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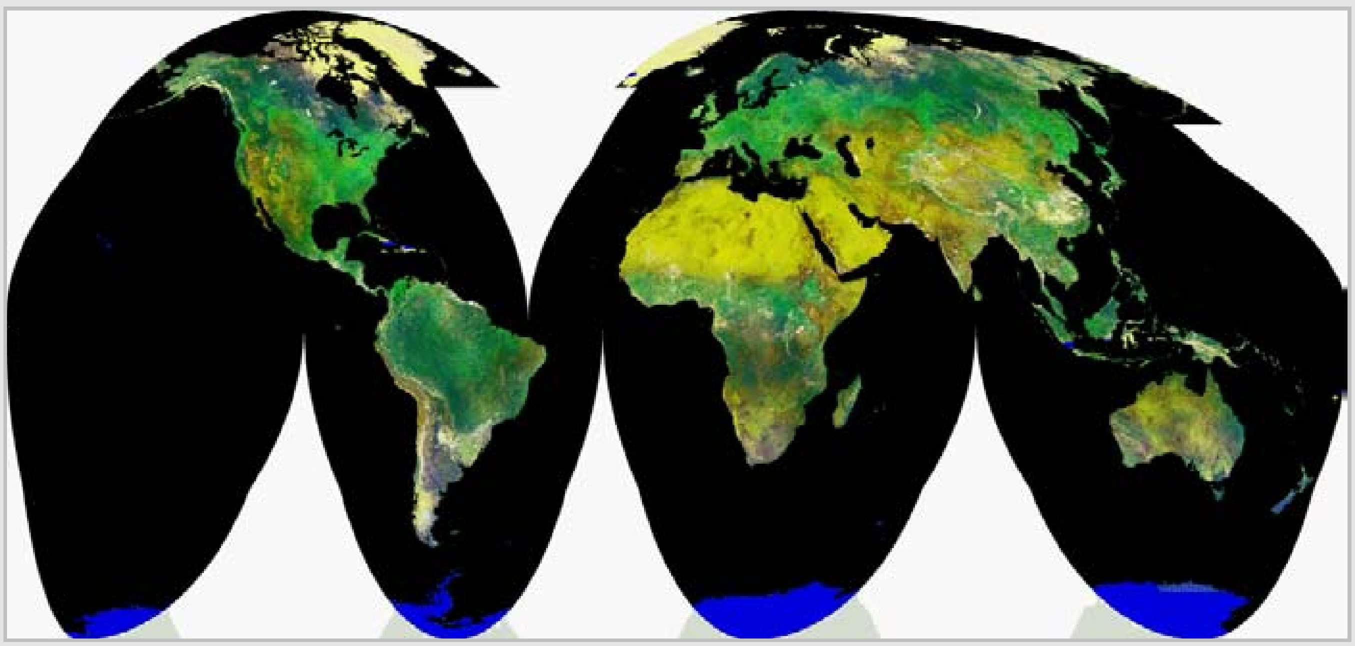
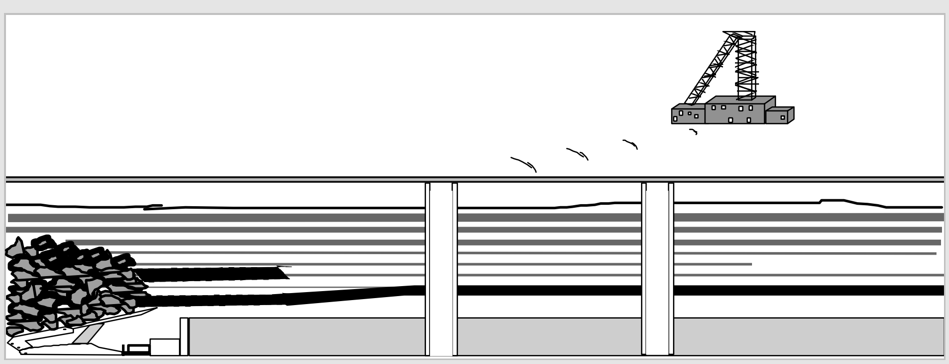
A Guide for Methane Mitigation Projects

Gas-to-Energy at Coal Mines

◆ Emissions Overview ◆ Identify Opportunities ◆ Preliminary Site Assessment ◆





◆ Government Policies ◆ Next Steps ◆ List of Experts ◆ Funding Sources ◆

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This document is a working draft being used by Country Study Program participants to develop methane mitigation projects. Users of this document and those implementing methane mitigation projects are encouraged to provide feedback. Please direct comments to:

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1. INTRODUCTION

THIS report provides guidance for developing programs to reduce methane emissions from underground coal mines through coal mine methane recovery and use. Methane trapped in the coal and surrounding strata is released during mining. Because methane is a valuable source of energy, recovering and utilizing coal mine methane is an economically attractive option for reducing greenhouse gas emissions.

This document is directed towards program managers responsible for developing greenhouse gas (GHG) mitigation programs in developing countries and countries with economies in transition. By focusing on identifying and evaluating opportunities to reduce emissions, this report complements the guidance developed by the U.S. Country Studies Program and materials available from related efforts of the U.S. Environmental Protection Agency and others. Furthermore, as a guidance document for reducing methane emissions from coal mines, this report assists countries in fulfilling commitments under the United Nations Framework Convention on Climate Change (UNFCCC) to implement greenhouse gas mitigation programs.

Given the economic value of methane as a fuel source and the potential availability of international donor funding, coal mine methane recovery and utilization presents one of the most cost-effective options for reducing methane emissions.

The main goal of this report is to provide a step-by-step method for performing a national assessment of the opportunities to reduce methane emissions from coal mining. The report presents steps for identifying and evaluating gassy, underground coal mines. Those characteristics that make gas recovery and utilization technically and economically attractive are presented. Additionally, this report discusses how national policies affect the viability of coal mine methane recovery projects and identifies the steps which may be taken to encourage the development of this resource.

The remainder of this report is organized into the following five chapters:

2. **Overview of Coal Mine Methane Emissions and Emissions Reduction Opportunities:** This section provides a brief background to the topic of methane emissions and emissions reductions from coal mines.

3. **Identify Opportunities to Reduce Methane Emissions:** This section describes a screening process by which the program managers can identify whether underground coal mines in their countries present attractive options for reducing emissions.

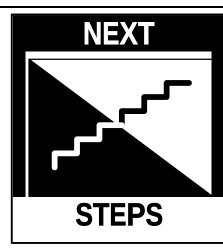
4. **Perform Preliminary Site Assessments:** This section presents the process for conducting preliminary site assessments for individual sites or representative facilities identified as being good candidates for gas recovery projects in Section 3. Based on this information, the program manager can begin to design an emissions reduction strategy for this source of methane emissions.

5. **Identify and Assess Key Government Policies:** This section identifies the key government policies that will promote or hinder coal mine methane recovery projects. . Based on this information, potential policy options will be assessed in the context of national priorities.

6. **Next Steps:** This section discusses the steps that may be taken by program managers to further the development of an emissions reduction program for underground coal mines. Information on international funding sources for coal mine methane recovery projects is presented in this section.

Exhibit 1-1 summarizes how this document can be used to meet various objectives. The first column lists several common objectives and the second column lists the chapter to consult and key elements of that chapter

Exhibit 1-1: How to use this Document

Objective	Chapter to Consult
I WANT AN OVERVIEW OF METHANE AS A GREENHOUSE GAS • What are the sources of methane emissions and how does methane contribute to the greenhouse effect?	 **2. Overview Of Methane Emissions And Emissions Reduction Opportunities** 2.1 Methane is a Potent Greenhouse Gas 2.2 Methane Emissions from Coal Mining 2.3 Opportunities to Reduce Methane Emissions from Coal Mines
SHOULD I TRY TO REDUCE METHANE EMISSIONS FROM COAL MINES? • How do I assess whether we have coal mines that would be conducive to methane emissions reductions? • What data can I collect to identify promising opportunities to reduce methane emissions from coal mines?	 **3. Identify Opportunities For Reducing Methane Emissions** Identify Basins or Coal Regions with Gassy Underground Mines Determine the number of Large Mines Obtain Methane Release Information Determine Mine Lifetimes Evaluate Energy Demand
I WANT TO ESTIMATE POTENTIAL EMISSIONS REDUCTIONS • How do I estimate the emissions reduction from individual methane projects? • How do I estimate and compare costs and revenues from individual methane recovery projects? • How do I develop a national assessment of emissions reduction and energy production?	 **4. Preliminary Site Assessments** 4.1 General Site Information Required 4.2 Identify Potential Recovery Methods and Estimate Gas Production 4.3 Identify Potential Uses for Recovered Methane 4.4 Assess Economic Feasibility
WHAT POLICIES AND REGULATIONS ARE IMPORTANT? • What policies affect the economic viability of coal bed methane recovery projects? • How can methane recovery projects help meet other environmental goals? • What policies affect the availability of financing and technology?	 **5. Identify And Assess Key Government Policies** 5.1 National Energy Pricing, Subsidies, and Taxes 5.2 National Energy Supply Priorities 5.3 Environmental Goals 5.4 Financing 5.5 Technology Development 5.6 Concession Process
WHAT CAN I DO NEXT TO FACILITATE A PROJECT? • What additional studies are needed? • How do I remove the barriers that are slowing down the process? • Where can I get funding to undertake these activities?	 **6. Next Steps** 6.1 Focus on the Most Promising Projects 6.2 Availability of Technology and Expertise 6.3 Motivate Decisionmakers 6.4 Review Regulatory Framework 6.5 Obtain Project Funding
WHERE CAN I GET ADVICE FROM EXPERTS?	**Appendix A: Directory of Select Coal Bed Methane Recovery Experts in the U.S.**
WHAT ARE THE MAIN FUNDING SOURCES APPLICABLE TO COAL MINES?	**Appendix B: Directory of Possible Funding Agencies**

2. OVERVIEW OF COAL MINE METHANE EMISSIONS AND EMISSIONS REDUCTION OPPORTUNITIES

THIS chapter provides a brief background to the topic of methane emissions and opportunities to reduce emissions from underground coal mines. First, background information is provided about the atmospheric importance of methane. Next, methane emissions from coal mines is discussed. Finally, the opportunity to reduce methane emissions and the benefits of reducing emissions are presented.

2.1 Methane is a Potent Greenhouse Gas

Because methane is a source of energy as well as a greenhouse gas, reducing methane emissions coal mines is economically beneficial.

Methane (CH_4) is an important greenhouse gas and a major environmental pollutant. Methane is also the primary component of natural gas and as such can be a valuable energy source. Methane emissions reduction strategies offer one of the most effective means of mitigating global warming in the near term for the following reasons:

- **Methane (CH_4) is one of the principal greenhouse gases**, second only to carbon dioxide (CO_2) in its contribution to potential global warming. In fact, methane is responsible for roughly 18 percent of the total contribution in 1990 of all greenhouse gases to "radiative forcing," the measure used to determine the extent to which the atmosphere is trapping heat due to emissions of greenhouse gases. On a kilogram for kilogram basis, methane is a more potent greenhouse gas than CO_2 (about 24.5 times greater over a 100 year time frame).

- **Methane concentrations in the atmosphere have risen rapidly.** Atmospheric concentrations of methane have been increasing at about 0.6 percent per year (Steele et al. 1992) and have more than doubled over the last two centuries (IPCC 1990). In contrast, CO_2's atmospheric concentration is increasing at about 0.4 percent per year.

- **Reductions in methane emissions will produce substantial benefits in the short-run.** Methane has a shorter atmospheric lifetime than other greenhouse gases -- methane lasts around 11 years in the atmosphere, whereas CO_2 lasts about 120 years (IPCC 1992). Due to methane's high potency and short atmospheric lifetime, stabilization of methane emissions will have an immediate impact on mitigating potential climate change.

- **Because methane is a source of energy as well as a greenhouse gas, many emissions control options have additional economic benefits.** In many cases, methane that would otherwise be emitted to the atmosphere can be recovered and utilized or the quantity of methane emitted can be significantly reduced through the use of cost-effective management methods. Therefore, emissions reduction strategies have the potential to be low cost, or even profitable. For example, methane recovered from coal mines can be used as an energy source.

- **Well demonstrated technologies are commercially available for reducing methane emissions.** For all of the major sources of anthropogenic methane emissions (except rice cultivation and biomass burning), cost effective methane reduction technologies are commercially available. While offering substantial emissions reductions and economic benefits, these technologies have not been implemented on a wide scale in the U.S. or globally because of financial, informational, legal, institutional, and other barriers.

The unique characteristics of methane emissions demonstrate the significance of promoting strategies to reduce the amount of methane discharged into the atmosphere.

2.2 Methane Emissions from Coal Mining

Underground coal mines account for 70 to 85 percent of methane emissions from the coal fuel cycle.

Methane and coal are formed together during coalification, a process in which vegetation is converted by biological and geological forces into coal. Methane is stored within coal seams and surrounding rock strata and is released to the atmosphere during mining or through natural erosion. Typically, significant quantities of methane are trapped in the coal and surrounding strata of underground mines, while little methane is associated with surface-mined deposits.

In underground mines, methane is hazardous in the working areas because methane is explosive in concentrations of five to fifteen percent in air. Therefore, all underground coal mines use ventilation systems. These systems pump large quantities of air through the mine to dilute the methane to safe levels. In very gassy mines, however, additional degasification techniques must be used along with ventilation systems. The methane recovered from these systems is frequently vented into the atmosphere.[1]

There are two important factors that influence the amount of methane generated in coal seams:

- **Coal Rank.** Coal is ranked by its carbon content; coals of a higher rank have a higher carbon content and generally a higher methane content.[2]

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1 Methane does not typically pose a hazard at surface mines, and ventilation systems are not used. Methane released during the mining of surface deposits disperses in the atmosphere and does not reach explosive concentrations.

2 In descending order, the ranks of coal are: Graphite, Anthracite, Bituminous, Subbituminous, and Lignite.

- **Coal Depth.** Pressure, which increases with depth, tends to keep methane in coal seams and surrounding strata from migrating to the surface. Thus, within a given coal rank, deep coal seams tend to have a higher methane content than shallow ones.

In 1990, the coal fuel cycle (which includes coal mining, transportation, and usage) emitted an estimated 24-40 teragrams (Tg) of methane.[3] An additional 1.3 Tg of methane was recovered by coal mines and used as an energy source. Underground coal mines were responsible for 70 to 85 percent of all emissions, while surface mines and the transportation of coal were estimated to contribute 10 to 20 percent. Coal combustion was estimated to contribute the remaining 5 to 10 percent (USEPA 1994).

2.3 Opportunities to Reduce Methane Emissions from Coal Mines

There are many opportunities to expand the recovery and use of methane fron gassy underground coal mines. The techonolgies are well known and have been demonstrated worldwide.

Methane recovery and use is technically feasible at many large and gassy coal mines, but may require a shift in the traditional perception that coal companies and government authorities have of mine degasification. Techniques for removing methane from mines have been developed primarily for safety reasons. Thus, in many cases the recovered methane is released to the atmosphere with little attention paid to the development of gas use projects. At mines throughout the world, however, these same techniques have been successfully adapted to recover methane, allowing the mines to both improve mine safety and harness the methane for fuel. Many additional opportunities exist to expand the use of these technologies and reduce worldwide emissions of methane into the atmosphere.

There are a variety of reasons why coal mine methane projects are a good way to reduce methane emissions. First, individual gassy coal mines can be large emitters of methane. Therefore, developing a few key projects can result in significant emission reductions. Current data indicate that there are a significant number of large and gassy underground mines around the world that are good candidates for such emissions reduction projects.

Second, the technologies for recovering methane in conjunction with coal mining have been well demonstrated and are currently in use throughout the world (see Exhibit 2-1). The methane recovered using these technologies can be used in a variety of ways to meet local energy needs, including: on-site use as gas; on-site use to generate electricity; or sale for off-site use to residential, commercial, or industrial customers (see Exhibit 2-2).

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3 One teragram is 10^6 metric tons, or 10^{12} grams.

EMISSIONS OVERVIEW

Exhibit 2-1: Summary of Methods for Recovering Methane from Underground Mining	
Method	**Description**
Vertical Wells	Drilled from the surface to the coal seam several years in advance of mining.
Gob Wells	Drilled from the surface to a few meters above the coal seam just prior to mining.
Shorthole Horizontal Boreholes	Drilled from inside the mine to degasify the coal seam.
Longhole Horizontal Borehole	Drilled from inside the mine to degasify the coal seam.
Cross-measure Boreholes	Drilled from inside the mine to degasify surrounding rock strata.

Exhibit 2-2: Summary of Methods for Utilizing Methane from Underground Mines	
Method	**Description**
On-site	Recovered methane can be used on site directly as gas, or can be used to generate electricity to meet on-site mine requirements. For example, the methane can be used in the coal preparation plant or for space heating or water heating. To produce electricity, the methane can be used to power an engine-generator.
Off-site	Coal mine owners and developers can sell recovered methane to nearby industrial, commercial, and residential users. The quantity and quality of methane produced and the local demand for the energy will determine the distance that the gas must be transported and how it will be used. In some cases the methane can be sold to the local gas distribution network. Similarly, if more electricity is produced than is required on site, the excess electricity can be sold to the local power grid.

The benefits of recovering and using coal mine methane are summarized in the following four main areas:

In addition to reducing methane emissions, recovering coal mine methane has other important benefits: the gas can be used as an energy source; ventilation requirements are reduced; and local air quality is enhanced.

- **Economic.** There are several ways by which coal mine methane recovery and use can lead to economic benefits. For example, methane recovery through degasification systems can reduce ventilation costs and improve mine productivity. Also, the mine can realize cost savings by using the methane for on-site energy needs. Alternatively, the methane can be sold to customers off site. If the cost of recovering and using (or selling) the gas is less than the value of the energy derived, the mine will earn a profit.

- **Energy.** Coal mine methane can be used to meet the energy requirements of the mine and nearby areas. The gas can also be used as a residential, commercial, or industrial fuel. This increased source of domestic energy can be especially important in nations where demand is growing rapidly and domestic supplies are

Exhibit 2-3: The UN Framework Convention on Climate Change (UNFCCC)

The signature of the **United Nations Framework Convention on Climate Change (UNFCCC)** by around 150 countries in Rio de Janeiro in June 1992 indicated a widespread recognition that climate change is a potentially major threat to the world's environment and economic development.

The Convention aims to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level is to be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change. The Convention calls for Annex I countries to take measures designed to limit emissions of carbon dioxide dioxide and other greenhouse gases, with the aim of returning to 1990 emissions levels by the year 2000.

To achieve this objective, the Convention sets out a series of principles and general commitments. The key principles incorporated in the treaty are the precautionary principle, the common but differentiated responsibility of states (which assigns industrialized states the lead in combating climate change), and the importance of sustainable development. The general commitments, which apply to both developed and developing countries, are to adopt national programs for mitigating climate change; to develop adaptation strategies; to promote the sustainable management and conservation of greenhouse gas "sinks" (such as forests); to take climate change into account when setting relevant social, economic, and environmental policies; to cooperate in technical, scientific, and educational matters; and to promote scientific research and the exchange of information.

constrained. The increased reliance on domestic energy resources can also help reduce energy imports, thereby improving energy security and the balance of payments.

- **Environment.** As explained above, methane is a potent greenhouse gas. By reducing emissions, coal mine methane projects fulfill a country's commitment to the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC requires developed countries (also known as Annex I countries) to adopt measures to reduce greenhouse gas emissions, with the aim of reducing to 1990 emissions levels by the year 2000 (see Exhibit 2-3).

  Furthermore, the recovery of methane increases the supply of natural gas, which has several advantages over other fossil fuels. The displacement of coal (and to a lesser degree oil) with gas will reduce emissions of SO_2, NO_x, and particulates (USEPA 1986). This will lead to a cleaner local environment.

