Conducting Pre-Feasibility Studies for Coal Mine Methane Projects

Module 7 – Market, Risk, and Financial Analyses

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 MMT CO_2e.

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 7: Market, Risk, and Financial Analyses

What You Will Learn

After completing this module, you will:

- Be able to identify and analyze potential markets available for a CMM recovery and use project.

- Understand the importance of quantifying greenhouse gas (GHG) emission reductions.
- Be prepared to identify and characterize certain project risks.
- Understand the basic concepts of a financial analysis in a pre-feasibility study, including the primary financial metrics used to evaluate project viability.

Time needed to complete this module – Approximately 60 minutes.

Market Analysis

Project Financial Feasibility

Project financial feasibility depends on generating and maintaining a revenue stream that is capable of producing cash flows sufficient to maintain operations over the life of the project.

Project owners generate revenue by:

- Selling CMM and/or CMM-based energy on the market.
- Selling environmental commodities such as emission reduction credits.
- Reducing costs by using CMM on-site.

Assessing the Market and Identifying CMM End-Use Options

One of the primary goals of a pre-feasibility study is to identify potential revenue opportunities.

To achieve this goal, a study needs to identify viable CMM end-use options and assess all potential markets.

Market identification, market assessment, and assessment of CMM end-uses are inter-linked activities.

Policy incentives and barriers, gas availability, market pricing, market access are components of a pre-feasibility study and are used to identify CMM end-use options.

Steps in a Pre-feasibility Study Market Analysis - Summarize

Step 1: Summarize economic conditions:

- Local
- Regional
- National
- International (that can impact the project)

Steps in a Pre-feasibility Study Market Analysis - Review

Step 2: Review energy commodity markets available to CMM:

- Physical access
- Legal access
- Technical access
- Market pricing

Steps in a Pre-feasibility Study Market Analysis - Assess

Step 3: Assess environmental commodity markets & incentives:

- Type of market: carbon credit, renewable energy credit, feed-in tariff, tax credit, other
- Voluntary or regulatory framework
- Status, term, and liquidity of the market
- CMM project eligibility
- Market pricing

Steps in a Pre-feasibility Study Market Analysis - Conduct

Step 4: Conduct legal and regulatory review:

- Available incentives: subsidies, tax credits, fee waivers
- Mine safety and other legal jurisdictions
- Restrictions on CMM or VAM recovery and use
- Permitting and authorization schedules

Step 1 - Summarize Economic Conditions

The economic conditions summary should provide a broad overview and focus on the general state of the economy in the pre-feasibility study report.

The objective is to provide a snapshot of the current state and future direction of the economy, political situation, and investment climate.

Summary should reflect local, regional, national, and international considerations.

Economic Conditions Summary Questions

1. How are the coal and energy sectors performing?
2. How is the broader economy performing?

3. What are the future prospects for the economy generally, and the coal industry and energy sector more specifically?
4. Does the locality or host country offer an attractive investment climate?
5. Is there political and civil stability?
6. Are transparency and the rule of law valued and implemented effectively?
7. Are local partners required and what is the experience with such partnerships?
8. What is the currency and how has it performed against benchmark currencies such as the US$, GBP, € and CHF?
9. Would this be the first or are there other CMM projects in the area?
10. What is the trade relationship with neighboring countries if energy is to be exported?

Step 2 - Review Energy Commodity Markets

There is no hierarchy to define the "best" end-use technology. A project developer will be guided by:

- Gas quality and quantity
- Market access
- Mining company priorities
- Project economics
- Access to finance
- Public policy priorities

The end uses shown below are proven options for CMM projects based on global experience.

- Chemical feedstock
- Power generation
- Regional and export gas sales
- Transportation fuel
- Cooling
- Combined heat & power
- Flaring
- Industrial use

Review Access to Energy Markets

Although CMM can be used in many applications across a range of markets, this does not guarantee project success.

To be successful, a CMM project must have access to a financially viable market.

The pre-feasibility study report should address:

- Physical access
- Technical access
- Legal access
- Commodity market pricing

Review Access to Energy Markets: Physical Access

Does the market have an actual presence in the area of the CMM project to allow for delivery of CMM or CMM-based energy into the market?

Examples:

- Is there a natural gas pipeline within a reasonable distance for natural gas sales? A trunkline 50 kilometers (km) from the mine will require a 50 km pipeline lateral with multistage compression to deliver the gas into the pipeline that will carry the gas to market. The cost of the lateral and compression are unlikely to be economic.
- If a pipeline is located nearby, does it have excess capacity for new supplies?

Review Access to Energy Markets: Technical Access

Will the project be able to meet the technical standards for delivery into the market?

Examples:

- Is the gas quality likely to be sufficient for pipeline injection?
- Will the electricity grid operator allow an interconnect to the grid?
- Will the average methane concentration in produced gas be at least 25-30% for use in flaring and power generation or at least 0.30% for VAM?

Review Access to Energy Markets: Legal Access

Can the CMM or CMM-based energy legally enter into the market and are there any known legal impediments that could prohibit use in specific markets?

