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

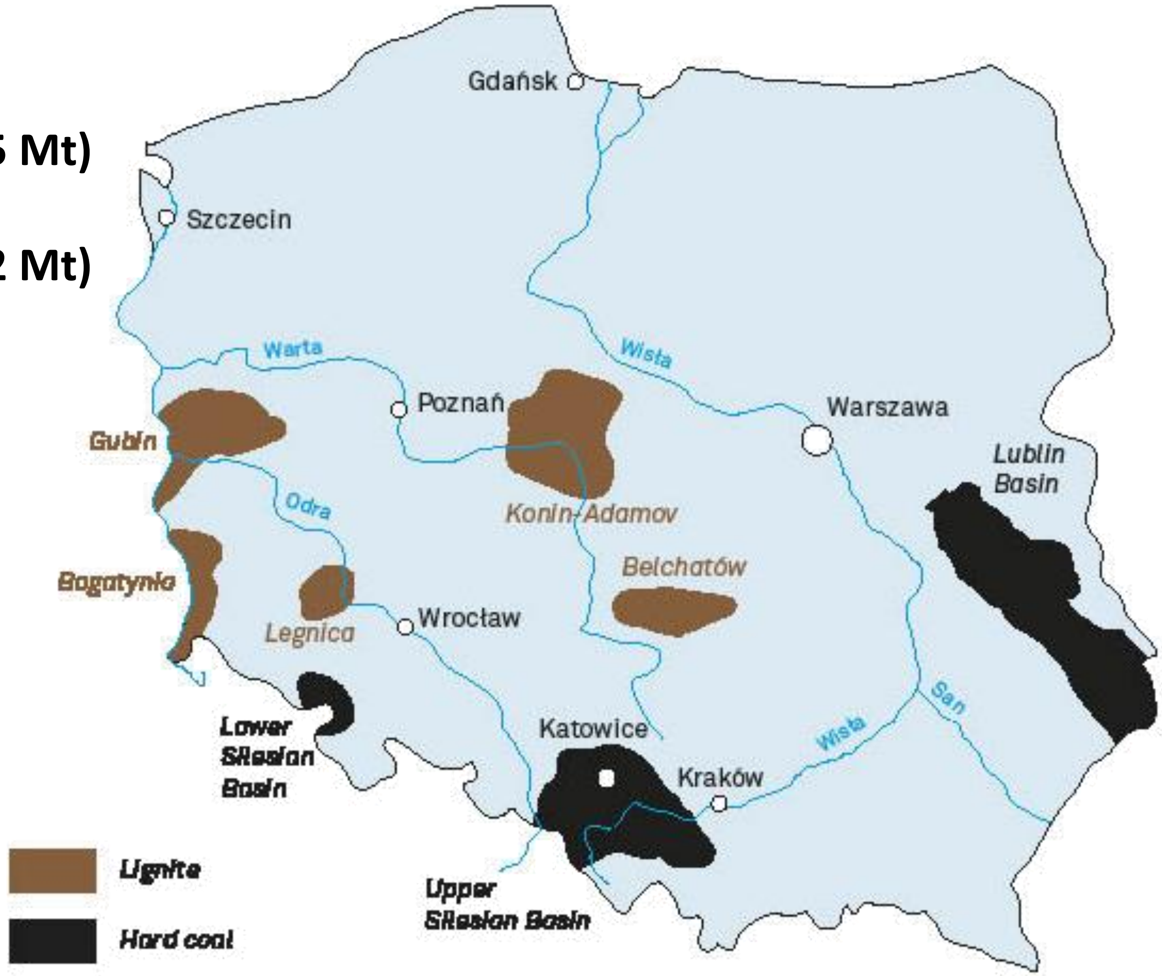
Conditions in Polish hard coal mining industry

- 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 – 65.8Mt
(2016: 70.5 Mt)
Lignite (brown coal) – 61.2 Mt
(2016: 60.2 Mt)



Polish hard coal industry – current state

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		JSW		TAURON WYDOBYCIE		PG SILESIA
Number of mines (2017)	9	4	1	3	1	1
Annual Extraction 2017 [Mt]	30.01 (2016: 33.5)	14.7 (2016: 16.8)	9.05 (2016: 9.0)	6.4 (2016: 6.4)	2.58 (2016: 2.0)	no data (2016: 1.5)
Employment 2017 [thous. EE]	43 (2016: 43)	20.748 (2016: 27.4)	4.3 (2016: 4.5)	6.5 (2016: 6.5)	2.8 (2016: 2.9)	no data (2016: 1.7)
CAPEX [million PLN]	1324	823	no data (2016: 440)	160 (2016: 280)	51.9	no data

GIG

Methane drainage - potential in Poland

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.

(Information Circular 9486, Handbook for Methane Control in Mining
By Fred N. Kissell, Ph.D. DHHS (NIOSH) Publication No. 2006–127)