- **Safety.** At gaseous concentrations of 5 to 15 percent, methane is explosive. Thus the buildup of methane in underground mines poses a serious safety hazard. Increased use of degasification systems may improve safety by reducing methane levels in the mine. Techniques for recovering methane before mining (through use of vertical wells drilled from the surface, for example) can significantly reduce the amount of methane in the coal when mining occurs (USEPA, 1993).

A variety of coal mine methane recovery activities are currently in place around the world. There are examples of profitable projects involving gas sales and on-site use. However, many more coal mines can implement economically viable methane recovery and utilization projects. In some cases, national or local policies hinder these projects from being undertaken. Relevant policies should be evaluated to assess if they encourage or discourage methane recovery and utilization projects. Important issues to analyze include energy production and pricing, environmental policy, financing issues, and technology transfer policies.

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3. IDENTIFY OPPORTUNITIES FOR REDUCING METHANE EMISSIONS

THIS chapter presents a screening process for national program managers to determine if there are coal mines in their countries that are good candidates for emissions reduction projects. This screening of project opportunities requires five important pieces of information: (1) the location of regions or basins that are known to have gassy mines; (2) the number of large mines in those regions; (3) the amount of methane emitted from each mine; (4) the expected lifetime of each large and gassy mine; and (5) potential uses of the recovered methane. This information may be assembled for all mines in the nation, or, in those nations with a large number of mines, for the largest mines from each region or basin.

A step-by-step approach is presented to assess whether opportunities for the implementation of gas recovery projects exist. Each step in the process is a hurdle to be crossed. If a hurdle cannot be crossed, it is unlikely that promising emissions reduction opportunities exist. For example, if the gassy mines in the nation are likely to close in the near future, then there are no emissions reduction opportunities and the analysis ceases. Assuming that there are gassy mines, you may find that there can be no market for the recovered gas. In this case, gas recovery projects cannot be profitable, and emissions can only be reduced at a cost. The analysis would only proceed if the program manager is willing to consider emissions reduction options that cost money. In many countries, this step-by-step process is likely to identify gassy coal mines with potential for energy recovery resulting in emission reductions.

The initial screening steps are as follows:

1. **Identify Basins or Coal Regions That Contain Gassy, Underground Mines.** The first step in the screening process involves locating coal basins or regions that have gassy coal mines. Typically, coal industry experts will be knowledgeable regarding the gassiness of the underground coal mines in each mining region. In the absence of specific gas content information, the presence of degasification systems, the coal rank, or the coal depth can be used as indicators of gassiness. If suitable coal basins or regions exist, the analysis proceeds to the next step.

The first step i[…] to determine […] underground c[…]

2. **Determine the Number of Large, Underground Mines in Each Coal Basin or Region Identified.** For initial screening purposes, coal mines producing more than 300,000 metric tons of coal annually will be considered as potential candidates. Coal mines of this size could generate enough methane to support a recovery project. It should be noted, however, that this size criterion is <u>not</u> absolute. Smaller coal mines potentially could support successful recovery and use projects, given a high level of methane content in the seams.

urposes, mines cubic meters of ton of coal d as potential ence of data on ndicators of gas used.

3. **Obtain Information on Methane Released During Coal Mining.** For initial screening purposes, mines that emit more than 10 cubic meters of methane per metric ton of coal produced are considered sufficiently gassy to be regarded as potential candidates. Like the criteria regarding coal production, this criterion is <u>not</u> absolute. In addition, while annual production data may be readily available, information on methane emissions may not be available without directly contacting individual mine operators. If emissions data is unavailable, other indications of gasiness may be used, including in-situ methane content, records of outbursts or explosions, or use of mine degasification systems.

4. **Determine Projected Mine Lifetime.** For a project to be economically viable, the mine should remain open for at least five years. Once again, this minimum lifetime is only an estimation. The lifetime necessary for a project to be economically viable will be specific to each mine. Because some nations are liberalizing and privatizing their energy sectors, as well as enacting environmental legislation that may affect coal consumption, many factors other than the geology of the reserve must be considered in estimating the likely life time of a coal mine. If this information is not readily available, the remaining life span may be estimated by dividing the total remaining reserves by the annual production. Examining the economic and geological status of other mines in the basin or region may also provide some clues.

5. **Determine Use for the Recovered Methane**: In nearly all cases, the mine will be able to use the recovered methane on-site. Because the candidate mines are relatively large, they have significant energy and electricity needs for the mining equipment, for the coal preparation process, and for water and space heating. In cases where the amount of methane recovered exceeds on-site energy requirements it is important to determine if there are other potential energy customers in the surrounding area.

There are a variety of sources from which the above data may be obtained. These include the following:

- **Various Government Organizations.** In many nations, the coal mines are owned by the central or local governments and/or government ministries that may be familiar with the mining industry because they are involved in energy planning, policymaking, or regulation. For this reason, government entities such as the Ministry of Coal, Ministry of Industry, Ministry of the Environment, Mine Safety Bureau, or Geologic Ministry or Institute may have readily available sources of information.

  For example, many countries have a ministry that collects coal production and coal reserve data for each mine in the nation. Also, one or more government agencies may collect data regarding methane emissions and mine life time. Alternatively, if specific data are not readily available, industry experts may know if mines in a particular basin or region are known to be gassy. The mine safety agency staff might know that mine operators in a particular area were experiencing problems due to high methane levels and planned to expand their degasification systems. Similarly, central planning ministry staff might be aware of likely shifts in coal production among mines or mine shutdowns resulting from government actions such as coal sector restructuring or additional environmental regulation.

- **Coal Mine Operators.** If all the information is not readily available in a centralized location, it may be necessary to contact individual mine operators. Data on methane emissions, in particular, may be difficult to obtain from sources other than those at the mine. Mine operators will almost certainly have this information because it is needed to design and operate their mine ventilation system. The feasibility of contacting individual mine operators however, will depend on the time and resources available for conducting this screening step.

- **Trade Associations, Energy Institutes, and Research Organizations.** These entities may have some of the necessary data, and in fact, may have more data or may be more accessible than the government ministries in some cases. Some of these organizations may prepare energy studies, publish reports, and have their own energy databases.

- **Coalbed Methane Project Developers.** Project developers who recover and use coal mine methane or have done so in the past may be a good source of information. They may be able to assist in obtaining the preliminary information or may be willing to share their experiences with those interested in promoting the implementation of similar projects.

Using the information from the above five steps, the initial appraisal can be performed. Exhibit 3-1 lists the questions addressed by each of the five steps. If each of the questions listed in the exhibit can be answered "Yes," there are likely to be good opportunities for reducing methane emissions through the implementation of gas recovery and use projects.

Even if one or more questions cannot be answered "Yes," there may exist, under certain circumstances, attractive opportunities for reducing emissions.

Exhibit 3-1: Initial Appraisal Results Checklist

1.	Are there any coal regions that have underground mines?	Yes ❑	No ❑
2.	Do any of the underground mines in the identified region(s) produce more than 300,000 metric tons annually?	Yes ❑	No ❑
3.	Do any of the mines in the identified region that produce more than 300,000 metric tons annually: 1) emit more than 10 cubic meters of methane per metric ton of coal produced; 2) employ degasification methods; or, 3) exhibit other indications of high methane emissions?	Yes ❑	No ❑
4.	Do any of the mines that meet the above criteria have a life span greater than another five years?	Yes ❑	No ❑
5.	Do the coal mines meeting the above criteria have significant energy requirements; OR are there energy requirements in the surrounding area?	Yes ❑	No ❑

If the answer is **YES** to all of the above questions, there are promising options for gas recovery. Proceed to Chapter 4, where the technical and economic feasibility of gas recovery at each candidate site will be evaluated.

The following economic and social conditions would favor gas recovery from coal mines:

- **High Energy Cost.** If the cost of alternative fuels -- such as oil, coal, and conventional natural gas -- is high in the area surrounding the mine, smaller sites may be able to undertake a recovery and utilization project profitably.

- **Recovery Systems Already in Place.** Some gassy mines already may use degasification systems to recover methane for safety reasons. In such cases, the cost of the project would include only the cost incurred to employ the recovered methane. Smaller coal mines would be potential candidates for methane recovery and utilization projects in such cases.

- **Energy Shortage.** Providing coal mine methane to areas facing energy shortages offers social and economic benefits that will not be apparent in a simple financial assessment of the particular project. The government may undertake a gas recovery project to provide households with low cost and clean energy, thereby improving their standard of living. Indirectly, such projects also may have economic benefits. In such cases, the attractiveness of a gas recovery project is better evaluated in terms of the social value of energy provided rather than on a financial cost-revenue comparison.

Finally, it may be desirable to recover and combust methane recovered from coal mines even if they do not meet the criteria listed above. In particular, even if there is no opportunity to use the gas economically, methane emissions can be reduced at relatively low cost by simply collecting and flaring the gas. Such projects may be attractive to investors in developed countries who are identifying low-cost options for reducing greenhouse gas emissions through joint international action. There are a number of safety issues that must be addressed, however, before flaring may be considered a viable option. The U.S. Environmental Protection Agency is currently examining this issue.

4. PRELIMINARY SITE ASSESSMENTS

HIS section presents guidance for conducting preliminary assessments of the candidate sites identified in Section 3. These assessments will provide a more comprehensive and concrete evaluation of the attractiveness of each of the gas recovery opportunities. Using site specific information, project development options that are most technically appropriate and cost effective will be identified.

Some countries may not have the technical and labor resources needed to conduct site assessments. Appendix A (at the end of this document) lists experts that may be contacted to conduct project feasibility assessments and develop gas recovery projects. Furthermore, Chapter 6 presents steps for identifying and filling gaps in the availability of technology and expertise required.

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In most cases, the screening process in Section 3 will identify several candidate sites worthy of this level of analysis. Under this circumstance, a preliminary site assessment can be conducted for each site. In some cases, however, so many sites may be considered candidates that it may not be possible to conduct preliminary site assessments for each at this time. In this case, it is recommended that several sites with significant emissions reduction potential be selected for assessment. For example, the mine with the largest estimated emissions in each coal region or basin could be selected. Alternatively, sites could be selected to represent a range of mine characteristics. Based on the results of the analysis of these sites, the need for additional preliminary assessments at additional sites can be determined.

The preliminary site assessment examines the main factors influencing the attractiveness of gas recovery projects. Section 4.1 describes the general site information required. Section 4.2 presents the various recovery techniques and Section 4.3 discusses the possible use options. Finally, Section 4.4 discusses the economic feasibility of these methods.

4.1 General Site Information Required

The preliminary site assessment begins by collecting general site information. which will be used to examine the following: methods for recovering methane; the quantity of gas likely to be produced; and the potential uses for the gas recovered. For purposes of this preliminary assessment, the amount of gas that can be produced will be estimated from information on the amount of methane released by the mine during mining activities. The following information should be obtained or estimated:

- **Current and Future Coal Production.** Obtain recent annual coal production statistics from the mine (metric tons per year). Estimate the number of years that the mine will continue to produce coal.

Identify whether the rate of coal production is expected to change significantly in the near future.

- **Degasification System.** Identify whether the mine has a degasification system (in addition ot the ventilation system). Section 4.2 (below) describes various degasification systems that may be in use.

- **Methane Emissions.** Estimate current and expected future methane emissions from this mining activity. Options for estimating this quantity include:

  1. *Ventilation System Emissions:* Methane emissions from the ventilation system equal the methane concentration in the ventilation air (typicaly less than one percent) times the volume of ventialtion air (e.g., in cubic meters per day). The mine's engineering staff generally knows or can estimate these quantities.

  2. *Degasification System Emissions:* If the mine has a degasification system (in addition ot the ventilation system) the methane emissions from this system must be estimated and added to the emissions from the ventilation system. Degasification system emissions are highly site-specific and must be estimated from individual mine data obtained from the mine's engineering staff. Identify the amount of methane emitted (e.g., in cubic meters per day) and the concentration of the methane in the gas flow from the degasification system (e.g., in percent).

  3. *In Situ Gas Content:* The methane emissions from the mine can be approximated using the *in situ* gas content of the coal. At a minimum the methane emissions will be equal to the gas content per ton times the annual coal production in tons. In addition to these emissions, methane is generally released from strata surrounding the coal. The emissions from the surrounding strata are highly site-specific, but may be equal in magnitude to the emissions from the gas in the coal itself. The mine's engineering staff can normally estimate the *in situ* gas content and emissions from surrounding strata if emissions cannot be estimated from ventilation and degasification system data.

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- **Coal Characteristics.** The permeability of the coal will influence the types of gas production techniques that can be used. Obtain from the mine's engineering staff whether the coal has high or low permeability. Permeability of 1-2 millidarcies (md) is considered low, 3-10 md is medium, and permeability of over 10 md is high.[4]

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[4] Permeability is a measure of fluids to flow through the coal and surrounding strata. Permeability is measured in darcies.

- **Terrain and Land Use.** The local terrain and land use may impose constraints on the types of gas production techniques that can be used. Obtain a general description of the local terrain and land use condition. In particular, assess whether wells can be drilled from the land surface into the coal seam being mined and its surrounding strata.

- **On-site Energy Requirements.** Estimate current and expected future on-site energy requirements. Current or potential on-site gas use (e.g., for coal preparation or water and space heating) may be estimated in terms of energy requirements (e.g., megaJoules (MJ) or BTUs required per day). Estimate electricity usage in kiloWatt-hours (kWh) per day. In addition to the quantity of on-site energy use, estimate the cost of this energy.

- **Potential Off-site Gas Use.** If the mine is unable to use all the gas produced, off-site gas use options must be examined. To conduct this examination, a general survey of energy-using opportunities around the site may be required. At a minimum, determine whether there is a gas transmission/distribution system or an electric power grid in close proximity to the mine. Also, identify any large energy using facilities near the mine. A more detailed survey should be conducted once it is clear that on-site energy requirements are less than the amount of energy produced.

It is expected that not all the above information will be available from all the relevant facilities. As much information should be obtained as possible within the time and resources available so that a reasonable overview of the mine and its energy situation can be obtained. If necessary, "general usage factors" regarding energy requirements for the mine can be applied to provide a rough approximation of the likely energy demand.

One way to obtain this information is to prepare a survey send it to the mine. The mine's engineering staff should be able to provide the information relatively easily. If possible, verify the information in follow up meetings with the mine personnel. Once the information is obtained, the assessment moves to the next step to identify potential gas production techniques.

4.2 Identify Potential Recovery Methods and Estimate Gas Production

The purpose of this step is to identify one or more potential gas recovery techniques that can be used to produce gas at the mine site. The final selection of the preferred technique requires a detailed gas production assessment that is beyond the scope of the preliminary site assessment. However, this step will provide a rough indication of the alternatives to be considered so the potential economic performance of the project can be examined.

Each of the major gas production techniques is described in the next section. Following these descriptions, the criteria for selecting one or more method for evaluation in the preliminary assessment are presented.

4.2.1 Gas Production Methods

Methods for producing gas from active coal mines include vertical wells, short horizontal boreholes, longhole horizontal boreholes, gob wells, and cross-measure boreholes. Vertical wells and gob wells are drilled from the surface to the coal seam, while the various types of boreholes are drilled from inside the mine. Vertical wells, horizontal boreholes, and longhole horizontal boreholes recover methane in advance of mining, and typically can produce nearly pure methane gas. Gob wells and cross measure boreholes recover methane from areas that have already been mined and consequently usually produce gas that is contaminated with mine air, so that it is not pure methane.

This section describes each of the major degasification methods and provides information for determining whether a method might be appropriate for a particular mine.

Vertical Wells

Description: Similar in design to conventional oil and gas wells, vertical wells are drilled from the surface into the coal seam several years in advance of mining. In the U.S., they range from 300 to 600 meters in length, depending on the depth of the mine. Well spacing depends on reservoir, geological, and surface conditions. In the U.S., well spacing can range from one well per 8 hectares (20 acres) to one well per 65 hectares (160 acres).

Vertical wells usually require hydraulic fracturing of the coal seam to activate the flow of methane. These wells may produce large quantities of water and small volumes of methane during the first several months of operation. As this water is removed and the pressure in the coal seam is lowered, gas production increases. This water produced by vertical wells is the same water that would be removed when the coal is mined. Generally, this water must be treated and disposed in a manner that is similar to the treatment and disposal performed for the water produced during mining. Since vertical wells are operated several years in advance of mining, the equipment for water treatment would need to be installed and operated sooner than would be necessary if the water were handled during mining.

Vertical wells typically produce gas with a methane content greater than 95 percent because the methane that is recovered is not diluted with air from the mine workings. The total amount of methane recovered using vertical pre-drainage will depend on both the site specific geology and the number of years the well is drilled prior to the start of mining. Recovery of from 50 to over 70 percent of the methane that would otherwise be emitted during mining operations is possible for operations drilling vertical degasification wells at least 10 years in advance of mining.

Although not widely used in the coal mining industry, vertical wells are used by numerous stand-alone[5] operations that produce methane from coal seams for sale to natural gas pipelines. The use of this recovery method is growing in the U.S. Exhibit 4-1 presents a schematic of a vertical degasification well.

Suitability/Technical Feasibility: Vertical wells (along with longhole horizontal boreholes) are the preferred recovery technique when nearly pure methane must be produced. Vertical wells are suitable for mines that have access to advanced technology, can plan several years in advance of mining, have medium or highly permeable coal seams, and have geological characteristics that permit drilling from the surface. One advantage of vertical wells is that they may be used in conjunction with virtually all coal mining methods. U.S. coal mines employing this technique have successfully recovered large amounts of high quality methane for sale through conventional gas pipelines.

Vertical wells cannot be used on low permeability coals (less than 3 md), when surface access is restricted, or when degasification cannot be planned in advance. In low permeability coal seams, vertical wells may not be effective due to limited methane flow through the seam. Additionally, there is some concern that in certain geologic conditions the hydraulic fracturing required to stimulate production from a vertical well may cause damage to the roof rock, which would hinder mining operations. However, U.S. mines employing this technique have shown that hydraulic fracturing can be controlled and should not adversely affect future mining. Finally, due to the need to fracture the coal seam in advance of mining, vertical wells require a more advanced technological expertise than do some of the other methods.

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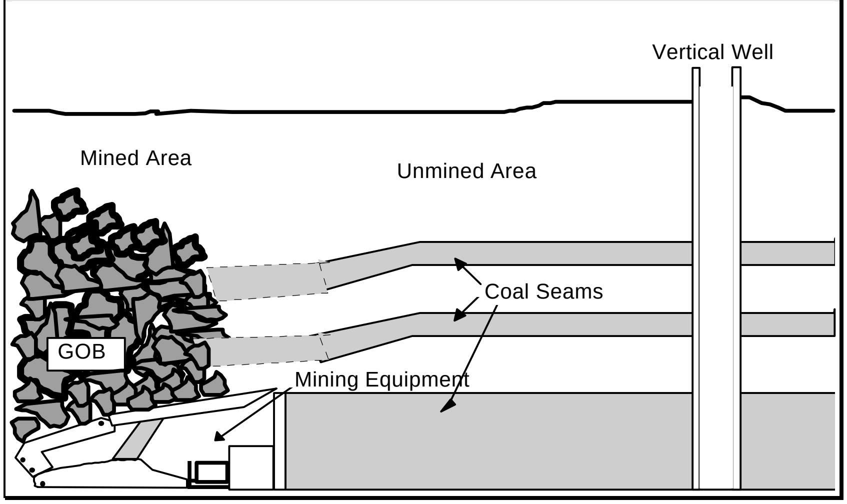
5 The term "stand-alone" refers to coalbed methane operations that produce methane from coal seams that are not being mined. In most cases, these operations recover methane from deep and gassy coal seams that are not likely to be mined in the foreseeable future.

