OVERVIEW OF CMM RECOVERY AND UTILIZATION TECHNOLOGY

Jonathan R. Kelafant
Sr. Vice President
Advanced Resources International, Inc.
Arlington, VA USA

Methane to Markets Conference
February 22-23, 2007
New Delhi, India
Presentation Outline

1. Terminology

2. CMM Recovery Technologies
   - Pre-Drainage via Vertical Wells
   - Gob Wells
   - In-Seam/In-Mine Horizontal Boreholes
   - Cross-Measure Boreholes

3. CMM Utilization Technologies
   - Power Generation
   - On-Site Applications (boiler fuel, coal drying)
   - Pipeline Injection
   - LNG
1. Terminology
Terminology

- **Coalbed Methane (CBM)**
  - Methane contained in coal seams. Often referred to as virgin coalbed methane, or coal seam gas.

- **Coalmine Methane (CMM)**
  - The subset of CBM that is released from the coal seams during the process of coal mining.

- **Abandoned Mine Methane (AMM)**
  - Methane that continues to be released from the coal bearing strata once a mine is closed and sealed. May also be referred to as coal mine methane because the liberated methane is associated with past coal mining activity.
Terminology (Cont’d)

• **Vertical Pre-Drainage Well**
  – Well drilled through a coal seam or seams and cased to pre-drain the methane prior to mining
  – Similar to conventional oil and gas wells, hydraulic fracturing or open-hole cavity completions generally used
  – Gas quality typically high and pipeline quality

• **Horizontal Pre-Drainage Well**
  – Vertical wells that are turned with directional drilling techniques to be completed horizontal in the coal seam
  – Use in mining applications becoming more widespread

• **Gob Well**
  – Well drilled from the surface to a point 10 to 50 feet above the working coal seam prior to mining
  – As mining advances under the well, the methane-charged strata around the well subside and create a fractured zone known as the "gob" area, which releases gas and is a significant source of methane
  – Gas quality starts high initially but will deteriorate over time due to contamination with the mine ventilation system
Terminology (Cont’d)

• **In-Seam/In-Mine Horizontal Boreholes**
  – Well drilled into the working coal seam from underground workings
  – Drains methane from the virgin and unmined areas of the coal seam shortly before mining
  – Drilled in both relatively short and long lengths. Gas quality is high and typically pipeline quality

• **Cross-Measure Boreholes**
  – Common international methane drainage technique used outside the US and Australia to drain methane from gob areas in conjunction with longwall mining
  – High angle boreholes are drilled from underground sites typically on the tail gate (return) side of the longwall panel into overlying and underlying rock strata
  – Typically tens to a few hundred meters in length and are installed just prior to and generally close to the working face
  – Gas quality is typically low (e.g. 25-50%) due to contamination of the gas with the mine ventilation system
2. CMM Recovery Technologies
CMM/CBM: Production Through Utilization

METHANE EXTRACTION AND RECOVERY

- Vertical Degasification Wells
- In Mine Well
- Gob Wells

GATHERING, COMPRESSION, AND PROCESSING

- Compression
- Dehydration
- Gas Processing
- Sales Metering
- Power/Heat Generation
- Cottage Industries
- High Quality Methane (90%+ CH₄)
- Low/Medium Quality Methane (30%-70% CH₄)
- High Quality Methane (95%+ CH₄)

METHANE TO MARKETS

- Regional and Export Gas Sales
- Power Generation
- Chemical Feedstock
- Methanol Production Plant
- Transportation Fuel
- Compressed Natural Gas Refueling Station
- Cottage Industries
- Transportation Fuel

Advanced Resources International, Inc.
2. CMM Recovery Technologies

The production and recovery of methane prior to and during coal mining can greatly improve mine safety as well as lower production costs by decreasing ventilation requirements and improving productivity.
Ventilation vs. Methane Drainage

- Relative Cost Comparison & Gas Content Reduction From Methane Drainage
Surface-Based Degasification Methods

• **Vertical, Stimulated Wells.** Wells drilled from the surface that are generally cased, cemented, and hydraulically stimulated. Studies by the U.S. Bureau of Mines show that up to 73% of the original gas in-place can be produced via vertical wells. These type of wells are ideally suited for multiple, thin seam situations.

• **Horizontal Wells.** These types of well are gaining in popularity and can produce 70 to 80% of the gas in-place. Good application for settings where there is one or two principal seams.
Design of Vertical CBM & CMM Wells
Pinnate Drilling - CDX

CDX’s proprietary Z-pinnate Horizontal Drilling and Completion System configured in the shape of a leaf (single pinnate pattern)

Multiple Pinnate patterns can be nested and drilled from one well site
Gardes Energy Services
Radial Multi-lateral Technology
Methane Drainage Techniques

- Pre Mining – Long, In Seam Boreholes
Methane Drainage Techniques

- Pre Mining – Long, In Seam Boreholes
Methane Drainage Techniques

- Pre Mining - Cross-Panel Boreholes
Methane Drainage Techniques

- Effect on Gate Road Development MIMOSA #1 Mine
Long Hole Directional Drills
Gob Gas Drainage Techniques

- Vertical Gob Wells
- In-Mine Horizontal Gob Boreholes
- Cross-Measure Boreholes
- Longwall Panel
Gob Gas Drainage Techniques

- Gob Gas – Vertical Gob Wells
Gob Gas Drainage Techniques

- Gob Gas – Cross Measure Boreholes
Gob Gas Drainage Techniques

- Gob Gas – Long, In-Mine Gob Boreholes Willow Creek Mine
Gas Handling and Collection

- Post Drilling
3. CMM Utilization Technologies
Appin-Tower Side (Australia)

Engine-Based Power Project

- Located in New South Wales
- Operating since 1996
- Project uses 94 one-megawatt engines to produce electric power using drained CMM at Appin & Tower Collieries
- The 54 engines at the Appin site also consume mine ventilation air as combustion air
- GHG reduction of nearly 3 MM tons per year of CO₂ equivalent
- Through equipment redesign and management practices, thermal efficiencies of engines improved from 30% to 35%
Appin-Tower Side (Australia)

VAM Oxidation

- Demonstration project
- 12-month period in 2001-2002 at BHP’s Appin Colliery
- Used MEGTEC Systems’ VAM-to-energy technology
- Demonstrated thermal flow-reversal technology capable of handling variations in VAM flow
- Led to full-scale VAM oxidation project at West Cliff Colliery
JWR Cryogenic Gas Processing

• Jim Walter Resources operates one of the most extensive commercial programs for coal seam degasification in the U.S.
• Medium quality gas obtained from gob wells, vertical wells, and underground horizontal wells
• Low Quality gas plant installed to upgrade gas to pipeline quality
• BCCK cryogenic gas processing facility chosen over pressure-swing adsorption
• JWR sells an average of 23 MMcf/d of pipeline quality gas, preventing 3.4 MM tons of CO₂ equivalent from being emitted into the atmosphere
• Plant has produced gas for 6+ years at a profit (breakeven gas price approximately $3.50 per Mcf)
JWR/BWM Low Quality Gas Plant

LQG Plant
Brookwood, AL