Conducting Pre-Feasibility Studies for Abandoned Mine Methane Projects

Module 6 – Market, Financial, and Risk Analysis

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).

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.

This course introduces principles for assessing the potential of developing projects to mitigate Abandoned Mine Methane (AMM).

Conducting Pre-Feasibility Studies for AMM Projects: Course Modules

- Module 1: Introduction and Objectives
- Module 2: Gathering Mine Information and Data
- Module 3: AMM Resource Assessment
- Module 4: Production Forecasting and Well Testing
- Module 5: Mine Closure Design for AMM Production
- Module 6: Market, Financial, and Risk Analysis
- Module 7: AMM Pre-feasibility Case Study

Market, Financial, and Risk Analysis

What You Will Learn

In this module, you will learn about:

- Market analysis: assessing AMM markets, utilization options for AMM, and regulatory and policy factors that impact the financial and legal feasibility of an AMM project
- Financial analysis: capital and operating cost estimates and assumptions, and carbon emission reductions

- Risk analysis: identifying and analyzing risks for developers of AMM projects, and developing strategies to mitigate risks
- Attracting finance
- Formulating recommendations and next steps

AMM Market Analysis

AMM Project Financial Feasibility

The financial feasibility of an AMM project depends on generating and maintaining a revenue stream that, after costs, will produce cash flows sufficient to maintain operations over the life of the project.

Project owners generate revenue by:

- Selling AMM and/or AMM-based energy on the market.
- Selling environmental commodities, such as emission reduction credits.
- Reducing costs by using AMM or AMM-based energy on-site or at a nearby site (for example, re-purposed mining buildings or nearby industries).

AMM Markets and Interests of the Developer

The pre-feasibility study may be aimed at specific markets and will be guided by the business model of the entity that has commissioned the work (usually, but not always, a developer):

- Individual AMM projects can be quite small and, in general, will be unattractive to major energy providers. Large corporate entities are therefore unlikely to be a target as a developer.
- AMM developers are likely to be associated with one of the niche markets or businesses listed on the next slide. They will commission pre-feasibility studies and promote the most promising projects to attract finance.
- Institutional and environmental organizations may commission pre-feasibility studies to promote AMM development with the aim of highlighting social, energy, and climate change mitigation benefits. This type of pre-feasibility study will generally offer a wider focus on end use. The aim is to encourage developers to pursue the identified projects.

AMM Developers

AMM developers are likely to be small- or medium-sized businesses specializing in similar projects, such as:

- Those with an existing portfolio in small-scale power generation (for instance, using biogas or landfill gas) that could be extended to include AMM using similar technology, and hence a good business fit through common technology and a similar scale of activity.
- A provider of solutions for peak power supply yielding increased revenue from the higher peak tariffs paid by grid operators to ensure high demand can be met (reliable peak power supply is

becoming more important where the grid relies increasingly on weather-dependent renewables).

- An existing AMM developer with an established track record expanding their project portfolio.
- Operator of a local gas grid supplying industrial customers with medium quality gas for thermal processes.
- A developer of greenhouse gas emission reduction offset projects.
- An entrepreneur with the vision (and venture capital) to develop a suite of AMM projects where dual revenue streams have been identified (for example, power or gas sales plus carbon credits).

Assessing the AMM Market

The AMM market depends on the scale of the resource, demand for the gas as an environmental and an energy commodity, and local options for use.

Features of AMM as a commodity include:

- AMM power generation projects are generally small-scale, especially compared to CMM-based power projects at working mines.
- Revenue declines over time as AMM flow decreases, and there is potential for over-estimating gas production in the forecasting stage using flow decline curves.
- AMM is a significant source of coal mining-related greenhouse gas emissions, so any utilization or destruction is beneficial and has the potential for development as an offset project generating emission reduction credits.
- AMM as a gas is less valuable than natural gas due to generally lower purity, variable quality, and limited supply quantity (therefore, it attracts a lower price than natural gas).

Gathering Market Information

The pre-feasibility study should include information on environmental and energy commodity markets.