Exhibit 4-1: Schematic of a Vertical Degasification Well



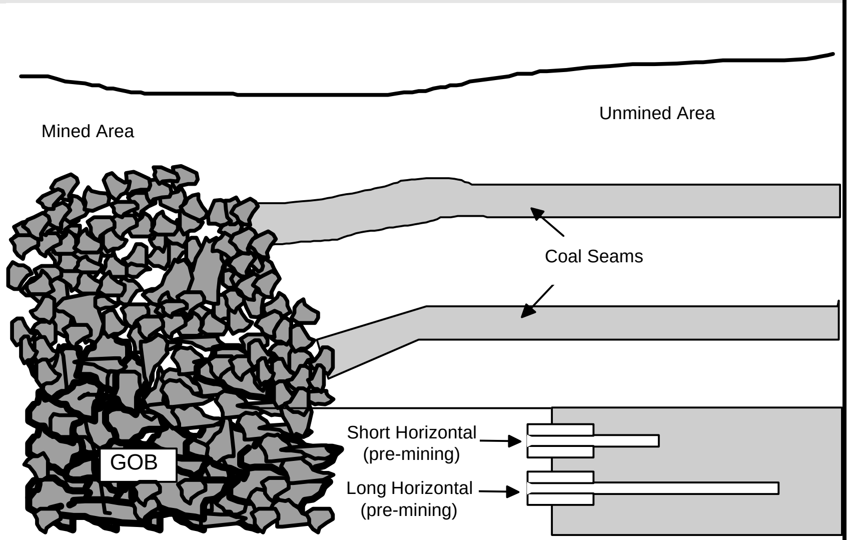
Short Horizontal Boreholes

Description: Short horizontal boreholes are drilled from inside the mine (as opposed to from the surface) and they drain methane from the unmined areas of the coal seam or blocked out longwall panels shortly before mining. These boreholes are typically 10 to 300 meters in length. Several hundred boreholes may be drilled within a single mine and connected to an in-mine vacuum piping system, which transports the methane out of the mine and to the surface. Most often, horizontal boreholes have been used for short-term methane control during mining.

Because methane drainage only occurs from the coal seam being mined (and not from the surrounding strata), the recovery efficiency of this technique is low -- approximately 10 to 18 percent of methane that would otherwise be emitted is captured (USEPA 1990). However, this methane is typically 95 percent pure methane. (USEPA 1993a). Exhibit 4-2 presents a schematic of a short horizontal borehole.

Suitability/Technical Feasibility: Horizontal boreholes recover nearly pure methane and therefore can be used when high quality gas is desired. They require access to advanced drilling technology and are most successful when the coal is relatively permeable. As the recovery efficiency is quite low, however, other recovery methods may be preferred for economic reasons. Because they drain methane prior to mining, horizontal boreholes can be used in conjunction with all mining methods. They are difficult to implement, however, when coal seams are steeply inclined.

Exhibit 4-2: Schematic of Short- and Longhole-Horizontal Boreholes



Longhole Horizontal Boreholes

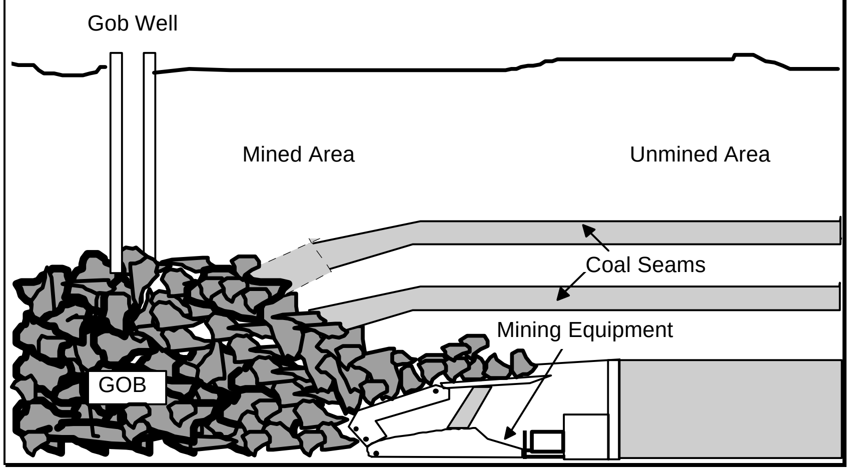
Description: Like horizontal boreholes, longhole horizontal boreholes are drilled from inside the mine in advance of mining. They are greater than 300 meters in length and are drilled in unmined seams using directional drilling techniques. Nearly pure methane is recovered and the recovery efficiency is about 50 percent. Exhibit 4-2 presents a schematic of a longhole horizontal borehole.

Suitability/Technical Feasibility: Longhole horizontal boreholes recover nearly pure methane and therefore can be used when high quality gas is desired. They are most suitable for mines that have access to advanced drilling technology. They are particularly effective for gassy, low permeability coal seams that require long diffusion periods. As they drain methane prior to mining, longhole horizontal boreholes can be used in conjunction with all mining methods.

Gob Wells

Description: The fractured zone caused by the collapse of the strata surrounding the coal seam in longwall and room-and-pillar mining is known as a "gob" area. Following collapse of this area, a significant amount of methane is released. Gob wells are drilled from the surface to a point 2 to 15 meters above the target seam just prior to mining. In the U.S., they range from 300 to 600 meters in length, depending on the depth of the mine. Although the spacing of gob wells varies at each mine, generally two to six gob wells are used per longwall panel. As mining advances under the well, the methane-charged coal and strata around the well fractures. The methane emitted from these fractured strata flows into the gob well and up to the surface. A vacuum

Exhibit 4-3: Schematic of a Gob Well



is pulled on the well in most cases to prevent methane from entering mine working areas. Exhibit 4-3 presents a schematic of a gob well.

Initially, gob wells produce nearly pure methane. Over time, however, additional amounts of mine air can flow into the gob area and dilute the methane, reducing purity to between 30 and 80 percent. In some cases, it is possible to maintain nearly pure methane production from gob wells through careful monitoring and management. For example, the Jim Walter Resources mines in Alabama have been able to maintain nearly pure methane production from their gob wells.

Methane production rates from gob wells can be very high, especially immediately following the fracturing of the strata as mining advances under the well. Jim Walter Resources reports that their gob wells initially produce at rates in excess of 56,000 cubic meters per day. Over time, production rates typically decline until a relatively stable rate is achieved, typically in the range of 2,800 cubic meters per day (USEPA 1990). Depending on the number and spacing of the wells, gob wells can recover an estimated 30 to over 50 percent of the methane that would otherwise be emitted from the coal mine (USEPA 1990).

Suitability/Technical Feasibility: Gob wells can be used to produce medium quality gas, and if the initial quality is maintained, can produce high quality gas as well. Such wells are suitable for all types of mining methods where gobs are created, and for mines where wells may be drilled from the surface. Gob wells can be effectively used in both low and high permeability seams as the coal seam is fractured by the mining activity. This fracturing and breaking of the seam and strata releases large amounts of methane, even in low permeability areas. As with the vertical wells, it is necessary to consider the surface conditions when assessing the technical feasibility of using gob wells. If it is heavily populated or if the terrain from the surface to the target seam is harsh, it may be difficult to drill a well. In addition, gob wells may be difficult to place in mines where multiple seams have been mined. However, the technology required to drill a gob well is not as complex as that required to drill a vertical

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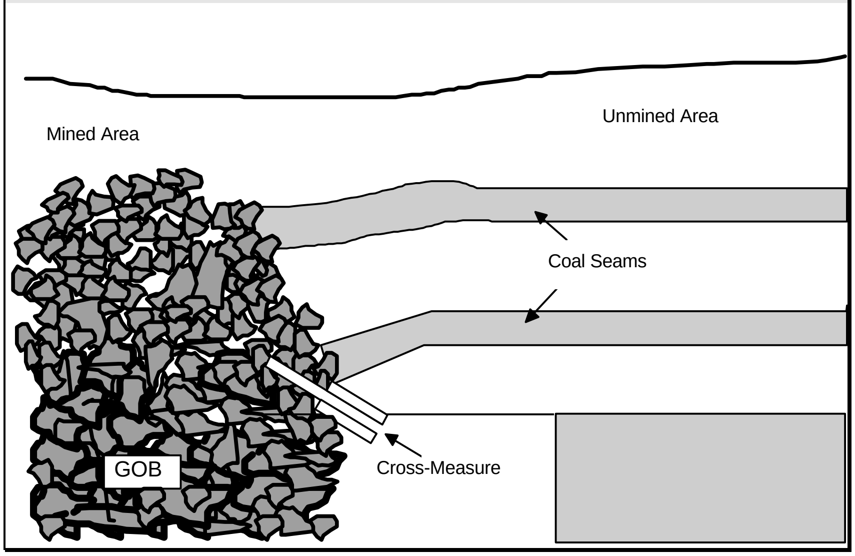
Exhibit 4-4: Schematic of a Cross Measure Borehole



well. This is because hydraulic fracturing of the coal seam in advance of mining is not required for gob wells.

Cross-Measure Boreholes

Description: While horizontal boreholes recover methane from the target coal seam, cross-measure boreholes degasify the overlying and underlying rock strata. These boreholes are drilled from within the mine and generally produce medium quality gas (similar to the gas produced by gob wells) depending on site specific conditions. In the U.S., these boreholes typically range from 45 to 90 meters in length, are developed to depths ranging from 45 to 85 meters, and are installed 60 to 90 meters apart. Cross-measure boreholes recover up to 20 percent of methane that would otherwise be emitted. A schematic of a cross measure borehole is presented in Exhibit 4-4.

Suitability/Technical Feasibility: Methane recovered from cross-measure boreholes can be used when medium quality gas is sufficient. This method requires only a low level of technology, and can be used effectively in both low and high permeability seams. However, as recovery efficiency is quite low, alternative production techniques may be preferred for economic reasons.

Exhibit 4-5 summarizes the characteristics of the gas production technologies. As shown in the exhibit, vertical wells have the highest recovery efficiency (up to 70 percent) and can typically recover nearly pure methane.

4.2.2 Criteria for Selecting a Gas Production Method

For purposes of conducting the preliminary assessment, select one or two gas production options for evaluation. As mentioned above, when the project moves beyond the preliminary assessment a detailed gas production assessment will be conducted to select the preferred gas production method. Therefore, this selection is strictly for preliminary evaluation purposes. The following criteria are recommended.

- **Existing Degasification System.** If the mine already has a degasification system that is optimized to promote efficient mine production, then this existing system should be the primary candidate for consideration.

- **Coal Mining and Site Conditions.** Select the option that is consistent with existing coal production conditions. If the terrain and land use activity permit it, vertical wells and gob wells would likely be the two options most worthy of consideration. Both methods have high recovery efficiencies. Additionally, both vertical and gob wells do not require advanced in-mine drilling technology. Vertical wells should not be considered, however, when the coal has low permeability, or when degasification cannot take place in advance of mining. Gob wells cannot be used if the mining technique does not produce gob areas.

- **Gas Quality Requirements.** If nearly pure methane is required for gas use, gob wells may be less preferred. In this case, vertical wells and in-mine drilling options should be examined. If longhole drilling can be conducted, its higher recovery rate may make it attractive.

The selection of the gas production method may need to be revisited when the gas use options are examined. As discussed below, the perferred gas use may impose constraints on gas quality and quantity.

4.2.3 Estimate Recovery Potential

Once the preferred gas production methods are selected, the amount of gas that can be produced by each is estimated. If a mine has an existing degasification system, gas quantity and quality are simply estimated based on the current performance of the system. This information was collected as part of the general site information (see above). If the mine's engineering staff expects that enhanced production is possible as part of a recovery project, increased rates of gas production can be considered.

Exhibit 4-5: Summary of Methods for Recovering Methane from Underground Mining				
Method/Description	**Methane Quality**	**Recovery Efficiency[a]**	**Applicability**	**Possible Utilization Options**
Vertical Wells				
Drilled from the surface to the coal seam several years in advance of mining.	Recovers nearly pure methane.	up to 70%	May be used with all mine types where the terrain permits drilling from the surface; not suited for low-permeability seams.	All use options; preferred method for use options requiring nearly pure methane.
Gob Wells				
Drilled from the surface to a few meters above the coal seam just prior to mining.	Recovers medium quality gas: methane mixed with mine air. Quality can vary over time.	up to 50%	Can be used with all mining methods that create gob areas; can be used in low and high permeability seams; the terrain must allow for surface drilling.	Some mines may be able to recover nearly pure methane from gob wells. In such cases, the use options would be the same as for vertical wells. When recovery of high quality methane is not feasible, gas use would be limited to power generation and other options that can use medium quality gas.
Short Horizontal Boreholes				
Drilled from inside the mine to degasify the coal seam.	Recovers nearly pure methane.	up to 20%	Can be used with all mining methods; may not be suited for low-permeability or steeply inclined seams; best when used in conjunction with other degasification techniques.	Same as vertical wells, though recovery efficiency is low, so may need to be used in conjunction with another method.
Longhole Horizontal				
Drilled from inside the mine in advance of mining.	Recovers nearly pure methane.	up to 50%	Can be used with all mining methods; effective in low and high permeability seams.	Same as for vertical wells.
Cross-measure Boreholes:				
Drilled from inside the mine to degasify surrounding rock strata.	Recovers medium quality gas: methane mixed with mine air. Quality can vary over time.	up to 20%	Can be used with all mining methods that create gob areas; can be used in low and high permeability seams; best when used in conjunction with other degasification methods.	Gas use options are limited to power generation and other options that can use medium quality gas. May need to be used in conjunction with another method as recovery efficiency is low.

Sources: USEPA 1993a,b.

[a] Percent of methane recovered that would otherwise be emitted.

If there is no degasification system in place, the amount of methane that may be recovered from a new system can be estimated by multiplying methane emissions from the ventilation system by the recovery efficiency listed in Exhibit 4-5. The emissions from the ventilation system were etimated as part of the general site information. For example, if a mine emits 600 million cubic meters of methane annually from its ventilation system, gob wells, which recover up to fifty percent of the methane emitted, should be expected to produce up to 300 million cubic meters of methane annually. Alternatively, vertical wells would produce up to 420 million cubic meters (70 percent of emissions). Actual gas production will vary with site conditions and system operation.

Exhibit 4-5 also lists the quality of the gas likely to be produced by each of the methods. For example, the gob wells would likley produce medium quality gas, whereas vertical wells can produce high quality gas (nearly pure methane).

4.3 Identify Potential Uses for Recovered Methane

Methane recovered from coal mines can be used in a variety of applications. In general, any equipment that can use natural gas as a fuel source can be operated using coal mine methane. Additionally, coal mine methane can substitue for oil and coal in many applications. The preferred methane use option at each mine will depend on a variety of factors including the quantity and quality of the methane recovered and local energy needs. First, the main use options are described. Then, a process for selecting which options to consider in the preliminary assessment is presented.

4.3.1 Options for Using Coal Mine Methane

The easiest and often least costly option for using coal mine methane is to use the gas to fuel equipment at the mine. Both high quality and medium quality gas (methane mixed with air) can be used in a variety of on-site applications, including:

- **Coal Preparation Plants.** Coal preparation involves cleaning and drying the coal. Coal mine methane can fuel the thermal dryers that heat the air used to remove surface moisture from the coal. Although coal is typically used to fuel the coal drying process, the equipment can be converted to use gas. The coal that would have been used to fuel the thermal dryer can then be made available for sale.

- **Mine Boilers.** Recovered methane can be used in boilers for space and water heating. For example, some mines may have bath houses or dormitories that require hot water. Also, in some regions, it may be necessary to heat the ventilation air in the winter before it is pumped into the mine. In the Donetsk Basin in Ukraine, a small amount of coal mine methane is used in mine boilers.

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- **Cooking.** Mines that have kitchens can use the recovered methane for cooking purposes.

- **Water Treatment.** Coal mine methane can be used to fuel the process of treating water recovered during mining. A demonstration project is underway at the Morcinek mine in Poland that involves using the methane for this purpose. Once the water is treated, it will be used for agricultural purposes.

The advantages of using coal mine methane in these uses on-site include: (1) the gas does not need to be tranported over a long distance; (2) gas quality need only be maintained at the level required for the on-site equipment; and (3) purchase agreements or other sales arrangements do not need to be negotiated. Additionally, experience indicates that only minimal conversion of existing equipment is needed to convert from other fuels to coal mine methane.

An alternative to using the gas on site in heating, drying, and related applications is to use the gas to produce electricity. The electricity can be used on site or, as discussed below, sold off site.

Gas turbines, internal combustion (IC) engines, and boiler/steam turbines can each be adapted to generate electricity from coal mine methane. However, the most likely choice of a prime mover for a coal mine methane project would be a gas turbine. Boiler/steam turbines are generally not cost effective in the size range typically encountered with coal mine methane projects (e.g., below 30 MW), and IC engines are more sensitive to variations in fuel heating values than are gas turbines. Furthermore, gas turbines are smaller and lighter than IC engines and historically have had lower operation and maintenance costs. A methane/air mixture with a heating value of at least 13,000 kJ/m^3 is a suitable fuel for each of the prime mover options. All of the gas production methods discussed above, including gob wells, can produce gas of this quality, which is the equivalent of about 35 percent methane in air.

Generating electricity is an attractive option because most coal mines have significant electricity loads. Electricity is required to run nearly every piece of equipment including mining machines, conveyor belts, desalination plants, coal preparation plants, and ventilation fans. Ventilation systems in particular require large amounts of electricity because they run 24 hours a day, every day of the year. In the U.S., about 24 kWh of electricity are required per ton of coal extracted from the mine and 6 kWh are required per ton of coal processed in the coal preparation plant. Several small power generation projects are operating at coal mines in China, the Czech Republic, Poland, Australia, England, and Germany (Sturgill 1991).

The viability of producing electricity from coal mine methane may be limited, however, if the amount and consistency of the gas produced varies considerably from day to day. For example, some gob wells are not predictable with respect to length of production, methane concentration, and rate of flow. Equipment to blend the air and methane may be needed to ensure that variations in heat content remain within an acceptable range for the prime mover. A supplemental gas source may be desired, and a reliable back-up power source may be required to guard against potential gas production or equipment problems.

In the event that electricity generating potential exceeds on-site needs, the excess electricity can be sold to the local power grid. Because on-site electricity requirements vary by time of day and day of week depending on mining activity, the availability of excess electricity for sale may be intermittent. Arrangements will be required with the local power authority to sell the electricity into the system.

If the opportunity to use gas on site is similar to the level of estimated gas production, direct on-site use will likely be the preferred use option for subsequent evaluation.

If on-site use and electricity generation are not feasible, the gas can be sold to customers off site. The most attractive off-site sales option is to a gas transmission or distribution system in close proximity to the mine. To be viable, the coal mine methane must be processed to meet the specifications of the pipeline receiving the gas. For most coal mine methane, the principal contaminants are water and sand, which can be easily removed. After being processed, compressors are used to pressurize the gas to the appropriate pressure for injection into the pipeline.

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In most regions, conventional gas pipelines carry high quality gas, which would be the equivalent of nearly pure methane. Therefore, to sell gas to this type of pipeline, the coal mine methane recovery system would need to be designed and operated in a manner to produce this high quality gas. If lower quality gas were produced it would need to be enriched. However, enrichment is often too costly to be economically viable.

In some areas, medium quality gas is distributed through pipelines. These pipelines are typically separate from the pipelines that distribute conventional gas, depending on the local pipeline quality standards. Because coke oven gas and methane recovered from coal mines can have similar heating values, in some cases medium quality coal mine methane can be transported via existing coke oven gas pipelines. If a medium quality gas pipeline is available, the constraints on gas quality produced at the mine are reduced.

To be economical, the pipeline receiving the coal mine methane must be in reasonably close proximity to the mine. Building and operating a pipeline solely to carry the coal mine methane can be costly, and consequently the transport distance should be minimized. If no suitable pipelines are in proximity to the mine, alternative gas uses near the mine must be identified.

As described above, coal mine methane can be used to fuel nearly all types of equipment that use natural gas. Additionally, the gas can be substituted for oil or coal in many applications. Therefore, industrial, commercial, institutional, or household energy requirements near the mine can be met using coal mine methane. The principal limitation to using the gas in these sectors is the cost of transporting the gas to its point of use.

