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Session – Coal Mine Methane as a Valuable Energy Source
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Polish Regulatory Framework on CMM/CBM; Estimating CMM Resources and Reserves – Polish Experience

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Agenda

- Polish Mineral Exploration and Production Regulatory System – Comparison to Other (Mature) Jurisdictions.
- Terms Related to Coalbed Methane Resources/Reserves Evaluation.
- Regulatory Framework for evaluating resources of coalbed methane as ”main mineral” and ”accompanying mineral” (CBM/CMM).
- Estimation of coalbed methane resources as ”accompanying mineral” (CMM)

Polish Mineral Exploration and Production Regulatory System – Comparison to Other (Mature) Jurisdictions

- As a result of changes from centrally planned economy to market economy, the Polish regulatory system was created in the early 1990s. Geological and Mining Law (GML) is the principal legislation (Act 1994 replaced by Act 2011): mineral exploration and production is licensed by the Federal Government (Ministry of the Environment).
- In spite of the legislation changes, unquestionable supremacy of government owned companies in the mineral and petroleum extraction industry is still preserved.
- Minerals and petroleum are under the same regulatory regime.

- Evaluation of mineral resources/reserves (with a particular reference to petroleum) in Poland is somewhat different from international practices. Peculiarities of mineral resources evaluation in Poland are as follows:

  - ✓ Formal definition of a mineral deposit within strictly defined boundaries by the use of arbitrarily prescribed "balance" criteria in order to determine "balance" resources;

  - ✓ "Geological Documentation" of a deposit – the final report on resources/reserves evaluation which must be officially approved by the government as a prerequisite for mineral extraction;

  - ✓ Resource classification is expressed by geological assurance categories (A, B, C), which is driven by the need to show increasing accuracy of reservoir parameters determination and deposit characterization during exploration process, but not directly related to commercial success or investment risk.

Terms Related to Coalbed Methane Resources/Reserves Evaluation

International terms:

- **Coalbed Methane (CBM) or Coal Seam Gas (CSG) – coalbed methane (*sensu stricto*), this term refers to methane recovered from un-mined coal seams using surface boreholes;**
- **Coal Mine Methane (CMM) – gas released during coal mining process, can be captured by underground methane drainage techniques;**
  - **Abandoned Mine Methane (AMM) – gas released from closed and sealed mines.**

Poland terms:

- **Coalbed Methane – any methane gas originated from coal seams;**
- **Secondary subdivision (with regard to resources/reserves evaluation and licensing process):**
  - **Coalbed methane (designated) as ”main mineral” = CBM (+ AMM)**
  - **Coalbed methane (designated) as ”accompanying mineral” = CMM**

Regulatory Framework for Evaluating Resources of Coalbed Methane as ”Main Mineral” and ”Accompanying Mineral” (CBM/CMM)

Geological and Mining Law (2011), Art. 6. 1. states:

Hydrocarbons – shall be construed as oil, natural gas and their natural derivatives, as well as <u>coalbed methane, except for coalbed methane as ”accompanying mineral” (CMM)</u>;

<u>Coalbed methane as ”main mineral”:</u>

- **Exploration/production license – GML regulations concerning hydrocarbons (petroleum) are applicable (joined license for exploration and production: exploration phase lasts 5 years);**
- **Resource/reserves evaluation process – regulated by the Ordinance of the Minister of the Environment of July 1, 2015, concerning ”Geological-Investment Documentation” of a hydrocarbon deposit.**

<u>Coalbed methane as ”accompanying mineral”:</u>

- **Exploration/production license – issued jointly with the license for coal production (coal is designated as ”main mineral”);**
- **Resource/reserves evaluation process – regulated by the Ordinance of the Minister of the Environment of July 1, 2015, concerning ”Geological Documentation” of a deposit, excluding hydrocarbon deposits.**

Evaluating Coalbed Methane Deposits as ”Main Mineral” and as ”Accompanying Mineral” – Delineating a ”Balance Deposit”

- **Boundaries of a mineral deposit have to be delineated using the <u>prescribed cut-off values of reservoir parameters defining a deposit</u> (also called <u>”balance criteria”)</u> as stated in the applicable regulations.**
- ***Delineating deposit boundaries using other parameters (which are different from those prescribed) is permitted if special geological conditions are encountered, but it has to be justified.***

#	Reservoir parameter defining a deposit	Unit	Prescribed cut-off value	
			Methane as „main mineral”	**Methane as „accompanying mineral”**
1.	Maximum depth for resource/reserves evaluation	m	**1500**	**Limited by the depth of the coal deposit**
2.	Minimum methane content for delineating deposit boundaries	$m^3/t(daf)$	**4,5**	**2,5**
3.	Minimum average methane content	$m^3/t(daf)$	**Greater than the residual methane content**	**Greater than the residual methane content**
4.	Minimum coal seam thickness	m	**0,6**	**0,1**

Evaluating Coalbed Methane Resources – Categories of Geological Assurance

- It is mandatory that coalbed methane resources are classified into three categories of geological assurance (C, B, A) in the ”Geological Documentation” of a deposit.
- Categories of geological assurance for coalbed methane as ”main mineral” indicate increasing accuracy (from C to A) of data depicting reservoir geometry and reservoir parameters. The most important difference between categories is a minimum value of a resource estimation error: 50%, 35%, 20% assigned for categories C, B, A respectively.

