

Conducting Pre-Feasibility Studies for Coal Mine Methane Projects

Module 1 – Introduction and Objectives

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 introduced general approach 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 MMTCO_{2e}.

Who Can Benefit from this Training?

In most cases, assessment of CMM project potential through a pre-feasibility study will be carried out by a project developer or another 3rd party in partnership with a mine.

Project Developers

Role in CMM Project Development: Design, build and operate most CMM projects.

After this training, project developers will: Understand a systematic approach and the key elements of a study that will be the foundation of a “bankable” document.

3rd Parties

Role in CMM Project Development: International Centres of Excellence on CMM, Coalbed Methane (CBM) clearinghouses and other independent experts prepare studies in support of project development.

After this training, 3rd parties will: Be able to improve the quality and value of pre-feasibility studies by working with project developers, mining companies or other stakeholders.

Mining Company Personnel

Role in CMM Project Development: Provide access to gas and land, are recipients of energy recovery from CMM projects, and may self-develop/co-develop projects.

After this training, mining company personnel will: Be able to anticipate the technical and market data required for pre-feasibility and feasibility studies.

Government Officials

Role in CMM Project Development: Regulate and incentivize project development and operation.

After this training, government officials will: Understand the purpose, scale and benefits of CMM projects.

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 1: Introduction and Objectives Title Slide

What You Will Learn

In this module, you will learn about:

- Mine methane as a safety hazard, climate pollutant and energy resource.
- Mine methane use options.
- Use of a pre-feasibility study as a tool to assess project viability.
- Key concepts for conducting pre-feasibility studies.

Time needed to complete this module – Approximately 20 minutes.

Methane Hazards and Climate Pollution

Methane in mines poses safety risks due to its explosiveness when mixed with air.

In addition, methane is a potent greenhouse gas. While methane's lifetime in the atmosphere is much shorter than carbon dioxide's (CO₂), it is 28 times as efficient at trapping radiation than CO₂ over a 100-year period.

Methane is also the main precursor of ground level ozone pollution and thus affects air quality. However, methane is also an energy resource that can be captured and used.

CMM Capture

Benefits of capturing and recovering CMM include:

- Generating a source of local, clean-burning energy
- Enhancing mine safety by reducing in-mine concentrations of methane
- Increasing mine productivity
- Adding revenue to the mine through sale or use of the gas
- Reducing greenhouse gas emissions and improving air quality

CMM Use Options

Viable CMM use options depend on a range of factors, including gas quantity and quality, energy prices, access to the gas, incentives and other factors.

Worldwide, CMM is most often used as the following:

- Power Generation/Combined Heat & Power (CHP)
- Pipeline Injection/Town Gas
- Direct Thermal
- Ventilation Air Methane (VAM)
- Flaring
- Transportation Fuel/Compressed Natural Gas (CNG)

Uses of CMM Use Globally

The most common types of CMM projects in 2019 (excluding Abandoned Mine Methane [AMM] projects) are

- Power/CHP: 68
- Pipeline Injection/Town Gas: 28
- Direct Thermal: 23
- VAM: 9
- Flaring: 8
- Transportation Fuel: 1

If project economics do not allow for a positive return on investment, CMM can be flared, if allowable, for safety and methane emission reduction benefits.

Pre-feasibility Study as a Tool

Several type of studies can be used to evaluate the viability of methane recovery projects.

Desk Study

Objective:

- First order analysis based on limited data

Characteristics:

- Basic assumptions
- Simple financial modeling

Pre-Feasibility Study

Objective:

- More detailed analysis with site-specific information

Characteristics:

- More detailed review of gas resources
- Review of gas drainage
- Gas production forecast
- More thorough financial analysis

Feasibility Study

Objective:

- “Bankable” document (i.e., sufficient to secure project financing)

Characteristics:

- Thorough report investigating the economic and technical feasibility of project development
- “Bankable” document sufficient for 3rd party financing

Pre-feasibility studies are most common because they offer a robust yet cost-effective option to initially assess a project’s technical and economic potential.

What Does Project Financing Require?

Financing requires “investment grade,” or “bankable,” documentation including:

- Thorough and complete technical assessment of the feasibility of the project.
- Robust financial analysis backed by an auditable and well-constructed financial model based on realistic assumptions.