Coal mine methane can also be used as a feedstock in chemical production. Methane is a feedstock in several important chemical processes, such as the

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synthesis of ammonia, methanol, and acetic acid. Using high quality gas as a chemical feedstock may be attractive for gassy mines in countries with substantial domestic petrochemical markets. Alternatively, high quality methane from several small mines could be collected at a central location in order to meet the volume required by the chemical plant. Currently, in Poland's Upper Silesian Basin, a small amount of coal mine methane is being used as feedstock for a chemical plant.

Exhibit 4-6 summarizes the characteristics of these gas use options.

4.3.2 Select Use Options for Further Analysis

For purposes of conducting the preliminary assessment, each of the major gas use options should be examined. When the project moves beyond the preliminary assessment a detailed gas use assessment will be conducted to select the preferred option..The following options are recommended.

- **On-site Use.** Compare the on-site energy requirements (estimated as part of the general site information) to the amount of gas anticipated to be produced. If the opportunity to use gas on site is similar to the level of estimated gas production, direct on-site use will likely be the preferred use option for subsequent evaluation. If the potential for direct on-site gas use is much less than the anticipated gas production, an alternative use option should be identified.

  It is recommended that the estimated gas production be compared to on-site gas needs on an *energy* basis. The energy content of the gas is estimated from its methane content. Pure methane has a heating value of approximately 37 million Joules per cubic meter (MJ/m^3) at standard temperature and pressure. Gas that is 50 percent methane, for example, will have a heating value of 50 percent that amount, or about 18.5 MJ/m^3.

- **Electricity Generation.** If on-site gas use is not feasible, or if the amount of gas produced greatly exceeds on-site needs, electricity production may be an attractive option. Compare the on-site electricity requirements (estimated as part of the general site information) to the amount of electricity that can be generated from the gas anticipated to be produced. The amount of electricity that can be generated from the methane may be estimated using the following formula:

Electricity Generated (kWh) =
[Gas Recovered (m^3) x Heating Value of the Gas (MJ/m^3)] /
Generator Heat Rate (MJ/kWh)

The generator heat rate varies somewhat among generation technologies, but can be assumed to be about 11.6 MJ/kWh, which is appropriate for combustion turbines.

Using these values, an example calculation of potential electricity production is as follows. Assume that 200,000 m^3/day of gas is produced that is 50 percent methane. The heating value of the gas is 18.5 MJ/m^3. The total electricity that can be produced is therefore: 200,000 m^3/day x 18.5 MJ/m^3 / 11.6 MJ/kWh = 318,965 kWh/day. The generator capacity is this value divided by 24 hours, or about 13,300 kW, or 13.3 MW.

If on-site requirements are much less than potential electricity production, then off-site electricity sales may be required to make electricity production economically feasible. Such off-site sales may be less attractive than off-site gas sales, discussed next. Also, a combined gas use/electricity production approach can be examined in which a portion of the gas is used directly or sold, and a portion is used to produce electricity.

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- **Off-site Gas Sales.** Generally, off-site gas sales should be considered when the above on-site use options are not attractive. Some site-specific conditions, however, may make off-site gas sales the most attractive gas use option. In particular, if an off-site customer in close proximity to the mine can use the gas without costly gas enrichment or processing, this option will be attractive. Off-site gas sales can also be examined in combination with on-site use.

  To assess the off-site gas sales option, a brief survey of potential gas use in the area around the mine is warranted. Identify the location of existing gas pipelines as well as potential industrial, commercial, or residential

Exhibit 4-6: Summary of Coal Mine Methane Use Options

Option	Min. Quality Necessary	Applicability
Direct use on-site	Medium	Suitable for most mines, can be used to fuel coal preparation plants, heat space and water, and treat water
On-site electricity generation	Medium	Most suitable for mines with large electricity needs, especially those which already produce their own electricity.
Sale into an Existing Gas Distribution or Transmission System	High Medium	Most suitable for mines using premining degasification and located near existing high quality gas pipelines. Most suitable for mines located near medium quality pipelines.
Sale directly to an industrial, residential, or commercial user	Medium	Suitable for mines located near industrial or commercial facilities, or near residential areas.
Chemical Feedstock	High	Most suitable for very gassy mines using degasification techniques that recover nearly pure methane and are located near chemical plants.

customers. The distance to these potential gas customers should be determined because distance is one of the key driving factors of the cost of supplying gas to them.

The choice between off-site electricity sales and off-site gas sales will depend on site-specific conditions. The advantage of off-site electricity sales is that the gas quality need only be maintained at the level required for the on-site electric power generator system. If only medium quality gas is produced, this advantage can be important. The disadvantages are that an electric power grid must be near by, and a power sales agreement must be negotiated. The price at which the electricity can be sold will determine the economic feasibility of this approach.

The advantage of off-site gas sales is that if a customer is near by, the cost of producing and transporting the gas can be quite low. However, if the gas customer needs high quality gas and only medium quality gas is produced by the mine, the enrichment cost may make the project uneconomical. Given the site-specific nature of the choice between these off-site sales options, it is recommended that if off-site sales appear to be required, that both electricity sales and gas sales be evaluated as part of the preliminary assessment. If either or both of the options appears promising based on the preliminary assessment results, they can both be evaluated in subsequent site-specific studies.

to be required, and gas sales as part of the t.

4.4 Assess Economic Feasibility

The purpose of evaluating the economic feasibility of the project options is to ensure that the project meets a target level of cost effectiveness. There may be several goals of a gas recovery project: profitability; energy supply; or emissions reductions (or a combination of the three). If only profitable projects are to be considered, then revenues must exceed costs. If a net cost can be incurred to reduce methane emissions and meet other environmental goals, the threshold may be set in terms of cost per ton of emissions (e.g., $2/ton of CO_2 equivalent emissions avoided). Alternatively, if the goal of the project is to meet national or local energy demands, the threshold may be set in terms of cost per unit of energy supplied (e.g., $0.07/kWh). Regardless of the objective, the capital and operating costs of the project must be estimated and balanced against the estimated revenues and other benefits.

Information from all parties potentially involved in the gas recovery project should be considered at this stage of the assessment, including potential energy users, the facility owner or operator, and equipment suppliers. If energy production or prices are regulated, information from the appropriate ministries should be obtained as well to help assess potential costs and revenues. First, the cost analysis is presented, followed by the benefits analysis, which includes a discussion of how to compare the costs and benefits to assess economic feasibility.

It should be noted that labor and equipment costs can vary significantly among countries and regions within countries. The dollar cost estimates presented in this section represent U.S. prices. Potential additional transportation costs or tariffs are not reflected. Additionally, operating and maintenance costs include labor charges, which can vary significantly. Adjustments to local currencies and cost conditions should be attempted whenever possible.

4.4.1 Costs Analysis

Costs of recovering and using coal mine methane are highly dependent on the amount of gas involved, the specific technologies used, and site-specific factors. The cost estimates developed as part of this preliminary assessment will be compared to revenue (or cost savings) estimates to make a rough assessment of the economic viability of the project alternatives. If one or more alternative project configurations looks promising, more detailed cost estimates will be conducted as part of subsequent more detailed studies. Therefore, the cost estimates prepared here are solely for preliminary assessment purposes.

As with all project evaluations, both capital costs and annual operating costs will be considered. To estimate these costs, a listing of each piece of equipment required must first be prepared. Exhibit 4-7 lists the major pieces of equipment required for the project configurations that may be considered. As shown in the exhibit, three main systems are required for all projects: the degasification system; the gas collection and gathering system; and the gas processing system. If the mine already has one or more of these systems, and does not plan modifications for this project, then the costs for the existing components may be excluded. For example, some mines will already have a degasification system in place and operating.

The pieces of equipment required for on-site gas use, electricity production, and off-site gas use are also listed. Gas enrichment equipment is listed for off-site gas sales, but will only be required when the gas quality must be enhanced.

In addition to the costs for these pieces of equipment, additional costs that must be considered include:

- **System Design**. The costs of the system design and construction management may be on the order of 15 percent of the total capital cost for the project.
- **Legal**. Siting, permitting, and land use requirements must be met. These costs, which can be substantial, include the costs of obtaining necessary permits and licenses, and potentially installing pollution control equipment.
- **Financing**. Financing costs include the cost for obtaining financing as well as interest payments. These costs depend on the financing method and project specific factors.

- **Rights-of-Way**. Costs of obtaining rights-of-way to run pipelines or power lines must be considered and may be substantial.

Experience in the U.S. indicates that these additional non-equipment costs can be substantial. However, due to their site-specific nature, general cost factors cannot be provided to estimate each type of cost.

Given this approach, the equipment capital and operating costs are the primary costs estimated in the preliminary assessment. Exhibit 4-8 provides cost coefficients for the main pieces of equipment required. It must be noted, that costs will vary significantly among projects and among countries. The costs presented here are based on U.S. experiences and technologies and are presented in U.S. dollars.

To estimate project costs, perform the following:

1. Define the project configuration in terms of the gas production system and gas use option.

2. Identify the pieces of equipment required for the project configuration. Do not include equipment that the mine already has in place (e.g., if the mine has an existing degasification system).

3. Select a project lifetime, for example between 10 and 20 years. The sensitivity of the costs and benefits to the project lifetime can be examined.

4. Estimate the average annual amount of coal mined (in tons) during the life of the project.

5. Estimate the average daily total gas production during the life of the project (cubic meters per day).

6. If off-site gas sales are anticipated, estimate the distance to the point of sale (in meters).

7. Using the cost coefficients in Exhibit 4-8, estimate the capital and operating costs for the system components required.

8. Summarize the estimated costs to show one-time capital costs in year 1, and recurring capital costs and operation and maintenance costs in each year of the project. Add a percentage of the one-time capital costs (e.g., 20 percent) to account for system design and other costs.

For example, to estimate the costs for gob wells, the annual average coal production (tons per year) is used to estimate the number of wells required per year. The cost per well ($25,000 to $50,000) is multiplied by the number of wells required per year to estimate the annually recurring cost of installing these wells.

If vertical wells are planned instead of gob wells, the number of wells required is estimated using the total planned coal production over the life of the project. The cost per well is then used to estimate the total one-time capital costs for these wells, which is incurred at the start of the project. Unlike the other gas recovery wells which are drilled throughout the life of the project as the coal is mined, all the vertical wells are typically drilled at the beginning of the project.
The other cost components are estimated in a similar manner. Compressor

Exhibit 4-7: Summary of Major Pieces of Equipment Required

System Component	Purpose	Equipment Required
Degasification System (Required for all options)	Withdraw the gas from the coal and and/or surrounding strata.	• Withdrawal wells (vertical; gob; or in-mine) • Water treatment and disposal equipment (required only for vertical wells)
Gas Collection and Gathering System (Required for all options)	Collect the gas from the withdrawal wells to a central point for use or sale.	• Wellhead exhauster/blower • Wellhead and satellite compressors to move the gas to the central collection point • Gathering line
Gas Processing System (Required for all options)	Remove water and impurities from the gas.	• Wellhead separator • Dehydrator
On-site Gas Use System	Convert on-site equipment for direct gas use.	• Preparation plant conversion equipment
Electric Power Generation System	Produce electricity from the recovered coal mine methane.	• Gas turbine • Utility interconnect
Off-site Gas Sales System	Prepare and transport gas to an off-site customer.	• Gas enrichment equipment • Sales compressor • Sales meter and gas analyzer • Transmission pipeline

requirements, for example, are estimated based on the horsepower (HP) required per million cubic meters of gas production per day and the cost per HP. Gathering line costs are estimated based on distance estimates.

It should be emphasized that the cost ranges are representative of conditions found in the U.S. For an initial evaluation, values in the middle of the ranges presented may be used. However, if possible, site-specific conditions should be considered in selecting values from the ranges. Particularly important site-specific factors may include well depths, water treatment requirements (vertical wells only), gathering line distances, gas enrichment requirements, and equipment conversion costs.

4.4.2 Benefits Analysis

The goals of a gas recovery project may be several - profits from revenues or cost savings, energy supply, and/or emissions reductions. The benefits of gas recovery will be evaluated in terms of these project goals. The benefits analyzed in this section include: revenues generated from the utilization of the gas; energy supplied; and methane emissions avoided.

Revenues/Savings

The revenue from the project is estimated as the amount of energy (gas or electricity) produced multiplied by its price. If the energy is used to offset on-site energy costs (e.g., coal, natural gas, oil, electricity), the value of this offset is counted as revenue to the facility. If the energy is sold, the revenue is the quantity sold times the price. Tax credits or other government incentives may supplement these revenues.

The value of the energy will vary according to local energy prices. These prices may be negotiated with individual suppliers or customers, or may be set by national or state policy. Important factors affecting energy prices include the price of competing sources of energy, supply reliability, energy subsidies and taxes, and the quantity purchased.

The revenue or savings resulting from each project must be estimated using local information obtained from electricity/energy authorities. A brief description of how these values may be estimated is as follows.

- **On-Site Use.** The savings associated with the use of coal mine methane on-site are estimated using the cost of the fuel displaced, or the value of the coal that otherwise would have been used. These values should be estimated from on-site energy consumption records.

Exhibit 4-8: Gas Recovery and Utilization Cost Factors			
System Component/ Equipment Required	**Number or Size of Units Needed**	**Cost Per Unit**	**Comments**
Degasification System (Cost to drill, install, and complete wells and boreholes)			
Gob Wells	1 well for every 200,000 to 500,000 tons of coal mined each year. This estimate was derived by assuming that approximately 1 million tons would be mined per longwall panel and that from 2 to 5 wells would be drilled per panel. More accurate data can be substituted if more detailed information is available regarding longwall panel sizes and well spacing.	$25,000 to $50,000 per well. This estimate assumes that drilling costs are roughly $90 to $140 per meter of well depth.	Cost for drilling gob wells is an annual capital cost (incurred each year). The rate of advance of mining dictates when gob wells are drilled.
Pre-mining Vertical Wells	1 well for every 250,000 to 1,000,000 tons of coal mined over the life of the project. This estimate was developed assuming well spacing of from 20 to 80 acres.	$100,000 to $500,000 per well	Cost per well includes cost of hydraulic fracturing of coal seam to stimulate gas production. Cost for drilling vertical wells is a one-time capital cost. Total number of wells required over project lifetime may be drilled during first year so that individual wells can produce gas for as long as possible before being mined through. However, if up-front capital is limited, well drilling can be spread out throughout the life of the project.
Longhole Horizontal Boreholes	1 longhole borehole drilled each year per 1 million tons of coal (approximately 1 borehole per longwall panel). Typical length of longhole borehole may be 1200 meters.	$60,000 to $100,000 per 1 million tons of coal (approximately 1 longwall panel). Estimate assumes borehole length of approximately 1200 meters and drilling cost of $50 to $80 per meter.	Drilling longhole horizontal boreholes is an annual capital cost (incurred each year). Rate of drilling longhole horizontal boreholes determined by rate of advance of mining.
Shorthole Horizontal Boreholes	4,500 meters of borehole drilled each year per 1 million tons of coal (approximately 1 longwall panel). Shorthole horizontal boreholes are drilled perpendicular to the longwall panel. This estimate assumes 30 boreholes are drilled into the longwall panel and that each borehole is 150 meters long. Given that a typical longwall panel is about 1800 meters long, boreholes would be spaced every 60 meters.	$30 to $50 per meter or $135,000 to $225,000 per 1 million tons of coal (approximately 1 longwall panel).	Drilling shorthole horizontal boreholes is an annual capital cost (incurred each year). Rate of drilling shorthole horizontal boreholes is determined by the rate of advance of mining.
Capital Cost for Water Disposal Costs for Vertical Pre-Mining Degasification Wells	1 disposal system needed per project.	Range: $100,000 to $2,800,000. Capital costs vary substantially depending on local environmental conditions and disposal requirements. The low end of the range of capital costs is for a simple aeration system with discharge to surface water, which may be used for relatively low volumes in some areas. The higher end cost represents deep-well injection, which may be required in some areas.	Cost for a water disposal system are a one-time capital cost. Note that a coal seam is dewatered as part of the normal mining process. Accordingly, the same water produced from pre-mining degasification wells would otherwise have been removed as part of the normal mining process. Therefore, unless there is significant recharging of the water table during the time between well drilling and mining, costs for water disposal should not be considered as an incremental cost associated with a degasification project. However, costs would be incurred at the time of well drilling, as opposed to at the time of mining.

Exhibit 4-8: Gas Recovery and Utilization Cost Factors			
System Component/ Equipment Required	**Number or Size of Units Needed**	**Cost Per Unit**	**Comments**
Operating Cost for Water Disposal for Vertical Pre-Mining Degasification Wells	Water production might range from 17 to 70 barrels per thousand cubic meters of gas produced. Water production will be highly site specific. Water production is significantly higher during the first years of production.	Annual operating costs for water disposal range from $0.02/barrel to nearly $2/barrel. The lower operating cost is typical for a simplified aeration system, while the higher operating cost is typical for a system requiring transport to an off-site disposal location.	
Gas Collection and Gathering System Costs			
Wellhead exhauster/blowers for gob wells	1 blower per maximum number of gob wells drilled in a year. Number of gob wells drilled annually estimated above based on annual coal production.	$20,000 per gob well.	If a mine already uses gob wells, the mine will already have an exhauster/blower at the wellhead.
Wellhead and satellite compressors for all degasification systems.	14,000 to 25,000 HP per million cubic meters per day of total gas production (maximum projected daily gas production).	$650/HP	Horsepower includes total horsepower for wellhead compressors and satellite compressors.
Gathering Lines from Satellite Compressors to Central Collection Point	6,000 to 25,000 meters of gathering line, depending on overall size of project and whether there is more than one gob field.	Average: $26/meter. Ranges from $13/meter to $46/meter, depending on whether line is buried, material used (HPDE or steel), and size of line. Most projects will require a combination of less expensive and more expensive piping material.	One-time capital cost. Highly dependent on site-specific conditins.
Gathering Lines for Gob Well System: Lines from the wells to the Satellite Compressor	Movable Lines from Gob Wells to Satellite Compressors: 2,500 meters per 1 million tons of coal mined annually (assuming a typical longwall panel may contain 1 million tons of coal).	Average: $26/meter. Ranges from $13/meter to $46/meter, depending on whether line is buried, material used (HPDE or steel), and size of line. Most projects will require a combination of less expensive and more expensive piping material.	Lines running from gob wells to satellite compressor can be moved from year to year as some gob wells stop producing and others come on-line. (A typical gob well might produce gas for a few months to a few years, though typically will produce gas for less than one year). Since gathering lines can be moved, costs for purchasing gathering lines is a one-time capital cost. However, the cost for moving and installing gathering lines is an annual cost. Roughly half of the costs shown are for recurring (i.e., annual) installation costs.
Gathering Lines for Pre-Mining Vertical Well Degasification System: Lines from the wells to the Satellite Compressor	Lines from Wells to Satellite Compressors: 3,000 meters per well.	Average: $26/meter. Ranges from $13/meter to $46/meter, depending on whether line is buried, material used (HPDE or steel), and size of line. Most projects will require a combination of less expensive and more expensive piping material.	Cost for purchasing and installing gathering lines is a one-time capital cost. Lines running from vertical wells to satellite compressors would not be moved on a regular basis, since vertical wells will likely produce gas for many years.
Gathering Lines for In-mine Borehole Systems: Lines from the wells to the Satellite Compressor	Underground Lines: 2,500 meters per 1 million tons of coal mined (assuming a typical longwall panel may contain 1 million tons of coal).	$20/meter	Underground lines can be moved from one borehole to another. Cost for purchasing line would be a one-time capital cost, while cost for moving and re-installing lines would be an annual cost. Roughly half of the costs shown are for recurring (i.e., annual) installation costs.

