Overview of Abandoned Mine Methane Activities: Project Development and Policy Issues

Workshop on Coal Mine Methane and Abandoned Mine Methane in the context of Sustainable Energy

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Presentation Outline

- AMM is an important emissions source
- Including AMM in national GHG emissions inventories
- Forecasting peak coal and AMM opportunity
- Preparing coal mines for AMM projects
- AMM policy and legal issues
AMM as an Emissions Source

- An abandoned coal mine can be a very large reservoir of methane and source of fugitive emissions
  - Gas is stored in the void volume of the workings
  - Gas is also stored in the coal remaining in contact with the void

- Abandoned mine gas has favorable characteristics
  - Generally contains between 50% and 90% methane, nitrogen, and with small amounts carbon dioxide
  - Just a few wells can drain large underground areas

- Abandoned mines are often nearby active underground mines and CMM projects
  - Combined AMM and CMM projects
AMM as an Emissions Source

Using decline curve method to estimate emission rates for AMM inventory or project

- IPCC Guidance includes AMM decline curve tables

![Graph showing emission decline over time](chart.png)

- 2 Years After Closing = 25% of Initial Emission Rate
- 10 Years After Closing = 11% of Initial Emission Rate
- 30 Years After Closing = 7% of Initial Emission Rate
- 50 Years After Closing = 5% of Initial Emission Rate
AMM as an Emissions Source

Decline curve not just theoretical!

Source: US EPA Inventory of Sources and Sinks 1990-2015
INCLUDING AMM IN NATIONAL GHG INVENTORIES
AMM Emissions Included in U.S. GHG Inventory

Source: US EPA Inventory of Sources and Sinks 1990-2015
Historical AMM Emissions and Recovery in the U.S.

Source: US EPA Inventory of Sources and Sinks 1990-2015
CMM and AMM Emissions Reported to UNFCCC

Emissions from Reporting Years 2005 and 2010

Source: UNFCCC National Inventory Report 2017
**AMM Emissions and Utilization Reported in GMI Country Profiles**

AMM Emissions and Utilization from 2005 and 2010

Source: UNFCCC National Inventory Reports & GMI CMM Country Profiles
Where are the Current AMM Projects Located?

Top AMM Producing Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of AMM Projects</th>
<th>Methane Emissions Avoided (million M³)</th>
<th>Primary Utilization Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>40</td>
<td>400</td>
<td>Electric Power</td>
</tr>
<tr>
<td>United States</td>
<td>20</td>
<td>185</td>
<td>Pipeline Sales</td>
</tr>
<tr>
<td>France</td>
<td>5</td>
<td>70</td>
<td>Industrial Use</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>20</td>
<td>45</td>
<td>Electric Power</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>10</td>
<td>25</td>
<td>Electric Power</td>
</tr>
</tbody>
</table>

Source: GMI CMM Country Profiles, 2015
Forecasting Peak Coal and AMM Opportunities
Forecasting Peak Coal and AMM Opportunities

What is Peak Coal?

– Generally defined as:
  • The point in time when production and/or consumption reaches its highest level prior to terminal decline (Hubbert’s peak theory)
– Forecasts for worldwide peak coal consumption range between 2010 to 2048
– 5 Largest coal producing countries in 2016 (million tons):
  • China – 3,411
  • India - 692
  • United States - 661
  • Indonesia - 434
  • Russian Federation - 385
Forecasting Peak Coal and AMM Opportunities

World Coal Production - 1981-2016

Source Data: BP Energy Outlook 2017
Forecasting Peak Coal and AMM Opportunities

### Peak Coal Forecast Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Outlook 2017, BP</td>
<td>Coal consumption expected to peak in the mid-2020s</td>
</tr>
<tr>
<td>International Energy Outlook 2017, U.S. DOE EIA</td>
<td>Peak consumption by 2025, then levels out through 2040</td>
</tr>
<tr>
<td>Coal Information: Overview 2017, IEA</td>
<td>World coal production declined in 2014 for the first time this century, likely peak 2020</td>
</tr>
<tr>
<td>New Energy Outlook 2017, Bloomberg</td>
<td>Global coal-fired power generation peaks in 2026</td>
</tr>
<tr>
<td>Global coal production outlooks based on logistic model, 2010, Höök, Zittel, Schindler, &amp; Aleklett</td>
<td>A plateau will be reached around 2025 and global production will decline after 2030</td>
</tr>
<tr>
<td>Forecasting coal production until 2100, 2009, Mohr &amp; Evans</td>
<td>Worldwide coal production will peak between 2010 and 2048</td>
</tr>
<tr>
<td>Energy Transition Outlook 2017, DNV GL</td>
<td>By 2022, if coal use has not already peaked</td>
</tr>
</tbody>
</table>
Forecasting Peak Coal and AMM Opportunities