Examples:

- Who owns or controls rights to the CMM - Does the mine owner/operator or the project developer have rights to produce and sell or use the CMM at the surface?
- Are there any legal directives prioritizing or prohibiting certain uses of CMM? For example, is flaring permitted as a stand-alone activity or must it be paired with another end use?

Review Access to Energy Markets: Market Pricing

Are market prices sufficient to generate necessary cash flows to cover capital and operating costs?

Examples:

- Provide a summary of current commodity prices and, if available, projected commodity prices.
- Identify future events that may impact prices.
- Will the CMM project sell into the wholesale or retail market and do prices reflect the correct market?

Step 3 - Assess Environmental Markets and Incentives

Financial returns for CMM projects can improve through:

- Use of different incentives
- Participation in environmental markets

Environmental markets that are potentially available to a CMM project are listed on the next slide and are based on experience in the sector.

Markets and Incentives

To the extent possible, a pre-feasibility study report should summarize all potential environmental markets and incentives by providing the following information for each:

- Name and type of market or incentive
- CMM project eligibility
- Current status and other relevant background information about the market or incentive, including the start and end dates, any volumetric or monetary limits, and any eligibility limits or prohibitions
- For markets, the market liquidity and participation
- Value proposition for CMM projects, including market prices or incentive values

Regulated or Compliance Carbon Markets

Carbon markets, which are usually regulated by a government authority, define a cap for carbon emissions and allow emission reduction credits to be created and traded under the cap. In most carbon markets thus far, coal mines are not regulated sources under GHG emission caps, allowing CMM project developers to sell credits as emission offsets to regulated facilities in other industry sectors, or so-called "compliance buyers."

However, carbon finance can be difficult to access and barriers to securing carbon finance include: regulatory limitations on the sources and end uses of CMM, validation and verification processes, offset issuance, price fluctuation and uncertainty, and market longevity.

When developing forecasts for a pre-feasibility study, price discovery is usually possible through regulatory agencies, commodities exchanges, or information clearinghouses.

Voluntary Carbon Markets

These are unregulated carbon markets where CMM projects can sell carbon emission credits to buyers. However, such credits and transactions may not be recognized by a government authority.

These sales may be private "over-the-counter" sales or may be listed through voluntary registries.

Contract prices are usually not publicly available.

Renewable Energy Credits

Some jurisdictions have classified CMM as a renewable or alternative energy source, allowing CMM electricity projects to qualify for renewable energy certificates or credits (RECs).

RECs may have monetary value for an electricity buyer that desires to use renewable energy for some or all of its source portfolio.

Feed-in Tariffs

Feed-in tariffs (FITs) are a policy mechanism used to incentivize the deployment of renewable electricity technologies.

The FIT price paid to a CMM power project (US$/kWh) would normally be higher than the market price paid to 3rd party electricity suppliers to the grid.

Direct Subsidies

In some cases, government authorities may make a policy decision to encourage greater CMM recovery and use by providing a direct subsidy to the project developer for each kilowatt of electricity sold or each cubic meter of pure methane used.

Tax Credits

To support greater deployment of environmentally sustainable technologies and encourage GHG emissions reductions, some jurisdictions have authorized tax credits for CMM projects specifically or as part of a larger portfolio of environmentally friendly project types.

Credits can be in the form of an actual credit to income, reducing a project's tax liability, or a waiver to a tax levy. In addition to reducing costs, tax credits can also be used by CMM project developers to obtain financing through tax equity finance structures.

"Green Gas" Markets

Similar to renewable energy markets, natural gas markets may classify certain sources of natural gas as "green gas" to establish a preference for more environmentally sustainable supplies of natural gas.

Doing so will often result in a price premium for green gas.

Direct Investment

Governments, industry groups, or other stakeholders may choose to invest directly in a CMM project to support market development, technology R&D, local economic development, or for another reason.

The investment can take the form of direct equity in the project, debt financing with favorable terms, or grants.

Mandated Off-takes

Governments and other authorities can mandate that the electricity grid or natural gas pipeline network take or pay for all electricity or natural gas delivered to the system by the CMM project regardless of whether the market demand requires the additional capacity at that time.

This approach significantly reduces the market risk for a project.

Step 4 - Conduct Legal and Regulatory Analysis

A CMM project may be impacted by laws and policy in several areas. Detailed legal research is not necessary for a pre-feasibility study, and the study is not expected to include an exhaustive legal review and analysis. However, it should identify major legal and regulatory requirements that could impact the project, if they are known.

- Mine safety regulations, including any permitting, registration, and inspection requirements as they pertain to CMM recovery and use
- Environmental regulations including air quality, water quality, and waste disposal standards
- GHG reporting, management, and mitigation requirements
- Land use and construction permitting

- Noise abatement
- Mineral rights to produce and use the CMM
- Fees and taxes

Market Evaluation Examples

This module includes 2 examples from GMI pre-feasibility studies to demonstrate the analysis used to identify potential and relevant markets for GMI pre-feasibility studies.