Exhibit 4-8: Gas Recovery and Utilization Cost Factors			
System Component/ Equipment Required	**Number or Size of Units Needed**	**Cost Per Unit**	**Comments**
Gas Processing System			
Wellhead Separators	For surface wells: 1 separator for each well (1 separator for maximum number of wells drilled per year). For in-mine boreholes: 1 separator is needed for every four longwall panels drilled (every 4 million tons of coal drilled each year). Since separators can be moved, total number of separators needed would be based on maximum number of longwall panels drilled each year.	$2,000 per separator	Wellhead separators are a one-time capital cost. Because vertical wells produce simultaneously, one separator is required for each well drilled. Because gob wells and in-mine boreholes produce sequentially, one separator is needed for the maximum number of wells drilled in a single year. For long project lifetimes (more than 15 years), separators may need to be replaced once.
Glycol Dehydrator Capital Cost	1 Dehydrator per project.	Initial capital cost: $30,000 to $50,000.	Dehydrator costs are a one-time capital cost. For long project lifetimes (more than 15 years), the dehydrator may need to be replaced once.
Dehydration Operating Cost		Annual operating cost: $3,000 per year	
On-Site Gas Use System			
Preparation plant conversion equipment		$250,000 to $750,00	Initial capital cost (depends on site-specific equipment requirements).
Electric Power Generation System			
Gas Turbine Capital Cost	Installed capacity of the turbine in kiloWatts (kW)	$1,100/kW installed capacity.	Initial capital cost. Capacity estimated based on gas production and engine-generator heat rate (see text).
Gas Turbine Operating Cost		$0.01/kWh of electricity generated.	Annual operating cost. Electricity generated estimated based on gas production and engine-generator heat rate (see text).
Utility Interconnection Cost	Initial cost per project.	$300,000 to $500,000 per project.	Initial capital cost.
Off-Site Gas Sales System			
Gas enrichment equipment capital cost.	One system per project.	$1 to $3 million, depending on gas flow rates and gas quality.	Initial capital cost. Enrichment will not be required for gas produced from vertical pre-mining degasification wells or horizontal boreholes. Gas produced from gob wells or cross-measure boreholes, however, may require enrichment. Enrichment equipment includes cost for pressure swing adsorption system and a catalytic deoxygination unit.
Gas enrichment system operating cost.		$3.50 per thousand cubic meters of gas enriched.	
Sales compressor to bring the gas to pipeline pressure	3,500 HP per maximum expected production in million cubic meters per day. Compressor HP needed will vary based on pressure of sales pipeline and distance to sales pipeline or pressure required by industrial end-user and distance to end-user.	$650/HP	Initial capital cost.
Sales meter and gas analyzer	1 sales meter and gas analyzer per project	$20,000 per project.	Initial capital cost.

Exhibit 4-8: Gas Recovery and Utilization Cost Factors			
System Component/ Equipment Required	**Number or Size of Units Needed**	**Cost Per Unit**	**Comments**
Transmission Pipeline	Length of transmission pipeline will vary substantially depending on distance between mine and commercial pipeline or industry end-user.	$32/meter.	Initial capital cost.

- **Electricity Sales.** If electricity is to be distributed through the electric power grid, the owner/operator of the grid (such as a national electricity company) will typically purchase the electricity at the point at which it enters the grid. There are a variety of methods by which the electricity price may be determined. For example, the price could be set at the average marginal cost of generating electricity elsewhere in the system, or it could be set at the price given to electricity producers using conventional fuels. It is recommended that potential pricing arrangements be explored with the proper authorities as part of this preliminary assessment. In some cases, the electric power generation aspect of the project is best developed jointly with the electric power authority.

- **Sale of Gas.** The expected price of gas sold directly to customers can be based on the price of alternative fuels, such as propane, oil, natural gas or coal, on an energy basis (e.g., price per million Joules). The relevant fuel price to use depends on which fuel the coal mine methane will be replacing. The price of gas sold to a pipeline company can be based on the price paid for other gas supplies on a comparable energy basis. If the customer must convert his equipment to use the coal mine methane, the gas may need to be sold at a discount.

- **Tax credits.** Tax credits or other government programs can also affect project revenues. Some government programs may offer tax credits or subsidies for producing energy from non-conventional sources, including coal mines. The applicability of these incentives usually depends on the structure of the project and the coal mine owner/operators' tax situation. Therefore, a complete understanding of the tax laws and their application is critical to ensuring a project's ability to take full advantage of the incentives.

Under some conditions royalties are paid to the resource owner. Royalties can be viewed as compensation for gas rights or as a financial incentive for allowing the project to be developed. Royalties are usually estimated as a percentage of total revenue or energy produced. Any royalty payments should be subtracted from the revenue estimate prior to comparing costs and revenues from the project developer’s perspective.

Cost/Benefit Analysis

Once the revenues are estimated, they must be compared to the costs (estimated in the previous section). This comparison requires a *time profile* of the project’s costs and revenues. From the information above, the capital costs, annual operating costs, and annual revenues can be estimated. Possible increases or decreases in energy prices and gas production over the life of the project should be taken account when estimating annual revenues and savings. For purposes of evaluation, it can be assumed that the project continues for 10 to 20 years, and the annual operating expenses are incurred

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each year. Using the time profile of costs and revenues, three main techniques can be used to determine the economic feasibility of the project:

- **Payback Method.** The payback method involves determining the number of years it would take for a project to generate profits equal to the initial capital outlay. The advantage of this method is that it is simple. It may be particularly suitable where there is a great amount of risk and uncertainty associated with a project and the emphasis is on recovering capital expenditures as quickly as possible. Its main drawbacks are that it does not consider the costs and benefits that accrue at the end of the payback period and that it takes no account of the time when costs are incurred or benefits received The payback method is appropriate to use when making a rough preliminary assessment of a project's economic feasibility.

- **Discounted Cash Flow Method.** The basic premise of the discounted cash flow technique is that costs or benefits occurring in the future are worth less that those occurring now. This means that costs and benefits cannot simply be added up over the years of the project. The costs and benefits in each year of the project are adjusted by a discount factor so that costs or benefits occurring in one year can be compared with the costs or benefits occurring in another year. The discounted costs and benefits in each year can be aggregated to give a **net present value** (see Exhibit 4-9) of future cash flows of the project. The discount rate used will normally be chosen on the basis of prevailing interest rates or on the basis of the minimum desired rate of return for the project. If the net present value is positive, the appraisal shows that the project is capable of yielding this minimum rate of return.

Exhibit 4-9: Net Present Value

The Net Present Value (NPV) is the present value of a project's cash flows, including all investment costs. If the NPV is greater than 0, a project is considered to be profitable at the chosen discount rate. The net present value can be expressed as follows:

$$NPV = \sum_{t=1}^{n} \frac{ACF_t}{(1+r)^t} - IO$$

where:

ACF_t	=	*annual cash flow in year t*
r	=	*discount rate*
IO	=	*initial cash outlay*
n	=	*life of the project*

- **Internal Rate of Return Method.** The internal rate of return (see Exhibit 4-10) is the discount rate at which the present value of the project would be zero. This value shows the total rate of return achieved by the project. This rate can be compared to return rates from alternative investment opportunities.

Exhibit 4-10: Internal Rate of Return

The Internal Rate of Return is calculated as follows:

$$0 = \sum_{t=1}^{n} \frac{ACF_t}{(1+IRR)^t} - IO$$

where:

ACF_t	=	*annual cash flow in year t*
IO	=	*initial cash outlay*
n	=	*life of the project*
IRR	=	*internal rate of return.*

Sensitivity analyses should be carried out to examine how changes in key parameters such as electricity prices or gas production can affect the economic viability of the project. These sensitivity analyses can carried out before the financing arrangements for the project have been worked out and are useful in providing an initial indication of the project's viability. Further analysis can be conducted to examine the implications for viability of different financing schemes.

Energy Supplied

The cost effectiveness of a gas recovery project may be evaluated in terms of the quantity of energy supplied. The cost of gas recovery would be compared with alternative energy supply options to determine the most cost effective option. The threshold level of cost effectiveness may be set in terms of energy supplied per unit cost. For example, gas recovery projects that supply energy at a cost of $0.07/kWh may be defined as being cost effective if the marginal cost of alternative electricity supply options is $0.07/kWh.

In some cases, energy from the gas recovery project may be provided to customers who otherwise would be using wood (e.g., for residential cooking). In this case, the value of preventing over-harvesting of forest resources may be the measure of cost effectiveness for the project. An alternative may be to set a threshold level in terms of the number of households served by the energy supplied. This would require data on average household energy consumption. For example, a cost effective project may be one that costs less than $3 per household served. Such evaluations are prudent particularly in areas of energy scarcity.

Emissions Avoided

Benefits of emission reduction are difficult to evaluate in monetary terms as they do not accrue directly to a project developer. However, such benefits are important to consider in the formulation of national energy policy and tax and subsidy regimes for emissions mitigation or renewable energy projects.

Recovery and utilization of methane from coal mines prevent the release of methane and provide a clean energy source. Methane is a potent greenhouse gas; over a 100 year period, a ton of methane emitted into the atmosphere has the equivalent global warming impact of about 21 tons of carbon dioxide. Combusting the coal mine methane prevents its emission into the atmosphere, thereby reducing greenhouse gas emissions

Although the emphasis of this document is to identify projects that are economically viable in their own right, gas recovery projects may be implemented specifically to reduce methane emissions from the mine. The economics of such a project will be evaluated in terms of the cost of emissions avoided. For example, a threshold level of cost effectiveness may be set at $50 per ton of methane emissions avoided. If the project costs less than $50 per ton of methane emissions avoided, the project is considered cost effective.

The emissions impact of a gas recovery projects is, simply, the amount of gas recovered and combusted. The methane emissions avoided can be expressed in terms of carbon dioxide emission avoided using a Global Warming Potential of methane equal to 21.[6] The following equation expresses the relationship.

CO_2 Equivalent Emissions Avoided (tons/yr)
=
CH_4 Emissions Avoided (tons/yr) x 21 tons CO_2 Equivalent/ton CH_4

[6] The Global Warming Potential (GWP) is a measure of the relative warming impact of a gas relative to the warming impact of carbon dioxide. One gram of methane has 21 times the impact of one gram of carbon dioxide over a 100 year period.

By expressing the emissions reduction in terms of an equivalent amount of carbon dioxide, the reductions from this project can be compared to alternative methods of reducing greenhouse gas emissions. The extent to which the recovered coal mine methane is substituted for more polluting fuels, emissions of other pollutants will also be reduced.

4.4 References

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5. IDENTIFICATION AND ASSESSMENT OF KEY GOVERNMENT POLICIES

THE government can play an important role in developing domestic coal mine methane resources. The policies that it formulates can promote or hinder the recovery and use of this clean energy source. The purpose of this section is to: 1) identify the key policies that will affect the development of coal mine methane projects; and 2) assess whether these policies pose barriers that must be overcome or are potential leverage points to promote project development. Although there are various policies that can encourage coal mine methane projects, it is not possible to recommend a general set of policies for every circumstance. Rather, policies must be tailored individually to suit each country.

5.1 National Energy Pricing, Subsidies, and Taxes

A primary barrier to coal mine methane recovery and use in both developing and developed countries is often artificially low energy prices. Conditions influencing electricity and natural gas prices, such as government energy policies and subsidies, can have an important effect on the economic viability of coal mine projects.

Energy subsidies can both help and harm coal mine methane recovery and utilization projects. Artificially low energy prices can pose a barrier to coal mine methane utilization. If the prices of natural gas, oil, and coal are less than the cost of producing coal mine methane, it will be difficult to develop a profitable coal mine methane project. Using market prices for natural resources would allow coal mine methane to compete fairly. If even under market prices coal mine methane is uncompetitive, however, the government may offer tax credits or other financial incentives to encourage these projects because of their environmental and safety benefits.

Energy taxes must also be assessed for their impact on gas recovery projects. Energy taxes based on fossil carbon content would give recovered methane an edge over coal and oil. Similarly, higher taxes on imported energy would allow domestic coal mine methane to be more competitive. Depending on a nation's energy goals, the tax structure may prefer one source of energy over another.

For example, in the United States, several federal, state, and local incentives are available for coal mine methane projects, such as the Internal Revenue Service (IRS) Section 29 Tax Credit (see Exhibit 5-1).

5.2 National Energy Supply Priorities

The nation's energy supply goals will help determine the emphasis placed upon coal mine methane development. There are two main national energy concerns that may affect coal mine methane promotion: supply security and increasing domestic demand.

Many nations are concerned about relying on foreign sources of energy. The most notable example is reluctance of many nations to depend on oil and gas from unstable regions. Because the price of natural resources has a great impact on a nation's economy, and domestic sources of energy are considered to be more stable, many nations share the common goal of increasing domestic natural resources. Therefore, nations may choose to encourage coal mine methane recovery and utilization to expand their domestic supply of energy.

For nations where energy demand is growing rapidly and there are shortfalls in supply, energy policy may include the development of coal mine methane to help meet the nation's energy needs. For example, in many developing nations, the shortage of energy has slowed down the process of electrification of towns and villages. The use of coal mine methane as a fuel to generate electricity could help to meet the goal of universal electrification. Furthermore, the use of domestically produced energy will decrease the amount of foreign exchange required to import energy. Many developing countries and those with economies in transition face a shortage of foreign exchange. Coal restructuring may force uneconomic or unsafe coal mines to close down, which may cause some economic hardships. However, the benefits that coal mine methane recovery produces, including jobs and safer, more profitable mines, can offset the losses.

If coal mine methane recovery and utilization is consistent with a nation's energy supply priorities, it may be easier to create policies to promote its development. For example, a detailed resource assessment may be undertaken or information on technologies, financing, and pertinent policies can be made publicly available. If, however, a nation has ample quantities of domestically produced energy, it may not involve itself in the issue simply for the purpose of expanding energy supplies. Rather, in such cases, environmental goals may be more important.

Exhibit 5-1: U.S. Internal Revenue Service (IRS) Section 29 Tax Credit

This is a U.S. federal tax credit for producing energy from non-conventional sources, including coal mines. This tax credit applies to wells drilled before 1992 and will expire on January 1, 2003. When the tax credit was established in 1979, the value of the credit was set at $0.52 per thousand cubic feet of gas. The value of the credit changes annually, depending on a number of factors, including the domestic oil price and the inflation rate. In 1994, the credit equaled $0.90 per thousand cubic feet of gas.

5.3 Environmental Goals

A nation's environmental goals will also play a large role in determining the importance given to coal mine methane projects. Coal mine methane may be encouraged when environmental issues are placed highly on the national agenda. The two main issues concerning environmental policy and their impact on coal mine methane can be divided into a global concern and a local/national concern.

As explained in Chapter 2, methane is a greenhouse gas, affecting the global environment. If a nation has an active interest in reducing methane emissions, it may promote the recovery of methane from coal mining.

Both national and local environmental policy may call for the use of cleaner fuels to reduce local pollution and for the clean up of water discharged during mining. Coal mine methane can be used to displace more polluting fuels, such as coal or oil. Methane has several advantages over other fossil fuels. Emissions of SO_2, NO_x, and particulates can be reduced through the displacement of coal (and to a lesser degree oil) with gas. Natural gas combustion produces no SO_2 or particulate emissions, and lower NO_x emissions.

Coal mine methane can also be used to treat mine water before it is discharged into rivers or used for other purposes. The disposal of this water is a significant local environmental problem in many countries. As described above, a demonstration project is underway at the Morcinek mine in Poland that involves using coal mine methane for this purpose.

5.4 Financing

In order to assess the impact of government investment polices on the financing of coal mine methane projects, one must look at both the overall investment regime and the financial regulations specifically concerning coal mine methane. When studying the overall regime, it is necessary to look at the corporate tax structure, import and export taxes and quotas, and laws concerning foreign ownership. Low limits on foreign ownership and a high corporate tax structure in comparison to other nations with potential coal mine methane projects may pose barriers to foreign investors. In cases in which the equipment must be imported from abroad, high import duties will place a burden on both domestic and foreign investors.

The government also may have financial regulations dealing specifically with coal mine methane. For example, low interest loans, tax credits, loans, grants, and subsidies for coal mine methane projects will ease the financial burden on the investor. As mentioned above, the use of such incentives will depend on the overall energy and environment goals of the government.

For example, in the U.S., many state governments provide grants or low interest loans to projects that improve the environment or increase the local supply of clean fuels. As coal mine methane projects can do both, they may be eligible to receive various types of state funding. Examples of such programs include one by the Pennsylvania Energy Development Authority that provides loans and grants for the development of new sources of energy, as well as the Indiana Recycling and Energy Development Program, which provides assistance for the development of new energy resources and recycling programs.

5.5 Technology Development

As some of the technologies associated with coal mine methane recovery and utilization may not be available in many nations, the government's policy towards the development of technology is important to assess. There are various ways in which the government can encourage the development of technologies specific to coal mine methane projects:

- **Encourage foreign participation** in coal mine methane projects. This would allow foreign technology to be introduced without requiring domestic capital. Foreign participation, however may bring forth issues of ownership of the recovered methane. These arrangements may thus require detailed contracts regarding use and rights of both parties involved, discussed further in section 5.6 below.

- **Lower import duties, taxes, and restrictions** on required technologies, thereby reducing the cost of a coal mine methane project.

- **Fund demonstration projects** at domestic mines to allow the industry to see and understand new technologies.

- **Organize study tours and training trips** abroad for key personnel so that they may learn from the experiences of other nations.

- **Finance research and development** into recovery and use methods to assist the local industry.

If technology is a strong barrier to the development of coal mine methane projects, government policies that encourage the transfer of technology and the development of local technology can help promote these projects. An important part of technology transfer that must not be overlooked is the need to ensure the safety of those using the equipment. Governments could involve safety and certification agencies to examine and evaluate the technology; in some cases a formal licensing or approval process could be established.

5.6 Concession Process

Through the granting of natural resource concessions, governments can encourage project development. In granting a concession, a government authorizes a developer to extract and sell a natural resource. Typically, the grantee pays to obtain the concession, and often is required to pay a royalty based on the amount of resource extracted.

There are two main issues that must be analyzed in this process. First, before the concession process can begin, the issue of ownership of the coal mine methane must be resolved. If natural resources are owned by the private sector, coal mine methane resources can belong to the owner of the surface rights, the owner of the coal rights, or the owner of the oil and gas rights. If natural resources are nationalized, it may be uncertain whether the national or regional government has the authority to grant concessions. This uncertainty can prevent projects from being developed. Furthermore, in nations in which the natural resource sectors are being privatized, the laws concerning ownership may be in flux.

The second matter concerns the clarity, efficiency, and stability of the actual concession process. A long, complex concession process can act as a deterrent to investment in coal mine methane resources. Common problems faced by investors include delays in the decision making process, confusion over who is in charge, sudden changes in regulations, and the reversal of decisions. These problems are exacerbated in nations where all natural resources were previously owned by the government and the concession process is still being formulated. The following questions are useful in determining whether the current concession process may be a potential barrier to project development:

- Who should be contacted for questions concerning various steps of the concession process? Is it clear exactly who is in charge of what step and are those persons easily accessible?
- How long does the concession process take?
- Once a decision has been made, what is the likelihood of it being overturned?

Clear laws concerning coal mine methane ownership and a clear, efficient, and stable concession process will help to promote coal mine methane projects.

5.7 References

USEPA (U.S. Environmental Protection Agency). 1993. *Anthropogenic Methane Emissions in the United States*, Report to the Congress, prepared by the Global Change Division, Office of Air and Radiation, EPA, Washington, D.C.

USEPA (U.S. Environmental Protection Agency). 1994. *International Anthropogenic Methane Emissions: Estimates for 1990,* Report to the Congress, prepared by the Office of Policy, Planning and Evaluation, EPA, Washington, D.C.

