company Canada
Padgett V. Eastman	Champion Technologies Ltd.
Marc D.. Melnic	Enerplus Resources Fund
Rolf D. Wenzel	Ferus Gas Industries Inc.
Bob Dixon	Forward Energy Group Inc.
Joseph Korol	GeoKorr Consulting Inc.
Wayne Redecopp	Halliburton Energy Services
Angela Mah	Husky Energy Inc.
Dave Nuth	Kudu Industries, Inc.
Len Flint	Lenef Consulting Ltd.

List of Attendees (continued)

David Mitrovica	Maxwell Drummond
Matt Groza	National Energy Board
Bobbi-Lee Feduniak	National Energy Board
Jim Davidson	National Energy Board
Stephen Lougheed	Noetic Engineering Inc.
Myles B. McDougall	PetroJet
Dave Quirk	Pinnacle Technologies Inc.
Denis Gaudet	PTAC
Leah Lawrence	Real Data Analysis Inc.
Colin Flanagan	Real Resources Inc.
Tom Charuk	Real Resources Inc.
James Brewer	Shell Canada Limited
Duncan Stanners	Shell Canada Limited
Gerhard J. Pflug	TransCanada Pipelines Ltd.
Rong Guo	University of Calgary
Mehran Pooladi-Darvish	University of Calgary
John Van Ham	Van Ham Resources

Breakout Group Operations

There were three breakout groups in the morning, and each was asked to consider the CBM 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 Developent 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

AM - Breakout Group # 1

RESOURCE DEFINITION

CBM or NGC is natural gas found in most coal seems. NGC is unconventional gas because the coal acts as both the source of the gas and the storage reservoir. Most of the NGC is attached to or "adsorbed" on the coal surfaces and may also be trapped in the coal fractures. *(Source: CSUG)*

Comments

- Will leave out sandstone commingling on purpose.
- Will leave out neighboring sandstone contribution to coal seam production.
- Reserves (size of prize)
- Range is huge
- Recovery factor depends on technology actually developed.
- Can't check numbers and agree / disagree unless we see the sources and methods which is out of scope.

NON- ENVIRO DEVELOPMENT CHALLENGES

- Lack of infrastructure
  - Pipeline
  - Roads
  - Especially in remote areas
- Stakeholders / land owners
  - Public image
- Government regulations
  - Revision of data submission requirements
  - Lack of compliance
  - Commingling

- Land prices have quadrupled
- Macro-economic concerns
  - Forecast reliability
  - Pipeline risk
  - Costs and revenue

NON- ENVIRO DEVELOPMENT CHALLENGES

- Lack of manpower
  - Technical people
  - Government agencies
  - Truck drivers
  - Drilling
- Lack of supplies / commodities
  - Cement
  - Nitrogen
  - CO_2
- Different model from operator perspective
- Speculative mode
- Risk adverse to apply technology
  - Low producing wells encourage
- Lack of information sharing
  - Affects competition
- Incentive by government
    - Grants
    - Tax incentives
    - Royalty relief

ENVIRO-BASED DEVELOPMENT CHALLENGES

- Water opportunities without deep well injection.
  - Save money on disposal
  - Save money and issues on fresh water supply to
- Footprint
- Abandonments
- Wellbore integrity
- Fresh water aquifer protection
  - Sampling before and ongoing after drilling and cementing new wells
- Fresh water abandonment practices
- Cummulative effects
  - Integration with other industries
- Noise with compression
- Shallow fracture containment

CURRENT RECOVERY TECHNOLOGY

GEOSCIENCES / RESOURCE CHARACTERIZATION / MODELLING

- Characterize geology through the drill bit (core etc)

FUTURE TECH DEVELOPMENT NEEDS/OPPORTUNITIES

GEOSCIENCES / RESOURCE CHRACTERIZATION/ MODELLING

- Subsurface visualization
  - Can not model
- Current seismic resolution greater than coal seams
- Need to monitor and capture data