Methane drainage - potential in Poland

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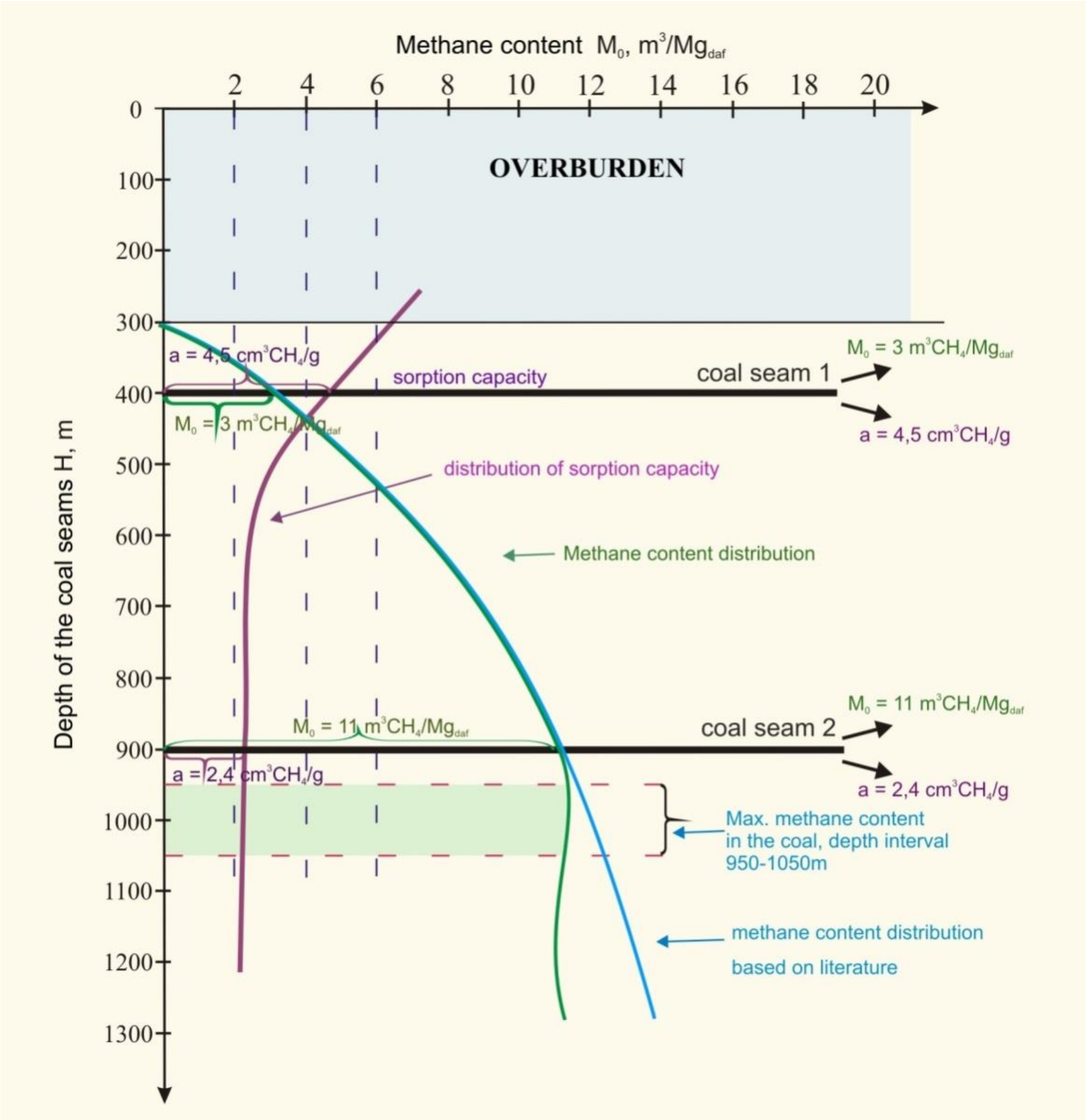
Whereas ***porosity*** informs us about the storage capacity of gas in coal, ***permeability*** defines the level of transportability of that gas.

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)

Methane drainage - potential in Poland



Development of methane content and sorption capacity of the coals depending on their depth

Methane drainage - potential in Poland

Methane prognostic and perspective geological resources

123.75 – 350 billion m^3

(http://dx.doi.org/10.7494/drill.2013.30.4.433)

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 drainage - potential in Poland

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Specification	Year										
	2006	2008	2010	2011	2012	2013	2014	2015	2016	2017	Trend
Absolute methane bearing capacity (million m^3/year)	870.3	880.9	834.9	828.8	828.2	847.8	891.2	933.0	933.8	918.7	↓
Methane drainage (million m^3/year)	289.5 33.26%	274.2 31.13%	255.9 30.65%	250.2 30.19%	266.7 32.20%	276.6 32.63%	321.1 36.03%	338.97 36.33%	342.1 36.64%	324.9 35.37%	↓
Amount of economically utilized methane (million m^3/year)	158.3 18.19%	156.5 17.77%	161.1 19.30%	166.3 20.07%	178.6 21.56%	187.7 22.14%	211.4 23.27%	197.09 21.12%	195.0 20.88%	209.1 22.76%	↑
Number of the hard coal mines	33	31	32	31	31	30	30	30	23 (34 plants)	21 (27 plants)	↓
Hard coal output (Mt)	94.3	83.6	76.1	75.5	79.2	76.5	72.5	72.2	70.4	65.8	↓

CBM potential in Poland

1929 First application:
- Marklowice mine

Production

– 1st stage 1929 – 1950 - abandoned shaft as drainage borehole

350 million m^3 CH_4

(40 m^3/min in 1929 and 20 m^3/min in 1945)