6. NEXT STEPS

THIS section outlines the next steps for evaluating and implementing coal mine methane recovery and utilization projects in developing countries and countries with economies in transition. The steps encompass a range of initiatives that may be tailored to meet individual country objectives. These initiatives are divided into the following five main areas:

- **Focus on the Most Promising Projects.** This section presents next steps for focusing on the most promising coal mine methane projects in your country.
- **Availability of Technology and Expertise.** This section identifies approaches for assessing whether the technology and expertise required for implementing projects are available.
- **Decisionmaker Motivation.** This section presents approaches for motivating decisionmakers to undertake coal mine methane recovery and utilization projects.
- **Resolution of Regulatory Issues.** This section lists regulatory issues that should be examined to assess whether existing policies hinder or further the goal of implementing coal mine methane projects.
- **Funding.** This section identifies possible sources of funding for these next step activities.

Exhibit 6-1 summarizes how this chapter can be used to meet various objectives. The first column lists several common objectives and the second column lists the chapter section to consult.

6.1 Focus on the Most Promising Projects

Although the site screening and preliminary assessments discussed above in chapters 3 and 4 may show that a variety of promising projects exist, the available data may be insufficient for identifying the most promising project opportunities. In particular, if there are a large number of gassy mines, detailed site-specific information on all the sites may not have been collected in the screening step (chapter 3) because of the level of resources that are required. This section provides guidance for collecting additional site-specific information that will enable prefeasibility assessment activities to be focused on the most promising opportunities. This initiative is only required when there are a large number of potential sites that need to be evaluated.

Exhibit 6-1: How to use this Chapter

Objective:	Section to Consult:
To focus on the most promising coal mine methane projects.	**Section 6.1 - Focus on the Most Promising Projects** summarizes steps for collecting additional data on candidate sites to better focus efforts.
To assemble the technology and expertise needed to develop coal mine methane recovery and utilization projects.	**Section 6.2 - Availability of Technology and Expertise** presents steps for identifying and filling gaps in the availability of technology and expertise needed to develop projects.
To motivate decisionmakers to invest in and implement coal mine methane projects.	**Section 6.3 - Motivate Decisionmakers** presents options for assisting decision makers and providing incentives.
To identify and eliminate regulatory barriers.	**Section 6.4 - Resolution of Regulatory Issues** discusses those policies and regulatory structures that should be reviewed to identify potential barriers.
To obtain funding for program development or project implementation.	**Section 6.5 - Funding** presents candidate funding sources that can be consulted.

To collect this information, a specific program activity should be defined with data collection as its objective. Such an initiative was conducted in the United States to identify the most promising coal mine methane opportunities (see Exhibit 6-2). Section 6.5 describes funding sources that may be contacted to obtain funding for these types of activity. A sample five step program plan for collecting the necessary data is as follows:

Step 1: Define Minimum Information

The first task is to define the minimum information that is required for each coal mine. As discussed in Chapter 3, the three primary factors that makes a site a promising opportunity for gas recovery and use are 1) coal production of at least 0.3 million tons of coal annually, 2) methane emissions of at least nine cubic meters per metric ton of coal produced, and 3) a remaining life span of at least five years. Therefore, it is recommended that this information collection effort focus on obtaining the best possible information on three factors:

- The number of tons of coal produced annually;
- Methane emissions per ton of coal mined; and
- Remaining mine lifespan.

Exhibit 6-2: US EPA Coal Mine Profiles Project

The US EPA Coal Mine Profiles Project was developed to identify the most promising coal mine methane project opportunities in the United States. This information is being provided to coal mine owners and operators, electric utilities, natural gas pipeline companies, state and local government officials, and potential project developers. Based on publicly available data collected primarily from state and federal reports and industry press, a minimum data set was developed for large and gassy mines from which a profile is created. These profiles are then used to identify those mines that may offer attractive energy development opportunities.

The profile for each coal mine has the following information:

- Coal mine location and operating status;
- Coal production;
- Methane emissions;
- Energy potential of the methane (including the amount of electricity that may be generated from the recovered methane);
- Existing methane recovery and use;
- Distance from mine to a pipeline;
- Nearby institutional or industrial facilities; and
- Contact information (i.e., coal mine owner/operator).

Based on this information, the gas recovery and use potential and associated environmental and energy benefits from a potential project are estimated. These profiles are currently available from the US EPA for over 80 mines in 10 states.

Additional information on energy needs surrounding the coal mine and potential consumers in the area may also be collected if the information is readily available. Since methane can be used at the mine itself, this information is not on the list of the minimum information required.

Step 2: Define the Data Collection Method

The purpose of this second step is to define how the data will be collected. Options may include working with local government officials who collect coal production and methane emissions data or surveying individual coal mines to collect or estimate this data. The techniques to be used to collect the data should be selected based on the type of information most likely to be available and the resources available for collecting the data. It may be appropriate to test several different data collection methods before settling on the recommended approach.

Step 3: Develop a Data Handling System

The purpose of this third step is to develop a system for handling the coal mine data. A database program can be used to organize the data so the subsequent data analysis and evaluation is facilitated. Data handling and quality control procedures should be developed as part of this step, including checking the accuracy of both the data collection and data entry activities.

Step 4: Collect the Data

In this step the program personnel collect the data according to the method defined in step 2. The data are entered into the data system developed in step 3.

Step 5: Analysis and Recommendations

Based on the data collected, the gas recovery and use potential for candidate coal mines is estimated (Chapter 4 presents equations for estimating gas recovery). The most promising project opportunities will be those that produce the most gas in areas that can use the energy. A list of the most attractive projects can be created, along with the information available on each.

Once the most promising opportunities are identified, this information can be disseminated to potential project developers to promote the projects (see section 6.3).

6.2 Availability of Technology and Expertise

Specific technical expertise is required to plan and implement coal mine methane recovery and utilization projects. Additionally, access to and experience with specialized drilling and gas monitoring equipment are needed. The absence of the necessary expertise and equipment can be a significant barrier to the implementation of these projects. This issue may be particularly important in developing countries and countries with economies in transition because technical and labor resources may not be available to construct and operate the projects.

Once it has been determined that promising opportunities exist, necessary expertise and equipment should be located. Ideally, one or more local experts with coal mine methane recovery and use expertise should be identified. For example, a request for qualifications can be issued to identify local or regional individuals and organizations with the necessary expertise.

In some cases a coal mine methane expert familiar with the latest technologies may not exist in the nation. In this circumstance, a program can be organized to train local personnel in the detailed aspects of coal mine methane recovery and utilization. Training programs could include visits to existing projects in other countries as well as inviting experts from other countries to give seminars.

To augment local expertise, nations may wish to contact foreign companies with the expertise necessary to complete the project. Foreign involvement may take any of a variety of forms, including the build-operate-transfer (BOT) financing model. The BOT is currently being used for various infrastructure projects in developing countries and is applicable for coal mine methane projects as well. Such arrangements with foreign companies allow technology

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to be introduced without requiring the use of domestic capital. For countries that have limited or no experience with coal mine methane recovery and utilization, this may be an attractive short-term option. Appendix A lists selected U.S. coal mine methane development experts available to provide training or participate in project development.

6.3 Motivate Decisionmakers

Because coal mine methane recovery and utilization projects are relatively new in many countries, steps to motivate decisionmakers may be necessary to get promising projects built. Examples of decisionmakers include coal mine owners, government officials in the energy and environment ministries, and potential project developers. In addition to financial incentives, several targeted initiatives have proven effective for both raising awareness regarding the benefits of such projects, as well as creating the nucleus of interested parties needed to create a viable project. Three main initiatives are recommended to provide the information needed to motivate decisionmakers: outreach activities, demonstration projects, and information clearinghouses.

6.3.1 Outreach Activities

Because the concept of recovering and utilizing methane from coal mines may be unfamiliar, outreach activities may be required to educate and motivate the community and its leaders on the technology and benefits of coal mine methane projects. Outreach should be targeted to the following parties:

- **Coal mine owners and operators**, who may not recognize the resource they have;
- **Potential users of coal mine methane**, who may not recognize the opportunity to obtain low cost energy;
- **Energy planners**, who may not recognize how energy from coal mine methane can contribute to meeting local energy needs; and
- **Environmental and community groups**, who may not be aware of the environmental and safety benefits of coal mine methane projects.

Outreach activities to educate and motivate these parties must be defined in terms of the *message* that is being delivered and the *mechanism* that is used to deliver the message. The message must include the information needed to educate and motivate each target group. The information must be presented in a way that each target group can understand, and must be delivered in a manner that ensures that each target group receives and assimilates the information. Because each target group is different, separate outreach strategies may be needed for each.

Exhibit 6-3: The US EPA Coalbed Methane Outreach Program

EPA's **Coalbed Methane Outreach Program** encourages the use of coal mine methane as an energy resource. EPA enlists the support of coal mine owners and operators, electric utilities, state agencies, private financiers, and project developers to reduce methane emissions from coal mines through the development of profitable energy recovery projects.

The Coalbed Outreach Program promotes coal mine methane recovery and use projects in the U.S. as well as in countries such as Russia, China, Poland, and Ukraine. Projects undertaken by the Program in the U.S. include:

- Profiles of the gassiest mines in the nation (these profiles are discussed above);
- Guides to possible sources of funding for coal mine methane projects in West Virginia and Pennsylvania, two state with several gassy mines;
- Study of the barriers facing coal mine methane projects and possible solutions to these barriers; and
- Detailed technical and financial feasibility assessment for potential coal mine methane project developers.

To promote coal mine methane projects abroad, EPA has helped establish clearinghouses in Poland, Russia, and China. EPA has also written reports on the coal mine methane potential of these nations and has profiled some of the gassiest mines. At present, EPA is working with the Chinese Coalbed Methane Clearinghouse to develop a financial model to evaluate coal mine methane projects in China.

For example, outreach to national planners and decisionmakers may employ existing decisionmaking processes. Alternatively, outreach to local officials responsible for the local coal industry may require seminars, training sessions, or technical guidebooks to inform them of the coal mine methane recovery and utilization opportunities. Options for reaching potential foreign partners may include conducting studies through international funding agencies (discussed below in section 6.5) or issuing requests for proposals for specific projects or studies. Exhibit 6-3 summarizes the outreach program currently being used in the United States to reach these various groups.

Exhibit 6-4: Demonstration Project in Russia

During its visit to Russia in 1995, the EPA identified a demonstration project at the Kirov mine in the Kuzbass coal basin. This project would use methane recovered from the degasification systems to fuel the three central boilers. At present, these boilers run on coal. Currently, EPA is preparing a project opportunity report on this project. This report will be distributed to potential lenders.

The successful implementation of this demonstration project will facilitate the development of other coal mine methane projects in Russia.

6.3.2 Demonstration Projects

Sometimes information is not enough to promote the use of a new technology. Users may want to see the technology in use. Demonstration projects are an effective tool to test and promote the effectiveness of coal mine methane recovery and use projects, especially in developing countries and countries with economies in transition where such projects may be uncommon. By providing analysis, technical support, and funding, the government can facilitate projects to serve as examples for the industry as a whole.

In selecting projects to support and promote, several criteria should be considered, including: choice of technology, time frame for the project, type of government assistance required, and how projects will promote the government's goals. In most cases, after a specific project is selected, technical and financial analyses will be required to evaluate the effectiveness of the technology, as well as its costs and benefits.

Upon completion of the demonstration project, the results of the project must be summarized, including both positive and negative aspects and recommendations for improvement. This information must be disseminated to promote the technology. The demonstration site itself can then be used for training and education purposes.

6.3.3 Information Clearinghouses

To provide owners, developers, regulators, and other stakeholders with comprehensive information concerning all aspects of coal mine methane recovery and utilization technology, finance, and economic development, a central information clearinghouse could be established. Information clearinghouses provide a central location for information where current environmental, technical, financial, and business contact information is available.

The clearinghouse can function at the national level of the country and can involve professionals from leading research and development laboratories, educational institutes, industries, and other organizations. The clearinghouse can strengthen the existing infrastructure of national and regional bodies involved in the training, information dissemination and implementation of the programs in energy efficient technology. It can also facilitate training programs and interactions with local and international experts.

The clearinghouse can also assist in developing the technical capabilities of non-governmental organizations, consultants, industry associations, and any other groups engaged in the promotion of energy efficiency activities. This can be done by conducting regular training programs (both in the field and in the classroom), thereby exposing the participants to the latest tools and techniques.

At a minimum, the information clearinghouse should contain information in the following areas:

- profiles of gassy mines;
- current technologies and new research;
- coal mine methane ownership laws;
- permitting requirement;
- applicable energy purchase rules (if any);
- international and domestic capital/funding sources; and
- government energy development policies.

An automated index of all materials could be made available electronically through a bulletin board, or as a "fax-back" system. A collection of hardcopy materials could also be assembled for use by anyone interested in coal mine methane projects. US EPA has helped establish three clearinghouses abroad. A description of these clearinghouses along with their contact information is presented in Exhibit 6-5.

6.4 Review Regulatory Framework

Regulatory barriers are key obstacles facing potential coal mine methane projects in many developing countries and countries with economies in transition. In many of these nations, the regulatory frameworks do not address issues related to coal mine methane recovery and use projects. This is not unusual, given that such projects may be relatively new in these countries.

There are many types of regulatory barriers that a project may face. For example, local, state, and national ownership and permitting legislation can obstruct coal mine methane projects. Artificially low energy prices can pose a barrier to coal mine methane utilization if the prices of alternative fuels are less than the cost of coal mine methane. Furthermore, in most developing countries

Exhibit 6-5: Coalbed Methane Clearinghouses

The Polish Coalbed Methane Clearinghouse

The Polish Coalbed Methane Clearinghouse, established in January, 1991, is part of the Polish Foundation for Energy Efficiency (FEWE) and is jointly sponsored by the FEWE and the US EPA. The clearinghouse provides consulting services to public- and private-sector clients (e.g., assisting contractors with pre-feasibility studies on directional drilling and gob gas recovery), hosts workshops, and publishes journals, brochures, and newsletters (e.g., the Silesian Coalbed Methane Newsletter). Together, EPA and the Polish Clearinghouse prepared a report entitled "Reducing Methane Emissions from Coal Mines in Poland: A Handbook for Expanding Coalbed Methane Recovery and Utilization in the Upper Silesian Basin." This report profiles the top candidate mines in Poland. For more information, contact:

Jan Surovka, Director
Polish Coalbed Methane Clearinghouse
ul. Powstancow 41a
40-024 Katowice, Poland
48-3-10355114 (phone)
48-3-10355120 (fax)

Chinese Coalbed Methane Clearinghouse

The Chinese Coalbed Methane Clearinghouse was established in August 1994 in Beijing. The Clearinghouse is part of the Ministry of Coal Industry's (MOCI) China Coal Information Institute and is jointly funded by the MOCI and the US EPA. Activities of the Clearinghouse include providing consulting services, hosting seminars and conferences, and publishing the journal China Coalbed Methane in both English and Chinese. In a joint report with EPA entitled "Reducing Methane Emissions from Coal Mines in China: The Potential for Coalbed Methane Development," the Clearinghouse has profiled coal mining administrations that have the top candidate mines for coalbed methane projects. For further information, contact:

Mr. Sun Mayouan, Director
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21 Hepingli Beijie
P.O. Box 1419
Beijing 100713, China
86-10-420-1328 (phone)
86-10-421-5187 (fax)
adb310@istic.sti.ac.cn (email)

Russian Coalbed Methane Clearinghouse

The Russian Coalbed Methane Clearinghouse opened in 1995 in Kemerovo. It is located at the Russian Institute of Coal and is affiliated with Partners in Economic Reform (PIER) and the U.S. EPA. Like the other Clearinghouses, the Russian Clearinghouse is promoting the development of coal mine methane projects by disseminating information. It assisted the U.S. EPA in preparing a report entitled "The Potential for Coalbed Methane Development" which includes profiles of the top candidate mines. The Clearinghouse is also working with EPA to develop a demonstration project at the Kirov mine (see box above). For further information, contact:

Dr. Oleg Tailakov, Director
Russian Coalbed Methane Clearinghouse
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and countries with economies in transition, all major power and natural gas producers and distributors are or have been State-owned. Privatization of the energy industry is only recently occurring in many countries; therefore, the concept of private, independent power producers or private gas producers may be unfamiliar (Watts, 1995). These, and other barriers, are discussed in Chapter 5.

The following is recommended to review the regulatory framework for coal mine methane recovery and utilization: identify and evaluate existing regulations; develop feasible options for removing barriers that will not compromise other regulatory objectives; and implement the necessary changes.

6.4.1 Evaluate Existing Regulations

To evaluate the existing situation, the relevant laws, rules, regulations, and policies must first be identified and summarized by conducting literature reviews and contacting appropriate regulatory and legislative experts. In addition, attention must be paid to institutional arrangements. The following steps should be undertaken:

- **Step 1: Identify Decisionmakers.** The purpose of this step is to identify the key decisionmakers involved in the approval of coal mine methane projects. These decisionmakers may include local, provincial, or national regulatory bodies that are involved in coal production, land ownership, energy production, financing, and equipment purchasing/importing.

- **Step 2: Identify Decision Criteria.** The purpose of this step is to identify the decision criteria used by the key decisionmakers and the underlying objectives they are trying to achieve. This information would be obtained principally through contacts with the relevant agencies and institutions in the country.

- **Step 3: Identify Typical Project Development Path.** The purpose of this step is to describe the typical path that a project would take in order to be developed. A concise listing of the major steps in getting the project defined, approved, financed, and built should be developed based on discussions with the relevant institutions involved. This summary of the project development path could then be used to promote the implementation of coal mine methane projects.

The results of the above steps should be compiled in a concise summary report highlighting the policies and current practices affecting gas recovery and use the options available to the government to reduce the barriers to projects. Any policies or requirements that significantly add to the cost of the project, create uncertainty in the viability of the project, or delay its implementation should be identified as major barriers requiring further analysis.

6.4.2 Develop Feasible Options

The purpose of this section is to develop available options for overcoming any major barriers identified above. The options selected will be those that most effectively promote the government's development objectives and are feasible in terms of political acceptance, effectiveness, secondary impacts, costs, and legality.

An Evaluation Team consisting of the decisionmakers and participants involved in coal mine methane recovery and utilization can be established as a working group to guide this process. This group would be charged with ensuring that the recommended options incorporate the views of the representative stakeholders in each area. At a minimum, the Evaluation Team should include the following groups:

- **Regulatory Community:** municipal agencies, local government regulators, ministries in charge of power, coal, natural gas, and the environment, and others;
- **Owner, Operator, and Developer Community:** coal mine owners and operators, recognized local, national, or international coal mine methane project developers; and
- **Financial Community:** local, national, or international grant/loan agencies and venture capitalists.

The assessment of available options will involve considerable debate on which options can be implemented without compromising other pressing national priorities. As such, proposed regulatory changes must be viewed in the context of their impact on other national priorities.

6.4.3 Implement Options

Using the input and recommendations of the Evaluation Team, the options or optimum mix of options can be implemented. The implementation strategy will depend on the type of option to be implemented. Implementation strategy options include, among others:

- legislative/regulatory actions (environmental, safety, ownership, import restrictions);
- administrative and executive actions (committees, meetings, conferences);
- inter-governmental liaison actions (local, municipal, national, inter-national); and
- outreach (training programs, demonstration projects, etc.)

The above options must be evaluated on an ongoing basis in terms of their ability to promote promising projects. A structured program of data collection for monitoring the progress of the objectives may be developed in this regard. Once data has been collected, reviewed, and analyzed, an evaluation of the impact of the option can be made and the established objectives can be retained or modified as appropriate.

6.5 Obtain Project Funding

Each of the activities discussed above requires resources, as does the implementation of individual projects. This section lists steps for obtaining assistance from international funding agencies for these initiatives. The key steps are to review the types of assistance available, identify funding requirements, and select specific source(s) of funding. Once the appropriate source of funding has been identified, a project proposal can then be prepared in accordance with the specific criteria of the funding agency.