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

DRILLING

- Cost
- Drilling fluid
  - least damage
  - most effective
- Locked into oil and gas paradigms
  - practices, materials, standard designs
- Will the regulatory regime allow innovation?
- Coiled tubing drilling vs jointed pipe
- Drill bits
  - near wellbore damage
  - predicting arrival of coal seams,
  - detecting natural fractures while drilling
  - Pressure monitoring while drilling
- Hole stability and risks while drilling

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

COMPLETION / STIMULATION

- Perforating technology application
  - Small diameter and deep
  - Large diameter and shallow penetrating
- Need to optimize stimulation technologies
- Predicting coal seam break thoughs or not on fractured vertical wells
- Complex fracture mapping in coal versus tilt-meter mapping
- Frac models
  - Sufficient to model complex results in coal
  - Enough information to input into models
  - Simpler models “tweaked” to emulate complex results
- Coal fines and chunks
- Hole stability during life of well

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

COMPLETION / STIMULATION

- Horizontal drills on dry, shallow seams
  - Cost
  - Effectiveness
- Horizontal drills on wet, deep seams
  - Hole stability during dewatering phases
  - Fracture stimulating using a variety of fluids and proppant
    - Fluids
      - Produced water
      - Low efficiency, low damage fluids
    - Proppant
      - Light weight
      - Resin coated
      - Ceramic

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

Lift

- Coal fines plug pumps
- Lift requirements change throughout well life cycle
- Downhole dewatering an opportunity
- Cheap downhole sensing and pump control
- Cheap pumping system
- Multi-phase pump

Surface

- Compression – harmonic stability issues?
- Water handling
- Reducing footprint
- Water treatment

AM - Breakout Group # 2

RESOURCE DEFINITION

CBM or NGC is natural gas found in most coal seems. NGC is unconventional gas because the coal acts as both the source of the gas and the storage reservoir. Most of the NGC is attached to or "adsorbed" on the coal surfaces and may also be trapped in the coal fractures. *(Source: CSUG)*

Comments

•Clear definition in this case – gas that comes from coal

•Naming the resource
- •US calls it non-conventional versus unconventional (national petroleum council)
- •Coal bed methane – natural gas from coal – coal bed gas – which one?
- •Producer's perspective – perhaps name doesn't matter
- •Regulator's perspective – may matter more
- •EUB uses CBM, BC government uses CBG

•Call it what it is

•How big is the play? 60 – 80 Tcf potential recoverable reserve
•How big is resource? Resource number taken from background material
•Sproule – has good number on resource/reserve… but changes all the time

NON- ENVIRO DEVELOPMENT CHALLENGES

- Local issues are societal in nature
- Direct challenges to society
- Surface lease rentals (getting appropriate price for lease)

- Regulatory – rules specific to what is underground
    - No H2S in coal, no BOPs
    - Land tenure system – developed for section/1/4 sections… CBM requires large contiguous blocks
    - Many current rules relate to conventional oil and gas
        - Too strict in some ways and not enough in others
        - Co-mingling regulations will be difficult
    - Conventional has left a legacy in minds of stakeholders; doesn't necessarily apply to CBM but is in minds of stakeholders

    - Need specific CBM regulation that addresses these issues, and regulations put in place must be applied rigorously

- Ownership issue over coal versus CBM – waiting for courts
- Landowner concerns

ENVIRO-BASED DEVELOPMENT CHALLENGES

- Cumulative impacts
  - Regulators look at single issues, not the cumulative impacts
  - Alberta Chamber of Resources
  - Not just one industry, many industries
  - Drilling and industry support, e.g. people, rigs, infrastructure (non-environmental)

- Surface infrastructure footprint
  - From wells sites, roads, other infra…
  - Pad drilling one way to mitigate (centralization reduces cost and reduced footprint)
  - Noise abatement

