Identifying U.S. Coal Mine Methane Project Opportunities

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US EPA Coalbed Methane Outreach Program
Roundtable for CMM Project Developers & Financiers
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Presentation Overview

1. Introduction and Background
2. US CMM Sector Today
3. CMM Opportunities in the US
4. What We Do: CMOP Activities
5. CMOP Tools and Resources
6. Summary

1. Introduction and Background

Coalbed Methane Outreach Program

- Voluntary program since 1994
  - We don't have any sticks, just carrots!
  - Part of EPA's Climate Change Division

- Our mission
  - Promote the profitable recovery and use of coal mine methane (CMM) by working cooperatively with coal companies and related industries
- Our focus
  - Greenhouse gas emission reduction opportunities: CMM rather than coalbed methane (CBM)

1. *Introduction and Background*

Coal Mine Methane

- Methane is an important greenhouse gas that contributes to global climate change
  - Global warming potential is 23 times greater than carbon dioxide (over 100 years)
  - Shorter average atmospheric lifespan than carbon dioxide
- CMM vented to the atmosphere wastes a clean-burning energy resource

1. Introduction and Background

Types of CMM

Recovery of CMM from diverse sources

Ventilation Air Methane

Ventilation shafts produce large volumes of very dilute methane (~ 1% or less)

Drainage from Underground Mines

Surface Mine Methane

Abandoned (closed) Mine Methane

In-Mine boreholes and/or Gob or Goaf gas

Drainage during or after mining yields low to medium quality CMM

Pre-Mine Drainage

Pre-mine drainage qualifies as CMM if coal is part of mine's production plan

Photos Courtesy Various Sources

CMM end-uses depend on gas quality

High-Quality Gas

- Natural gas pipelines
- Vehicle fuel (LNG)

upgrade

Medium-Quality Gas

- Power generation
- Combined heat & power
- Coal drying
- Boiler fuel
- Industrial applications
- Heating or cooling applications
- Fuel cells