6.5.1 Review Types of Assistance Available

The main types of assistance offered by international funding agencies are grants, loans, and other packages (including loan guarantees, venture capital funds, and business consulting assistance). These types of assistance are available to both governments and businesses. In some cases, the government may reallocate the funds to eligible businesses. The funds provided may cover costs to conduct feasibility assessments, implement demonstration projects, or acquire equipment and technical expertise. The main types of financial assistance are further described below:

The first source of funding that countries should consider is forming a partnership with local and foreign private sector project developers. This method is often the quickest and cheapest method of obtain funding. However, such funding is only available for projects that are clearly profitable. For projects with a lower economic rate of return, funding may be available from international agencies.

- **Grants.** These are direct monetary payments for specific projects that do not need to be reimbursed. For example, grants may be used to develop a demonstration project or to fund a training program to enhance local expertise.

- **Loans.** These are made by the funding agencies directly to the eligible parties and must be paid back in a specified period of time. Typical recipients of such loans may be government agencies (for direct use or reallocation to businesses); or businesses in manufacturing, industrial export/import services, or technology development.

- **Other.** Loan guarantees, venture capital funds, and business consulting services are some of the other types of assistance that are offered by these institutions. These are described below:

  - *Loan Guarantees* are commitments to repay the lender if the borrower defaults. In these cases, a funding agency guarantees its proportionate share of loss in accordance with the percentage of the guarantee. Loan guarantees are important to mitigate risk at projects that have a high degree of uncertainty.

- *Venture Capital Funds* offer loans or equity to support the start-up of new businesses or expansion of existing businesses. Funding agencies may appropriate funds or generate funds from private investors by selling shares in the company.

- *Business Consulting Services* include technical, managerial, and financial consulting and support services. Typical sources of such assistance are governments, multilateral and bilateral agencies, and business- and research-related entities. Technical services may range from providing technology transfer to providing engineering assistance to offering use of research and development facilities. Managerial consulting includes offering seminars, workshops, and consultations on improving project operations. Financial consulting may involve assistance in creating packages to finance a project or group of projects.

6.5.2 Identify Funding Requirements

The type of funding required is driven primarily by two factors: the objectives of the program, and the country's resource allocation. These are briefly described below.

◆ **Program Objectives.** Government programs aimed at exploring the opportunities for coal mine methane projects (e.g., by conducting feasibility studies) would most likely seek grants or other concessional funds. On the other hand, businesses and government agencies pursuing profitable projects are eligible for loans, loan guarantees, and venture capital funding.

◆ **Resource Allocation.** The extent of economic development and resource endowments for a given country will determine its financial requirements. Countries with a low GNP per capita will typically require grants to undertake coal mine methane projects. Some countries may face difficulty when securing loans, if they have creditworthiness problems.

Once the funding requirements have been assessed, the next step is to identify the funding available.

6.5.3 Select Sources of Funding

There are a wealth of possible funding sources which provide assistance that can be used for coal mine methane projects. These include multilateral institutions, regional development banks, U.S. government agency programs, country- and region-specific enterprise funds, and other institutions. Exhibit 6-5 lists funding sources most applicable to coal mine methane recovery and use projects, and summarizes the types of funding offered by each. Summary profiles of the funding agencies are presented in Appendix B. The main categories of funding sources are briefly described as follows:

- **Private Sector.** Funding may be available from private sector associations or firms interested in coal mine methane recovery. Such funding is most commonly available for projects with a high expected rates of return and usually takes the form of a profit-sharing partnership. This method is often the quickest and cheapest method of obtaining project funding.

- **World Bank Institutions.** The World Bank institutions fund environmental and energy infrastructure projects in developing countries for which the procurement of technical assistance, civil works, materials and equipment, are necessary. These agencies provide grants and loans to government ministries and businesses, which implement projects under local procurement and contracting regulations. Examples of such institutions include the World Bank itself (also known as the International Bank for Reconstruction and Development), International Finance Corporation (IFC), and the Global Environment Facility (GEF).

- **Multilateral Development Banks.** These are international lending institutions owned by member countries that promote economic and social development in developing member nations by providing loans, technical assistance, capital investment, and help with economic development plans. Examples of such institutions include the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), and the Inter-American Development Bank (IDB).

- **U.S. Government Agency Programs.** There are several U.S. government agencies that promote development by funding feasibility studies, training programs, and seminars in developing countries. In most cases, these agencies/programs support projects that offer export or investment potential for U.S. enterprises. Examples of such agencies/programs include the Trade Development Agency (TDA) and the Overseas Private Investment Corporation (OPIC).

- **U.S. Initiative on Joint Implementation (USIJI):** The USIJI is a voluntary private program that provides recognition and select technical assistance to U.S. companies implementing greenhouse gas reduction projects in other countries. While no funding is available through the USIJI, projects that meet the USIJI criteria will be likely to attract U.S. investors solely on the recognition of USIJI acceptance.

For more information on the types of funding available and sources of funding for coal mine methane recovery and use projects contact:

U.S. Environmental Protection Agency
Methane Branch
Mail Code 6202 J
401 M Street, S.W.
Washington D.C. 20460
Tel: 202/233-9768
Fax: 202/233-9569

Exhibit 6-5: Summary Table of Promising Sources of Funding and Other Assistance

Name of Agency	Type of Assistance Provided			Comments
	Grants	Loans	Other	
World Bank Agencies/Programs				
International Bank of Reconstruction and Development (IBRD)				The World Bank finance capital infrastructure projects through the International Bank for Reconstruction and Development (IBRD) and its affiliates - IFC, IDA, and MIGA.
Global Environment Facility				GEF funds the difference between expected project revenues and project costs. Therefore, GEF funding is ideal for conducting feasibility assessments.
International Finance Corporation (IFC)				IFC provides loans and other financial packages to private sector enterprises only. The minimum support provided by IFC is $10 million.
Multilateral Development Banks				
European Bank For Reconstruction and Development (EBRD)				EBRD provides loans, equity, and guarantees to Central and Eastern European countries for developing into market-based economies.
Inter-American Development Bank (IDB)				IDB provides loans for development projects in Latin America and the Caribbean. Grants are available for poorer member countries.
Asian Development Bank (ADB)				ADB provides loans for the economic and social advancement of member countries. Concessional funds are available through special funds established by the ADB.
Africa Development Bank (AfDB)				AfDB provides loans for the economic and social advancement of African countries. Grants are available for the poorest countries through special funds.
U.S. Government Agency Programs				
Trade Development Agency				TDA provides funding to projects in developing countries that offer export or investment potential for U.S. enterprises. The average grant size ranges from $300,000 to $400,000.
United States Agency For International Development (USAID)				USAID's Office of Environment, Energy, and Technology assists in developing market-based solutions to environmental problems in developing countries.
Overseas Private Investment Corporation (OPIC)				OPIC provides funding by facilitating U.S. private investment in developing countries through loans, loan guarantees, and special services.
Export-Import Bank (EXIMBANK) of the United States				EXIMBANK provides loans and guarantees to foreign buyers of U.S. goods and services. The bank finances up to 85% of the U.S. export value.
U.S. Initiative on Joint Implementation (USIJI)				Projects that meet the USIJI criteria are likely to attract U.S. investors seeking to obtain recognition and other amenities available to U.S. participants in the USIJI program.

This includes loan guarantees, venture capital funds, consulting services etc.

NEXT STEPS

6.6 References

Watts, Robert A., (1995) *Profitable Market Opportunities for Pollution Prevention - International Market Opportunities*, Presentation for US EPA Atmospheric Pollution Prevention Division Forum, April 10, 1995, Washington D.C.

APPENDIX A: DIRECTORY OF SELECT COAL MINE METHANE RECOVERY AND USE EXPERTS IN THE U.S.

Listing of experts does not constitute endorsement or recommendation for use.

PROJECT DEVELOPMENT				
	Name	**Address**	**Contact Person**	**Area(s) of Expertise**
1.	Alternative Energy Development, Inc.	8455 Colesville Road, Suite 1225 Silver Spring, MD 20910	Mathew S. Mendis, President Tel: (301) 608-3666	Project Development
2.	Burns and Roe NIS Consortium	1400 K Street N.W., Suite 910 Washington, DC 20005	John Leonhardt Tel: (202) 898-1500	Project Development
3.	Dominion Energy Advisors	14389 Emerald Pool Drive Centreville, Virginia 22020	Charles M. Boyer Engineering Consultant Tel: (703) 803-6007	Project Development
4.	Energy Resources International, Inc.	1015 18th Street NW Washington, DC 20036	David W. South Vice President Tel: (202) 785-8833	Project Development
5.	HVS Consulting	4898 Hartland Parkway Lexington, KY 40515	Hilmar von Schonfeldt Tel.: (606) 272-7112	Project Development
6.	ICF Incorporated	1850 K St., NW, Suite 1000 Washington, DC 20006	Mary DePasquale, Project Manager Tel.: (202) 862-1124	Project Development; Gas Use
7.	ICMG / E.L. Lasseter & Associates	3610 Watermelon Road Suite 104 Northport, AL 34576	Edward L. Lasseter President Tel: (205) 759-2046	Gas Production, Project Development
8.	I. Havyrluk and Associates	P.O. Box 252 Carnegie, PA 15106-0252	Ihor Havryluk, President Tel.: (412) 343-3285	Project Development
9.	Murray & Associates	200 Union Blvd. Suite 215 Lakewood, CO 80228-1830	Keith Murray President	Project Development
10.	Resource Enterprises	1245 East Brickyard Rd. Suite 170 Salt Lake City, UT 84106	Jeffrey Schwoebel, Vice President Tel. (801) 467-9981	Project Development, Gas Production and Resource Assessment
11.	United Energy Development Consultants	Park West One, Suite 170 Pittsburgh, PA 15275	Isaias Ortiz Tel.: (412) 787-7880	Project Development

Gas Production and Resource Assessment				
	Name	**Address**	**Contact Person**	**Area(s) of Expertise**
1.	Amoco Production Company, Natural Gas (International)	550 West Lake Park Boulevard Houston, TX 77079-2696	Bruce N. Erickson Marketing Advisor Tel: (713): 556 4128	Gas Production and Resource Assessments
2.	Bureau of Economic Geology University of Texas	University Station Box X Austin, TX 78713-8924	Andrew Scott Research Associate Tel: (512) 471-1534	Gas Production
3.	CD Exploration, Inc.	5485 Beltline Rd. STE 280 Dallas, Texas 75240	James W. Akers Mining Engihneer Tel: (214) 392-1880	Gas Production
4.	Conoco, Inc.	P.O. Box 2197 Houston, TX 77252	John Oehler Tel: (713) 293-6292	Gas Production
5.	CONSOL, Inc.	Route 1, Box 119 Morgantown, WV	Pramod Thakur Tel.: (304) 983-3207	Gas Production and Resource Assessment
6.	Enron Exploration Company	1400 Smith Street Houston, TX 77002	J. Bradley Williams Director, Oil & Gas Ventures Tel: (713) 853-4777	Gas Production
7.	GeoMet, Inc.	1826 3rd. Ave., North Suite 301 Bessemer, AL 35020	Bret Camp Senior Vice President Tel: (205) 425-3855	Gas Production
8.	Gustavson Associates	5757 Central Avenue Suite D Boulder, CO 80301	John B. Gustavson President Tel: (303) 443-2209	Gas Production
9.	Halliburton Energy Services	Halliburton Center Suite 2300, 5151 San Flipe Houston, TX 77056	Bruce D. Thomas Regional Technical Manager Tel: (713) -624-2000	Gas Production
10.	ICMG / E.L. Lasseter & Associates	3610 Watermelon Road Suite 104 Northport, AL 34576	Edward L. Lasseter President Tel: (205) 759-2046	Gas Production, Project Development

GAS PRODUCTION AND RESOURCE ASSESSMENT				
	Name	**Address**	**Contact Person**	**Area(s) of Expertise**
11.	Jim Walters Resources, Inc.	P.O. Box 133 Brookwood, AL 35444	Charles Dixon, Senior Vice President, Engineering Tel.: (205) 554-6106	Gas Production and Resource Assessment
12.	LAHD Energy, Inc.	P.O. Box 2185 Granbury, TX 76048	David Elliot Tel: (817)- 326-2562	Gas Production
13.	Lapp Resources, Inc.	4900 Sportsman Drive Anchorage, AK 99502-4169	David W. Lappi President Tel: (907) 248-7188	Gas Production
14.	North American Drillers	Rt. 9 Box 106-C Morgantown, WV 26505	Bill Maloney President Tel: (304) 291-0175	Gas Production
15.	Pennsylvania State University	Hosler Building Pennsylvania State Univ. University Park, PA 16802	Jan Mutmansky Tel: (814) 863-1632 Raja V. Ramani Tel: (814) 863-1617	Gas Production and Resource Assessment
16.	Pocahontas Gas Partnership	P.O. Box 200 Mavisdale, Virginia 24627	Randall Albert Program Manager	Gas Production
17.	Raven Ridge Resources, Inc.	584 25 Road Grand Junction, CO 81505	Raymond Pilcher, President Tel.: (970) 245-4088	Gas Production and Resource Assessment
18.	Resource Enterprises	1245 East Brickyard Rd, Suite 170 Salt Lake City, UT 84106	Jeffrey Schwoebel, Vice President Tel. (801) 467-9981	Project Development, Gas Production and Resource Assessment
19.	The River Gas Corporation	511 Energy Center Blvd. Northport, AL 35476	Joseph Stevenson Vice President Tel: (205) 759 3188	Gas Production
20.	Taurus Exploration	2101 Sixth Avenue North Birmingham, AL 35203-2784	Walter Ayers, JR. Senior Exploration Geologist Tel: (205) 326-2774	Gas Production
21.	Union Texas Petroleum	1330 Post Oak Boulevard P.O. Box 2120 Houston, TX 77252-2120	R..D LoPiccolo Project Manager Tel: (713) 968-2522	Gas Production

GAS USE				
	Name	**Address**	**Contact Person**	**Area(s) of Expertise**
1.	Allison Gas Turbines	P.O. Box 420 Indianapolis, IN 46206	R.F. Merrion, Director Tel: (317) 230-411	Gas Use
2.	AquaTech Services, Inc.	P.O. Box 946 Fair Oaks, CA	John Tait, Principal Tel: (916) 723-5107	Gas Use
3.	Black Warrior Methane Corp.	P.O. Box 140 Brookwood, AL 35444	R.G. Sanders, President/ General Manager Tel.: (205) 554-6288	Gas Use
4.	Energy Systems Associates	300 Gateway Two Pittsburh, PA 15222-1402	Roger Glickert Tel: 412-392-2390	Gas Use
5.	Gas Separation Technologies	1667 Cole Blvd. Suite 400 Golden, CO 80401-3313	Jerry Comer Tel: (303)-232-0658	Gas Use
6.	ICF Incorporated	1850 K St., NW, Suite 1000 Washington, DC 20006	Mary DePasquale, Project Manager Tel.: (202) 862-1124 Fax: (202) 862-1144	Project Development; Gas Use
7.	International Fuel Cells	195 Governors Highway P.O. Box 739 South Windsor, CT 06074	Murdo J. Smith Tel: (203) 727-2269	Gas Use
8.	Michael Baker Engineering Group	4301 Dutch Ridge Road Beaver, Pennsylvania 15009	Rebecca Rannich Tel: (412) 495-4042	Gas Use
9.	Nitrotec Engineering	611-M Hammonds Ferry Road Linthicum, MD	Joseph D'Amico President Tel: (301) 636-7200	Gas Use
10.	Northwest Fuel Development	P.O. Box 35833 Canton, OH 44735	Dale R. Jesse V.P. Engineering Tel: (909) 736-1203	Gas Use
11.	Powerbridge	3710 Rawlins Street Suite 1060 Dallas, TX 75219	James R. Clemments President Tel: (214) 520-8177	Gas Use
12.	Solar Turbines Inc.	818 Connecticut Ave., NW	Peter A. Carroll	Gas Use

GAS USE				
	Name	**Address**	**Contact Person**	**Area(s) of Expertise**
		Suite 600 Washington, DC 20006-2702	Vice President Tel: (202) 293-4327	
13.	Stord, Inc.	309 Regional Road South Greensboro, NC 27409	Jeff Johnson Tel: (910) 668-7727	Gas Use
14.	UOP	13105 Northwest Freeway, Suite 600 Houston, TX 77040	Ronald J. Buras Account Representative Tel: (713) -744-2881	Gas Use
15.	Viking Systems	20270 William Pitt Way Pittsburgh, PA 15238	Jack Saluja President Tel: (412) 826-3355	Gas Use

APPENDIX B: DIRECTORY OF POSSIBLE FUNDING AGENCIES

Profiles of the following funding agencies are provided:

World Bank Agencies/Programs

International Bank of Reconstruction and Development (IBRD)

Global Environment Facility (GEF)

International Finance Corporation (IFC)

Multilateral Development Banks

European Bank For Reconstruction and Development (EBRD)

Inter-American Development Bank (IDB)

Asian Development Bank (ADB)

Africa Development Bank (AfDB)

U.S. Government Agency Programs

Trade Development Agency (TDA)

United States Agency For International Development (USAID)

Overseas Private Investment Corporation (OPIC)

Export-Import Bank (EXIMBANK)

U.S. Initiative on Joint Implementation

International Bank of Reconstruction and Development (IBRD)

Overview: The World Bank, established in 1945, comprises the International Bank for Reconstruction and Development (IBRD) and its affiliates: the International Development Agency, the International Finance Corporation (IFC), and the Multilateral Investment Guarantee Agency (MIGA). 155 member countries have subscribed capital to the Bank enabling it to finance its lending operations primarily from its own borrowing in capital markets. However, a substantial portion of the IBRD's resources also come from the retained earnings and the flow of repayment.

The World Bank finances capital infrastructure, such as roads and railways, telecommunications, and port and power facilities. However, the Bank's development strategy emphasizes investments that can directly affect the well-being of poor people in developing countries by making them more productive and integrating them as active partners in the development process. The Bank's efforts to reduce poverty include investments to improve education, ensure environmental sustainability, expand economic opportunities, strengthen population-planning, health and nutrition services, and develop the private sector.

The World Bank, through its affiliates IBRD, IDA, IFC, and MIGA, provides financial assistance to developing countries for social and economic development projects.

Criteria: The IBRD's charter requires that it: (1) lend for productive purposes to stimulate economic growth in developing countries; (2) pay due regard to the prospects of repayments; (3) make loans to governments or with guarantees from the government; (4) not restrict procurement to purchases from any particular member country; and (5) make lending decisions on economic considerations alone.

The IDA provides assistance to poorer developing countries, i.e., those with an annual per capita gross domestic product of $580 or less, expressed in 1989 U.S. dollars. Terms of the IDA loans are less stringent than those of "regular" IBRD loans.

The IFC is legally and financially a separate entity. Its purpose is to promote growth in the private sector of the less developed country economies, largely by taking equity positions in projects (see profile).

The MIGA encourages equity investment and other direct investment through the mitigation of non-commercial investment barriers. MIGA must: (1) offer investors guarantees against non-commercial risks; (2) advise developing member countries on policies, programs, and procedures related to foreign investment; and (3) sponsor a dialogue between the international business community and host governments on investment issues.

Contact Information: For further information, contact

The World Bank
1818 H Street, N.W.
Washington D.C. 20433 USA
Tel: 202/477-1234

Global Environment Facility (GEF)

Overview: The Global Environment Facility (GEF), an organization established by the United Nations Development Program (UNDP), the United Nations Environment Program (UNEP), and the World Bank, offers grants and concessional funds to developing countries for projects that are beneficial to the global environment. GEF funds are used to cover the difference between the costs of a project undertaken with global environmental objectives in mind, and the costs of an alternative project that the country would have implemented in the absence of global environmental concerns. GEF resources are available to projects that address the following four areas: climate change, loss of biological diversity, pollution of international waters, and depletion of the ozone layers. Listed below are several types of projects that the GEF may fund.

GEF will fund only those projects which cannot pay for themselves, i.e., whose project costs exceed project revenues. Therefore, GEF funding is ideal for conducting feasibility assessments.