– 2nd stage 1951 – 2000 - 30 boreholes 107 – 300 m in length

301 million m^3 CH_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

CBM Coalbed Methane in Poland

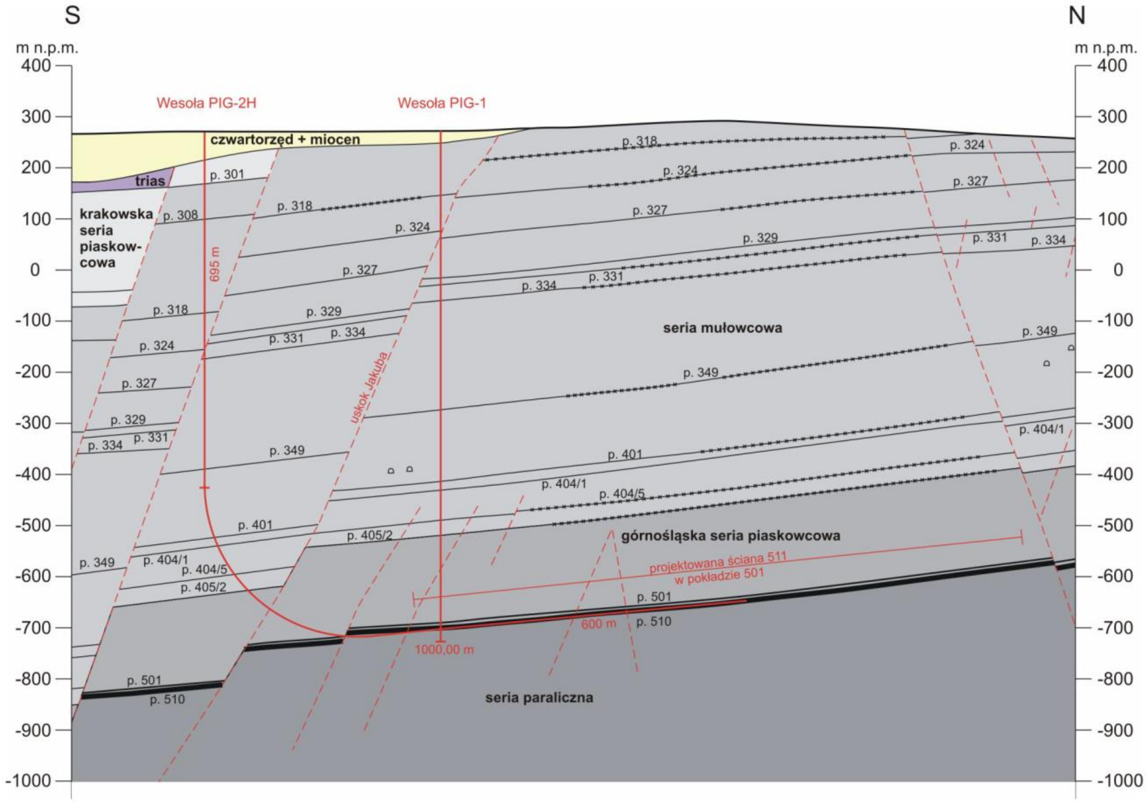
2014

Wesoła borehole PIG-1 - Length – 1000m

- 51 coal seams with total thickness 69m and average methane content - 6.43 m^3 CH_4/t
- coal seam 510: thickness - 11.05m; depth - 977m; methane content – 8.62 m^3 CH_4/t

- permeability of coal **:**
<0,008 – 1.422mD (av. 0.21 mD)

Methane production:
- ?? m^3 CH_4/min
- million m^3 CH_4/min



CBM Coalbed Methane in Poland

2014

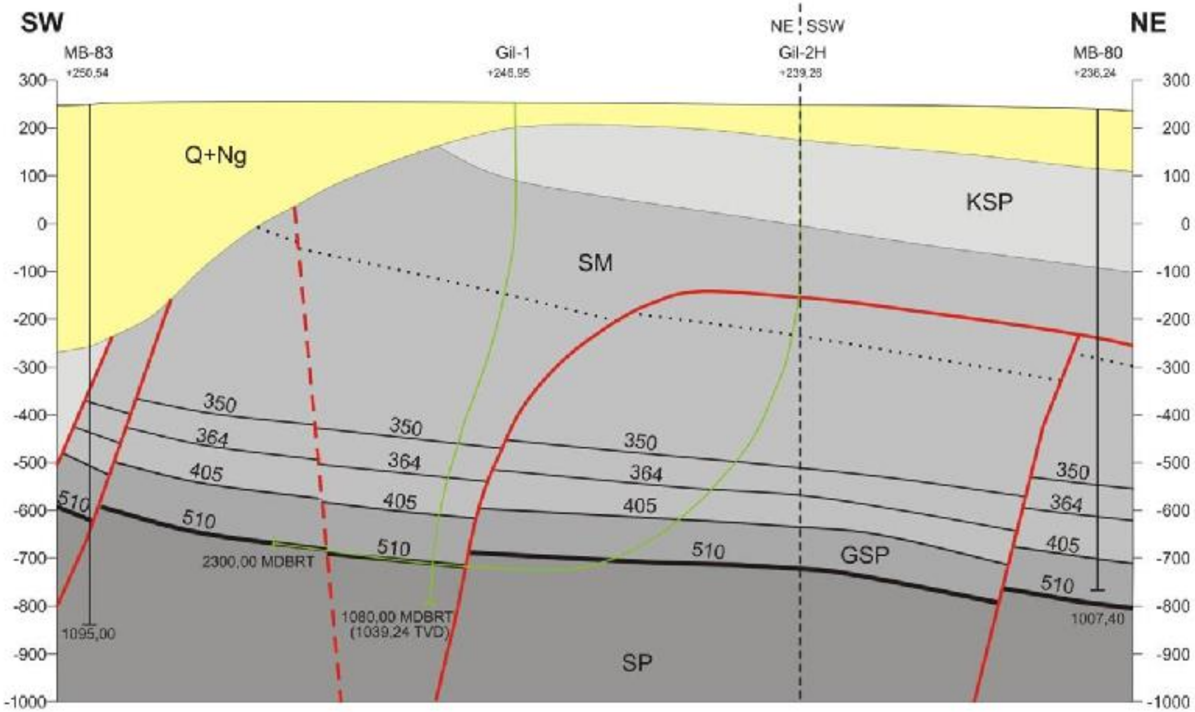
Gilowice borehole Gilowice-1 Length – 1080m

