Conducting Pre-Feasibility Studies for Coal Mine Methane Projects

Module 6 – Quantifying the Benefits of Improvements to Methane Drainage Systems

Welcome

The United States Environmental Protection Agency (EPA) developed this course in support of the GMI and in conjunction with the United Nations Economic Commission for Europe (UNECE).
This course introduces principles for assessing the potential of developing projects to capture and/or use Coal Mine Methane (CMM). The general approach described in the course should be underpinned by mine-specific data and analyses, allowing the principles to be tailored to the unique conditions at each mine. Ideally, such an assessment will lead to project development and implementation.

What is the GMI?

The Global Methane Initiative (GMI) is a voluntary, multilateral partnership that aims to reduce methane emissions and to advance the abatement, recovery, and use of methane as a clean energy source.

GMI Partner Countries account for nearly 70% of total global manmade methane emissions, which is equivalent to approximately 5,000 MMTCO2e.

Conducting Pre-Feasibility Studies for CMM Projects: Course Modules

Module 1: Introduction and Objectives

Module 2: Mine Background Information and Evaluation

Module 3: Resource Assessment

Module 4: Forecasting Methane Production from Gas Drainage Systems

Module 5: Improvements to Gas Drainage

Module 6: Quantifying the Benefits of Improvements to Methane Drainage Systems

Module 7: Market, Risk, and Financial Analyses

Module 8: Case Study – Liulong Mine, China

Module 6: Introduction and Objectives Title Slide

What You Will Learn

In this module, you will learn about:

- Methods used to quantify the benefits of improvements to methane drainage systems (as discussed in Module 5 – Improvements to Gas Drainage).
- How to assess the value of improvements and the impact of these improvements relative to the performance and cost of current gas drainage system practices.

Time needed to complete this module – Approximately 25 minutes.

Metrics to Quantify Methane Drainage System Improvements

Project developers/operators can obtain metrics to help quantify the benefits of improvements to methane drainage systems.

Key metrics include:

- Quantity and quality of the recovered gas attributed to the improvements
- Cost of implementing the improvements compared to current practices
- Benefits of improvements on coal production
- Benefits of improvements on mine safety
- Value of increased gas production rates at higher gas quality

Benefits of Quantifying Improvements to Methane Drainage

Quantifying benefits before or after they are implemented allows stakeholders to make better decisions related to:

- Future mining plans
- Coal production targets
- Capital investments
- Project end-use options
- Project economics
- CMM project investments

Example of Quantifiable Benefits

The “Gas production rates for in-seam boreholes and horizontal gob boreholes” graph illustrates an example of a quantifiable benefit of improving methane drainage systems:

- In-seam boreholes that are not spaced closely together (Case 1 in the graph) produce less volumes of gas compared to in-seam boreholes that are closely spaced together (Case 2 in the graph).

- Horizontal boreholes above the gob area (Case 3 in the graph) produce the greatest volume of gas compared to other types of boreholes.

Steps to Quantify Improvements to Gas Drainage: Overview

The following steps are commonly used in a pre-feasibility study to determine the benefits of improvements to gas drainage systems:

- Step 1 - Develop gas production and gas quality forecasts for the proposed improvements.
- Step 2 - Compare key performance metrics of the current gas drainage system to the improved gas drainage system.
- Step 3 - Conduct a comparative analysis of associated costs (explored in Module 7 – Market, Risk, and Financial Analyses).

Completing these steps will help project managers summarize the benefits of improving gas drainage systems, as identified during the pre-feasibility stage.

Step 1: Methane Production Forecasts

During the pre-feasibility stage, project developers/operators can use methane production forecasts to assess the potential benefits of methane drainage improvements.

Methane production forecasts are projections of the quantity and quality of recovered gas based on various factors, such as:

- Mine plan for the project period
- Projected coal production rates for developments and longwalls
- Gas content of mined and adjacent seams (e.g., the gas resource that will be affected by mining) of the current and future mining districts

Example Methane Production Forecast

Accurate production forecasting relies on the use of current methane drainage rates and gas quality, considering planned improvements to the gas drainage system.

Methane Production Forecast Models

Methane drainage production forecasts are developed using forecast methods (described in Module 4), and if feasible, reservoir simulation models, to predict gas production within the project area.

Methane production depends on borehole spacing and configurations:

- Reservoir simulation models can help optimize methane production.

- Optimized designs should also consider the drainage times and/or residual gas content targets.

Ideally, project developers obtain input parameters for simulation models from geologic and reservoir data that are derived from the gas-bearing strata at the mine. Analysts may have to use supplemental data from analogous projects, where appropriate.