Characteristic	Example 1	Example 2
Location	Guizhou Province, China	Shanxi Province, China
Terrain	Karst terrain	Mountainous
Nearest urban area?	3 km	10 km

CMM Market Evaluation: 2 Examples

Both examples follow a similar approach to complete a CMM market evaluation:

- STEP 1: Preliminary review of possible markets
- STEP 2: Detailed review of markets with potential
- STEP 3: Identification of best market(s)

Preliminary Review of Markets

- 7 potential market options are evaluated to determine if they warrant further evaluation.
- Basic criteria for each are used to eliminate markets that present no real opportunity for the CMM project.
- Normally, this step is performed quickly once relevant data are collected.

Detailed Review of Markets

- Remaining options are evaluated on site-specific factors including:
    - Technical, physical, and legal access to the markets
    - Market prices and basic “back of the envelope” economic analysis
    - Regulatory restrictions and corporate objectives
- This step further eliminates most remaining markets as viable options and produces a list of potentially viable options that will be subject to further analysis in Step 3.

Identification of Best Market(s)

- The final evaluation is based on a more detailed assessment of project financial feasibility.
    - Do the identified end-uses have the support of mine management and the project developer?
    - Even though the projects chosen are technically possible, can the projects actually be implemented?
    - Does the financial analysis indicate the potential for a positive financial return?
    - Which are the best options and how do they compare?

CMM Markets Example #1 – Initial Evaluation

Mine Location: Near City

Terrain: Karst

Other Factor: Sensitive environmental area

Gas Quality: 30-40% CH_4

Market	Evaluation	Continue with Option?
Local natural gas distribution	A local distribution system is located in the area	Yes
Power generation: on-site use	Mines normally have large demand for electricity	Yes
Power generation: grid sales	A physical interconnect and sales to the grid are possible	Yes
Boiler fuel	There is typically demand at mines for hot water and steam	Yes
Natural gas transmission	There is no access to a high-pressure transmission line in the area	No
Industrial use	There are no industrial users within a reasonable distance to the surface gas production site	No
CNG/LNG	CNG could be possible; Gas quality is too low for LNG production	Yes

CMM Markets Example #1 – 2nd Evaluation

Market	Evaluation	Continue with Option?
Local natural gas distribution	Subsidy available improving economics, but: system oversubscribed; capacity not available for many years; no existing interconnect from the mine's drainage	No

	system to the gas distribution system; low gas sales price – unlikely to be profitable	
Power generation: on-site use	Demand for power at the mine: in line with corporate policy and has support of management; significant in-country experience with CMM power projects; capacity to design & build; could be economically attractive; offset high industrial electricity price; subsidy available	Yes
Power generation: grid sales	Subsidy available: physical grid interconnect possible; sales to the grid may be difficult	Yes
Boiler fuel	Limited demand for hot water/heating due to warm climate	No
Natural gas transmission	Eliminated in first evaluation	No
Industrial use	Eliminated in first evaluation	No
CNG/LNG	CNG and LNG are not economic	No

CMM Markets Example #1 – Final Evaluation

Market	Evaluation	Preferential Mark for Project?
Local natural gas distribution	Eliminated in second evaluation	No
Power generation: on-site use	Preferred by mine company management; preliminary analysis indicates option is most economic	Yes
Power generation: grid sales	Economics are positive, but sales to the grid are difficult	No
Boiler fuel	Eliminated in second evaluation	No
Natural gas transmission	Eliminated in first evaluation	No
Industrial use	Eliminated in first evaluation	No
CNG/LNG	Eliminated in second evaluation	No

CMM Markets Example #2 – Initial Evaluation

Mine Location: Rural area

Terrain: Mountainous

Gas Quality: 30-40% CH_4

Market	Evaluation	Continue with Option?
Town gas	There is no existing system or demand in nearby cities and towns	No

Power generation: on-site use	Mines normally have large demand for electricity; existing CMM power plant provides existing infrastructure for easy expansion	Yes
Power generation: grid sales	Physical grid interconnect and sales to the grid are possible	Yes
Boiler fuel	There is typically demand at mines for hot water and steam	Yes
Natural gas transmission	There is no access to a high-pressure transmission line in the area	No
Industrial use	There is a fertilizer plant close by with demand for heat	Yes
CNG/LNG	CNG could be possible; gas quality is too low for LNG production	Yes

CMM Markets Example #2 – 2nd Evaluation

Market	Evaluation	Continue with Option?
Town gas	Eliminated in first evaluation	No
Power generation: on-site use	Additional demand for power at the mine: management support; existing CMM power plant – mine has infrastructure, experience and expertise; reduce high-cost grid purchases; subsidy available	Yes
Power generation: grid sales	Subsidy available: physical grid interconnect possible	Yes
Boiler fuel	Low priority for mine management	No
Natural gas transmission	Eliminated in first evaluation	No
Industrial use	High gas prices for sales to fertilizer plant make project economically attractive; close proximity of plant to gas drainage pump station minimizes transportation costs	Yes
CNG/LNG	CNG and LNG are not economic	No