- 36 coal seams with total thickness 42m and average methane content - 11.0m^3 CH_4/t
- coal seam 510: thickness - 5.38m; depth - 984m; methane content – 13.7 m^3 CH_4/t

- permeability of coal **:**
0.2 – 0.8mD

Methane production:

- 3.5 m^3 CH_4/min
- million m^3 CH_4/min



AMM potential in Poland

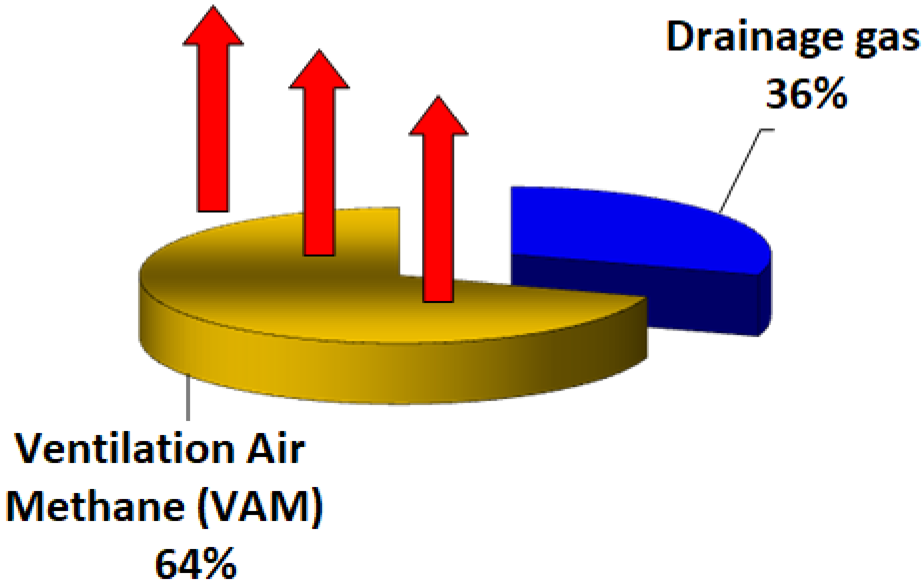
2004 – 2011
Abandoned Mine Morcinek
2009 – 2011
Abandoned Mine Żory
Total production:
17.1 million m^3 CH_4

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

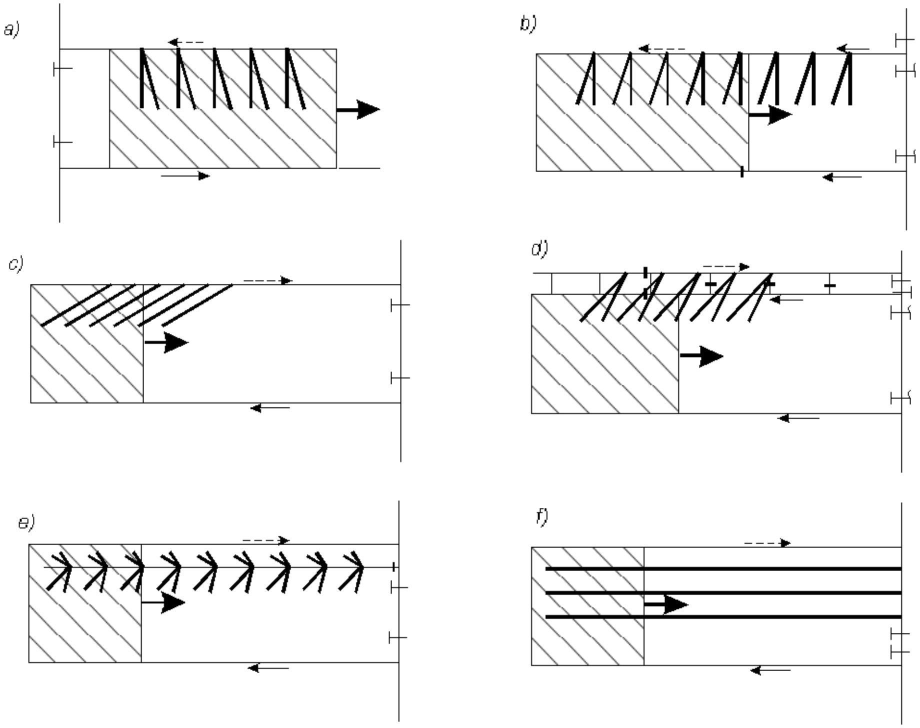
Total gas released during mining operations
918.7 million m^3 (2017)

