Methane Drainage and Utilisation in Polish Hard Coal Mines
Plan of Presentation

- Polish hard coal industry – current state
- Methane drainage potential in Poland
- CBM drainage potential in Poland
- AMM drainage potential in Poland
- CMM drainage potential in Poland
- CMM drainage:
  - methods
  - planning
  - implementation & utilisation

- Conclusions
Polish hard coal industry – current state

Conditions in Polish hard coal mining industry

- Gas (methane) hazard
- Fire hazard
- Dust hazard
- Seismic and rock burst hazard
- Water hazard
- Climatic hazard
- Radiation hazard
Polish hard coal industry – current state

Poland:
Total coal production – 127.0 Mt
Hard coal – 65.8 Mt
(2016: 70.5 Mt)
Lignite (brown coal) – 61.2 Mt
(2016: 60.2 Mt)
### Polish hard coal industry – current state

<table>
<thead>
<tr>
<th></th>
<th>JSW</th>
<th>Tauron Wydobycie</th>
<th>PG Silesia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of mines</strong></td>
<td>9</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>(2017)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Annual Extraction</strong></td>
<td>30.01 (2016: 33.5)</td>
<td>14.7 (2016: 16.8)</td>
<td>9.05 (2016: 9.0)</td>
</tr>
<tr>
<td>2017 [Mt]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Employment</strong></td>
<td>43 (2016: 43)</td>
<td>20.748 (2016: 27.4)</td>
<td>4.3 (2016: 4.5)</td>
</tr>
<tr>
<td>2017 [thous. EE]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[million PLN]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CAPEX</strong></td>
<td>51.9</td>
<td></td>
<td>no data</td>
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Reservoir properties governing the emission of methane from coal seams can be divided into two groups:

(1) properties that determine the capacity of the seam for total gas production, e.g., adsorbed gas and porosity, and

(2) properties that determine the rate of gas flow, e.g., permeability, reservoir pressure, and diffusivity of coal.
Whereas *porosity* informs us about the storage capacity of gas in coal, *permeability* defines the level of transportability of that gas.

Even if a coal seam has high gas volume low permeability can result in uneconomic gas production rates. (Coalbed methane: A review  Tim A. Moore. International Journal of Coal Geology 101 (2012) 36–81)

**Upper Silesia Coal basin**

Permeability:

0.1 mD do 10mD (Nawrat AGH)
Development of methane content and sorption capacity of the coals depending on their depth.
Methane drainage - potential in Poland

Methane production

13.734 billion m$^3$ (1929-2017)

CBM Coalbed Methane - 6.0%

AMM Abandoned Mine Methane - 0.1%

CMM Coal Mine Methane - 93.9%

VAM Ventilation Air Methane - 0.0%

Methane prognostic and perspective geological resources
123.75 – 350 billion m$^3$

(http://dx.doi.org/10.7494/drill.2013.30.4.433)
### Methane drainage - potential in Poland

<table>
<thead>
<tr>
<th>Specification</th>
<th>Year</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute methane bearing capacity (million m³/year)</td>
<td>870.3</td>
<td>880.9</td>
</tr>
<tr>
<td>Methane drainage (million m³/year)</td>
<td>289.5</td>
<td>274.2</td>
</tr>
<tr>
<td>Amount of economically utilized methane (million m³/year)</td>
<td>158.3</td>
<td>156.5</td>
</tr>
<tr>
<td>Number of the hard coal mines</td>
<td>33</td>
<td>31</td>
</tr>
<tr>
<td>Hard coal output (Mt)</td>
<td>94.3</td>
<td>83.6</td>
</tr>
</tbody>
</table>
CBM potential in Poland

1929 First application:
- Marklowice mine
  Production
  – 1\textsuperscript{st} stage 1929 – 1950 - abandoned shaft as drainage borehole
  350 million m\textsuperscript{3} CH\textsubscript{4}
  (40 m\textsuperscript{3}/min in 1929 and 20 m\textsuperscript{3}/min in 1945)
  – 2\textsuperscript{nd} stage 1951 – 2000 - 30 boreholes 107 – 300 m in length
  301 million m\textsuperscript{3} CH\textsubscript{4}