CMM Markets Example #1 – Final Evaluation

Market	Evaluation	Preferential Mark for Project?
Town gas	Eliminated in first evaluation	No
Power generation: on-site use	Preferred by management; preliminary analysis indicates option is most economic	Yes
Power generation: grid sales	Economics are positive, but sales to the grid are difficult	No
Boiler fuel	Eliminated in second evaluation	No

Natural gas transmission	Eliminated in first evaluation	No
Industrial use	Preliminary analysis shows gas sales to fertilizer project are potentially profitable; logistics are easy to manage due to close proximity of the plant and gas conditioning and cleanup are not required	Yes
CNG/LNG	Eliminated in second evaluation	No

Risk Analysis

Identify and Characterize Project Risks

CMM projects, similar to any industrial project, can be impacted by external and internal factors that can influence project development and operations, worker health and safety, profitability, and ultimately, the viability of a project.

Therefore, it is critical to identify, assess, and develop a plan to manage these factors or project risks prior to project development, to the extent possible.

This should be done not only as a prudent planning and development exercise for the project developer, but lenders and investors will also examine this risk analysis closely. The analysis must be sufficiently credible to support any decision to continue to the full feasibility stage.

A comprehensive risk assessment and management plan is expected for a full feasibility report. However, a less thorough assessment is acceptable for a pre-feasibility study report.

Risk Classification

The objective of the pre-feasibility study report should be to identify and categorize a limited number of the most significant known risks to the project.

Risk assessments in a pre-feasibility study can be qualitative due to limited time and resources.

Identification and a brief description of each risk and possible risk mitigation strategies are acceptable.

In general, project risks can be classified as:

- Development risks
- Operational risks
- Technical risks
- Market risks
- Financial risks
- Legal/policy risks

Developmental Risks

Developmental risks include:

- Design errors
- Construction delays
- Equipment delays
- Start-up problems

Operational Risks

Operational risks include:

- Maintenance & repairs that are more than those expected
- Monitoring systems malfunctioning
- Lower combustion efficiencies than expected
- Mine closure or change of ownership

Technical Risks

Technical risks include:

- Overestimating gas resource
- Gas quality/quantity decline
- Poor coordination with mine operator
- Physical link with market not possible

Market Risks

Market risks include:

- Commodity or carbon prices decline
- Transaction costs increase
- Counterparty unable to pay for gas supply
- Market access denied

Financial Risks

Financial risks include:

- Development, operating, and capital costs higher than expected
- External finance not available
- Financing costs higher than expected

Legal/Policy Risks

Legal/Policy risks include:

- Regulations prohibit or limit the project
- Change in law or policy impacting project
- Required permits or authorizations not issued

Project Risk Mitigation Examples: Development

Risk	Impact	Mitigation
Construction and start-up delays result in later start date	Project costs increase, revenue lost, and potential penalties from energy and carbon off-takers for delayed delivery	Develop and regularly update detailed project development plan. Structure contracts to incentivize project construction, commissioning, and start-up on time while limiting or eliminating penalties for delays – consider mechanism to share benefits and costs for completion ahead of or behind schedule.
Project design does not effectively consider site-specific conditions	Additional costs incurred to design and build plant to necessary specifications	Perform thorough due diligence including evaluating roads and other transport requirements, testing soils for foundations, and identifying other features which can impact site.

Project Risk Mitigation Examples: Operational

Risk	Impact	Mitigation
Connection to power grid or pipeline delayed	Revenue start date delayed	If project appears feasible, start negotiation at early stage or link to existing on site connection inherited from a CMM scheme. Implement offset project initially, with flaring if feasible for early revenue.

Escalated connection cost	Reduced profit	Seek fixed price contract

Project Risk Mitigation Examples: Technical

Risk	Impact	Mitigation
More rapid decline of gas supply than expected – isolation of sources, more rapid flooding, erroneous interpretation of data	Reduced revenue, early project termination, unable to deliver contracted energy supply	Improve forecasts: conduct in-depth investigations and testing in the full feasibility study and develop more detailed geological and decline reservoir models
Failure of a production well	No revenue until remedied	Install dual production pipes in entries (pre closure) or drill replacement borehole post closure
Loss of gas quality	Power or thermal energy supply reduced or in worst case, halted	Undertake remedial work on mine entry seals
Equipment failure	Loss of revenue until repaired	Detailed warranties; business interruption insurance; planned maintenance; use only original equipment manufacturer spares

Project Risk Mitigation Examples: Market

Risk	Impact	Mitigation
Failure of sole customer's business	Loss of revenue stream until new customer found	Multiple customers; dual revenue stream if feasible
Fall in power or industrial gas prices	Loss of revenue	Dual revenue streams; develop only high return on investment projects so there is some flexibility
Carbon market collapses	Loss of carbon revenue	Dual revenue streams

Project Risk Mitigation Examples: Financial

Risk	Impact	Mitigation
Lenders and investors averse to funding coal-related projects	Unable to finance	Emphasize the positive GHG mitigation benefits. If applicable, use carbon financing.
Carbon assets fail to deliver	Additional cost of emission reduction credits from the market	Accepted business risk

Project Risk Mitigation Examples: Legal/Policy

Risk	Impact	Mitigation
Required permits or authorizations not issued	Project construction not able to proceed	Thorough due diligence to identify all required permits and authorizations: mine safety, environmental, construction, carbon market, local, provincial, and national. Consider outsourcing to an expert to reduce risk.
Change in law or policy impacting project	Project unable to complete construction or continue operating	Knowledge of local, provincial, and national laws impacting the project coupled with outreach to authorities to convey impacts of changes to the long-term operation of the project.