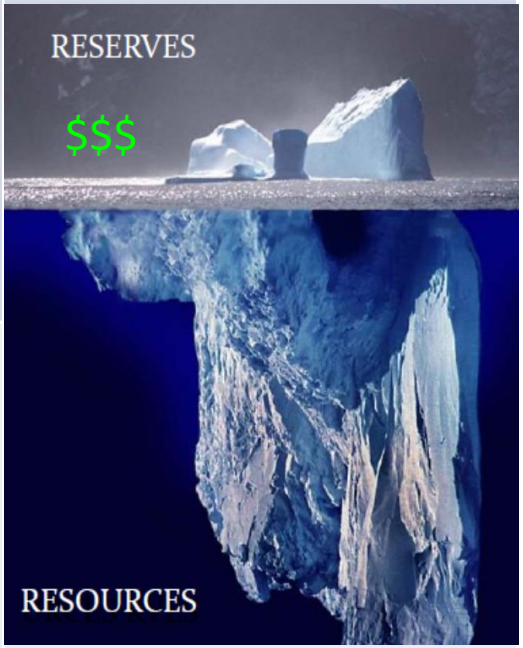
- Categories of geological assurance for coalbed methane as ”accompanying mineral” are related to the categories of geological assurance of coal resources in the following way:
  - C of methane corresponds to D, C1, C2 of coal;
  - B of methane corresponds to B of coal;
  - A of methane corresponds to A of coal.

Polish Classification of Hydrocarbon Resources (including CBM) for Assessing Economic Value of a Deposit

- **„Geological Documentation" of a coalbed methane deposit should include estimation of methane resources, in accordance with categories of geological assurance along with estimation accuracy, which are broken down into the following classes:**
  - ***"Balance" resources – as estimated within deposit boundaries defined using the prescribed cut-off values of reservoir parameters.***
  - ***"Sub-balance" resources – as estimated outside of deposit boundaries which are defined using the prescribed cut-off values of reservoir parameters.***
  - ***Recoverable resources – part of resources that can be technically recovered.***
  - ***"Industrial" resources – part of „balance" or „sub-balance" resources, within the boundaries of the planned mining area or the portion of the deposit designated for development, which are technically and economically feasible to extract, taking into account environmental protection requirements.***
  - ***"Non-industrial" resources – part of "balance" or "sub-balance" resources not classified as "industrial" resources, which may become feasible to extract as a result of future changes in technical and economic conditions, or environmental protection requirements.***

Polish Classification of Petroleum Resources vs International Classifications – Definition of Resources and Reserves

	Equivalent in the Polish system of resource evaluation	Definition according to international standards (PRMS)
Reserves [-] (Rezerwy?)	Virtually does not exist; **„Industrial" Resources [Zasoby przemysłowe]** is the closest in meaning, but lacking commercial criteria.	Those quantities of petroleum anticipated to be **commercially recoverable** by application of development projects to known accumulations from a given date forward under defined conditions. Reserves must satisfy 4 criteria: they must be **discovered, recoverable, commercial, and remaining** (as of a given date) based on the development project(s) applied.
Resources [Zasoby]	**„Geological" Resources [Zasoby geologiczne]**	All quantities of petroleum (recoverable and unrecoverable) naturally occurring in an accumulation, discovered and undiscovered, plus those quantities already produced. It includes all types of petroleum whether currently considered conventional or unconventional.



PRMS definition of Commerciality - the essential social, environmental and economic conditions are met, including political, legal, regulatory and contractual conditions. In addition, there is sufficient evidence that the operator is committed to develop the accumulation and place it on production within a reasonable time frame.