Is a Pre-feasibility Study “Bankable?”

Bankable is a term used to characterize a document's usefulness in securing investors in a project. Generally, the more rigorous and site-specific the analysis, the more likely it will be to secure project investment.

A pre-feasibility study is generally not considered a bankable document for a CMM project because:

- Geologic review is limited in scope.
- Improvements to gas drainage or ventilation are preliminary and require a more thorough engineering study.
- The CMM utilization project is conceptual and costs are estimates.

The pre-feasibility study does provide a reasonable approximation of project requirements and costs, and it leads to development of a full feasibility study (which is generally considered bankable).

Are You Ready to Initiate a Pre-feasibility Study?

These critical first activities help to ensure the success of the pre-feasibility study, whether it is carried out by a project developer, the mining company, or a 3rd party.

Clarify study objectives & scope

Answer these questions to clarify the objectives and scope of the study:

- Is it a pre-feasibility or full feasibility study?
- Is it at one mine or multiple mines?
- What are the expected outputs of the study?

Confirm commitment of mine management

Confirm with the managers of the mine that you will:

- Obtain access to the site.
- Have support from mine staff.

- Be provided with sufficient data.

Verify project type

Verify the type of project. For example, clarify:

- VAM or CMM drainage?
- Energy recovery or destruction only?
- Use energy on-site or off-site?

Steps in a Pre-feasibility Study

1. Assess regional and national coal industry and methane emissions: Understand the project's economic viability
2. Identify regulatory barriers: Consider the project's potential regulatory viability
3. Request, obtain and validate data from mine: Obtain data to determine the scope of work
4. Assess gas resources: Determine the project viability
5. Review existing gas drainage practices: Review current practices to develop alternatives
6. Evaluate potential CMM markets: Determine possible end uses of the gas captured
7. Identify and assess project risks: Determine if alternatives must be considered due to risk
8. Identify best end use option: Maximize the revenue of the project
9. Define assumptions and perform financial economic analysis: Determine realistic expectations for the project
10. Review results, adjust assumptions, and develop a recommendation: Make adjustments to recommendations based on all available data

These components will be covered in more detail in subsequent modules.

Pre-feasibility Study Report Outline

A pre-feasibility study report includes the following:

- Executive Summary
- Background and Introduction
- Summary of Mine Characteristics
- Gas Resource Assessment
- Market Information Overview
- Technical Possibilities Assessment

- Project Cost Estimate
- Cost-Benefit Analysis
- Conclusions
- Recommendations

Module 1 Summary

In this module you learned about:

- The role that methane plays as a greenhouse gas.
- CMM capture and use.
- Pre-feasibility studies as a tool for CMM projects.
- Components of a pre-feasibility study.

Looking ahead - The components of a pre-feasibility study will be explored in greater detail in the upcoming modules. This course also includes a practical example of a pre-feasibility study conducted in Liulong Mine, China to help link theoretical concepts presented in the training with a practical example.

Thank you!

You have completed Module 1.

Glossary of Terms

Abandoned Mine Methane (AMM) — Coal mines that are temporarily or permanently closed that produce significant methane emissions from diffuse vents, fissures, or boreholes.

Adsorbed Methane — Methane accumulated on the surface of coal.

Adsorption Isotherm — An empirical relation between the concentration of a solute on the surface of an adsorbent to the concentration of the solute in the liquid with which it is in contact.

Anticline — A rock fold that bulges upward in the middle.

Ash Content — The non-combustible residue left after carbon, oxygen, sulfur, and water has been driven off during combustion. The remaining residue or ash is expressed as a percent of the original coal sample weight.

Bankable — Project or proposal that has sufficient collateral, future cashflow, and high probability of success, to be acceptable to institutional lenders for financing.

Behind Shield — Longwall shearer machines have a protective shield that prevents the floor and roof from collapsing onto the shearer during mining of the longwall panel. The gob area exists behind the shield and is a source of methane emissions into the mine workings.

Beltways — Pathways within the mine where belt conveyors carrying coal or other products move product.