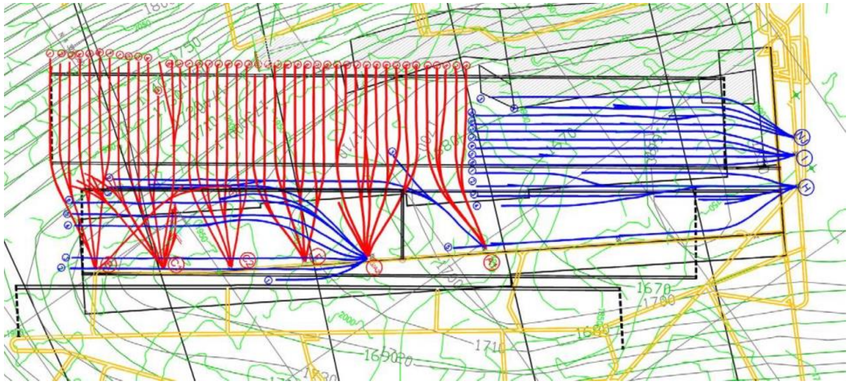


CMM drainage - methods

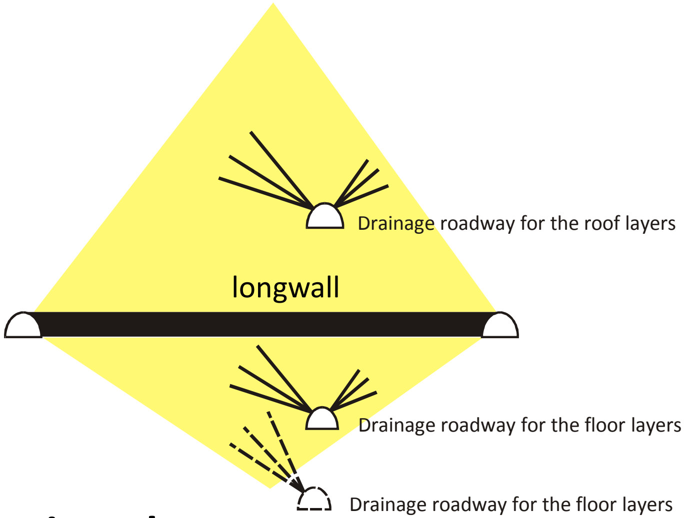
Methane drainage must be performed when the ventilation air cannot dilute the methane emissions in the mine to a level below the statutory limits.

CMM drainage - methods





Drainage holes deployment in the area of longwall excavation



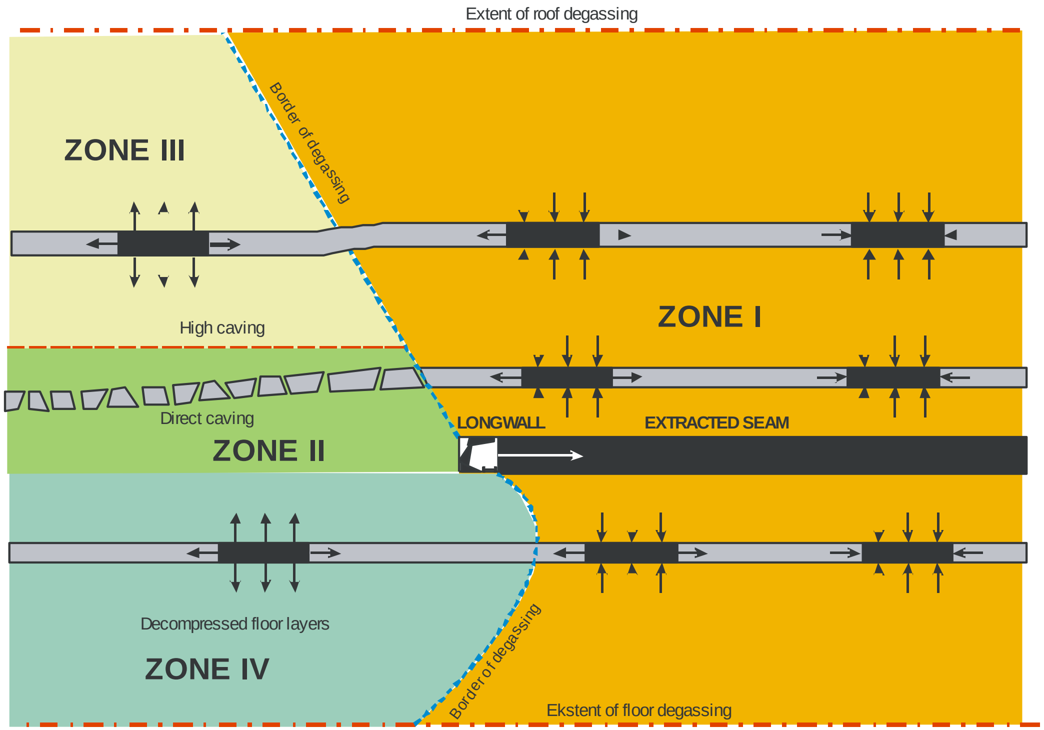
Location of drainage galleries against the longwall

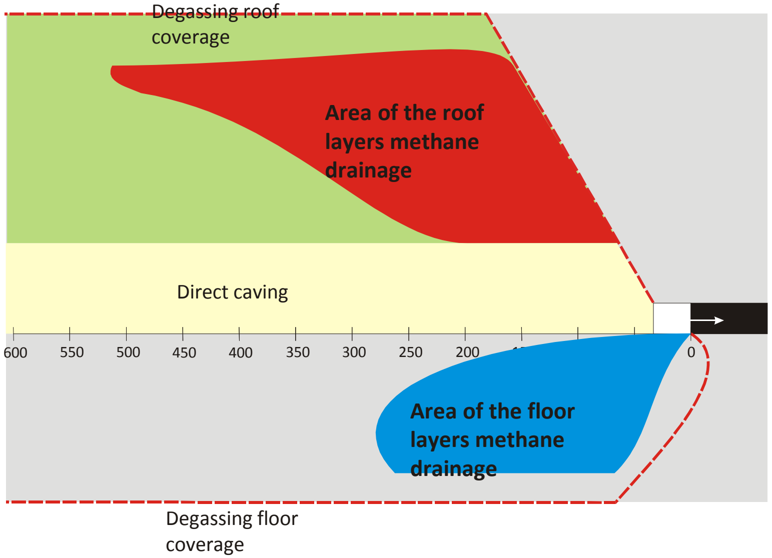
CMM drainage - planning

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 desorbabale methane resources,
- goaf after coal exploitation, which are connected with the exploited longwall environment.