Low-Quality Gas & Ventilation Air Methane

- Oxidation
- Combustion air
- Lean burn turbines

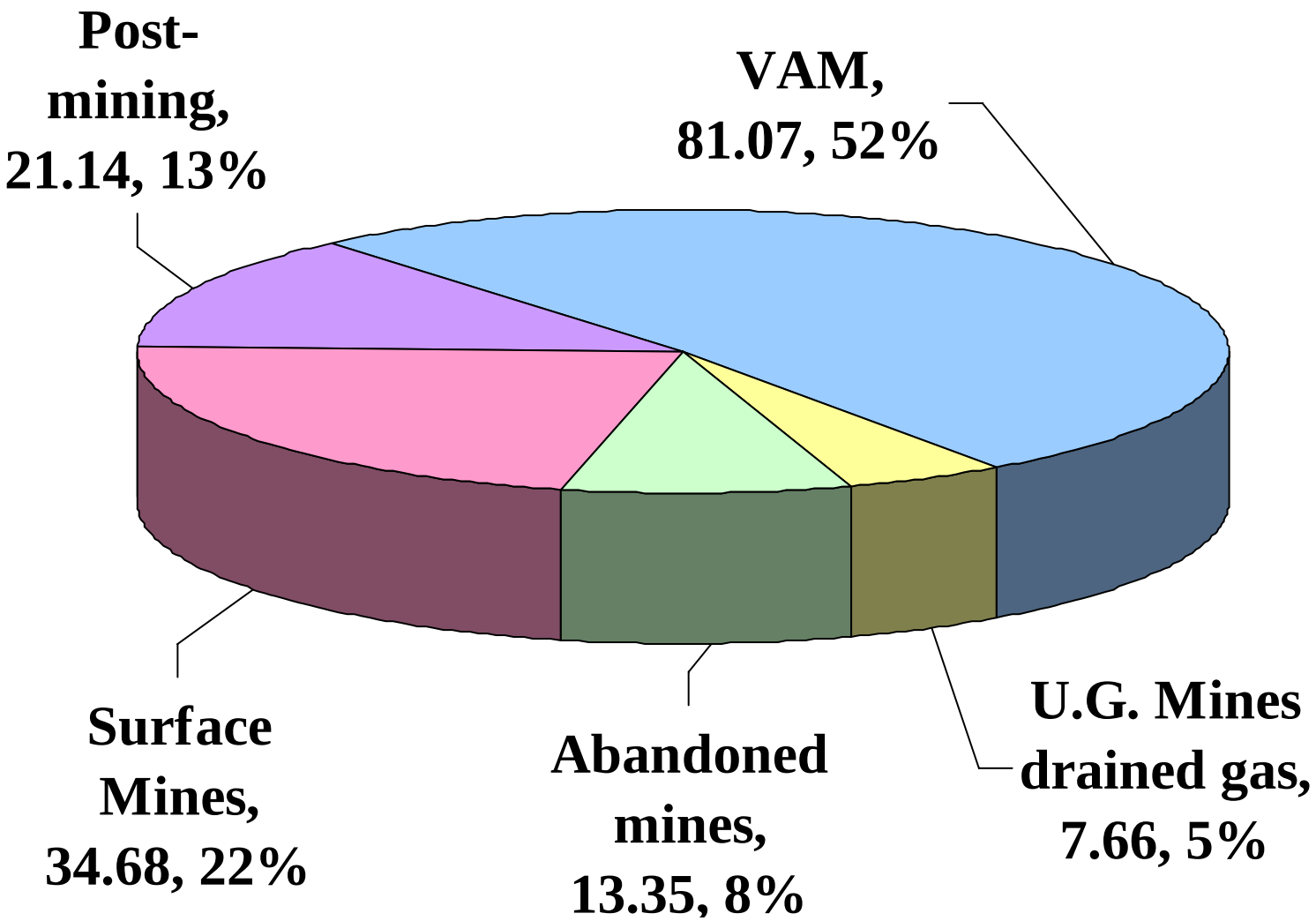
2. US CMM Sector Today

US CMM Emissions

- 2006 US coal production: 1.2 billion tons
  - 612 underground mines → 359 million tons
  - 812 surface mines → 803 million tons
- 2006 US CMM emissions:
  - EPA develops US GHG Inventory
    - Research, develop and refine methodologies
  - Active mines: 144.5 bcf = 58.4 MMTCO2eq
  - Abandoned mines: 13.4 bcf = 5.4 MMTCO2e
  - Account for 1% of all US anthropogenic CO2e emissions
    - CMM ~ 11.5% of all US anthropogenic CH4 emissions