Environmental Markets:

- Applicable carbon markets
- National emission trading scheme, if one exists
- Eligibility of offsets
- Carbon prices, including primary and secondary markets

Energy Markets:

- National and regional energy plans (highlight any mention of AMM use in energy goals)
- Pipeline infrastructure, accessibility, and proximity to the project site
- Power grid capacity, supply, and demand
- Regional industrial development growth

- Local economic drivers in the project area
- Local energy markets
- Precedent of CMM and AMM projects
- Geographic constraints on energy distribution

Analysis of AMM Utilization Options

A pre-feasibility study should briefly explore each potential utilization option at the site as part of the market analysis. Possible AMM uses and treatments include:

- Town gas for community use
- CHP/Power generation, using gas engine driven generators with an option for heat recovery
- Direct industrial thermal uses
- Natural gas pipeline injection
- Flaring (destruction only)

Town Gas

- For local residential and small commercial users.
- Transported through distribution lines at low pressure and medium to low gas concentration.
- May be supported by gas holding tanks.
- Used for cooking and heating.

Combined Heat and Power / Power Generation

- Power outputs of containerized engines and generators commonly used in CMM and AMM projects range from 1 – 3 MWe.
- While heat recovered from CMM power plants can be used for water heating and shaft heating at a working mine, similar heat uses are not available to an AMM project.
- AMM power projects could, in some cases, use waste heat to supplement power output with a steam turbine.

Direct Industrial Thermal Uses

- For local industry, transported in dedicated local medium- to low-quality gas pipelines (could be inherited from redundant CMM distribution schemes).
- The gas may be used for firing kilns, drying processes, and in hot water and steam boilers.
- Many AMM projects sell the methane locally to industrial users, but the demand and price often make them marginal.

Pipeline Injection

Subject to pipeline availability, capacity, and the approval of the pipeline operator, AMM can be used for natural gas pipeline injection as described on the next slide.

AMM Uses for Natural Gas Pipeline Injection

For local industry, transported in dedicated local medium- to low-quality gas pipelines (could be inherited from redundant CMM distribution schemes):

- The gas may be used for firing kilns, drying processes, and in hot water and steam boilers.
- Many AMM projects sell the methane locally to industrial users, but the demand and price often make them marginal.

Purification and pipeline injection:

- In order to be injected, AMM is enriched to pipeline quality by removing nitrogen and carbon dioxide.
- This will not be an attractive proposition, in many instances, because enriched AMM is unlikely to be competitive with conventional natural gas and shale gas.
- The higher cost of enriched AMM is due to processing requirements and costs, pipeline connection costs, and relatively small AMM volumes typically available compared with conventional gas sources.
- One less expensive option, depending on the country or jurisdiction, could be to inject small volumes of medium- or low-quality AMM into pipeline gas (known as spiking), provided that the total gas composition remains within pipeline quality specifications.

Flaring

Flaring will destroy methane to reduce the environmental impact of AMM and can generate revenue from emission reduction credits if there is an applicable carbon market.

- Can generate emission reduction credits as an offset project, subject to a carbon price, where energy use is not commercially feasible or mandated.
- Can be an attractive option for AMM projects due to lower cost and earlier payback compared to most other AMM utilization technologies.
- Is normally used as a stand-alone solution or in conjunction with AMM-based power generation or other use.
- Emission reduction credits may be also gained from power generation and direct use of the gas as a second revenue stream.

Flaring Limitations

There are some limitations to flaring AMM:

- Requires a carbon price or other value for the emission reductions.
- Some countries, where clean energy is at a premium, may only permit flaring in conjunction with energy uses in respect to CMM and AMM.
- Because AMM supply can often be adjusted to match demand (within flow limits), flaring is likely to be an option either when energy use is no longer viable, or as a standalone option.

Other Flaring Considerations

- Due to the acute need to reduce methane emissions, flaring might be considered a desirable default option for AMM treatment.
- There will be many mines where AMM resources are too small to justify energy exploitation, but which would support a flaring scheme, provided the carbon market conditions existed.
- A large number of such schemes would make a significant contribution to mitigation of methane associated with coal mining and could be financially attractive.

Developing a Recommendation for Utilization

To develop recommendations for AMM utilization options, it is helpful to:

- Review AMM uses and treatments described earlier.
- Make a choice based on market conditions such as the availability of energy, carbon, and customers.
- Concentrate on the selected end-use (or end-uses) when conducting financial analysis for a pre-feasibility study.
- Consider two independent revenue streams, as this may be a preferred solution (for example: energy and carbon).

For a project site with limited data and a small- to medium-sized mine, the viable solution might be destruction only, subject to satisfactory carbon market conditions and project applicability.