Bleeder Shaft — A vertical shaft through which gas-laden air from working districts is discharged to the surface. Bleeder shafts are typically not man/material shafts and have higher allowable methane concentrations.

Booster Fan — An underground ventilation device installed in series with a main surface fan that is used to boost the pressure of the air current passing through it.

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.

California Cap-and-Trade — The Cap-and-Trade Program is a key element of California's strategy to reduce greenhouse gas (GHG) emissions. It complements other measures to ensure that California cost-effectively meets its goals for GHG emissions reductions. The Cap-and-Trade Regulation establishes a declining limit on major sources of GHG emissions throughout California, and it creates a powerful economic incentive for significant investment in cleaner, more efficient technologies.

Capillary Pressure — The pressure difference across the interface between two immiscible fluids arising from the capillary forces. These capillary forces are surface tension and interfacial tension.

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.

Capital Expenditures (CapEx) — Funds used by a company to acquire, upgrade, and maintain physical assets such as property, plants, buildings, technology, or equipment. CapEx is often used to undertake new projects or investments by a company.

Carbon Registry — A publicly available system that tracks carbon offset projects and issues offsets for each unit of emission reduction or removal that is verified and certified.

Casing — A large diameter pipe that is assembled and inserted into a recently drilled section of a borehole.

Channels — Areas where the coal seam is truncated by noncoal rock.

Clean Development Mechanism — The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one ton of CO₂. These CERs can be traded and sold and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction limitation targets.

Clean Tons — Coal production from the mine following washing at a coal preparation plant.

Cleats — Naturally occurring orthogonal joints in coal. They occur as two perpendicular sets of fractures.

Coal Bed Methane (CBM) — Methane extracted from coal seams before mining occurs. CBM is also known as virgin coal seam methane or coal seam gas. It is widely considered an "unconventional" source of natural gas.

Coal Depth — The measured or approximate distance to the coal-bearing strata

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.

Coal Thickness — The measured or approximate thickness of the coal-bearing strata. Measured from the top of the coal-bearing unit to the top of the underlying unit.

Collar — A common component of drilling infrastructure that provides weight on bit for drilling. Drill collars are thick-walled tubular pieces machined from solid bars of steel, usually plain carbon steel but sometimes of nonmagnetic nickel-copper alloy or other nonmagnetic premium alloys.

Combined Heat and Power (CHP) — The concurrent production of electricity or mechanical power and thermal energy from a single source of energy. Also referred to as cogeneration.

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

Compressed Natural Gas (CNG) — Natural gas mainly comprised of methane that is stored under high pressures, mainly as a means for storage or transportation.

Concentration Distribution — A spatial representation of various coal mine methane concentrations within a given mine.

Core — A cylindrical section of a naturally occurring substance, typically obtained by drilling through the subsurface with a hollow steel tube called a core drill.

Degasification — The process of removing gases from a coal mine.

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

Destruction Only — A CMM project where the only objective of the project is to destroy methane to reduce greenhouse gas emissions. This contrasts with an energy recovery project which uses CMM to produce useable energy such as electricity or heat.

Diffusion Coefficient — A measure of the mobility of gases from one gradient to another.

Direct Thermal — The use of coal mine methane in direct combustion technologies other than flaring, most commonly in boilers, industrial burners, and similar applications.

Drainage Galleries — Existing roadways or purpose-driven roadways above or below the mined seam that collect methane from gob areas. The galleries are sealed, and vacuum pressure is applied to draw the gas from the galleries into the pipeline system. These are also sometimes referred to as superjacent boreholes.

Emissions Distribution — A spatial representation of various coal mine emissions concentrations within a given mine.

Emissions Factor — A representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant.

Extrapolated Cost — An estimation of future costs beyond the original observational range.

Faults — Breaks in the earth's crust across which movement has occurred.

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.

Flaring — Controlled combustion of natural gas. Flaring CMM at a coal mine can occur in an open flame, otherwise known as a candlestick flare, or in an enclosed flare, sometimes referred to as a ground flare.

Folding — Bending of rock layers caused by compression of rocks, usually as part of mountain-building when tectonic plates collide.

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

Friability — When coal is easy to break or crumble it is said to be friable. This has a significant impact on gas management as gas drainage boreholes drilled in friable coals can easily collapse, thereby inhibiting degasification of the mine.