2. US CMM Sector Today

2006 US CMM Emissions (bcf)



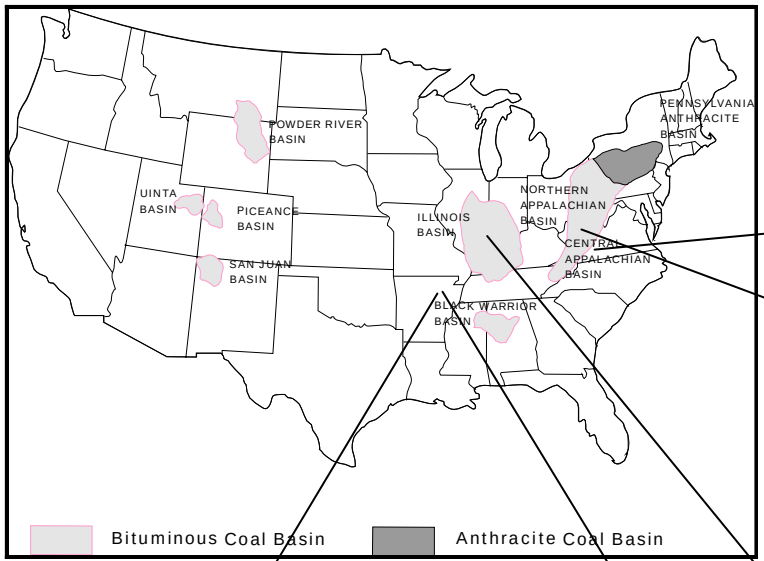
2. US CMM Sector Today

GHG Emissions avoided: Existing CMM projects

- 50 Bcf of CMM recovered and utilized (2006)
  - Active Underground Mines: 46.2 bcf
  - Abandoned Mines: 3.4 bcf
  - *No VAM reductions achieved yet*
- Current US CMM Projects
  - 14 active underground coal mines
  - ~ 33 abandoned underground mines
- CMM projects are larger in scale, complexity compared to landfill gas projects

2. US CMM Sector Today

Examples of existing projects



CONSOL
VP and Buchanan Mines
Integrated CMM projects: pipeline, 88 MW power plant, coal drying

Shoal Creek and Oak Grove
Natural gas pipeline injection

Pinnacle Mine
Pipeline injection project uses surface directional drilling to maximize gas production

CONSOL
Bailey Mine
Microturbine (70 kW)

JWR Blue Creek Mines
BCCK Cryogenic plant converts gob gas into pipeline quality gas

2. US CMM Sector Today

Existing projects overview

- Active underground mines
  - All projects currently use drained gas
    - Pre-mine drainage and/or gob wells
  - Nearly all located in Eastern US
  - Most utilize pipeline injection
    - With or without gas upgrade
  - Other (auxiliary) uses
- Abandoned mine projects
  - Many different end-uses
  - Many located in Illinois basin
- Surface mine projects
  - 1 project: North Antelope Rochelle Mine, PRB

2. US CMM Sector Today

Keys to project success

- Sufficient gas resources and understanding of gas production over time
- Successful integration with mining operations
- Clarification of gas rights
- Strong and consistent gas (or electricity) price signals
- Reasonable access to gas (or electricity) markets

3. US Project Opportunities

- Total Emitted 2006 (excl.post-mining) = 136.8 Bcf
- Active Mines
  - Degas (http://www.epa.gov/coalbed/docs/profiles_2003_final.pdf)
  - VAM (http://www.epa.gov/coalbed/docs/2008_mine_vent_symp.pdf)
- Abandoned Mines
  (http://www.epa.gov/coalbed/docs/cmm_recovery_opps.pdf)
- Surface Mines
  (http://www.epa.gov/coalbed/docs/cmm_recovery_opps_surface.pdf)

3. US Project Opportunities

Assessing "Gassy" Mines:

General Rules of Thumb for Underground Mines

- Gas Content = quantity of gas contained in one ton of coal (m^3/metric ton, scf/ton)
  - >75 scf/ton: mine considered "gassy"
  - 20 to 25 scf/ton: gas content of coal can be economic project under certain conditions
- Specific Emissions = quantity of methane liberated per ton of coal mined
  - 150 to 200 scf/ton = minimum for gassy mine
- MSHA defines gassy underground mines for regulatory purposes as 100,000+ scf/day of methane
- Other factors: mine size and life expectancy, mining method, drainage efficiency

3. US Project Opportunities

Active Underground Mines - Degas

- 7.7 Bcf available for utilization (2006)
- Many mines are gassy and can install drainage systems (even when not required by MSHA)
  - ~23 US mines currently use drainage systems
  - New systems installed as mines get deeper, more gassy
- Challenges:
  - Majority of vented drained gas is on federal lands (ownership)
  - Rugged terrain, limited access to pipeline, regulatory restrictions

3. US Project Opportunities

Western Mines: Good Near-term Candidates

STATE	MINE	OWNER/ OPERATOR	STATUS
Utah W	est Ridge Carbon County Piceance Basin	Utah American Energy (Murray Energy)	• Emissions of 3.6 m mcf/d (VAM) • Longwall operation
Colorado W	est Elk, Gunnison Cty., Uinta Basin	Mountain Coal (Arch Coal)	• Emissions of 9.1 m mcf/d (drained) • Longwall operation
Utah	Dugout Mine Carbon County Piceance Basin	Canyon Fuel (Arch Coal)	• Emissions of 1. 7 m cf/d (0.4 mmcf/d drained) • Longwall operations