CMM drainage - planning





Methane drainage areas in the longwall panel

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.

CMM drainage - planning

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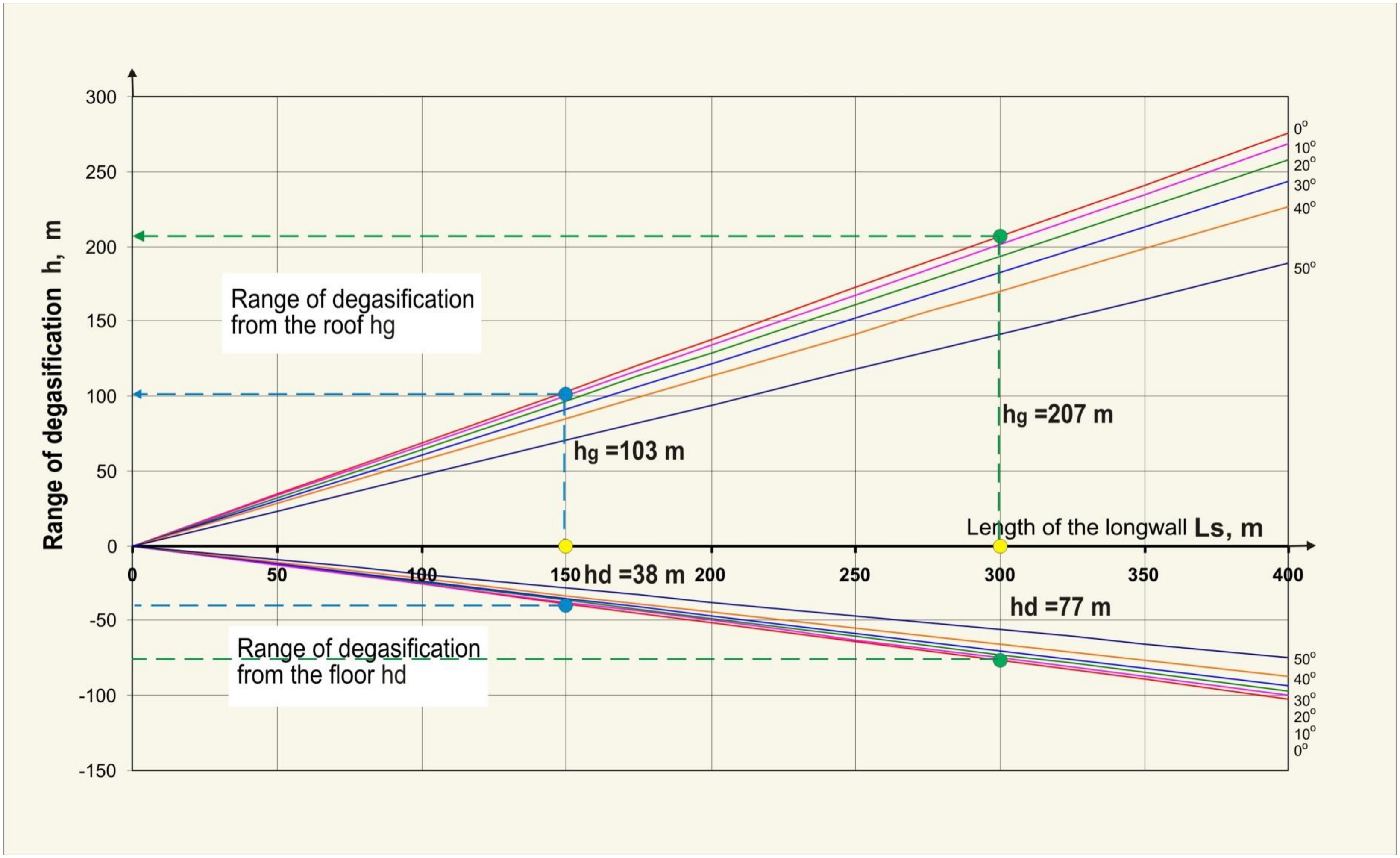
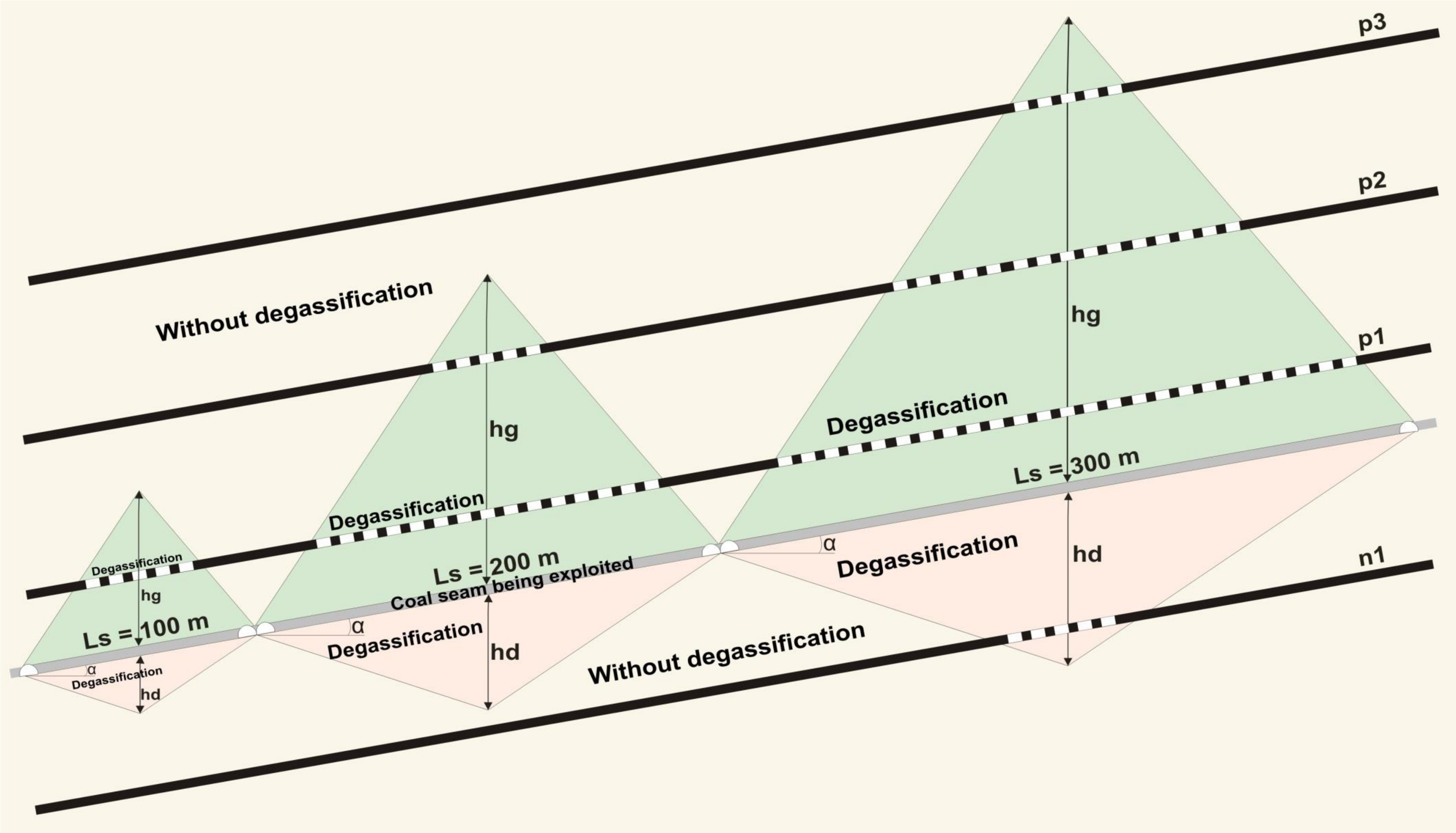
Range of degasification of the overmined and undermined layers depending on longwall's length and its incline