Regulatory and Policy Considerations for AMM Studies

A topical review and assessment of relevant legislation, regulations, and policies is an essential element of an AMM market analysis.

- Policies and regulations can affect payback and profitability prospects by determining taxation and fiscal incentives, as well as by defining the administrative burden companies face when obtaining ownership rights or gaining access to infrastructure.
- In some instances, environmental, political, and social drivers may also play an important part.
- Regulatory incentives may encourage utilization of AMM over destruction by flaring.

An AMM pre-feasibility study will identify policy and regulatory issues relevant to the AMM project, which can be either barriers or incentives and contribute to the financial feasibility of an AMM project.

Differences Between CMM and AMM Projects

This table explains the policy and regulatory differences between CMM and AMM projects.

Type	AMM (abandoned mines)	CMM (working mines)
Ownership	AMM may be included in the oil and gas estate if mineral rights are segregated.*	CMM extracted from a working mine is generally licensed to the operator as a mine safety activity.
Incentives	Incentivizing policies to encourage extraction and use of AMM may include favorable feed-in-tariffs.	Some countries have implemented policies to encourage CMM extraction and use.
Gas Resources	Regulation of AMM is more focused on minimizing hazardous emissions into structures and not on production. This leads to variable gas quality with declining AMM flow over time.	Regulatory standards contribute to more predictable CMM flows and gas quality for the life of a mine.
Coordination with Mine Safety Regulations	AMM schemes are implemented by third parties, usually unrelated to the former mining company, and are generally operated under non-mining regulations.	Coal mines capture CMM for mine safety reasons in accordance with regulations. Utilization of the gas introduces an additional revenue stream, even if the scheme is built and operated by a third party.

*Depending on the country, oil and gas licenses may be issued by national, provincial, or local government authority, or may be held privately.

Understanding the Regulatory and Legal Landscape

An AMM project developer will encounter a range of regulatory and legal requirements throughout the development process.

They should consider the relevant regulatory and legal requirements, understand the potential implications for the project, and assess their ability to comply with the requirements.

Mine Closure Regulations

An AMM project developer would be impacted by mine closure regulations. Regulations that require mine operators to incorporate measures for monitoring and control of gas and water hazards will reduce the technical risk to AMM projects.

A requirement to mitigate AMM after abandonment would encourage the owner of the post closure liabilities to promote AMM projects and assist developers.

Fugitive Gas Liabilities

An AMM operator may need to plan to exercise specific design measures at the termination of a project to leave a site in a safe condition.

A developer should be aware of policies that place long-term liability on AMM operators (which is not usual practice); this will disincentivize projects.

Mine and Gas Interaction Agreements

Policies might include a mechanism for avoiding or resolving disputes between working mines and adjoining AMM producers where interactions with CMM drainage and use could occur.

Procedures or protocols for resolving disputes between gas exploration and development licensees, when an AMM prospect straddles a gas license boundary, would reduce litigation risk.

Gas Ownership

Clearly defined gas ownership rights are essential to mitigate against legal challenges to AMM extraction and use.

Transferring ownership of AMM to a third party may reduce the project's financial risk in certain situations and allows the resource to be developed.

Countries with successful AMM projects have created an enabling environment by eliminating restrictions on transferring rights to the gas, regardless of whether it's sold as gas or converted to electricity.

Energy Infrastructure Access

AMM projects are generally only viable when they have easy and affordable access to industrial gas and power markets via pipelines and the electricity grid, respectively.

AMM development can be supported by policies requiring or encouraging pipeline and grid operators to grant access to their systems, thereby providing the means for AMM projects to transport electricity and gas to markets.

Financial and Fiscal Incentives

Project developers should make every effort to identify and confirm the applicability of financial and fiscal policies that may (or may not) encourage AMM project development. For example, a country could offer AMM gas producers preferential policies, such as an exemption from equipment import duties, refunds on value-added tax collected from gas sales, accelerated depreciation of assets, tax credits for investment in technical innovation, free-gas market pricing, or access to technology development funds.

Incentives to help finance methane utilization projects include tax credits, reduced royalties, and clean power incentives (for example, in Germany and several U.S. states).

Country Examples of Regulatory and Policy Incentives

- United States - Several U.S. states also provide reduced royalties for AMM produced on state land.
- United Kingdom - In the UK, AMM projects are exempt from the Climate Levy.