Source: Höök et. al. 2010
Forecasting Peak Coal and AMM Opportunities

Source: EIA Coal Information: Overview 2017

World coal consumption
quadrillion Btu

Source: EIA Coal Information: Overview 2017
Forecasting Peak Coal and AMM Opportunities

Source: Mohr and Evans 2009
PREPARING COAL MINES FOR AMM PROJECTS
Preparing Coal Mines for AMM Projects

Things to Consider:
- Accessing sealed mining districts
- Installing gas piping underground
- Using the mine roadways as conduit for gas flow
- Verifying integrity of surface seals to prevent atmospheric air intrusion

Project considerations:
- Methane resource assessment, field testing
- Lead times for financing, gas leasing, project permitting, and equipment manufacture
Preparing Coal Mines for AMM Projects

AMM Recovery - Sooner is Better!
• AMM Emissions Forecast Using Decline Curve Estimate

![Graph showing AMM emissions forecast over different time periods.](image)

- **First 5 years**
- **Next 13 years**
- **First 10 years**
- **Next 27 years**
- **First 20 years**
- **Next 58 years**

Active Mine Emissions = 100,000 M³ / Day
Preparing Coal Mines for AMM Projects

- Access methane via underground workings to avoid the need for surface gas gathering systems
  - Methods are used in both in European and some U.S. AMM projects
  - Minimizes project footprint
  - Reduces operational costs and permitting needs
  - Minimizes surface land disturbance
Accessing Sealed Areas Underground via Roadways
Installing Underground Pipes to Access Sealed Areas
Colorado AMM Project Example

Elk Creek AMM Project –
- 3 MWe and enclosed flare
- 5 coal mines

Source: Vessels Coal Gas
Similarities and Differences Compared to CMM Projects

- **Size and Scale of Projects**
  - AMM projects tend to be 10-25% the size of CMM projects at the same mine, but abandoned mines can be aggregated into a single larger project.

- **Utilization Technologies**
  - AMM projects are able to use medium-quality gas technologies such as boilers, heaters, reciprocating engines for electric power, and flares/combustors.

- **Coal Mine Involvement**
  - AMM projects are simplified by not having the mine control all methane extraction activities based on safety considerations.

- **Permits**
  - AMM projects are complicated somewhat by the need to apply for new (or separate the existing) permits.
AMM POLICY AND LEGAL ISSUES
AMM Legal Issues

AMM Ownership
- Coal mine operators are often allowed to vent (and use) CMM with just the coal mineral rights, and not necessarily the rights to the methane gas.
- Some coal mine operators may have the rights to all minerals (and gas) in the lease agreement.
- AMM projects typically need the rights to the methane gas.

Project Permitting
- Typically, large-scale coal mining operations include a number of permits under the umbrella of an approved mine plan.
- AMM projects may need to acquire or reapply for all the necessary permits to operate an AMM recovery and use project.
Policy Issues to Consider

- **Greenhouse Gas Markets – Carbon Offsets**
  - Three AMM projects currently registered in the California Air Resources Board Compliance Offset Program
  - Current value of credit = $12.00/metric tonne CO$_2$e
    - Equates to approximately $150/mM$ methane, which can exceed the value of the gas as an energy source

- **Renewable Energy Credits – Green Tariffs**
  - CMM/AMM included as a renewable energy resource in German Renewable Energy Act, five U.S. States Renewable Portfolio Standards, and formerly the UK
  - Value can range widely from 1-7cents/kW-hr
AMM Projects as Sustainable Energy Project Opportunities

- AMM Projects recover fugitive methane emissions similar to landfill, livestock, and wastewater biogas projects.
- Financial incentives for sustainable development such as carbon offset credits and renewable energy credits.
- Overall GHG emission reduction benefits enhanced due to the high global warming potential of methane.

Environmental Health & Safety Benefits – AMM recovery & flare system installed in Ostrava, Czech Republic neighborhood to prevent methane build-up in basements of buildings.

Source: RCE
AMM Best Practices Guide

- GMI and UNECE plan to prepare draft AMM Best Practices Guide (or guidelines)

- Covers the following areas:
  - Modeling the methane resource
  - Controlling factors of methane releases during active underground mining
  - Estimating potential methane recovery rates
  - Mitigating areas of risk
    - Atmospheric contamination
    - Water flooding
    - Compartmentalization
  - Preparing mines for closure
  - Sustainable development & management of AMM Projects
Conclusions

- Important to include AMM in national GHG inventories and UNFCCC reporting
- Set goals to reduce CMM/AMM emissions under policy frameworks
- Prepare closed mines for AMM recovery based on mine-specific conditions
- Need for incentives and policies that make AMM projects more financially attractive
- AMM as sustainable energy
- Need for AMM BPG
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