- Water management
  - Dry coal (not as much of a problem in this area)
  - Saline water production
  - Production of fresh water (no regulations at this point)
  - Use of fresh water in production (not real)
  - Groundwater protection – old data on hydrogeology (lack of government resources)
  - Aquifer depletion is serious concern (streamlined process to satisfy ABEN and EUB needs both)

ENVIRO-BASED DEVELOPMENT CHALLENGES

- Air issues
  - Flaring and venting
  - N2 flowback during stimulation
  - More greenhouse gases as result
  - CBM industry offers opportunity of CO2 sequestration
    - Need for gathering/transportation system

- Habitat issues
  - Potential rollout from prairie regions to eastern slopes of foothills

- More realistic view of environmental footprint in some areas
  - But recognize that issues are real in some areas
  - Improved communication between industry and stakeholders
  - Miscommunication on coal gasification vs. CBM

FUTURE TECH DEVELOPMENT NEEDS/OPPORTUNITIES

GEOSCIENCES / RESOURCE CHRACTERIZATION/ MODELLING

- Today
  - Template for Horseshoe Canyon in terms of drilling, fracturing, etc.
  - Desorption analyses available from EUB (Guide 14 for some information)
  - Spinner surveys – improved accuracy

- Future
  - Improved horizontal drilling techniques
    - Multilaterals
  - Surface permeability detection in-situ is a big desire (highly variable perm. laterally)
  - High rate N2 fracs do not work in all reservoirs
  - Update CBM forum data and revitalize concept of data exchange (pre CSUG)
  - Science – 'all coals are different' and need site specific information on geology, production, reservoir characterization
    - Work needs to be done here
    - Then need central repository
  - Formation damage (air vs. mud drilling)
  - Petrophysical tool for coal characterization (improved log interpretation)
  - Reservoir characterization (need better simulation)

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- Today
- Spinner surveys – improved accuracy

- Future
  - New drilling techniques
  - New completion/stimulation techniques
    - Fracturing versus cavitation
    - Need out of the box thinking here
      - Steam injection?
  - Improvement in downhole completion techniques
  - Unlearning what you knew about conventional gas
  - Better desorption techniques

  - Need better understanding of role of CO_2, how CO_2 and coal react (new information available)
    - DOE April 2005 (Lawrence Berkeley Laboratory), report on sequestration of CO_2 in CBM
    - Website up soon on this subject (Nov/Dec)
    - Bill Gunter

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

- Today
  - Use low pressure system, plastic pipe instead of steel
  - Today use separate system from the conventional infrastructure

- Future
  - Low-pressure infrastructure and on large scale (completely separate system for CBM)
    - Locally and provincially

AM - Breakout Group # 3

RESOURCE DEFINITION

CBM or NGC is natural gas found in most coal seems. NGC is unconventional gas because the coal acts as both the source of the gas and the storage reservoir. Most of the NGC is attached to or "adsorbed" on the coal surfaces and may also be trapped in the coal fractures. *(Source: CSUG)*

Comments

- How to handle co-mingled … different owners

NON- ENVIRO DEVELOPMENT CHALLENGES

- regulatory…enviro and EUB not joined at the hip
  ….enviro “on the fly”
- WCSB infrastructure…p/l…skill base in the right areas…
  understaffed
- land tenure system ….scalability
- regulatory environment needs to align itself with the
  producer environment
- legal issues around ownership for freeholders…risk in
  the absence of clear rules
- incentives for development technology …some in BC…
  new jurisdictions (in the East) with no clear direction

ENVIRO-BASED DEVELOPMENT CHALLENGES

- water handing..
  - non-saline water associated with coal gas production
  - low volume saline water
  - high volume saline water
- water depletion / reduced pressure in non-saline aquifers
- contamination from fracing
- CO2 in the CBM
- fugitive CH4 emissions vented to the atmosphere
- CO2 sequestration opportunities
- footprint…well density
- noise
- ecology …the flora and fauna

CURRENT TECHNOLOGIES

GEOSCIENCES / RESOURCE CHARACTERIZATION / MODELLING

- coring and lab tests used to characterize
- modelling can be used to determine the stimulation and spacing planning
- trail and error on fracturing the present norm even in the US