3. US Project Opportunities

Active Underground Mines - VAM

- VAM can be mitigated or utilized (81 Bcf emitted in 2006)
  - All underground mines have ventilation systems
  - Rule of thumb: >0.6% methane concentration for an economical oxidizer project. Drained gas can be blended in to boost lower methane concentrations. Ideally, ~0.9% for maximum output and revenue.
  - Technology available now
  - Clearly "additional"
- Challenges:
  - Newer technology - mines are still learning about their options
  - Adequate space for equipment footprint required

3. US Project Opportunities

Abandoned Underground Mines

- Many opportunities to recover and utilize methane from abandoned (closed) mines
  - 13.4 Bcf emitted (available) in 2006
  - Additional mines closed every year
- Challenges:
  - Identifying owner and acquiring rights, particularly for mines closed before 1972
  - Predicting future gas resources over time

Factors Influencing Abandoned Mine Emissions

- Time since abandonment
- Gas content & adsorption characteristics of coal
- CH_4 flow capacity of mine
- Mine flooding
- Presence of vent holes
- Mine seals

3. US Project Opportunities

Abandoned Mines

Basin	Mine Name	Estimated Emissions at Abandonment (mmcf/day)	Estimated Power Generating Capacity (MW)*	Estimated Pipeline Sales Potential (Bcf)*
Piceance	Sanborn Creek	5.0	7.6	0.7
Piceance	Hawk's Nest**	NA	NA	NA
Piceance	Bowie No. 1	0.11	0.6	0.06
Uinta	Willow Creek	2.0	3.0	0.30
Uinta	Kenilworth**	NA	NA	NA
Illinois	Orient 3**	NA	NA	NA
Illinois	Orient 6	0.7	1.0	0.1
Illinois	Nasson 20**	NA	NA	NA
Illinois	Little Dog**	NA	NA	NA
Illinois	Superior 1**	NA	NA	NA
Illinois	Superior 2**	NA	NA	NA
Illinois	Superior 3**	NA	NA	NA
Illinois	Superior 4**	NA	NA	NA
Illinois	Baker	1.51	2.3	0.2

* Assuming 40% recovery efficiency.

** Emissions from the pre-1972 mines are characterized using the methodology described in USEPA (2004)

3. US Project Opportunities

Active Surface Mines - Degas

- Opportunities exist at surface mines: 34.7 Bcf emitted in 2006
  - Gas content of 20 - 25 scf/ton can be economic project *if* seam is thick and permeable
  - Powder River Basin (PRB) produces > 50% of all surface- mined coal in U.S.
    - Extensive pipelines and other infrastructure
    - Transparent & well-developed ownership policies on PRB federal lands
- Challenges:
  - Limited information on current activities and future opportunities
  - Distinguishing between CBM and CMM may be unclear
  - Gas ownership can vary State to State, and from Private to Federal lands

3. US Project Opportunities
Surface Mines

Mine Name	2007 Coal Production (million short tons/year)	2007 Estimated CMM Emissions (million cf/year)
Jacobs Ranch	38.1	1,524
Black Thunder	86.2	3,448
North Antelope Rochelle	91.5	3,661
Caballo	31.2	1,247
Cordero Rojo Complex	40.5	1,619
Antelope	34.5	1,379
Eagle Butte	25.0	999
Belle Ayr	26.6	1,064
Buckskin	25.3	1,011
Rosebud	12.6	503

4. CMOP Activities

Our mission

To work with the private sector to reduce CMM emissions cost-effectively

What we do, in a nutshell:

- Identify profitable opportunities for CMM recovery
- Identify and help overcome market, regulatory, technical barriers
- Offer technical and analytic support where appropriate
- Conduct direct outreach to coal mines

4. CMOP Activities

CMOP Outreach Activities

- Coordinate with sister federal agencies
- Demonstrate cutting-edge technologies
- Internationally, we play a pivotal role in supporting Methane to Markets Partnership
- Inform and educate our constituents about coal mine methane
- Provide and support venues for industry information sharing and networking

Come to our conference!