Methane Production Forecast Parameters

The most important reservoir parameters to use for reservoir simulations include:

- Permeability
- Langmuir volume and pressure
- Gas content
- Relative permeability
- Coal seam depth and thickness
- Reservoir and desorption pressure
- Porosity and initial water saturation
- Sorption time
- Fracture spacing
- Borehole spacing
- Completion
- Well operation

When developing gas production forecasts, it is important to conduct simulations using historic production data (a process known as history matching) to calibrate the reservoir model so that the model can be confidently used to predict future production.

Step 2: Performance Analysis

Project developers/operators can analyze the following typical performance metrics to identify the effectiveness of the current methane drainage system:

- Mine safety record
- Historical methane-related incidents
- Mine development and production advance rates
- Methane-related coal production delays

- Methane drainage infrastructure requirements
- Total cost of methane drainage and ventilation
- Cost of coal production delays

A detailed analysis of performance metrics might not be possible during the pre-feasibility study stage. However, some of these performance metrics should be readily known by the mine, and could therefore be considered in the pre-feasibility study.

Step 3: Comparative Analysis of Costs

A cost comparison between current practices and proposed drainage improvements will help quantify the economic benefit of the proposed improvements.

The following must be considered when determining the cost of current methane drainage practices:

- Capital costs, including those for mine infrastructure developed specifically for methane drainage
- Operating costs, including those for mine ventilation and the gas drainage system
- Costs associated with methane-related coal production delays
- Costs for the continued implementation of current practices through the course of the evaluation period

Example: Determining the Cost of Improvements

The following must be considered when determining the cost of improvements:

- Capital costs of implementing the improvements
- Operating costs (mine ventilation and methane drainage) as a result of implementing the improvements
- Estimated costs of implementing the improvements through the course of the evaluation period
- Estimated value of the coal production and safety benefits of the improvements

Module 6 Summary

This module presented a high-level overview of quantifying the potential benefits of improvements to methane drainage systems. Quantifying improvement benefits can help identify the best options for optimizing cost production.

After quantifying benefits of improving the system, project developers will have to decide whether to implement the identified improvements. Overall, the decision to improve methane drainage systems should be influenced by gas production, key metrics, and costs.

Other factors that contribute to decision-making include the availability of technology and equipment, as well as environmental and mining regulations. If the technology or equipment is not readily available, then there may be delays in implementing the identified improvements. The timeframe is project-dependent, as each mine is unique.

Example: If making decision “x” will incur significant costs when compared to decision “y,” then a project developer will have to balance the associated costs with the incremental improvement that is attributed to making such a decision.

Next Steps

After quantifying the benefits of improvements to a methane drainage system, each developer will need to:

- Evaluate all of the factors.
- Make decisions that affect project development.
- Proceed to consider the effects of current market conditions, associated project risks, and financial analysis, as well as determining the potential end-uses for the produced methane.

Looking Ahead: Module 7 cover how to evaluate the potential market, risk, and financial aspects that affect project development.

Thank you!

You have completed Module 6.

Glossary of Terms

Borehole — A narrow shaft bored in the ground, either vertically or horizontally.

Borehole Spacing — The measured distance between two or more boreholes drilled for production.

Capital Cost — Fixed, one-time expenses incurred on the purchase of land, buildings, construction, and equipment used in the production of goods or in the rendering of services. In other words, it is the total cost needed to bring a project to a commercially operable status.

Coal Mine Methane (CMM) — Methane released from coal due to mining activities. Like CBM, CMM is a subset of the methane found in coal seams, but it refers specifically to the methane found within mining areas (e.g., within a mining plan), while CBM refers to methane in coal seams that will never be mined. Because CMM would be released through mining activities, recovering and using CMM is considered emissions avoidance.

Completion — The act of installing pipe in a borehole after the drilling operation is completed.

Desorption Pressure — A phenomenon whereby a substance is released from or through a surface related to the surrounding pressure of the reservoir.

Feasibility Studies — Thorough report investigating the economic and technical feasibility of project development. This document is considered "bankable", meaning it is sufficient to secure project financing.

Financial Analysis — The process of evaluating businesses, projects, budgets, and other finance-related transactions to determine their performance and suitability. Typically, financial analysis is used to analyze whether an entity is stable, solvent, liquid, or profitable enough to warrant a monetary investment.

Fracture Spacing — Spacing of factures measured as the distance between the fractures along a line perpendicular to the average orientation of the fracture set.

Gas Content — Volume of gas contained in a unit mass of coal and is generally expressed in cubic meters, at standard pressure and temperature conditions, per ton of coal.