Risk Assessment Tools

To facilitate risk analysis, the project developer can rely on risk assessment tools to systematically identify and address risks.

An example of a risk assessment tool is a Risk Register:

- Establishes primary risk categories (e.g., legal, market, technical, operational, etc)
- Identifies specific risks within each category (Inherent risks) and rates risks
- Lists mitigation action for each risk to reduce risk exposure (Residual risk)

Risk Assessment Tools Dashboard

Detailed project risk assessment tools are more appropriate for a full feasibility report since a pre-feasibility study report assesses only a limited number of major risks. However, a simplified register could be developed for a pre-feasibility study report.

Financial Analysis

Objectives of a Financial Analysis

In a pre-feasibility study, financial analysis is critical to forecast the cash flows to be generated by the CMM project and to help determine the project's financial feasibility.

What should a pre-feasibility study financial analysis tell decision makers about the financial aspects of the project? It should:

- Provide a reasonable estimate of future cash flows of a project – both positive in the form of revenue, and negative in the form of expenditures.
- Estimate the profit (or loss) and return on investment of the project.
- Quantify some of the risks (financial and technical) facing the project.
- Assess energy commodities and environmental commodities generated by the project.

A financial analysis prepared for the pre-feasibility study report should be thorough enough to estimate financial feasibility, but a financial analysis at this stage is unlikely to be considered an "investment grade" document appropriate for project financing.

Financial Assessment Analysis

The steps in a financial assessment analysis include:

- Step 1. Identify financial inputs.
- Step 2. Determine project-specific inputs.
- Step 3. Construct a discounted cash flow model.
- Step 4. Consider financial performance measures to evaluate the project.

Assessment Methodology: Financial Inputs

Step 1. Identify financial inputs.

- Project term
- Development costs
- Capital costs
- Operating costs
- Timing of expenditures
- Revenue sources and values
- Inflation, interest, discount, and exchange rates

Assessment Methodology: Project-Specific Inputs

Step 2. Determine project-specific inputs.

- Methane concentrations
- Methane flowrates

- Drilling schedule
- Combustion & generator efficiencies
- Project runtime (0-100%)
- Global Warming Potentials (GWP)

Assessment Methodology: Cash Flow Model

Step 3. Construct a discounted cash flow model.

- Build from scratch or use off-the-shelf
- Cash flows
- Income statement
- Key financial measures
- Sensitivity analysis

Assessment Methodology: Financial Measures

Step 4. Consider financial performance measures to evaluate the project.

The key financial performance measures to evaluate the project include:

Primary

- Net present value (NPV)
- Internal rate of return (IRR)
- Payback period (years or months)

Secondary

- Profit to investment ratio
- Return on investment (ROI)

Cost Estimates and Assumptions

Cost estimates for goods and services required for the development of a CMM project should be based on:

- A combination of data provided locally.
- Known average costs based on analogous projects in the region.
- Publicly available sources.

Negotiated contract values for cost and revenue inputs are not necessary. However, assumptions should be conservative in a pre-feasibility study.

A more detailed analysis will be conducted if the project advances to the full-scale feasibility study level.

Financial Inputs: Capital Costs

Capital costs that may be included in the analysis are:

- Site preparation costs
    - Compacted hardcore for parking, equipment, lay-down, and site access
    - Fencing and gates
    - Concrete pads for containerized equipment
    - Service connections
    - Portable cabins – office, stores, workshop
    - Environmental improvements (e.g., stormwater retention)
    - Initial permitting fees
- Capital works costs
    - Drilling gas and water monitoring boreholes
    - Additional sealing works on shafts or drifts
    - Additional underground works for gas and water management not met by the mine (any cost sharing would be a matter for negotiation by the developer)
- Equipment costs
    - Skid mounted containers
    - Gas extraction pumps
    - Gas cleaning, drying, and conditioning equipment
    - Delivered, installed, and commissioned utilization equipment such as gas engines and generator sets, flares, oxidizers, boilers
    - Pipework, ductwork, and valves
    - Electrical systems and monitoring and control systems
    - Export metering and power supply
    - Compressors and grid/pipeline connections
    - Vehicles and security

- Contingency for design or equipment specification change
- Equipment relocation costs if CMM plant is required to move during the term of the project to access gas supply
- Working capital

Note that it may not be possible to obtain realistic estimates for every cost item within the approved pre-feasibility study report budget and schedule.

Estimated values can be used when it is not possible to obtain cost estimates, but this should be noted in the analysis.