CMM drainage - planning

Vertical cross-section through desorption zones of the longwalls with different lengths



CMM drainage - planning

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Volume of methane emissions into environment of longwall during coal shearer extraction

$$V_{CH_4} = \frac{L_s\, m_e\, \gamma\, z\, M_o\, \eta_s}{100\, t}$$

Where:

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

Duration of shearer's mining cycle	Forecasted methane emissions into the environment of longwall during coal extraction
1	2
80 min	= 26.25 m^3CH_4/min
100 min	= 21.00 m^3CH_4/min
120 min	= 17.50 m^3CH_4/min

L_s – 250m
m_e – 3m
γ – 1,3Mg/m^3
z – 0,8m
M_0 – 8 m^3CH_4/Mg_{daf}
t – 80 min; 100 min; 120 min

CMM drainage – implementation and utilisation

2017:

Amount of economically utilized methane

209.1 million m^3

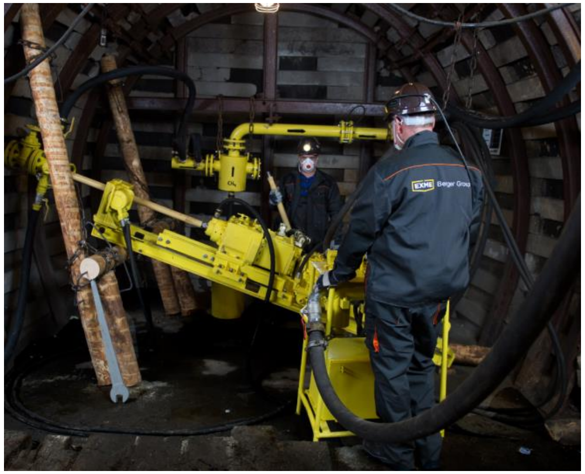
34 CH_4 engines

total power **72 MWe**

CMM drainage – implementation and utilisation

Typical activities of CH_4 drainage company covers the following:

- Methane draiange boreholes drilling, connecting and regulation;
- Methane drainage system maintenance in the underground excavations;
- Surface methane drainage system service and suport.



