Summary of U.S. Coal Mine Methane Emissions & Available CMM Resources

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For: U.S. EPA Coalbed Methane Outreach Program
Overview

- 2013 coal mining emissions overview
- Historical trends in coal production & CMM emissions
- State by State emissions
- Methane Resources
  - Degas
  - AMM
  - VAM
2013 CMM Emissions Overview
Total Coal Mine Methane Emission by Source

2013 Emissions (Bcf)

- Ventilation Emissions (UG) 88.9 60.2%
- Degasification UG Vented 6.9 4.7%
- Post Mining (Underground) 13.7 9.2%
- Post Mining (Surface) 4.4 3.0%
- Surface Mining 20.1 13.6%
- Abandoned (UG) mines 13.8 9.4%
Total 2012-2013 Emissions by State*

* Emissions include post mining emissions
2013 Updates & Trends

- Coal production and methane emissions decreased slightly for both underground and surface mines
- VAM amount destroyed was highest ever
  - About 500 mmcf methane
- Vented degas methane remains about 7 Bcf
- Number of underground coal mines decreased from 488 to 395
- Eight gassy mines abandoned in 2013
  - Total gassy abandoned mines now = 509
Historical Trends
20 Years of Underground Coal Mine Emissions

CMM Emissions from U.S. Underground Coal Mines

- Total Liberated
- Adj. Vent (VentUnadj/VentAdj %)
- Degas Lib.
- Used-Under

Year:
- 1993
- 1995
- 1997
- 1999
- 2001
- 2003
- 2005
- 2007
- 2009
- 2011
- 2013

Methane (mmcf):
- 0
- 20,000
- 40,000
- 60,000
- 80,000
- 100,000
- 120,000
- 140,000
- 160,000
- 180,000
- 200,000
U.S. Coal Production and Net CMM Emissions 1990-2013

Year

Coal Production (Mt)

CMM Emissions (mmcf)

Methane Emissions (mmcf)

Coal Production

CMM Emissions
2013 Updates & Trends

- VAM emissions peaked in 2010
  - Have remained flat for past two years
- Degas emissions also peaked in 2010
  - 20% lower in 2013
- AMM emissions continue a steady 13-year decline
- No real correlation between overall U.S. coal production and CMM emissions
State by State Emissions
CMM Emissions from Underground Mines by State

Emissions are in MMcf

Vented Degas 2013
- PA: 2,625 (40%)
- WV: 817 (13%)
- CO: 910 (14%)
- AL: 503 (8%)
- UT: 733 (11%)
- IN: 887 (14%)
- All Others: 2,625 (40%)

Vented VAM 2013
- WV: 28,004 (31%)
- PA: 11,535 (13%)
- CO: 6,367 (7%)
- AL: 7,282 (8%)
- UT: 6,252 (7%)
- KY: 15,450 (17%)
- VA: 14,939 (17%)
- IL: 910 (14%)
- All Others: 6,252 (7%)

Emissions are in MMcf
SMM Emissions from Surface Mines by State

Emissions are in MMcf

<table>
<thead>
<tr>
<th>State</th>
<th>Emissions (MMcf)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wyoming</td>
<td>1,912</td>
<td>10%</td>
</tr>
<tr>
<td>West Virginia</td>
<td>702</td>
<td>3%</td>
</tr>
<tr>
<td>Indiana</td>
<td>789</td>
<td>4%</td>
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<tr>
<td>Kentucky</td>
<td>1,007</td>
<td>5%</td>
</tr>
<tr>
<td>Montana</td>
<td>1,046</td>
<td>5%</td>
</tr>
<tr>
<td>Texas</td>
<td>1,146</td>
<td>6%</td>
</tr>
<tr>
<td>Ohio</td>
<td>1,346</td>
<td>7%</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>1,146</td>
<td>6%</td>
</tr>
<tr>
<td>All Other States</td>
<td>11,507</td>
<td>57%</td>
</tr>
</tbody>
</table>

Emissions are in MMcf
2013 CMM/SMM/AMM Emissions by Mine Methane Source

<table>
<thead>
<tr>
<th>State</th>
<th>Surface</th>
<th>VAM</th>
<th>Drainage</th>
<th>Abandoned</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Virginia</td>
<td>2,000</td>
<td>25,000</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>1,000</td>
<td>5,000</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>Alabama</td>
<td>500</td>
<td>2,000</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Illinois</td>
<td>1,000</td>
<td>2,000</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Virginia</td>
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<td>Kentucky</td>
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<tr>
<td>Indiana</td>
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<td>2,000</td>
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<td>Colorado</td>
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<td>Ohio</td>
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<td>2,000</td>
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<td>100</td>
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<tr>
<td>Utah</td>
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<td>New Mexico</td>
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<tr>
<td>Wyoming</td>
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<td>Montana</td>
<td>500</td>
<td>2,000</td>
<td>50</td>
<td>100</td>
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<tr>
<td>Texas</td>
<td>1,000</td>
<td>2,000</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>
States with Greatest CMM Emissions

- **Underground Mines**
  - Largest amount of VAM located in West Virginia, Pennsylvania, Alabama, and Illinois
  - Largest amount of vented degas located in West Virginia, Pennsylvania, Alabama, and Colorado

- **Surface Mines**
  - Wyoming

- **Abandoned Mines**
  - Largest AMM emissions located in West Virginia, Pennsylvania, Colorado, and Virginia
Methane Resources
2013 CMM Drainage Emissions

![Bar graph showing 2013 CMM Drainage Emissions for various states. Pennsylvania has the highest emissions, followed by West Virginia, Colorado, Alabama, Utah, New Mexico, and Indiana.]
2013 AMM Emissions

- West Virginia: 3,500 MMcf per Year
- Colorado: 2,000 MMcf per Year
- Virginia: 1,500 MMcf per Year
- Pennsylvania: 1,500 MMcf per Year
- Illinois: 1,000 MMcf per Year
- Utah: 900 MMcf per Year
Carbon Price & Potential VAM Projects (by Mine Shaft)

$9 / tCO2e = 0.70\%$
VAM Project Potential at 33 Shafts >0.4% CH₄

Scale of current VAM project - 160,000 CFM
## VAM Mitigation Potential

<table>
<thead>
<tr>
<th>% CH₄</th>
<th># of Shafts</th>
<th>% of Shafts</th>
<th>MMcf CH₄/yr</th>
<th>% of Total VAM</th>
<th>MM tCO₂e/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;0.05</td>
<td>210</td>
<td>100%</td>
<td>78,038</td>
<td>86%</td>
<td>37.6</td>
</tr>
<tr>
<td>&gt;0.1</td>
<td>100</td>
<td>48%</td>
<td>66,810</td>
<td>74%</td>
<td>32.2</td>
</tr>
<tr>
<td>&gt;0.4</td>
<td>33</td>
<td>16%</td>
<td>35,647</td>
<td>39%</td>
<td>17.2</td>
</tr>
<tr>
<td>&gt;0.7</td>
<td>21</td>
<td>10%</td>
<td>27,059</td>
<td>30%</td>
<td>13.0</td>
</tr>
</tbody>
</table>
Conclusions

• Majority of underground CMM emissions from Appalachian Coal Basins
  • West Virginia, Pennsylvania, Alabama, & Virginia
  • Other states include Illinois, and Colorado
• 21 underground coal mine shafts contain average methane content >0.7%
  • Represents 30% of total VAM emissions
  • Mitigation Potential – 13 million tonnes CO$_2$e/yr
• About 60% of SMM emissions from Wyoming mines
• Overall AMM potential on the decline
Contact Information

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