Financial Inputs: Operating Costs

Operating costs are recurring costs associated with the maintenance and administration of the project on a day-to-day basis.

Operating costs may include the following:

- Gas fee or royalty
- Rent or lease fees
- Recurring registration costs
- Management and administration overhead
- Labor and staff costs
- Maintenance
- Instrument calibration
- Spare parts
- Transport
- Fuel
- Water treatment and disposal
- Transactions fees for monetization of energy and environmental commodities including project validation, emission reduction verification, and trades
- Debt interest
- Taxes

Example Financial and Project Inputs

Inputs that were used in the financial analysis for a GMI pre-feasibility study report are shown below: [Pre-feasibility Study for Methane Drainage and Utilization at the TengHui Coal Mine, Shanxi Province, China](#).

- Project Inputs - Forecasted gas production rates
- Capital and operating cost estimates and other project inputs for CMM power project
- Capital and operating cost estimates and project inputs for the gas drainage improvements of a CMM project

Choosing an Appropriate Model for the Financial Analysis

The project developer conducting the pre-feasibility study has several options for the design of the financial model, with the choices ranging from more specific and robust to more general.

Custom-built project-specific model: The project-specific model is a purpose-built model that is designed and built specifically for the CMM project under study in a recognized and widely available spreadsheet software such as MS Excel®. The model may take some time to build and test; however, it is likely to produce the most accurate and defensible results because it is designed specifically for the project and can be modified as needed. It is also best suited to graduate to a more detailed and thorough model required for a full feasibility study.

Adapted or modified model: The project developer can choose a generic, ready-made financial model from a public source. These types of models are widely available on the Internet in commonly available spreadsheet software, but are not specific to CMM projects, will require modification, and are generally not fully customizable. Although these models may require less time to set up, they will usually produce less reliable results.

Publicly available standardized model: A final option is to use a more generic publicly available model, such as the USEPA CMOP cash flow model (https://www.epa.gov/cmop/cmm-cash-flow-model). This type of model requires users to provide inputs into a data entry form and the model produces a cash flow steam with financial metrics, such as net present value (NPV) and internal rate of return (IRR). This model provides the user with a quick analysis and general results and is not an "investment grade" model. This model option is least flexible, limiting a user's ability to tailor the model to a specific project.

Selecting a Financial Model

The choice of the financial model used to project cash flows will depend on:

- The objectives of the pre-feasibility study
- Timing
- Depth of analysis desired

- Data availability and accuracy
- Corporate policy

Regardless of the option chosen, the project developer should have a good understanding of the model's structure, accuracy, and limitations to effectively interpret and convey the model outputs.

Other Considerations in Choosing the Model

The project developer should decide whether the project will include debt financing and structure the model accordingly.

It is also important to determine if the model will be stand-alone or if it will need to be integrated or compatible with a corporate financial model.

Construction and presentation of the financial model should also follow the good practices listed on the next slide. This ensures that the model is reasonably easy to use, the inputs and outputs are clearly presented, and the model is readily auditable.

Good Practices for Financial Modeling

- Use standard conventions recognized by the financial community (for example, months/years and cash flow calculations over time flow horizontal, and data categories are listed vertically).
- Define major assumptions.
- Avoid overly complex models with too many tiers.
- Limit the complexity of formulas and the precedents and dependents for formulas.
- Minimize the use of macros.
- Make sure input, calculation, and output worksheets/screens are clean, well-organized, and easy to navigate.
- If possible, calculate costs, revenues, and cash flows on a monthly basis and roll-up the monthly totals into annual totals. Note, however, that calculating cash flows on an annual basis is acceptable for a pre-feasibility study report.

Quality Control of the Financial Model

The financial model is the foundation of the financial analysis. The model's integrity and accuracy are essential to the credibility of the analysis, pre-feasibility study report, and the project developer's success, since the project developer may have to provide the model to a potential investor.

Therefore, it is good practice to:

- Conduct quality control of the model.

- Subject the model to regular testing and review.
- Incorporate calculation checks in the model.
- Use “common-sense” tests to compare model results with expected values based on an informed estimate.

Providing the Model to External Parties

It is also a good practice to provide the model to external parties if you are seeking 3rd party finance.

- 3rd party investors will demand access to the model before providing investment.
- The model must be auditable: if an investor cannot understand and work through the model, then they are unlikely to finance the project.
- Assumptions must be clearly defined.
- A flow chart or basic users guide can help internal and external users.

Financial Analysis: Key Outputs

The cash flow model and financial analysis prepared for a CMM pre-feasibility study will produce several financial performance measures that will be used to evaluate the financial feasibility of the project.

Although many factors can influence the decision to approve a project, in many cases the decision will be based primarily on the results of the financial analysis and the availability of a market for the CMM.

The tables on the following slides present the primary and secondary financial metrics that are used to evaluate the potential financial viability of a CMM project.