- France - A feed-in tariff for electricity generated from AMM if the concession license is in force.
- Germany - AMM projects can access favorable “market premiums” when the methane is used to generate power.

AMM Financial Analysis

Objectives of a Financial Analysis

In a pre-feasibility study, financial analysis is critical to forecast the cash flows expected from the AMM project and to help decision makers determine the project’s financial feasibility.

A pre-feasibility study financial analysis:

- Provides a reasonable estimate of future cash flows of a project – both positive in the form of revenue and negative in the form of expenditures.
- Estimates the profit (or loss) and return on investment of the project.
- Quantifies some of the risks (financial and technical) facing the project.
- Assesses 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. However, a financial analysis at this stage is unlikely to be considered an “investment grade” document that is appropriate for project financing.

Project Development Overview

This section presents an approach to financial analysis in a pre-feasibility study for a single mine site or aggregated to apply to a group of closed mines.

The benefit of a multi-mine project is to spread and therefore mitigate AMM supply risk, enhance exchangeability of key equipment, and provide the opportunity to move equipment from a poor performing site to a high performing site that is capable of increased output.

Assessment Methodology

A financial analysis involves two steps.

- Step 1: Identify development, capital and operating costs, timing of expenditure, and potential revenue.
- Step 2: Construct a discounted cash flow model.

Key performance measures for evaluating the project include:

- Net present value (NPV) at a selected discount factor (for example, 10%)
- Internal rate of return (IRR)
- Payback period (years)

- Forecasted cash flow presented as earnings before interest, taxes, depreciation, and amortization (EBITDA)

Cost Estimates and Assumptions

Cost estimates for goods and services required for the development of the AMM project should be based on a combination of local data, known average costs based on analogous projects in the region, and publicly available sources.

Costs can generally be divided between capital and operating costs.

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.

Example assumption: inflation rate of 3% per annum.

Financial Inputs for 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 (e.g., water, electricity)
  - Portable cabins – office, stores, workshop
  - Environmental improvements (e.g., stormwater retention)
  - Initial permitting fees
- Equipment Costs
  - Skid-mounted containers
  - Gas extraction pumps
  - Gas cleaning, drying, and conditioning equipment
  - Utilization equipment (e.g., gas engines and generators, flares, etc. delivered, installed, commissioned)
  - 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 plant is required to move during the term of the project to access gas supply
    - Working capital
- Gas and Water Engineering 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)

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

Types of Financial Models

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

These options include:

- Custom-built project-specific model
- Adapted or modified model
- Publicly available standardized model

Custom-built Project-specific Model

A project-specific model is a purpose-built model that is designed and built specifically for an AMM project under consideration by the project developer in a recognized and widely available spreadsheet software such as MS Excel®.

The type of 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

Financial models typically use a similar architecture for data inputs, calculations, and summary of outputs. Generic, ready-made MS Excel® financial models are available from public sources and may be downloaded from the internet or acquired from specific suppliers. These types of models are not specific to CMM or AMM projects, and therefore require the project developer to customize the inputs, the underlying calculations, and the outputs to meet the needs of a financial analysis specific to AMM projects.

Because the goal of a pre-feasibility study is to make an initial assessment of the project in a relatively short time period, this type of model can present an attractive option for calculating project financials in short order with a higher degree of confidence than standardized models.

However, this type of model is unlikely to be as accurate as a model that is custom-built specifically for the project under consideration.

Publicly Available Standardized Model

For quick analyses when a project developer only requires general estimates of financial returns, publicly available models (such as the U.S. EPA CMOP cash flow model) can be used.

These models, often referred to as “Plug and Play” models, require users to provide inputs into a data entry screen. The model then produces a cash flow stream with financial metrics, such as net present value (NPV) and internal rate of return (IRR). Although these types of models may allow variation of some data inputs, generally they do not allow alternations to the underlying calculations and, most importantly, are not considered "investment grade" models.

This type of model option is the least flexible of the three options, but it can provide a very quick general estimate of a project’s financials based on initial inputs.

Selecting the 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, it is important for the project developer to have a good understanding of the model’s structure, accuracy, and limitations so that they can effectively interpret and convey the model outputs.

Other Considerations in Selecting the Model

The project developer should decide whether the project will include debt financing and design the model accordingly, or acquire an existing model that will compute debt service.

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.

Finally, it is important to select a model that is easy to use, the inputs and outputs are clearly presented, and the model is readily auditable.