FUTURE TECH DEVELOPMENT NEEDS/OPPORTUNITIES

GEOSCIENCES / RESOURCE CHRACTERIZATION / MODELLING

- develop a reprocessing paradigm for the data
- better understanding of *in situ* rock/fluid properties and interraction
- … ditto for drilling and fracture fluids
- better modelling required for planning development
- accurate fracture modelling a challenge for CBM
- cleat closure mechanisms and modelling
- better use of cuttings to characterize the resource

CURRENT TECHNOLOGIES

DRILLING / COMPLETION / STIMULATION

- largely based on vertical well
- more dry coals than the US experience
- more care on drilling/completion technology than earlier
- a number of fracing technologies…but the optimum
  not well known “up front”
- where necessary, sand used as propant, but carrying
  by gas a problem

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

DRILLING / COMPLETION / STIMULATION

- the application of coiled tubing technology; good for sequential fracturing
- the application of horizontal well drilling and control of pressure window…associated risk of ignition with air and/or oxygen ingress …regulatory issues here as well
- improving cost-efficiency of the drilling cycle
- better understanding of the water .v. gas producing layers better ability to segregate and eliminate “problem zones”
- carrying sand, proper placement are opportunities for improvement
- the future of increased “hole mining” to assist CBM recovery

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

LIFT MECHANISMS / SURFACE INFRASTRUCTURE

- cheaper and quieter compression
- cost effective dewatering (by improved downhole pumps)
- better utilization of downhole water disposal zones
- better downhole monitoring to know where the gas is coming from
- cheaper collection pipelines (more plastic…etc)
- better means to ensure no water traps
- better pigging

PM - Breakout Group # 1

Reassessment of
Geosciences / Characterization / Modelling

Geosciences/Prospecting

- Subsurface imaging that allows for better ‘sweet spot’ identification prior to drilling
  - Geophysical – electrical resistivity
  - Improved seismic
  - Geochemical –
  - Bio-prospecting – use of vegetation to ID below surface
  - Groundwater analysis
  - Improved regional geological mapping
  - Groundwater resource industry
  - Industrial CBM data pool (look to CBM Data Forum for model - pre-CSUG)
    - Consulting company, industry organization or government agency to be forum?

- Drilling and coring for better ‘sweet spot’ identification
  - Use borehole seismic
  - Log interpretations of existing wells, can the information be re-processed?
    - Need 3-D to do this, anything else will be inaccurate
  - New logs from new holes
    - Need more economic 3-D seismic
  - Stress/strain mapping
    - Need to learn from coal mining industry, has their imaging and mapping successfully IDed what is underground
- ‘Intelli-darts’

Resource/Reservoir Characterization

- Permeability and fracture mapping
  - Fracture density (spacing between fractures/cleats and size of fractures)
  - Change over time
    - as you produce some cleats close/open
  - Geologic correlation
    - Individual coal seams are tough to correlate
    - Chemical? Physical?
  - Connectivity
  - Orientation
  - Do more with existing cuttings, core samples, mud logs, gas content, etc.
  - Effectiveness (open vs. closed fractures)
  - Coal lithology
    - tectonic overprint
    - Depositional modelling
- Real time drilling
- New logging tools (petrophysical tools)
  - Bulk density
  - Want to get gas content, permeabilty, cleat orientation and frequency

Modelling

- Better development plan (e.g., optimize well spacing, location, etc.)
  - Try to rely less on history matching and more on physics… *if you can* (swing pendulum away from current state)
    - Cataloguing based on coal typology – its physics, chemical make-up, dynamics and biology
  - Understand fundamentals
    - Accurate natural fracture modelling
    - Cleat closure mechanisms
    - Recovery factor
- Reliable forecast model
- Gas composition and how it changes over time (CH_4/CO_2 analysis
  - Desorption, and how it reacts over time
- CO_2/CH_4 interaction from enhanced CBM
- University of Research Chair to study CBM modelling