Gas Composition — The gas composition of any gas can be characterized by listing the pure substances it contains and stating for each substance its proportion of the gas mixture's molecule count.

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 Drainage Efficiency — The volume of methane produced from gas drainage as a share of all methane produced at a mine.

Gas Gathering System — A system of pipelines, moisture and dust removal equipment, and prime movers (e.g., vacuum pumps, compressors) that transport gas from borehole wellheads to the surface.

Gas Gravity — The ratio of the density of the gas at standard pressure and temperature to the density of air at the same standard pressure and temperature.

Gas-In-Place (GIP) — The volume of gas stored within a specific bulk reservoir rock volume (e.g., coal).

Gas Outbursts — An outburst is the sudden and violent ejection of coal, gas and rock from a coal face and surrounding strata in an underground coal mine. When outbursts occur, they can be very serious events, possibly even resulting in fatalities.

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.

Gas Solubility — The solubility of a gas in a liquid is directly affected by temperature and pressure. As temperature increases solubility decreases; this is described by Le Chatelier's Principle. As pressure increases solubility increases; this is described by Henry's Law.

Gas Viscosity — The measure of the resistance to flow; the property that allows gas to be more mobile in a reservoir as the viscosity of gas is magnitudes lower than other fluids within a reservoir.

Geophysical Log — The collection of geological and hydrologic information in wells by lowering and raising probes on a wire. It is typically more useful to employ a suite of different geophysical logs when collecting information.

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.

Greenhouse Gas Emissions (GHG) — The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time. May be labelled as anthropogenic (resulting from human activities) or naturally occurring.

Historical Emissions — A record of the past volume of methane emissions associated with coal production.

Historical Production — A record of the amount of coal or natural gas produced from a given mine or CMM project. Often used as an analogous CMM project example for forecasting future gas production and emissions during a pre-feasibility study.

Igneous Intrusions — Molten magma that rises from the mantle that thrust into existing rock formations.

Infill Drilling — The addition of wells in a field that decreases average well spacing.

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

In-Situ — It can mean "locally", "on site", "on the premises", or "in place" to describe where an event takes place and is used in many different contexts. For example, in fields such as physics, geology, chemistry, or biology, in situ may describe the way a measurement is taken, that is, in the same place the phenomenon is occurring without isolating it from other systems or altering the original conditions of the test. The opposite of in situ is ex situ.

International Centres of Excellence on CMM — The International Centres of Excellence on Coal Mine Methane (ICE-CMM) are designed as non-profit entities subject to the national laws of the host Member States and operating under the auspices of the UNECE Group of Experts on Coal Mine Methane. The Centres support capacity-building activities in United Nations Member States and serve as a platform for discussion on safety, environmental and economic aspects of coal mine methane (CMM). In particular, they focus on such issues as effective drainage and use of methane in coal mines and abatement of carbon emissions through cost-effective and socially responsible use or destruction of captured methane.

Karst — Terrain that has sinkholes, sinking streams, caves, and springs.

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.

Longwall Face — The end of the longwall panel that is being cut by the longwall shearer.

Longwall Panel — Large blocks of coal that are mined with a longwall shearer.

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.

Mineral Matter — The solid inorganic material in coal.

Mining Seam — A bed of coal lying between a roof and floor.

Monte Carlo Simulation — Used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is a technique used to understand the impact of risk and uncertainty in prediction and forecasting models.

Operational Expenditures (OpEx) — An operating expense is an expense a business incurs through its normal business operations. Often abbreviated as OPEX, operating expenses include rent, equipment, inventory costs, marketing, payroll, insurance, step costs, and funds allocated for research and development.

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

Place-In-Box — The pore system connecting the coal matrix and the cleat system plays a key role in the desorption and gas flow rates.

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.

Post-Mine Drainage — Drilling boreholes (vertical gob wells, cross-measure boreholes, directional horizontal boreholes, or gob drainage galleries) in advance of mining so that they are in place prior to under-mining but producing gas during and after the seam is being mined.