1990 – 1999
CBM exploration works in the virgin fields of the Upper Silesian Coal Basin done by:
Amoco Poland Ltd., McCor-mick Poland, Metanel S.A., Pol-Tex Methane, Texaco Śląsk
40 boreholes / total length 57 km
Non profitable methane production
Wesoła borehole PIG-1 - Length – 1000m
- 51 coal seams with total thickness 69m and average methane content - 6.43 m³ CH₄/t
- coal seam 510: thickness - 11.05m; depth - 977m; methane content – 8.62 m³ CH₄/t
- permeability of coal : <0.008 – 1.422mD (av. 0.21 mD)

Methane production:
- ?? m³ CH₄/min
- million m³ CH₄/min
CBM Coalbed Methane in Poland

2014
Gilowice borehole Gilowice-1 Length – 1080m
- 36 coal seams with total thickness 42m and average methane content - 11.0 m³ CH₄/t
- coal seam 510: thickness - 5.38m; depth - 984m; methane content – 13.7 m³ CH₄/t
- permeability of coal : 0.2 – 0.8mD

Methane production:
- 3.5 m³ CH₄/min
- million m³ CH₄/min
AMM potential in Poland

2004 – 2011
Abandoned Mine Morcinek
2009 – 2011
Abandoned Mine Żory
Total production: 17.1 million m$^3$ CH$_4$

At present:
- Abandoned Mine Morcinek – company Karbonia sp. z o.o - 200 000 m3 CH$_4$ /y,

- Abandoned Mine Żory – company Gazkop sp. z o.o - supplies CH$_4$ to 2MW engine,
CMM potential in Poland

Total gas released during mining operations
918.7 million m³ (2017)
Methane drainage must be performed when the ventilation air cannot dilute the methane emissions in the mine to a level below the statutory limits.
CMM drainage - methods

Drainage holes deployment in the area of longwall excavation

Location of drainage galleries against the longwall
Methane emissions into the environment of the longwall during coal exploitation come from:

- exploited coal seam,
- undermined and overmined coal seams by exploited coal panel, which are within exploitation relaxation zone, having released desorbable methane resources,
- goaf after coal exploitation, which are connected with the exploited longwall environment.
Zone I – rock mass area located in front of the longwall at the distance up to 200m of the limited methane drainage efficiency,
Zone II – rock mass area involving “direct caving” (4-5 multiplicity of the longwall height). There is a high extent of gas permeability that allow to realize a methane drainage of quality with the growing longwall excavation distance.
Zone III – rock mass area of decompressed floor and roof coal seams with highest level of methane drainage efficiency.
Zone IV – rock mass area of decompressed floor seams with high extent of methane drainage.
Range of degasification of the overmined and undermined layers depending on longwall’s length and its incline
CMM drainage - planning

Vertical cross-section through desorption zones of the longwalls with different lengths
Volume of methane emissions into environment of longwall during coal shearer extraction

\[ V_{CH_4} = \frac{L_s \cdot m_e \cdot \gamma \cdot z \cdot M_0 \cdot \eta_s}{100 \cdot t} \]

Where:
- \( L_s \) – length of the longwall, m;
- \( m_e \) – heigh of exploited longwall, m;
- \( \gamma \) – density of coal, Mg/m³;
- \( z \) – shearer cut, m;
- \( M_0 \) – methane content of exploited seam, \( m^3CH_4/Mg_{daf} \);
- \( t \) – duration of coal extraction cycle, min;
- \( \eta_s \) – degree of exploited coal seam degasification – according to formula: \( \eta_s = 8.354 \cdot M_0^{0.67} \)