Gas Drainage — Methods employed by underground coal mines, abandoned mines, and occasionally surface mines, for capturing the naturally occurring gas in coal seams to prevent it entering mine airways. Gas drainage systems include a combination of drainage boreholes and/or galleries, a gathering network, and vacuum pumps to draw gas to the surface. Gas can be removed from coal seams in advance of mining using pre-drainage techniques and from coal seams disturbed by the extraction process using post-drainage techniques. It is often referred to as methane drainage if methane is the main gas component target to be captured. Gas drainage produces coal mine methane of a higher quality than ventilation, generally in the 25 — 100 percent range.

Gas Production — The quantity of gas produced by pre-mine drainage and post-mine drainage boreholes and drainage galleries.

Gas Production Forecast — An attempt to predict methane emissions from gas drainage systems using the following methods: basin-wide emission factors; generic gas content vs depth curves; mine-specific emission factors; probabilistic methods; engineering equations; reservoir simulation.

Global Methane Initiative (GMI) — Launched in 2004, the GMI is an international public-private initiative that advances cost-effective, near-term methane abatement and recovery and use of methane as a clean energy source in three sectors: biogas (including agriculture, municipal solid waste, and wastewater), coal mines, and oil and gas systems. Focusing collective efforts on methane emission sources is a cost-effective approach to reduce greenhouse gas (GHG) emissions and increase energy security, enhance economic growth, improve air quality and improve worker safety.

Gob (Goaf) — Broken, permeable ground where coal has been extracted by longwall coal mining and the roof has been allowed to collapse, thus fracturing and de-stressing strata above and, to a lesser extent, below the seam being worked. The term gob is generally used in the United States; elsewhere, goaf is generally used.

Initial Water Saturation — The saturation of an undisturbed reservoir with no prior production from any earlier well.

Langmuir Pressure — The pressure at which storage capacity equals one half of Langmuir volume. Also known as the critical desorption pressure, where gas is released from the surface of a substance.

Langmuir Volume — The total adsorption capacity of a substance. The maximum amount of gas that can be adsorbed to coal or shale at infinite pressure

Longwall — One of three major underground coal mining methods currently in use. Employs a shearer which is pulled mechanically back and forth across a face of coal that is usually several hundred feet long. This mining method can produce large quantities of coal and gas.

Methane — Methane is a potent greenhouse gas. Methane's lifetime in the atmosphere is much shorter than carbon dioxide, but it is 28 times as efficient at trapping radiation than CO2 over a 100-year period. Methane is the main precursor of ground level ozone pollution, and thus affects air quality. Methane is also an energy resource that can be captured and used. Methane in mines poses safety risks, due to its explosiveness when mixed with air.

Permeability — The state or quality of a material or membrane that causes it to allow liquids or gases to pass through it.

Porosity — The measure of void or pores space present when a solid and is represented by volume percentage of void in the solid. It defines the maximum possible amount of methane that can be retained in the coal.

Pre-Feasibility Studies — Typically provide a detailed technical analysis of site-specific information and considers project financing. Provides a gas production forecast and a review of current gas drainage practices. However, this document provides less granularity than a full feasibility study. This document is typically not considered a “bankable” document.

Relative Permeability — The ratio of effective permeability of a particular fluid at a particular saturation to absolute permeability of that fluid at total saturation.

Reservoir Pressure — An indication of how much fluid (gas, oil, or water) is remaining in the reservoir. It represents the amount of driving force available to drive the remaining fluid out of the reservoir during a production sequence.

Reservoir Simulation — Provides a consistent and reliable way to account for the complex mechanisms of coal seam gas desorption and diffusion. Also provides the opportunity for field and laboratory data to be integrated into a single geologic/reservoir model to evaluate exploration and development strategies.

Residual Gas Content — The quantity of gas remaining in a sample of coal following a period of gas desorption.

Sorption Time — A lumped parameter accounting both for diffusion and desorption time. It controls the rate at which gas molecules are released from micropores into the cleats. The smaller the sorption time the faster sorption/diffusion process.

Strata — A layer of sedimentary rock or soil; refers to a layer of coal in this instance.

United Nations Economic Commission for Europe (UNECE) — The United Nations Economic Commission for Europe (ECE or UNECE) is one of the five regional commissions under the jurisdiction of the United Nations Economic and Social Council. It was established in order to promote economic cooperation and integrations among its member states. The commission is composed of 56 member states, most of which are based in Europe, as well as a few outside of Europe. Its transcontinental Eurasian and non-European member states include: Armenia, Azerbaijan, Canada, Georgia, Israel, Kazakhstan, Kyrgyzstan, the Russian Federation, Tajikistan, Turkmenistan, the United States of America, and Uzbekistan.