The next slide presents good practices for financial modeling.

Good Practices for Financial Modeling

- Use standard conventions recognized by the financial community (for example, months/years and cash flow calculations over time are displayed horizontally, 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 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, the pre-feasibility study report, and the project developer's success, since the project developer may have to make the model available 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 make the model available to external parties if you are seeking third party finance.

- Third party investors will likely request 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.

Example of Financial Analysis: AMM Utilization for Power Generation

The project developer will have completed the AMM resource assessment and the AMM gas production forecast following the approaches that were outlined in the previous training modules of this course, as well as the market analysis discussed earlier in this module.

The following slides present an example of an AMM project where the utilization option considered is power generation. To evaluate this option, the project developer needs to input estimated parameters into a financial model.

Example Project Summary

The following theoretical analysis demonstrates an application of the concepts presented in this module.

The first step will be to select the type of model and specify the primary project criteria shown in the table.

Summary Information Needed	Characteristic
Source of methane:	Abandoned mine
Utilization option:	Power generation
Project Life	10 years
Access to electricity grid:	Yes
Calculate power generation (MWh):	Yes
Calculate emission offsets (tCO2e):	Yes
Carbon market:	No
Subsidy available for AMM use:	Yes
Cases analyzed:	Base, High, Low
Financial metrics:	Net Present Value (NPV) Internal Rate of Return (IRR) Payback

Example AMM-based Power Plant On-site Inputs to Model

Power plant input parameters - the major cost components for the power project are:

- Cost of the engine and generator
- Cost for gas processing to remove solids and water
- Cost of equipment for connecting to the power grid (there may also be a connection charge)

Example AMM-based Power Plant Calculation of GHG Emission Reductions

An AMM financial model should calculate the quantity of carbon emission reductions in addition to financial metrics.

- Identifies important environmental benefits of the project
- Provides an additional revenue source or allows avoidance of a carbon fee or penalty

The calculation of emission reductions is based on:

- Global Warming Potential of CH_4: A global warming potential of 28 is used. This value is from the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC, 2014).
- CO_2 from Combustion of CH_4: Combustion of methane generates CO_2. Estimating emission reductions from AMM 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 tCO_2 is emitted, resulting in a net emission reduction of 18.25 tCO_2e per ton of CH_4 destroyed.

The GWP can be entered as an input into the model or can be coded into the formulas used in the model, depending on the project developer's or model designer's preference.

Example AMM-based Power Plant Base Case and Sensitivity Analyses

Key inputs to the financial model are varied to examine sensitivity to possible performance variations as shown in the example below. The base case uses the original parameters selected based on the expected performance. High and low cases are specified to represent best- and worst-case scenarios. This particular example assumes the gas is free. In practice, in many countries there is likely to be some fee associated with the AMM under the prevailing gas licensing regime.

Example: High, base, and low case sensitivities used for key inputs of the financial analysis (power only).

Case	Low	Base	High
Power Sales Price ($/kWh)	-10%	0.094	+10%
Power Plant Delay (Years)	2 years	1.5 years	1 year
Power Plant CAPEX ($/kW) *includes contingency	+25%	1,188	-15%
Power Plant OPEX ($/kWh) *includes contingency	+10%	0.033	-10%
Gas Production (Mm3)	-30%	86.2	+30%
Operating Efficiency	30%	35%	40%
Run Time	55%	60%	65%

Example Results for an AMM-based Power Plant

The financial results for the selected utilization scheme are then calculated and tabulated as illustrated in the example below. The cumulative emission reductions depict the total reductions potential over the life of the project, which reaches 1,139,704 tonne CO2e in the base case scenario. If monetized, these emission reductions could significantly improve project performance.

Case	Max Power Plant Capacity	NPV ($,000s)	IRR	Payback (Years)	Net CO2e Reductions (t CO2e)
High	5.23 MW	$11,045	43.57%	2.3	1,481,616
Base	3.71 MW	$2,966	19.97%	4.5	1,139,704
Low	3.47 MW	$69	10.30%	6.3	797,793

Although all financial metrics are considered in combination with each other, the project developer will often first prioritize the Internal Rate of Return (IRR) to confirm that the IRR exceeds the developer's acceptable "hurdle rate" or acceptable minimum IRR for project investment. In this case, the 20% IRR will exceed the hurdle rate for many AMM project developers. If the IRR is acceptable, the project developer will then determine whether the Net Present Value and Payback support sufficient cash flow to progress with the project.