PM - Breakout Group # 2

Reassessment of
Drilling / Completions / Stimulation

CURRENT TECHNOLOGIES

DRILLING / COMPLETION / STIMULATION

- largely based on vertical well
- more dry coals than the US experience
- more care on drilling / completion technology than earlier years
- a number of fracing technologies…but the optimum not well known “up front”
- where necessary, sand used as proppant, but carrying by gas a problem
- Simple spinner surveys and low rate measurements used for allocations of production

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES
DRILLING

- Locked into oil and gas paradigms
  - practices, materials, conventional designs
  - Re-designing completions past conventional design application
  - Will the regulatory regime allow innovation?
    - Have CBM specific regulations and exceptions
    - Potential exemptions and encouragement for R&D and experimental approaches
  - Taking a multi-discipline approach to improving the overall process for drilling and putting a well on production

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES
DRILLING

- Cost reduction
  - Increase ROP
  - Fit for purpose for efficient
    - Reduction of non-drilling time and rig moves
  - Use produced water for drill fluid
  - Focus on increase production and ROI, not necessarily reducing costs, re-designing life cycle of well programs
- Drilling fluid
  - least damage
    - fluid compatibility
    - better fluid loss control
    - air drilling (need larger sampling of data wells to compare to mudded up systems – both new and old)
  - most effective (in terms of production)

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES
DRILLING

- Coiled tubing drilling versus jointed pipe
  - Rotary drilling
  - Combination for both in “fit for purpose”
  - Affects costs
  - Consistent underbalanced control with coil
  - Hole stability and risks while drilling
- Drill bits
  - near wellbore damage by the drill bits
  - predicting arrival of coal seams,
    - Drill cuttings quality with drilling methods and speeds
  - detecting natural fractures while drilling
  - MWD
    - Pressure monitoring while drilling

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

COMPLETION / STIMULATION

- CO_2 sequestration
  - How do CO_2 and coal react – new info available
    - Permeability impairment starts at what % CO_2, time, pressure and temperature
    - Sweep efficiency at what %CO_2, time, pressure and temperature
  - Transport and infrastructure required - economics
  - CO_2 and water being a by-product trade off for CBM and tar sands

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

COMPLETION / STIMULATION

- Complex fracture mapping in coal versus tilt-meter mapping
- Frac models
  - Sufficient to model complex results in coal
  - Enough information to input into models
  - Simpler models “tweaked” to emulate complex results
- Coal fines and chunks
- Hole stability during life of well
- Logging technology
  - Cleat spacing
  - Water saturation
  - Clay detection

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

COMPLETION / STIMULATION

- Need to optimize stimulation technologies
  - Nitrogen supply and costs
  - Coiled tubing applications
    - new patent licensing of annular fracturing from Exxon to service companies
  - Larger coil sizes for reduced friction and higher rates
  - Proppant in dry coal
    - Addition of proppant to nitrogen stream at surface
    - Placement of proppant into reservoir
  - Open-hole cavitation completions
  - Steam injection?
    - Fluid compatibility and recovery of condensed water
- Predicting coal seam breakthroughs or not on fractured vertical wells

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

COMPLETION / STIMULATION

- Horizontal drills on dry, shallow seams
  - Cost
  - Effectiveness
- Horizontal drills on wet, deep seams
  - Hole stability during dewatering phases
  - Fracture stimulating using a variety of fluids and proppant
    - Fluids
      - Produced water
      - Low efficiency, low damage fluids
    - Proppant
      - Light weight
      - Resin coated
      - Ceramic

FUTURE TECH DEVELOPMENT NEEDS / OPPORTUNITIES

COMPLETION / STIMULATION

- Perforating technology application
  - Small diameter and deep penetrating
  - Large diameter and shallow penetrating
  - Or some hybrid or completely different

- need better low rate measurements to replace spinner surveys

- Better desorption techniques (geology area or this one)