CMM drainage – implementation and utilisation

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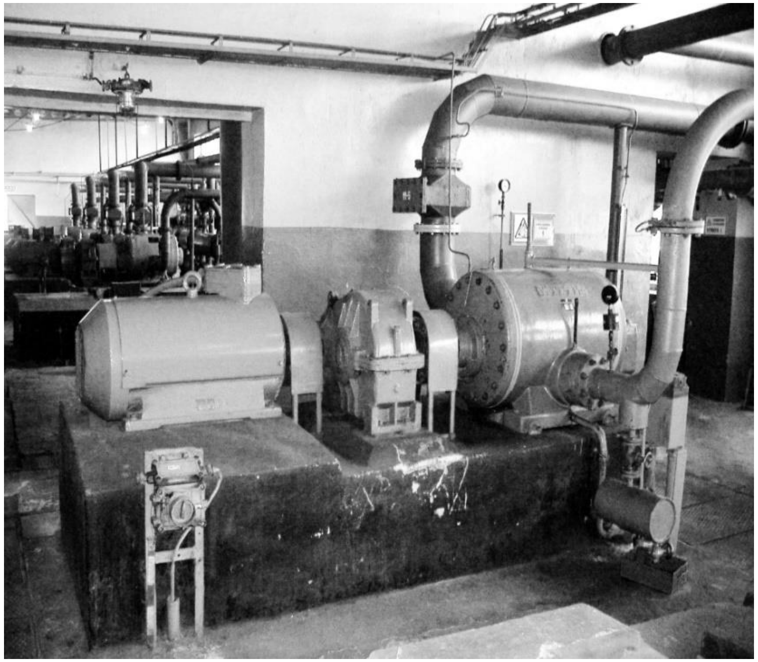
The biggest Polish methane drainage company

EXME 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.



CMM drainage – implementation and utilisation

The annual balance of captured and utilized methane by EXME Berger Group is as the following:

- JSW SA mines:

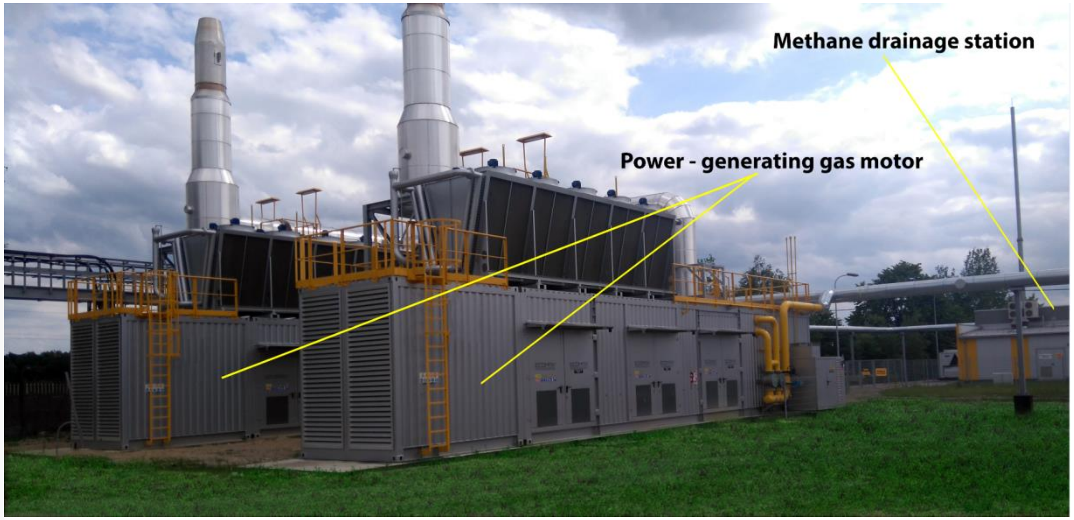
Captured CH_4 – 147.53 million m^3/year

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

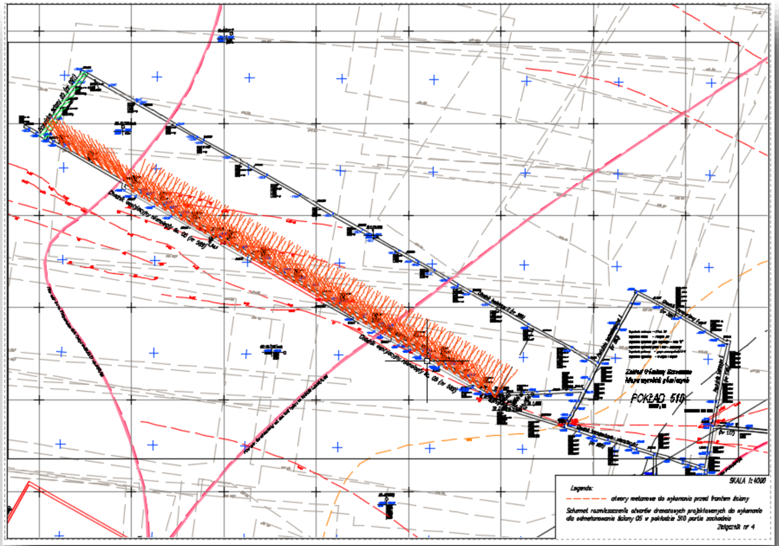


CMM drainage – implementation and utilisation

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 EXME 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 m^3/min,
- surface drainage station equipped with from 2 to 6 blowers,
- capacity of drainage station from 80 to 240 m^3 CH_4 /min,
- capacity of power generating gas engine(s):
  - electricity: from 2 to 4 MW,
  - heat: from 2 to 4 MW,
- number of power gererating gas engines depends of methane guantity.

Conclusions

1. Methane prognostic and perspective geological resources are estimated at the level of 95 – 350 billion m^3.

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

2. 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

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International Center of Excellence on Coal Mine Methane

Poland

ICE-CMM

Operating under auspices of the UNECE Group of Experts on Coal Mine Methane

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Founders of ICE-CMM Poland:

- Central Mining Institute
- Polish Geological Institute
- Oil and Gas Institute
- Polish Oil and Gas Company

Poland
ICE-CMM

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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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