Example AMM-based Power Plant Conclusions

The Base Case scenario in the example presented on the previous slides confirms that an AMM-based power project could be an attractive investment for the project developer. The project IRR, NPV and Payback are attractive, while relatively small cost decreases in project capex and opex and an increase in gas production could result in substantial financial upside as shown by the High Case.

However, increases in capex and opex combined with lower than expected gas production and reduced plant operating efficiency could result in a project that has a very small NPV with a long Payback time that could be unacceptable for the developer. The initial financial analysis would likely justify further assessment of the project opportunity, including a more refined and detailed financial analysis for a full feasibility study.

Where market conditions allow qualified offset projects, an alternative development option may be destruction only (especially a flaring project) that can easily be replicated at low risk. The capital cost of such projects is very low.

Risk Analysis and Mitigation

Identify and Characterize Project Risks

A pre-feasibility study should include a basic risk analysis that examines what can go wrong with all aspects of the proposed project (the 'what-ifs') and suggest ways to minimize or mitigate:

- Technical risks
- Infrastructure risks
- Market risks
- Financing risks

Lenders and investors will examine this risk analysis closely. The analysis must be sufficiently credible to aid decision-making on whether to continue to the full feasibility stage. A much more detailed risk analysis would be undertaken at the next stage.

Managing Uncertainty

Sudden, unexpected events cannot easily be predicted in an abandoned mine. For example, when a mine is abandoned, water pumps are turned off and many mines naturally begin to flood. A situation could arise in which a key connection pathway becomes totally flooded, isolating a large section of the reservoir from the production well.

However, when preparing a mine for AMM recovery prior to closure, the location of production wells can be planned accordingly, or engineering measures can be taken to forestall the problem where feasible.

There will be applicable engineering solutions, in some instances, but at additional cost which could compromise the project's financial viability.

How to Reduce AMM Project Risk:

- Develop projects at mines prior to closure where data are plentiful
- Develop a portfolio of projects that is not reliant on one project for revenue
- Modularize AMM production and processing equipment to allow relocation of equipment as performance declines

Project Risk Mitigation Examples: Technical

Risk	Impact	Risk Minimization & Mitigation
Gas supply declines more rapidly than expected due to: **1. More rapid flooding than projected** **2. Erroneous interpretation of data** **3. Gas sources being dispersed throughout the workings rather than acting as a contiguous reservoir**	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	Obtain detailed warranties, business interruption insurance, conduct planned maintenance, use only OEM spares

Project Risk Mitigation Examples: Infrastructure

Risk	Impact	Risk Minimization & Mitigation
Connection to power grid or pipeline delayed	Revenue start date delayed	Start negotiation on feasible projects 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: Market

Risk	Impact	Risk Minimization & Mitigation
Failure of sole customer's business	Loss of revenue stream until new customer found	Identify multiple customers, dual revenue stream, if feasible
Fall in power or industrial gas prices	Loss of revenue	Pursue dual revenue streams; develop only high ROI projects so there is some flexibility

Carbon market collapses	Loss of carbon revenue	Pursue dual revenue streams

Project Risk Mitigation Examples: Financing

Risk	Impact	Risk Minimization & Mitigation
Lenders and investors averse to funding coal-related projects	Unable to finance	Emphasize the positive greenhouse gas mitigation benefits; Use carbon financing If applicable; Include AMM emission reductions to commodity sales of steel and coal
Carbon assets fail to deliver	Additional cost of emission reduction credits from the market	Accept as business risk Pursue dual revenue resources Develop trading strategies, including hedging

Financing AMM Projects

Pre-Feasibility Studies and Finance for AMM Projects

A pre-feasibility study should establish that an AMM project can be designed for the specific mine site that meets technical criteria and will generate the projected revenue.

The project developer will want the pre-feasibility study documentation to contain sufficient information to show potential investors or lenders that, in principle, the project has commercial merit with manageable risk.

Raising Project Finance for AMM Projects

Although some project developers are capable of financing projects themselves, effectively financing the project off their balance sheets, most projects will likely require financing involving a mixture of debt (mainly banks) and equity capital. For start-ups, venture capital (a type of equity) may also be involved, Venture capital investors will expect greater ownership and higher returns for accepting early-stage risk.