Financial Analysis: Key Metrics

Financial Metric	What is it?	Decision Criteria	Key Considerations
Net Present Value (NPV)	Present value of future cash flows generated by the project. Future cash flows are “discounted” by the organization’s cost of capital. If NPV > 0, cash flow from the project will exceed the cost of investment. Reported as a currency value.	Proceed with project if NPV is greater than zero	Relies on projections for energy and environmental commodity prices and inflation rates. Discount rate (weighted average cost of capital) used.
Internal Rate of Return (IRR)	The internal rate of return is a discount rate that makes the net	Go ahead with project if IRR exceeds organization’s defined	Hurdle rate can be pre-tax or post-tax IRR (critical to clarify).

	present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis. Reported as a percentage.	"hurdle rate" – i.e., the minimum acceptable rate of return for the project developer (e.g. 11%)	IRR measure tends to favor shorter project and low capital expenditure projects. NPV should prevail if IRR / NPV give conflicting results.
Payback Period	The period of time required for the project to "break even" where revenues equal expenditures.	Shorter payback period is preferable	Can be calculated and presented as a simple payback (non-discounted) period or as a discounted payback where the break even is based on discounted cash flows. Not used by itself to make an investment decision. Provides broader perspective when used with other metrics.

Financial Analysis: Secondary Metrics

Financial Metric	What is it?	Decision Criteria	Key Considerations
Return on Investment (ROI)	Measures the amount of return on a particular investment at the end of project life by comparing net revenue against the investment's cost.	Proceed if ROI projected at 10-20%	Uses non-discounted values so does not consider time value of money. Therefore, NPV is preferred as a better metric to assess project feasibility. Acceptable ROI depends on many factors – risk tolerance, schedules, etc.
Profitability Index	Present value of a project's future cash flows divided by the initial investment. Reported as a percentage.	Greater than 1	Closely related to NPV. Will be greater than one when NPV is positive. The higher the ratio, the more profitable the project.

Monetizing Benefits from GHG Emission Reductions

CMM projects produce energy and environmental benefits. It is very important to account for the environmental benefits, which can be a market or financing requirement.

CMM projects can generate marketable carbon credits and offsets, which offer an additional revenue stream for projects. A best practice is to estimate the reduction of GHG emissions over the life of the project.

- Generally required for feasibility and pre-feasibility study reports prepared for bilateral or multilateral financing
- Requirement for all GMI-sponsored pre-feasibility study reports

If projects can access carbon credit or offset markets, project owners should expect rigorous requirements to demonstrate transparency and accuracy of GHG emission reductions.

Methodologies for Estimating Benefits from Reducing GHG Emissions

Methodologies for calculating GHG emission reductions can be market-specific. The pre-feasibility study preparer should conduct additional studies to understand the applicable methodologies to accurately calculate emission reductions.

Quantifying emission reductions is not only necessary to support the financial analysis, but it also highlights the beneficial environmental impacts of the project regardless of the monetary value of emission reduction credits and offsets.

In addition to calculating direct emission reductions from the CMM project, the project may also produce indirect emission reductions which can also be quantified.

- Direct emissions are the methane emissions that are a consequence of the mining activities; therefore, direct emission reductions reduce those methane emissions at the site.
- Indirect emission reductions are emissions that are a consequence of the activities of the mining operation but occur at sources owned or controlled by another entity. For CMM projects, indirect carbon dioxide emission reductions may result from supplying gas-fired power to the electric grid, displacing coal-fired power.

Methodologies for Estimating Benefits from Reducing GHG Emissions (continued)

For the purposes of a pre-feasibility study, where calculation methods and GWPs are not specified, direct and indirect emission reductions from CMM projects can be calculated based on published GWPs from the Intergovernmental Panel on Climate Change (IPCC).

However, the GWP used to determine the monetary value of methane-based carbon credits/offsets generated by the project should be the 100-year atmospheric life, because most carbon markets use the 100-year value as the benchmark.

Calculating Benefits of GHG Reductions: Role of GWP and Indirect Emission Factors

Where there is a price for carbon offsets, an additional revenue line can be added. The calculation of emission reductions is based on the following:

GWP of Methane: Currently, in most carbon markets, a GWP of 25 is used, meaning the emission of 1 metric ton of CH_4 to the atmosphere equals the impact 25 metric tons of CO_2. This value is from the IPCC Fourth Assessment Report (IPCC, 2007); however, the value has changed with each Assessment Report. The developer should confirm the referenced GWP in the market in which it intends to participate to accurately calculate the value of the CMM emission offsets it intends to sell.

CO_2 from Combustion of Methane: Combustion of CH_4 generates CO_2. Estimating emission reductions from CMM projects must account for the release of CO_2 from combustion when calculating net CO_2 emission reductions. For each ton of CH_4 combusted, 2.75 t CO_2 is emitted, resulting in a net emission reduction of 22.25 t CO_2e per ton of CH_4 destroyed.

Quantifying the Co-benefits of CMM Projects

Quantifying the emission reductions of other pollutants will identify important co-benefits of the project and may provide additional revenue to the project. Thus, calculating emission reduction of these pollutants might be beneficial.

- Sulfur dioxide, nitrous oxide, particulate matter, and mercury are the most common pollutants considered.