<table>
<thead>
<tr>
<th>Duration of shearer’s mining cycle</th>
<th>Forecasted methane emissions into the environment of longwall during coal extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 80 min</td>
<td>2 80 min = 26.25 m³CH₄/min</td>
</tr>
<tr>
<td>100 min</td>
<td>= 21.00 m³CH₄/min</td>
</tr>
<tr>
<td>120 min</td>
<td>= 17.50 m³CH₄/min</td>
</tr>
</tbody>
</table>

\( L_s = 250 \) m
\( m_e = 3 \) m
\( \gamma = 1.3 \) Mg/m³
\( z = 0.8 \) m
\( M_0 = 8 \) m³CH₄/Mg_{daf}
\( t = 80 \) min; 100 min; 120 min
CMM drainage – implementation and utilisation

2017:
Amount of economically utilized methane
209.1 million m³

34 CH₄ engines
total power 72 MWe
CMM drainage – implementation and utilisation

Typical activities of CH$_4$ drainage company covers the following:

- Methane drainage boreholes drilling, connecting and regulation;
- Methane drainage system maintenance in the underground excavations;
- Surface methane drainage system service and support.
CMM drainage – implementation and utilisation

The biggest Polish methane drainage company

Berger Group

founded in 1967 in order to deal comprehensively
with methane hazard in Polish coal mines and for
economic use of the utilized gas.
Since the beginning Company implemented and
operated methane drainage processes in 30 Polish
coal mines.
The annual balance of captured and utilized methane by Berger Group is as the following:

- **JSW SA mines:**
  - Captured CH$_4$ – 147.53 million m$^3$/year
  - Utilized CH$_4$ – 84.17 million m$^3$/year

- **PGG SA mines:**
  - Captured - CH$_4$ – 15.63 million m$^3$/year
  - Utilized CH$_4$ – 10.74 million m$^3$/year
The EXME Berger Group offers comprehensive services related to methane drainage of the coal seams, including:

- The project works in range of methane drainage technology and its equipment (including drilling of geological core recovery boreholes (up to 600m of length) & lab tests & numerical modelling);

- Methane drainage system implementation: drilling of drainage boreholes; drilling of technical boreholes up to diameter of 1600mm and length to 250m;
CMM drainage – implementation and utilisation

- Maintenance of methane drainage system in mines;
- Construction of methane drainage stations;
- Operating and servicing of methane drainage stations;
- Production and supply of accessories and equipment used in process of the methane drainage and process of drilling the boreholes from the underground excavations.
CMM drainage – implementation and utilisation

Typical solution implemented by Berger Group for methane drainage includes:

- drainage boreholes with a diameter from 65 to 95mm and length from 60 to 120m,
- underground drainage station equipped with 1 blower, capacity 52 m³/min,
- surface drainage station equipped with from 2 to 6 blowers,
- capacity of drainage station from 80 to 240 m³ CH₄/min,
- capacity of power generating gas engine(s):
  - electricity: from 2 to 4 MW,
  - heat: from 2 to 4 MW,
- number of power generating gas engines depends on methane quantity.
Conclusions

1. Methane prognostic and perspective geological resources are estimated at the level of 95 – 350 billion m³.

2. Methane emission into the environment of exploited coal panels constitutes serious problems which affect safety and economy of hard coal production.

3. At the depth more than 800m in conditions of Upper Silesian Coal Basin methane drainage must be performed because the ventilation air cannot dilute the methane emissions in the mine to a level below the statutory limits.

3. Experience in methane drainage in Upper Silesian Coal Basin shows that the most efficient technology is drainage of Coal Mine Methane during longwall...
International Center of Excellence on Coal Mine Methane
Founders of ICE-CMM Poland:

- Central Mining Institute
- Polish Geological Institute
- Oil and Gas Institute
- Polish Oil and Gas Company
Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines

A demand-driven capacity-building **workshop**
- promotes gas drainage,
- principles and best practices for pre-, during and post- mine gas drainage,
- use of the drained gas,
- destruction methods of unused gas,
- technologies and methods of gas drainage from CBM
- problems and opportunities associated with development of CBM projects

A demand-driven **seminars**
- practical application of best practices in two different coal mining regions
THANK YOU FOR ATTENTION

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