5. CMOP Tools & Resources

Visit the CMOP website

- Everything we produce is found on our website!
- Documents: technical reports and more
  - Profiles of project opportunities
  - Leading technology updates
  - CMOP Newsletters and weekly updates
  - Introductory and background material
- Tools
  - Database of US and international CMM projects
  - EIA CBM Maps
  - Unit converters and GHG equivalencies calculator
- CMOP Network contacts
- Useful links
- Future conferences and events

Methane Home

CMOP Home
Basic Information
Accomplishments
Network Contacts
Join the Network
Documents, Tools & Resources
Newsroom
Workshops / Conferences
International Activities
Frequent Questions

Documents, Tools & Resources

CMOP strives to provide users with the necessary tools to maximize profitable methane reductions. Support documents are available for categories of general information, U.S. activities, international activities, technical guidance, and finance and policy.

Documents

- Program Information - This section contains overview materials about CMOP, our accomplishments, and coal mine methane (CMM) projects generally.
- Identifying Project Opportunities - This section contains information about potential U.S. CMM projects, including conventional projects using drained gas at active underground mines, abandoned coal mines, and ventilation air methane.
- Implementing Projects - This section contains technical information about aspects of recovering and utilizing CMM, including degasification techniques, end use technologies, and flaring.
- Finance and Policy - This section contains information about financing CMM projects, regulatory barriers to these projects, and emissions inventories and methodologies.
- International - This section contains country-specific information about CMM projects and opportunities in key coal producing countries, including China, Russia, Poland, and Ukraine.
- Archived Documents - This section contains historical program reports in the above categories that contain useful information but may no longer be current.

Tools and Resources

- The International Coal Mine Methane Projects Database EXIT Disclaimer contains information on over two hundred coal mine methane recovery and utilization projects operating, in development, or planned around the world.
- Department of Energy (DOE) domestic energy prices EXIT Disclaimer This link offers access to DOE's Short-Term Energy Outlook, an annual document that contains various data on domestic electricity and natural gas prices.
- United States Coalbed Methane maps EXIT Disclaimer The two maps accessible from this DOE Web site show the location and size of CBM fields, CBM production, coal basins, and both abandoned and active gassy coal mines.
- Our Interactive Unit Converter allows you to convert figures among the many different units of measure in reference to CMM, power generation, etc.
- The Natural GasStar Program also offers a useful Methane Unit Converter (PDF) (2 pp, 76K) guide for its partners.
- The EPA's Greenhouse Gas Equivalencies Calculator allows you to translate greenhouse gas reductions into a more commonplace term.

Documents, Tools & Resources

- Program Information
- Identifying Project Opportunities
- Implementing Projects
- Finance and Policy
- International
- Archived Documents

Popular Documents

- Identifying Opportunities for Coal Mine Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines (1999-2003) (PDF) (202 pp, 1.2MB, About PDF)
- Methane Emissions from Abandoned Coal Mines in the U.S.: Emission Inventory Methodology and 1990-2002 Emissions Estimates (PDF) (90 pp, 678K, About PDF)
- Coal Mine Methane Global Overview, prepared by CMOP on behalf of the Methane to Markets Partnership Coal Subcommittee EXIT Disclaimer
- Technical Options Series
- Assessment of the World Market for Ventilation Air Methane (PDF) (132 pp, 1.5 MB, About PDF)

5. CMOP Tools & Resources

Join the CMOP Network

- Network Contacts List
  - Self-selected industry and government contacts
  - Sortable listing on our website
  - Allows CMOP to refer without recommending
- Join CMOP's Mailing List
  - Weekly email updates: CBM Notes
  - Quarterly newsletter: CBM Extra
  - Special announcements