Reliable grid emission factors are required at the regional or local level. Such estimates may only be practical for large-scale power or heating projects.

Why quantify emission reduction benefits from other pollutants?

- It may be required by law.
- There may be a market for emission reductions of these pollutants, creating a monetary value for their reduction.
- Noting the reductions in the pre-feasibility report highlights the environmental co-benefits of the project.

Financial Analysis: Accounting for Uncertainty

Every project faces uncertainties, such as delayed schedules, changes in equipment prices, fluctuation in sales prices, and unexpected changes in gas composition and flow rates.

The financial analysis should account for these and other uncertainties.

Accounting for uncertainties can be done by incorporating the following elements into the analysis:

- Create a range (base, high, and low cases) of potential outcomes.
- Incorporate a sensitivity analysis into the financial analysis.
- Include contingent funds for capital expenditures and operating expenses in the financial analysis.
- Use conservative assumptions for input values.
- Avoid “hockey stick” revenue growth.

Accounting for Uncertainty: Creating a Range of Potential Outcomes

One approach to account for uncertainty entails creating base, high, and low cases to show the most realistic financial outcome for the project but also the potential upside and downside that the project presents to an investor.

- Base case – Represents the expected outcome in a business-as-usual scenario.
- High case – Inputs to the analysis are adjusted to approximate the most reasonable upside case for the project. Examples include higher sales prices for commodities, lower capital expenditures and operating expenses, and lower interest rates.
- Low case – Inputs to the analysis are adjusted to approximate the worst economic case for the project short of project failure. Examples include low sales prices for commodities, higher financing costs, and lower than expected gas production.

Accounting for Uncertainty: Incorporate a Sensitivity Analysis

Another approach to account for uncertainty is to incorporate a sensitivity analysis into the financial analysis.

By altering the values of key inputs, the project developer will understand the costs and revenues that have the most significant impact on the project.

For a CMM project, sensitivity analyses are usually performed on changes in: produced gas quality and quantity, electricity or gas sales prices, carbon market prices, capital expenditures and operating expenses, or delays in construction and start-up.

The sensitivity analyses will support the development of the base, high, and low cases.

Accounting for Uncertainty: Include Contingent Funds for CapEx and OpEx

Another approach to account for uncertainty is to include contingent funds for capital expenditures and operating expenses in the financial analysis.

Contingencies are additional funds set aside at project start to offset unexpected costs. The contingent amount varies depending on:

- Project risk
- Corporate policy
- Other factors

The contingency is often in the range of 5-20% of the total expected capital expenditures and operating expense costs.

Accounting for Uncertainty: Using Conservative Input Values

Using conservative input values is another approach to account for uncertainty.

The financial analysis should be based on realistic and conservative assumptions and inputs to establish a realistic assessment of project financial feasibility.

Overly generous input values in the form of unrealistic growth in sales prices, below market costs for equipment and operation, and maximum gas production capacity sustained over the life of the project, will very likely lead to a misleading financial analysis.

Use of unrealistic inputs is also a red flag for project investors who are skilled in reviewing and assessing financial models.

Accounting for Uncertainty: Avoiding "Hockey Stick" Revenue Growth

Project proponents seeking finance will often project a revenue or profit growth curve that grows very slowly in the early to middle years of a project, only to show exponential growth in the out years – the so-called "hockey stick" curve.

Hockey stick growth is another red flag to investors, and the underlying data supporting any such growth curve will be closely scrutinized by investors as unrealistic.

GMI Pre-feasibility Study: Lessons Learned

Lessons learned from GMI pre-feasibility studies include:

- Clarify the study objective, definition, and scope with the host mine.

- Recognize time and budget limitations (keep in mind that it is not a full feasibility study).
- Expect and plan for differences in terminology, units, and practice.
- Expect gaps in available data.
- It is permissible to use other data sources or to make reasonable assumptions (but it should be stated in the final report).
- There are multiple options to forecast gas production.
- Examine all available markets for CMM use, but the choice is usually clear from the start.

Reasons for Project Discontinuation

Despite best efforts, the project under study may not move forward for any number of reasons, but commonly due to:

- Inability of the current market to support the project.
- Change in mine management or ownership.
- Change in operations, such as a refocus on core business of coal production.
- Decrease in gas quantity or quality.
- Change in regulatory framework.
- Unavailability of financing.
- Inability to accept or manage project risks.
- Inability of the project developer and host mine to negotiate a project development agreement.

Module 7 Summary

In this module, you learned:

- To identify and assess all potential markets through a detailed market analysis.
- About the environmental benefits associated with the reduction of GHG emissions through the development of a coal mine methane project.
- To characterize various project risks with various risk assessment tools.
- About the primary metrics of a financial analysis and the importance of a clear, well-structured model.
- GMI’s experience and recommendations in completing a pre-feasibility study.

Thank you!

You have completed Module 7.

Glossary of Terms

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

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.

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.

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.

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.

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.

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 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.

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.

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

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 CO_2 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.

Operational Expenses (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.

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.

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.

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

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 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.