The project revenue should create sufficient cash flow to service the debt, pay all operational costs, and create a rate of return acceptable to the project investors over the project life.

Where there is scope for the replication of projects in order to scale a business, investors may be willing to accept a smaller profit for the first project with the expectation that the experience gained will result in reasonable returns from subsequent projects.

Coal mining projects are becoming increasingly difficult to finance, as banks and investors are becoming more aware of climate change risk. The message that AMM use and destruction reduces the environmental and climate impact of coal mining significantly below the business as usual (BAU) case may need to be clearly articulated.

AMM Project Financing Terms

Financing Off the Balance Sheet: Coal mining companies and developers with significant asset bases are able to finance CMM projects off their balance sheets. In effect, this means that a company can secure a loan with little or no collateral, which can occur when an established investor holds assets of such scale that an equity investment or debt instrument will not threaten the solvency of the company.

Private Equity: Direct financing where the investor takes a share of the company in exchange for cash to the project. Most likely an equity investor will want to see that the project sponsor has a financial stake in the project. The advantage of equity financing for CMM projects is that it is more likely to be available than debt financing, and it strengthens the balance sheet by minimizing debt. However, any project developer accepting equity must recognize that equity shareholders may expect significant input in the project and will have an investment horizon of 4-7 years on average.

Venture Capital: Venture capital is a form of private equity that typically targets high risk/high reward investments with a shorter investment horizon and more aggressive expectations concerning investment payback. In addition, venture capital investors are likely to play a more active role in managing their investment compared to a typical equity investor.

Debt: Debt can be secured through a line of credit, commercial loan, private loan, vendor loan, bilateral or multilateral project-based loan, concessional loan through an international financial institution, or through issuance of a bond or other securitized instrument. Rarely will a lending institution finance 100 percent of the project through a loan or other debt vehicle. Typically, they apply debt to equity ratios with some willing to consider up to 80 percent debt and 20 equity investment, but ratios may be as low as 50/50. The availability of debt financing and the interest rates charged are very directly tied to financial markets, project risk, country risk, owner/developer's balance sheet, projected revenue stream from the project and the credit rating of the borrower's customers, any history with the borrowing entity, and maturity of the technology and the lender appetite for risk. For smaller companies or for companies with a limited operational history, securing debt financing is more difficult than for larger, more established companies.

Documentation of Project Financial Viability

In order to demonstrate the potential financial viability of the project, the pre-feasibility should clearly demonstrate that:

- The necessary approvals are in place, or there are no barriers for gaining approvals, especially regarding AMM production rights.
- The project life is at least 10 years.
- The project management team is competent, experienced, and is identified in the study.
- The market exists for energy and environmental commodities, and buyers are prepared to enter into a contract at a reasonable price with no penalties for interruptible supply.
- The project is of a sufficient scale to merit the investment.
- The technical and financial risks associated with the project can be mitigated to an acceptable level.
- The payback time and the projected return on investment is commensurate with the degree of risk.

- The project will generate projected cash flows that are not overly optimistic.

Carbon Financing

Carbon financing may be an option if:

- The project will qualify as an offset project, and emission reduction certificates can be sold in advance at a discount to traders, institutional investors, or compliance buyers to partially fund the project. Should a project be unable to supply emission reduction credits according to an agreed schedule, then it will have to buy from the market.
- The approved methodologies and protocols provide clear rules about what types of projects can qualify and how the emission reductions will be estimated. This is essential information for project developers to determine whether a project is viable.

Carbon Financing and AMM Emissions Reductions

Carbon finance has proved to be an effective market-based instrument to incentivize the development of CMM projects (UNECE, 2016) under the Clean Development Mechanism (CDM). The United Nations Framework Convention on Climate Change (UNFCCC) approved a CDM methodology for CMM use and destruction (ACM0008 version 08.0), and it also extends to AMM.

The California Cap-and-Trade Program under the control of the California Air Resources Board (CARB) has recognized AMM emission reductions as a qualifying offset type as long as the project follows the approved protocol. At least 16 AMM projects have received California offsets under this methodology as of July 13, 2022 (ARB Offset Credit Issuance Table).

There are also various international voluntary GHG programs for registering emission reduction projects, although the markets for these tend to be smaller with lower prices (although prices are increasing as markets mature).