- Technical assistance projects focused on human development, capacity building, training, and information sharing;
- Feasibility studies for investment projects and complex technical assistance projects;
- Small grants for community-based grassroots organizations and non-governmental organizations in developing nations; and
- Grants to investment projects to fund the incremental costs of achieving global environmental benefits.

Criteria: The GEF has established general criteria for all areas in which it may fund projects, as well as criteria specific to each of the four areas. The general points which are assessed include:

- Potential to benefit the global environment;
- Contribution to human welfare and sustainable development;
- Financability of project without GEF support;
- Scientific and technical basis of project;
- Plans for evaluation and dissemination of results;
- Host nation political, legal, economic, and administrative conditions under which the project must be executed
- Development of human and institutional resources;
- Plans for post-GEF project continuation; and
- Involvement of local communities.

Contact Information: For further information, contact the GEF at:

GEF Administrator, Environment Department
World Bank
1818 H Street, N.W.
Washington, DC 20433
Tel.: 202/473-1053
Fax: 202/477-0551

International Finance Corporation (IFC)

Overview: The International Finance Corporation (IFC) was established in 1956 to help strengthen the private sector in developing countries. IFC lends directly to the private sector. IFC aids private sector development by providing long-term loans, equity investments, guarantees and "stand-by financing", risk management and "quasi-equity instruments", such as subordinated loans, preferred stock, and income notes. IFC advisory services and technical assistance help private business increase their chances of success. Other relevant information on IFC is as follows:

- *Source of funds*: About 80% is borrowed in the international financial markets through public bond issues private placements and 20% is borrowed from IBRD;
- *Lending*: Each year, IFC approves about $4 billion in financing, including syndications and underwriting for private-sector projects in developing countries. The minimum amount of IFC support available is $10 million; and
- *Loan Conditions*: Interest rate on IFC loans and financing are based on market rates, which vary between countries and projects; maturity on loans ranges from 3 to 13 years.

IFC will provide loans and other financial instruments (equity investments, guarant- ees, etc.) to the private sector only. The minimum support provided by IFC is $10 million.

Criteria: Project proposals will be assessed on the basis of the following information:

- *Project Description*: brief description of the project and current status;
- *Sponsorship and Management*: history and business of sponsors, management arrangements, and technical arrangements;
- *Markets and Sales*: market orientation (export/domestic), production volumes and sales objectives, potential users and distribution channels, and relevant tariffs and protective measures;
- *Technical Feasibility*: equipment availability, labor and infrastructure facilities, resource accessibility, and potential environmental issues;
- *Financing Requirements*: breakdown of project costs, proposed financial plan, type of assistance sought, and expected profitability;
- *Government Regulations*: government controls, exchange controls, tax regulations, export/import licences, and price controls applicable to the project.

Contact Information: For further information, contact the IFC at:

International Finance Corporation
1850 I (Eye) Street, N.W.
Washington, D.C. 20433
Tel.: 202/477-1234
Fax: 202/477-6391

European Bank for Reconstruction and Development (EBRD)

Overview: The European Bank for Reconstruction and Development (EBRD) is a multinational institution set up with the specific aim of assisting countries of central and eastern Europe to develop into market-oriented economies. The EBRD provides financial assistance to both the private and public sector. The types of financial instruments offered include: loans; equity and quasi-equity investments; and guarantees. Other information about EBRD financing:

- *Minimum Loan Amount*: The minimum lending requirement for the Bank is ECU 5 million ($6.5 million, as of November 1995).
- *Interest Rates*: Interest rates are set at a margin over a market benchmark (usually LIBOR - London Interbank Offered Rate). Loans can be either variable rate or fixed rate;
- *Loan Term*: Maturities generally range from 5 to 10 years, depending on the individual operation requirements; and
- *Currency*: The EBRD lends in hard currencies - US dollar, the Deutschmark, and the ECU.

Criteria: The first step in the approval process is the *Concept Clearance* stage. Prospective borrowers approach the banking staff to advise on procedure and potential structuring options. Based on information on the scope of the project, financing requirements, and technical and economic/commercial aspects, the Bank will determine whether the project fits within its guidelines and strategies.

EBRD provides loans, equity, and guarantees to countries of central and eastern Europe that are developing into market-based economies.

If the project is cleared, a *Mandate Letter*, defining the legal requirements for entering to a relationship with the Bank, is signed and an *Operation Leader* is assigned as the key Bank contact for the project. The next stage is the *Initial Review* which requires detailed project information, including:

- detailed description of the enterprise, project, and key personnel;
- financial statements audited to international standards;
- financial projections about the viability of the project;
- regulations applicable to the project; and
- assessment of the environmental impact of the project.

Once the project has cleared Initial Review, it has to pass Final Review by the Bank's Operation Committee. This evaluation process covers financial, legal, economic , technical, and environmental issues.

Contact Information: For further information, contact:

EBRD, One Exchange Square
London EC2A 2EH, United Kingdom
Tel: 44 71 338-6282
Fax: 44 71 338-6102

Inter-American Development Bank (IDB)

Overview: The Inter-American Development Bank (IDB) is a multilateral development bank created to help accelerate the economic and social development of its member countries in Latin America and the Caribbean. The IDB provides the following types of assistance to its member countries: loans and other financial instruments; concessional funds for needier countries (through its Fund of Special Operations); and technical assistance to strengthen regional development institutions and help identify and implement investment projects. Other relevant information about the IDB is as follows:

- *Extent of Financing*: The IDB finances a certain percentage of project costs, ranging from 50% for more economically developed countries to 80% for poorer countries.
- *Loan Conditions*: Interest rates on IDB loans and financing are based on market rates, which vary between countries and projects; maturity on loans ranges from 15 to 25 years.
- *Capital Resources*: The IDB has a capitalization of over $100 billion that can support a level of annual lending of over $7 billion .

IDB provides loans to governments and private sector agencies for social and economic development projects in Latin America and the Caribbean. Grants are available for poorer member countries.

Typical borrowers of IDB funds include governments, ministries, or an agency or utility under a ministry. The borrower makes the key decisions on awarding contracts for engineering, design, project management, works construction, and purchase of capital goods. While governments and related agencies are the primary recipients of IDB funds, private sector enterprises too are eligible for some forms of assistance.

The IDB has an Environmental Division that monitors the environmental component of the Bank's operations and develops loans and technical assistance packages specifically directed towards protecting the environment.

Criteria: The following analyses are conducted to evaluate project proposals:

- *Institutional*: borrower's administrative and operational capability to carry out the project;
- *Technical*: technical equipment, labor, and infrastructure required;
- *Socio-economic*: social and economic costs and benefits, impacts on trade, income distribution, production, and employment; and
- *Environmental*: environmental impacts of the project.

Contact Information: For further information, contact:

Inter-American Development Bank
1300 New York Avenue, N.W.
Washington D.C. 20577 U.S.A
Tel: 202/623-1000
Fax: 202/623-3096

Asian Development Bank (ADB)

Overview: Established in 1966, the Asian Development Bank (ADB) is a multilateral development bank whose primary objective is poverty alleviation through sustainable economic growth in Asia. The Bank has 35 developing member countries, of which China, India, and Indonesia are the largest recipients. ADB assistance is channeled into the following sectors: agriculture and agro-industry; energy; industry and non-fuel minerals; financial services; transport and telecommunications; social infrastructure (e.g., education, health); and urban development.

Typical borrowers of ADB funds include governments, ministries, or an agency or utility under a ministry. The borrower makes the key decisions on awarding contracts for engineering, design, project management, works construction, and purchase of capital goods. While governments and related agencies are the primary recipients of ADB funds, private sector enterprises too are eligible for some forms of assistance. For private sector support, a project must play a catalytic role in the development of the country. For such projects, ADB assistance is limited to 50% of project costs or up to $50 million, whichever is less. The minimum loan is $5 million.

ADB provides loans for the economic and social advancement of developing member countries. Grants are available through special funds established by the ADB (e.g., ADF, ALGAS).

The financial resources of the Bank consist of ordinary capital resources comprising subscribed capital from member countries, reserves and funds raised through borrowings; and Special Funds, including the Asian Development Fund, which is made up of contributions from member countries and other accumulated income; and the ALGAS fund, which is designed to support GHG mitigation activities in developing member countries.

Criteria: The projects or programs are analyzed in terms of:

- the borrower's capacity to finance and administer the project;
- its economic, technical, and environmental feasibility; and
- its social and economic benefits to the recipient country.

Contact Information: For further information, contact:

Asian Development Bank
Office of the Environment and Social Development
6 ADB Avenue, 1501 Mandaluyong City
0401 Metro Manila, Philippines
Tel.: 632/813-2148
Fax: 632/741-7961

African Development Bank (AfDB)

Overview: The African Development Bank (AfdB) is a multilateral development bank whose primary objective is to finance economic and social development in African countries. It achieves this objective through the provision of: loans and other financial instruments; technical assistance and institutional support; and mobilization of external resources for investment in Africa. Grants and other concessional funds are allocated for the poorest countries through the African Development Fund (ADF) and the Nigeria Trust Fund (NTF). The main criteria for defining the poor countries is GNP per capita. The loan terms are as follows:

Terms	AfDB	ADF	NTF
Interest Rate	Variable	None	4%
Service Charge	1%	0.75%	0.75%
Repayment Period	20 years	50 years	25 years
The interest rate is reviewed every 6 months. As of June 30, 1995, the rate was 7.42%			

AfDB provides loans for the economic and social advancement of African countries. Grants are available for the poorer countries through the Africa Development Fund and the Nigeria Trust Fund.

Typical borrowers of AfDB funds include governments, ministries, or an agency or utility under a ministry. While governments and related agencies are the primary recipients of AfDB funds, private sector enterprises too are eligible for some forms of assistance. For private sector support, AfDB assistance is limited to a third of project costs. The size of private sector loans are generally in the $100,000 to $10 million range.

Criteria: The AfDB approves projects or program financing only on the basis of appraisal reports prepared and submitted by the Bank's own staff, even where a project have been previously appraised by other co-financing institutions. The appraisal process accounts for the following:

- the borrower's administrative and operational capability to carry out the project;
- technical equipment, labor, and infrastructure required and available; and
- social and economic costs and benefits.

Contact Information: For further information, contact:

African Development Bank
01 BP 1387 Abidjan 01
Cote d'Ivoire, Africa
Tel: 225/20 41 18
Fax: 225/20 40 06

Trade Development Agency (TDA)

Overview: Established in 1980, the U.S. Trade Development Agency (TDA) is a government organization that promotes U.S. exports by providing grants for feasibility studies for large development projects in developing and middle income countries. The purpose of these grants is to provide U.S. firms with the opportunity to undertake feasibility studies for large overseas projects, thereby increasing the chance that they will be involved in project implementation. TDA grants the funds on the condition that U.S. firms are utilized to conduct the study. TDA is currently involved in: energy, environment, mining and minerals development, health care, manufacturing, telecommunications, transportation, water resources, agriculture, and aviation.

There are two types of studies which the TDA may fund: (1) feasibility studies for projects in which U.S. companies intend to make equity investments, and (2) feasibility studies for public sector projects. Before TDA funds a feasibility study, experts are hired to develop reports regarding the feasibility study and the project to be implemented at the conclusion of the study. If the TDA decides to fund the feasibility study, it asks interested firms to submit proposals. The host government decides which of the competing companies will undertake the study.

TDA will provide grants to conduct feasibility studies in developing countries on the condition that U.S. firms be hired to conduct the study. The average grant size ranges from $300,000 to $400,000.

The agency may provide up to one million dollars per study, although the average grant amount ranges between $300,000 and $400,000. While up to 20 percent of the TDA funding may be used to pay subcontractors in the host country, the remainder must be used for services sourced in the U.S.

Criteria: All feasibility study proposals must include the following information: project description; U.S. export potential; information on host country partners; evidence of the host nation's commitment to the project; justification for why TDA funding is needed; a financial analysis of the project; an assessment of foreign competition for project implementation; and the impact of the project on U.S. labor. A few of the most important criteria include:

- The project must be a development priority for the host country.
- The export potential of the project must be significantly greater than the cost of TDA assistance.
- The procurement process must be open to U.S. firms.

Contact Information: For further information, contact the TDA at:

Trade Development Agency
Room 309, SA-16
Washington, D.C. 20523-1602
Tel.: 703/875-4357
Fax: 703/875-4009

U.S. Agency for International Development (USAID)

Overview: USAID's Office of Energy, Environment, and Technology assists developing countries and emerging economies find market-oriented solutions to their energy and environmental problems. The Office's programs address three main issues: 1) high rates of energy demand and economic growth accompanies with lack of energy, especially in rural areas; 2) financial problems, including lack of investment capital; and 3) growing environmental threats, especially global climate change, acid rain, and urban air pollution. The Office focuses its efforts in the following areas:

- Energy Efficiency
- Renewable Energy Project Development
- Private Sector Energy Development
- Energy Technology Innovation
- Training/Technical Assistance

USAID's Office of Energy, Environment, and Technology provides grants and technical assistance to developing countries for meeting their energy and environmental needs.

The Office has two main strategies for achieving its objectives:
- *Tapping U.S. Know-how:* The Office arranges cooperative relationships between developing countries and U.S. energy and environment industries, multilateral development banks, and non-governmental organizations; and
- *Promoting Private Sector Initiatives*: The Office assists countries put in place market-oriented policies and institutions to support private environment and energy initiatives.

The types of assistance offered include: financing (loans, investment funds); policy, legislative, and regulatory development assistance; reports and workshops on market conditions and opportunities; and engineering and other technical assistance.

Criteria: The criteria for USAID fund varies on a case-by-case basis. However, the following points are generally considered in the project evaluation process:

- Potential of the project to meet its goals
- Contribution to human welfare and sustainable development;
- Scientific and technical basis of project;
- Host nation political, legal, economic, and administrative conditions

Contact Information: For further information, contact:

U.S. AID: Office of Energy, Environment and Technology
Room 508, SA -18
Washington D.C. 20523-1810
Tel.: 703/528-4488
Fax: 703/528-2280

Overseas Private Investment Corporation (OPIC)

Overview: OPIC is a U.S. government agency that provides loans, loan guarantees, and political insurance to American business ventures in the developing world. These services are provided to those projects that are economically and technically sound but are unable to receive sufficient financing or insurance from the commercial sector. Projects supported by OPIC must have a positive effect on the U.S. economy, be financially sound, and provide significant benefits to the social and economic development of the host nation. While OPIC does not require the foreign enterprises to be owned entirely by U.S. interests, generally the U.S. investor is expected to own at least 25 percent of the equity in the project. Neither financing nor insurance will be available for investments in business that are majority owned by a foreign government. Furthermore, only the portion of the investment made by a U.S. investor may be insured by OPIC.

OPIC's finance division offers loans and loan guarantees. Loans are generally granted to small U.S. businesses and range from $2 million to $10 million. For larger projects, in the $10 million to $75 million range, loan guarantees are provided. OPIC's insurance division offers coverage against the following three risks: currency inconvertibility, expropriation, and political violence. Other investor services provided by OPIC include investment missions and outreach activities.

OPIC will provide loans and loan guarantees for projects in developing countries that US enterprises have a stake in. The project must have a positive effect on the US economy.

Criteria: Eligible projects must meet the following criteria:

- Positive effect on the U.S. economy: Projects must demonstrate positive balance of payments and employment effects on the U.S. economy;
- Development contribution: Projects must benefit the economic and social development of the host nation;
- Performance requirements: OPIC will not become involved in any project subject to performance requirements that will reduce the potential for U.S. trade and employment benefits.
- Environmental impact: the project should not have an unreasonable or major adverse impact on the host nation's environment; and
- Worker's rights: All projects supported by OPIC must meet internationally recognized standards with regards to worker's rights.

Contact Information: For further information, contact OPIC at:

Overseas Private Investment Corporation
1100 New York Avenue, N.W.
Washington, D.C. 20527
Tel.: 202/336-8799
Fax: 202/408-9859
Fax-ion-Demand System: 202/336-8700

Export-Import Bank (EXIMBANK)

EXIMBANK provides loans and guarantees to foreign buyers of US goods and services. The bank covers up to 85% of the US export value.

Overview: The Export-Import Bank (EXIMBANK) of the United States is a U.S. Government agency that facilitates the export financing of U.S. goods and services to foreign buyers. EXIMBANK supports export sales by providing direct loans to foreign buyers, guarantees to U.S. and foreign commercial lenders for credit risk protection, export credit insurance, to U.S. exporters against failure of foreign buyers to meet payment obligations, and pre-export financing for small business through its Working Capital Guarantee Program.

Relevant information about EXIMBANK loans includes:

- *Types of Loans*: EXIMBANK provides both direct and intermediary loans. Direct loans are provided to foreign buyers of U.S. exports; intermediary loans fund parties that extend loans to foreign buyers;
- *Interest Rates*: EXIMBANK loans carry the lowest interest rate permitted under the OECD Arrangement for the market and term. , this rate is the OECD Commercial Interest Reference Rate (CIRR), which changes monthly. For relatively poor countries, lower interest rates loans are available; and
- *Extent of Assistance*: Loan and guarantee programs cover up to 85% of the U.S. export value.

Criteria: Transactions are evaluated in terms of the creditworthiness of the buyer, the buyers country, and the exporters ability to perform. In general the following information is assessed:

- *Financial Data*: Balance sheets and income statements for the past 3 years for the buyer and any guarantor(s);
- *Credit Data*: at least two credit references are checked;
- *Technical Feasibility*: technical characteristics of the project, breakdown of costs, project scheduling, participant profiles, environmental aspects, etc.; and
- *Applicant and Exporter Data*: Evidence of the applicants ability to implement the requested loan or guarantee.

Contact Information: For further information, contact:

Export-Import Bank of the United States
Credit Information Section
811 Vermont Avenue, N.W.
Washington D.C. 20571
Tel: 202/377-6336
Fax: 202/566-7524
Fax -on-Demand system: 800/424-5201

U.S. Initiative on Joint Implementation (USIJI)

Overview: The U.S. announced its Initiative on Joint Implementation (USIJI) in October 1993. This voluntary pilot program provides recognition and select technical assistance to U.S. greenhouse gas reduction projects in other countries. This program allows U.S. companies to reduce emissions at a lower cost than would be incurred by projects undertaken at home. U.S. government agencies involved in this program include the Environmental Protection Agency, the Department of Energy, the Department of State, the Agency for International Development, the Department of Commerce, and the Department of Agriculture, among others.

The benefits of this program to U.S. participants include public recognition, including use of the USIJI logo and media events, and technical assistance. This assistance may include help in obtaining host country acceptance of the project, identifying or developing methodologies for establishing a greenhouse gas emissions baseline, and guidance on how to monitor and verify emissions reduced or sequestered. For foreign participants, the benefits may include technology transfer, investments in technologies that benefit the global environment as well as the local economy, employment opportunities and training, and local environmental benefits.

Projects that meet the USIJI criteria are likely to attract US investors seeking the recognition and other amenities available to participants in the USIJI program.

Eligible program participants include U.S. citizens, U.S. companies, and any U.S. federal, state, and local government entity. Foreign partners may include private citizens and public entities of all nations that have ratified the United Nations Framework Convention on Climate Change (UNFCCC).

Criteria: Projects accepted into the USIJI program must:

- obtain host country acceptance;
- prove that the specific measures to reduce or sequester greenhouse gases are being undertaken as a result of USIJI or in its anticipation;
- provide sufficient and reliable data to establish a baseline of current and future greenhouse gas emissions;
- provide for the tracking of emissions reduction or sequestration;
- allow for external verification of emissions reduction or sequestration;
- identify benefits or negative effects on the economic and social development of the host country and on the local environment.

Contact Information: For further information, contact:

The USIJI Secretariat
600 Maryland Avenue, SW Suite 200 East
Washington, D.C. 20585
Tel.: 202/426-0072
Fax-on-Demand System: 202/260-8677