International Projects Database

Methane to Markets International Coal Mine Methane Projects Database

Home | Find a Project | Submit a Project | Help

The Methane to Markets International Coal Mine Methane (CMM) Projects Database is designed to serve as the comprehensive repository of data and information on all CMM recovery and use projects in operation and development around the world. Project developers, technology vendors, investors, and other interested parties can use the database to come up to speed on the CMM sectors of several countries and to decide where and how to channel project resources. This database is also designed to provide a platform for the transfer of lessons learned from those involved in existing projects to those interested in developing future projects.

Currently, the database contains over 200 projects in 13 countries. In order to maintain this tool's accuracy and breadth, the Methane to Markets Coal Technical Subcommittee asks anyone with project knowledge to fill out a project submission form. Both new information on projects omitted from the database and additional information on already listed projects are welcomed. Thank you in advance for your contribution.

Find a Project to search for a project, view and export project details.

Submit a Project to download a project submission form.

The Flags displayed on the map above designate which countries have CMM data included in this database. For a list of all partner countries visit the Methane to Markets Web site.

The International CMM Database was developed by U.S. Environmental Protection Agency's (U.S. EPA) Coalbed Methane Outreach Program (CMOP) at the request of the Methane to Markets Partnership Coal Technical Subcommittee. Collecting CMM and using it in profitable and practical ways has a number of tangible benefits, including: improving worker safety, enhancing coal mine productivity, increasing revenues, and reducing greenhouse gas emissions from coal mines. Members of CMOP used publicly available resources and consulted with international CMM industry experts to compile the information listed in the database.

The Methane to Markets Partnership is a voluntary, non-binding framework for international cooperation to advance the recovery and use of methane as a valuable clean energy source from four sectors, including coal mining.

Frequent Questions >>

Disclaimer:

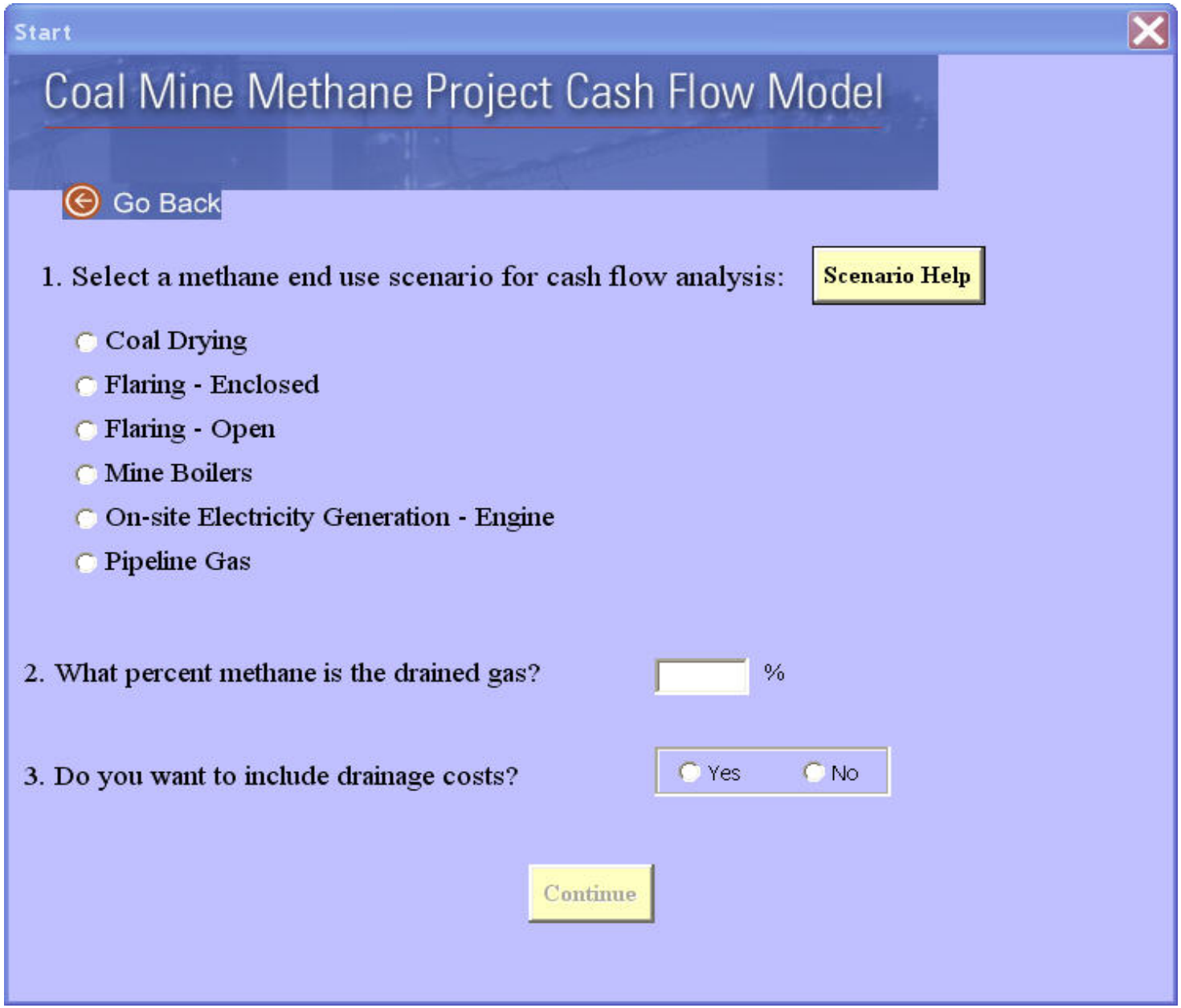
U.S. EPA does not:

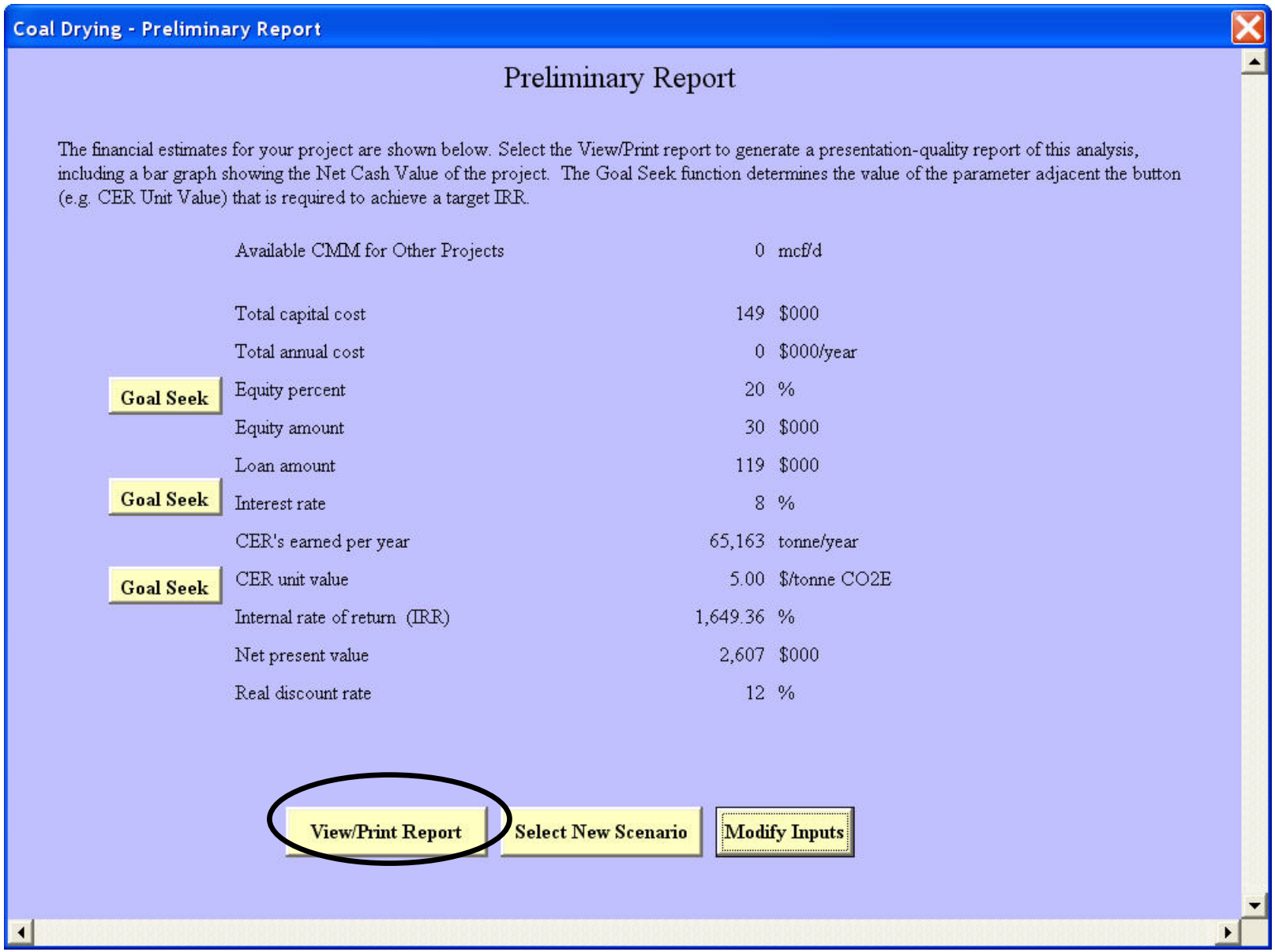
1. Make any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this database.
2. Assume any liability with respect to the use of, or damages resulting from the use of, any information disclosed in this database.