Communicating AMM Emission Reduction Benefits

It is important to note that coal mine-methane related emission reductions can be difficult to sell because of the linkage to coal mining. Many buyers are no longer purchasing emission reductions tied to coal mining or coal-related projects. In these instances, it is advisable to emphasize that AMM emission reductions are not associated with active mining and that they:

- Contribute to the decarbonization of the coal industry more broadly
- Support local economic development, energy independence, and a just transition to less carbon-intensive industries
- Improve public safety by mitigating emissions from migrating into structures

Pre-Feasibility Study Conclusions, Recommendations, and Next Steps

Pre-Feasibility Study Conclusions

The final step for the project developer is to make informed conclusions based on all data evaluated for the study and the results of the financial analysis.

The conclusions should be clear and concise and should identify recommendations for next steps.

If the recommendation is to proceed with a full feasibility study, the conclusions should specify what additional information should be collected and analyzed for the study.

Pre-Feasibility Study Report

When preparing a report, it is useful to re-iterate the reason for undertaking the pre-feasibility study and briefly summarize the work completed and the study findings as noted below.

Information to include in a pre-feasibility study report:

- Number of visits made to the site and types of work undertaken in the course of the study (see Modules 1 &2)
- The current status of the mine, such as if the mine is towards end of its life, closing, or closed (see Module 2)
- AMM resource and reserves, gas production forecast, project life, positive site selection factors, and mine closure engineering (see Modules 3, 4 & 5)
- Markets and recommended utilization options (see Module 6)
- Regulatory and policy barriers and incentives (see Module 6)
- The costs and benefits of the identified utilization scenario(s) (see Module 6)
- Financial returns and risk mitigation (see Module 6)
- Financing options (see Module 6)

Site Selection Factors

It is helpful to highlight in the report the positive site selection factors, such as those listed below.

Positive site selection factors to include in a pre-feasibility study report:

- Unambiguous ownership of the AMM
- Regionally competitive energy and/or carbon commodity
- Customers
- High gas flows from the working mine
- Large volume of un-mined coal de-stressed by longwall mining

- Deep gassy mine
- Few surface entries
- Isolated from abandoned shallow workings
- Low rate of mine water recovery
- Underground connectivity
- Suitable surface extraction location
- Pre closure engineering feasible

Pre-Feasibility Study Recommendations and Next Steps

A credible and value-added pre-feasibility study should present recommendations for future action. If recommending that evaluation of the project continue, the study should also clearly outline next steps to be undertaken for the more thorough review leading to project financing and development.

- A firm commitment for investment is not needed at this stage, but the project must show promise to justify proceeding to the more costly full feasibility study.
- Should the next stage of a feasibility study be initiated? Yes or no?
- If so, what are the next steps?

Pre-Feasibility Study Next Steps

If the project looks promising and the recommendation is to proceed to the next stage of assessing the project's feasibility, the following next steps are generally recommended:

- Undertake a detailed engineering study of the mine entry sealing and underground water management (if a pre-closure study).
- Conduct additional gas and water monitoring.
- Secure additional geologic data to develop a more accurate gas resource assessment.
- Further refine the reservoir simulation and gas production forecast based on new/revised data.
- Contact contractors to obtain firmer engineering and drilling costs.
- Conduct additional market research and investigate more thoroughly all utilization options and the viability of alternatives and their competitiveness.
- Contact equipment and service suppliers for pricing, sales terms, and product specifications.

Other Pre-Feasibility Study Next Steps

Other next steps include:

- Scope out engineering and construction requirements for the AMM plant.
- Develop a detailed project development and implementation schedule and determine internal costs for project development.

- Explore the markets for emission offsets, especially voluntary markets, to determine if the CO2 offsets from the project can be sold and to establish relationships with traders with an interest in forward sales which will help generate cash up-front for the project. Markets for emission offsets will require the establishment of an emission baseline and development of a monitoring, reporting, and verification (MRV) plan to create a formal system to credit emission reductions.
- Refine the financial analysis and develop a detailed project-specific model sufficient for internal or external financing entities.

Module 6 Summary

This module examined the key factors that determine whether an AMM project is likely to be commercially feasible and fundable, including:

- Markets
- Utilization options
- Legal and regulatory issues
- Financial analysis
- Risk analysis and mitigation
- Financing

This module also outlined a methodology for conducting a financial analysis (with illustrative examples) and described a pre-feasibility study report conclusions, recommendations, and next steps.

Thank You!

You have completed Module 6.