Optimizing Abandoned Mine Methane Projects

Global Methane Forum
Washington D.C., USA

March 29, 2016

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Presentation Outline

- Number of Abandoned Mines
- Advantages & Disadvantages of AMM Projects
- Evaluating AMM Resource
- Preparing Underground Workings
Number of Abandoned Coal Mines in the U.S.

- Number of Abandoned Mines
- Gassy abandoned mines

![Graph showing the number of abandoned coal mines in the U.S. from 1990 to 2014, with categories for mines producing less than 1 mmcf/day (28,316 m³/day) and those producing more than 1 mmcf/day (28,316 m³/day).]
Future AMM Projects

Annual Abandoned Mine Rate in U.S.

<table>
<thead>
<tr>
<th>Years</th>
<th>Gassy UG Mines Abandoned</th>
<th>Mines &gt;1mmcf/d (28.3 m3/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990 – 1999</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>2000 – 2009</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>2010 - 2014</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Questions:

How do you evaluate the resource?

What are some best practices when preparing to close a mine?
AMM v. CMM Projects

What are the differences?

- AMM flows decline over time
- No mine ventilation air to compete with
- AMM infrastructure smaller than CMM
- AMM gas ownership issues
- Sealing integrity of mine vents & pipes
- No mining company involvement
- High and consistent quality
Evaluating AMM Resources

Screening Criteria & Model Inputs

- Mine size; greater than ~1,000 acres
- Closure date; more recent is better
- Specific emissions; over ~200 scf/ton mined (6.2 m³/tonne)
- Mining method; longwall is best
- Location; market for energy
- Ownership; surface and mineral
Actual AMM Production vs. Decline Curve Model Forecast
Evaluating AMM Resources

- **Pressure Testing**
  - Using the void volume from the model, determine the expected pressure response relative to the volume of gas produced (gas law)
  - Drill borehole into roadway or use pre-existing borehole
  - Continuously monitor the static pressure of the borehole together with the barometric pressure
Evaluating AMM Resources

- **Flow Testing & Pressure Buildup**
  - Using a portable testing rig with a flare and blower can produce the gas at either constant rate or pressure
  - Continuously monitor gas rate, methane content and upstream pressure
  - Shut-in well, and let pressure stabilize at a predetermined volume recovered.
  - Compare actual pressure to expected pressure from model
Evaluating AMM Resources

Photo courtesy of Perennial Energy
Evaluating AMM Resources

Results

- A comparison of the **pressure change vs gas volume recovered** will provide an indication of the volume of the void in contact with the wellbore
- Modify model to conform to test results
- Once the test is completed, allow the pressure to build over time to determine the recharge rate of the gas desorbed from the coal
Evaluating Old Mine Maps & Coal Contours
Evaluating Coal Contours & Surface Topography
Overlay Surface Features to View Potential Drill Sites

Site 1
Preparing Underground Workings at Active Mines

- Installing gas piping underground
- Accessing sealed mining districts
- Using the mine roadways as conduit for methane flow
- Verify integrity of surface seals to prevent atmospheric air intrusion
Installing Underground Pipes to Access Sealed Areas
Accessing Sealed Areas Using Mine Roadways
Conclusions

- AMM projects offer a different set of opportunities and challenges
- Performing a proper resource evaluation to adequately size the project
- Integrity of mine seals at the surface can limit suction pressure and methane production
- Importance of preparing an active mine for methane extraction at the time of closure
Thank you!

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