5. CMOP Tools & Resources

Exciting new development: Cost – Benefit Analysis Tool

- Web-based, first-cut cost/benefit analysis tool
- Under development for two years
  - "Beta version" available by end summer 2008
- Priorities
  - Attractive and user-friendly
  - Provides as many input default values and suggested ranges as possible
  - Can be manipulated with flexibility
  - Detailed and thorough User's Manual


Start
Coal Mine Methane Project Cash Flow Model
Go Back
1. Select a methane end use scenario for cash flow analysis:
Scenario Help
Coal Drying
Flaring - Enclosed
Flaring - Open
Mine Boilers
On-site Electricity Generation - Engine
Pipeline Gas
2. What percent methane is the drained gas?
%
3. Do you want to include drainage costs?
Yes
No
Continue


Coal Drying - Preliminary Report
Preliminary Report
The financial estimates for your project are shown below. Select the View/Print report to generate a presentation-quality report of this analysis, including a bar graph showing the Net Cash Value of the project. The Goal Seek function determines the value of the parameter adjacent the button (e.g. CER Unit Value) that is required to achieve a target IRR.
Available CMM for Other Projects 0 mcf/d
Total capital cost 149 $000
Total annual cost 0 $000/year
Goal Seek
Equity percent 20 %
Equity amount 30 $000
Loan amount 119 $000
Goal Seek
Interest rate 8 %
CER's earned per year 65,163 tonne/year
Goal Seek
CER unit value 5.00 $/tonne CO2E
Internal rate of return (IRR) 1,649.36 %
Net present value 2,607 $000
Real discount rate 12 %
View/Print Report
Select New Scenario
Modify Inputs

Summary

- CMOP's mission: promote cost-effective recovery and use of CMM to reduce GHG emissions
- We have
  - identified multiple opportunities in the US for profitable CMM recovery and use
  - developed a repository of technical, analytic reports and tools to assist project developers – all available on our website
- CMOP wants to help you!
  - We welcome your suggestions for future tools, resources and project support

www.epa.gov/cmop

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