Post-Mine Drainage Boreholes — Boreholes drilled above or below the mined seam which produce methane from gob areas after the coal seam is mined. Post-mine drainage boreholes can be drilled from the surface or in-mine. Initially, methane concentrations can be high, but concentrations will decline relatively quickly as air from the gob area is drawn into the boreholes. There are also commonly referred to as post-drainage boreholes.

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.

Pre-Mine Drainage — Drilling in-seam boreholes to extract gas from the coal seam in advance of mining operations.

Pre-Mine Drainage Boreholes — Boreholes drilled into the mined seam or adjacent gas-bearing rock and coal strata in advance of mining to remove methane before mining occurs. Pre-mine drainage boreholes can be drilled from the surface or in-mine. Gas is produced in the boreholes before the coal seam is mined. Once mined-through, gas production ceases. Methane concentrations can be very high,

and boreholes can produce gas for many years in advance of mining. These are also commonly referred to as pre-drainage boreholes.

Probabilistic Methods — Methods based on the theory of probability or the fact that randomness plays a role in predicting future events.

Production Casing — Production Casing refers to the casing that is run across the reservoir in sections through which the well will be drilled. It is one of the final intervals of the casing which is performed during the casing of a well. The Production Casing is the deepest section of casing in a well just above the producing formation. It is used to isolate the zone which contains gas from other subsurface formations.

Proximate Analysis — An assay of the moisture, volatile matter, fixed carbon, and ash content of a coal sample.

Rank — The classification of coals according to their degree of metamorphism, progressive alteration, or coalification (maturation) in the natural series from lignite to anthracite.

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.

Risk Analysis — Examining how project outcomes and objectives might change due to the impact of the risk event. Once the risks are identified, they are analyzed to identify the qualitative and quantitative impact of the risk on the project so that appropriate steps can be taken to mitigate them.

ROM — Run of Mine coal production. It is the raw material produced from the mine and delivered to the coal preparation plant.

Sealed Airways — As coal is mined, mine-out districts are sealed off from the active workings to improve ventilation and reduce leakage of methane into the active workings.

Solubility — The property of a solid, liquid, or gaseous chemical substance called solute to dissolve in a solid, liquid, or gaseous solvent.

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.

Specific Emissions — The volume of methane emissions per ton of coal mined.

Spontaneous Combustion — A condition in which oxygen in the air is absorbed into coal during mining and transporting of coal, reacting to some of the hydrocarbon in the coal and being oxidized. The oxidation of hydrocarbons results in combustion.

Standpipe — A system of pipes that connect the components of a gas drainage system.

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

Structural Elevation — This refers to the geometry of strata deviating from its original depositional position because of tectonic activity, subsidence, etc. For example, older strata may be brought to a higher point because of thrust faulting.

Subsidence — The sudden sinking or gradual downward settling of the ground's surface with little or no horizontal motion.

Syncline — A rock fold that bulges downward ("sinks") in the middle.

Tailgate — Gate roads are driven to the back of each panel before longwall mining begins. The gate road along one side of the block is called the maingate or headgate; the road on the other side is called the tailgate.

The Commonwealth Scientific and Industrial Research Organization (CSIRO) — An Australian Government agency responsible for scientific research. CSIRO works with leading organizations around the world. From its headquarters in Canberra, CSIRO maintains more than 50 sites across Australia and in France, Chile and the United States, employing about 5,500 people.

Town Gas — Manufactured gaseous fuel produced for sale to consumers and municipalities. Also referred to as coal gas.

Unconformity — A buried erosional or non-depositional surface separating two rock masses or strata of different ages, indicating that sediment deposition was not continuous.

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.

United Nations Environment Program (UNEP) — The United Nations Environment Programme (UNEP) is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment.

United States Environmental Protection Agency (USEPA) — The Environmental Protection Agency is an independent executive agency of the United States federal government tasked with environmental protection matters.

Ventilation Air Methane (VAM) — CMM that is removed via ventilation systems which use fans to dilute the methane to safe levels by circulating fresh air through the mine. VAM is the largest source of methane emissions from underground coal mines.

Well Drainage Area — The area or volume drained by a single operating well.

Working Seam — The coal seam that is being mined is referred to as the working seam. Large mines may produce coal from multiple seams and each worked seam will have its own production plan.