‘Coal mine goaf gas predictor’ (CMGGP)

ACARP C17058 ‘07 project

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Wollongong
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**Multi longwall & district or whole mine gas emission versus time**

![Graph showing gas emission over lead time for LW1, LW2, LW3, LW4, and TOTAL DISTRICT.](image)
Multi longwall extraction & closed mine gas emission decline curves

Gas emission during coal extraction
Gas recovered by gas drainage

Goaf gas recovery & methane utilisation - Stage 1

Longwalls coal production stage

Goaf gas recovery & methane utilisation - Stage 2

Time (Months)

Gas emission (litres CH4 per second)
Selected district gas emission & goaves decline curve

District goaves
### U/G gassy coal mines classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>Mine entries and surface boreholes</th>
<th>Ventilation</th>
<th>Coal production</th>
<th>Water pumping</th>
<th>Responsibility</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary closed</td>
<td>Opened, not permanently or partially sealed</td>
<td>Operating on reduced capacity</td>
<td>Ceased Possible future production</td>
<td>Optional</td>
<td>Mine operator (maintenance)</td>
<td>Not a factor</td>
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<tr>
<td>Closed</td>
<td>Partially or fully sealed</td>
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<td>Mine operator</td>
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<tr>
<td>Decommissioned</td>
<td>Permanently sealed</td>
<td>Optional</td>
<td>Ceased No future production</td>
<td>Terminated Goaves gradually flooding</td>
<td>Transferred from mine operator to the relevant Government Authority</td>
<td>1-20 years Once transfer occurs</td>
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<tr>
<td>Abandoned</td>
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<td></td>
<td></td>
<td>Mine operator</td>
<td></td>
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<tr>
<td>Sealed longwall or district</td>
<td></td>
<td></td>
<td></td>
<td>Optional</td>
<td>Mine operator</td>
<td>Not a factor</td>
</tr>
</tbody>
</table>
Production & background gas emission

- Production & background gas
- Coal extraction period
- Background gas only
- Gas emission during coal extraction period
- Gas decay from goaf area
CMGGP formulae for rapid and long term decline curves

Stage 1. Production & background gas
Up to 12 months
*The logarithmic approximation curve*

\[ Q = -A \times \ln \text{(Time)} + B \]

Stage 2. Background gas only
Up to 30 years
*The exponential approximation curve*

\[ Q = C \times e^{-D \times \text{(Time)}} \]

Mathematical equation coefficients

- **A**: Gas emission decay rate
- **B**: Gas emission initial magnitude & strata permeability
- **C**: Gas reservoir capacity & characteristics
- **D**: Rate and quickness of decline
CMGGP formulae for long term background methane decline curve

\[ F(x) = a \cdot e^{-b \cdot x} \]

Where:
- \( x \) - time (months)
- \( a \) - quantity constant
- \( b \) - decline constant, or

\[ BM_{DE} = BM_{IN} \cdot \exp(-b \cdot months) \]

Where:
- \( BM_{DE} \) - Background methane decline emission (methane make)
- \( BM_{IN} = MM_f \cdot BM_{CC} \) - Background methane initial quantity (3-12 months after ceases coal production)
- \( MM_f \) - Mine methane final (1 month before ceases coal production)
- \( AT \) - Annual tonnage (last 5 years average coal production)
- \( BM_{CC} \) - Background methane contribution coefficient (either related to the annual coal production and/or various mine categories geological & mining conditions)
  - Cat I & II = c \cdot AT^{-d}
  - Cat III, V & VIII = e
  - Cat IV, VI & VII = f
Background methane contribution coefficient vs last 5 years annual tonnage
Background methane threshold $BM_{TH}$ vs dry mine methane final $MM_F$
GRM software simulation sequence

Two stages of coal mine gas quantity decline phenomenon

- **PRODUCTION gas** - rapid decline phase
- **BACKGROUND gas** - slow/long term decline phase

Outputs: Gas emission decline curve

- **DRYSIM** - Dry mine gas decline rate vs time and,
- **WETSIM** - Flooded mine gas decline rate vs time
WETSIM curve concept using zero methane emission

Gas emission will be zero when the mine is finally flooded and the time when this occurs is estimated from the void and water inflow data.
Example of high gassy mine methane emission & goaves gas decline curves prediction for 20 years.
Strata relaxation & gas release zones
Lunagas Pty Limited ‘GRM’ software - simplified concept
# Gas reservoir calculations

<table>
<thead>
<tr>
<th>Coal seam name</th>
<th>Depth (m)</th>
<th>Thickness (m)</th>
<th>Distance from Worked Seam (m)</th>
<th>In situ gas content (m(^3)/t)</th>
<th>Remaining gas quantity factor</th>
<th>Residual desorbing gas (m(^3)/t)</th>
<th>Coal volume (Mm(^3))</th>
<th>Available gas (Mm(^3))</th>
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<tbody>
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<td>n</td>
<td>155.00</td>
<td>0.65</td>
<td>159.23</td>
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<td>2.45</td>
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<td>7.52</td>
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<td>9.10</td>
<td>11.83</td>
<td>0.29</td>
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</table>

**Grant total (M m\(^3\))**: 27.15
### U/G gassy coal mines categories

**For CMGGP simulation**

\[ F(x) = a^* e^{-b^*x} \]

Where:
- \( x \) - time (months)
- \( a \) - quantity constant
- \( b \) - decline constant

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Coefficient ( a )</th>
<th>Coefficient ( b )</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>High gassy</td>
<td>( a_i )</td>
<td>( b_i )</td>
</tr>
<tr>
<td>II</td>
<td>Low gassy</td>
<td>( a_{II} )</td>
<td>( b_{II} )</td>
</tr>
<tr>
<td>III</td>
<td>Low permeability</td>
<td>( a_{III} )</td>
<td>( b_{III} )</td>
</tr>
<tr>
<td>IV</td>
<td>High permeability or shallow mine</td>
<td>( a_{IV} )</td>
<td>( b_{IV} )</td>
</tr>
<tr>
<td>V</td>
<td>Temporary closed</td>
<td>( a_V )</td>
<td>( b_V )</td>
</tr>
<tr>
<td>VI</td>
<td>Sealed district goaves</td>
<td>( a_{VI} )</td>
<td>( b_{VI} )</td>
</tr>
<tr>
<td>VII</td>
<td>Sealed longwall goaf</td>
<td>( a_{VII} )</td>
<td>( b_{VII} )</td>
</tr>
<tr>
<td>VIII</td>
<td>Room &amp; pillar goaf</td>
<td>( a_{VIII} )</td>
<td>( b_{VIII} )</td>
</tr>
</tbody>
</table>
CMG GP software
Dry mine inputs & outputs
CMG software

Flooded mine inputs-outputs

Gas emission & methane utilisation curves
Coal mine gas emission projection for temporary closed mine pumping water

Time (Days & Date)

Methane flow (litres CH₄ per second)

Jan 2003
1,189 l/s
14 Engines

Jan 2008
705 l/s
8 Engines

Jan 2013
411 l/s
5 Engines

Jan 2018
243 l/s
3 Engines

1 MW engine consumption
85 (litres CH₄ per second)