Estimation of Coalbed Methane Resources as ”Accompanying Mineral” (Coal Mine Methane) in Poland

- Total ”Balance” resources are estimated within deposit boundaries defined using the prescribed cut-off values of reservoir parameters in the ”Geological Documentation” of a coal deposit.
- Recoverable resources – methane released from coal (desorbable methane), which is emitted to mine workings and can be partially captured and used as energy source.
- Estimation of ”Balance-recoverable” resources of coalbed methane as ”accompanying mineral” (within depth intervals defined by mineable coal seams occurrence) is done with the following formula:

$$V(CH4) = Q * (M_{ŚR} - M_R) * A * B \quad [m^3]$$

  - Q – resources of mineable (”balance”) coal seams;
  - $M_{ŚR}$ – average methane content of coal [m^3CH4/Mg(daf)] within the depth interval;
  - M_R – average residual methane content of coal seams;
  - A – coal resources increasing factor to account for thinner coal seams and coal stringers;
  - B – correction factor for converting in-situ coal resources to dry, ash free coal resource (daf).

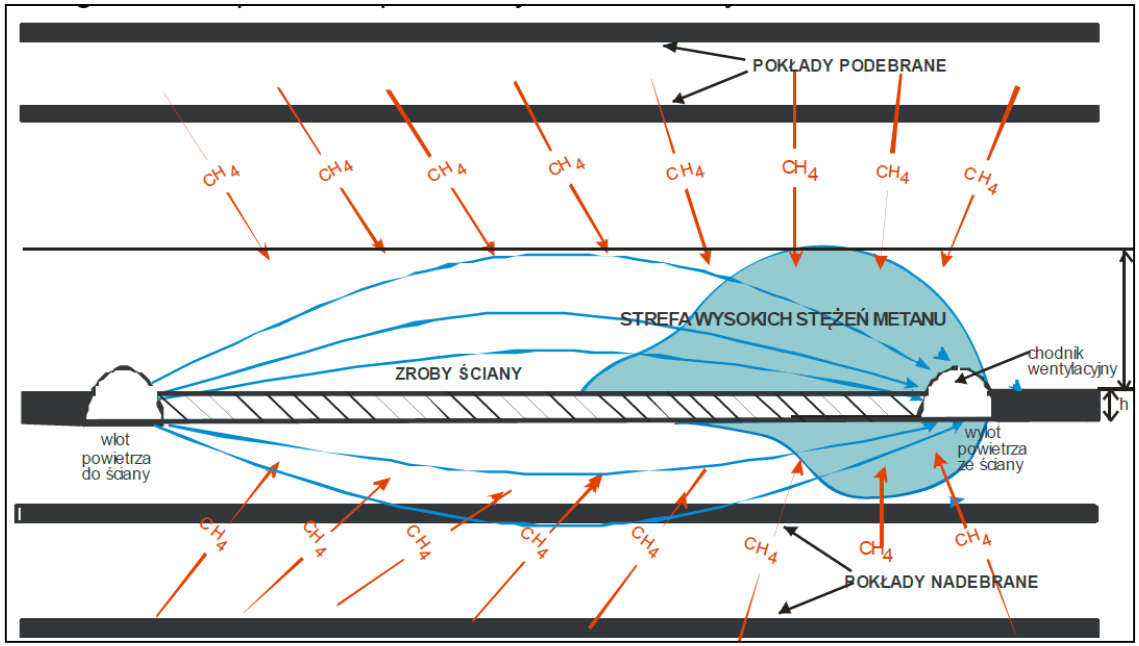
Estimation of Coalbed Methane ”Industrial” Resources as ”Accompanying Mineral” (Estimation of Reserves)

- <u>”Industrial” resources of coalbed methane as ”accompanying mineral”</u> are estimated in the Field Development Plan (FDP) of a coal deposit.
- Procedures of estimating coalbed methane resources as ”accompanying mineral” include:
  - Determination of total gas emission for the mined coal seams and the zone of strata relaxation in the longwall areas;
  - Determination of that part of resources which can be captured with the use of mining drainage system, and then utilized (=reserves).

Gas Emission from Coal Seams during the Coal Mining Process

Methane emission to the longwall working area comes from:

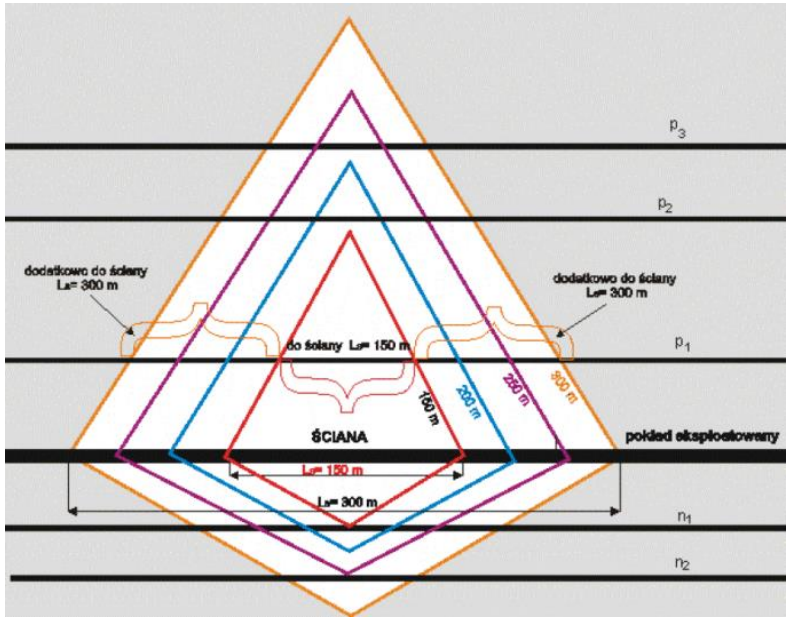
- **the mined seam - the coal being extracted and the exposed coal face (on average 40% of total emission),**
- **overlying and underlying coal seams within the zone of strata relaxation (on average 60% of total emission).**



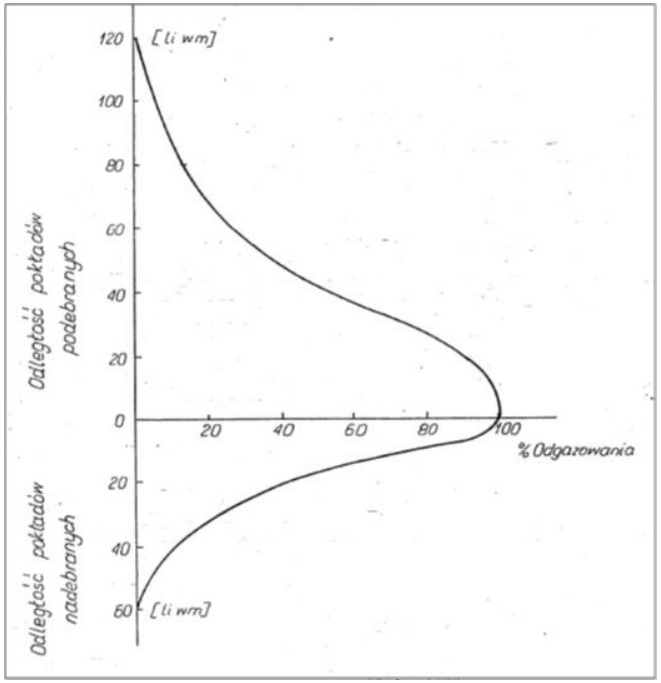
Methane emission to the longwall working area (Krauze et al., 2017)

Determination of Methane Emission for the Zone of Strata Relaxation

- **Methane emission from overlying and underlying coal seams is:**
  - **directly proportional to the area of exposed roof strata, as well as methane content and thickness of overlying/underlying coal seams;**
  - **inversely proportional to the distance from overlying/underlying coal seams to the coal seam being mined.**
- **Methane emission magnitude corresponds to the degassing percentage of overlying/underlying coal seams during the longwall mining operations, and is estimated from the relationship between the extent of roof/floor strata relaxation and the distance to the seam being mined.**



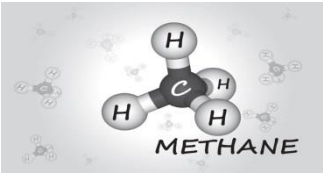
Extent of relaxation and degassing for overlying/underlying coal seams with varying lengths of the longwall panel Ls= 150, 200, 250, 300 m. (Krauze i in., 2017)



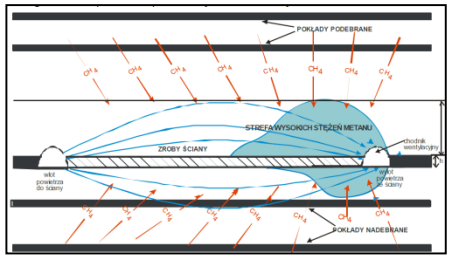
Graph showing the effect of roof/floor relaxation on the rate of degassing according to Stuffken, which is used for methane emission forecast.

Determination of Total Gas Emission for the Mined Coal Seam and the Zone of Strata Relaxation

- **The estimation procedure of coalbed methane emission within the zone of strata affected by the longwall mining entails calculating total methane emission for the coal seam being mined as well as methane resources for overlying and underlying seams according to the following formula:**



$$Qs = \sum_{n=1}^{i} \frac{P \cdot m_i \cdot \gamma_i \cdot n_i \cdot A \cdot W \cdot G}{100}$$



- P – area of the planned longwall panel,
- m_i – coal seam thickness
- γ_i – coal density
- n_i – relaxation magnitude for overlying and underlying coal seams [%]
- A – correction factor to account for reserves depletion due to the previous mining
- W – correction factor to account for ash and moisture content
- G – desorbable methane content: Gd = G(total) – G(residual).