

Workshop Report

New Trends in Coalmine Methane Recovery and Utilization

- Workshop location: Szczyrk, Poland
- Dates: 27-29 February, 2008
- Hosts and Organizers: the Central Mining Institute of Katowice, AGH University of Science & Technology and Mineral & Energy Economy Research Institute of Polish Academy of Sciences
- Supporters: International Energy Agency, The US Environmental Protection Agency and the United Nations Economic Commission for Europe
- Sponsors: the Jastrzebie Coal Company, a major Polish coal mining company, Lennetal Industrie Service GmbH from Germany, and MEGTEC Systems AB from Sweden

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Mr Richard Mattus, MEGTEC Systems, Sweden
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Introduction

From 27-29 February, 2008, an international workshop on coal mine methane utilisation (CMM) was hosted by the Central Mining Institute of Katowice, AGH University of Science & Technology and Mineral & Energy Economy Research Institute of Polish Academy of Sciences in Szczyrk, Poland. The workshop received additional support from the US Environmental Protection Agency and the United Nations Economic Commission for Europe. The workshop was also sponsored by the Jastrzebie Coal Company, a Polish coal mining company, Lennetal Industrie Service GmbH from Germany, and MEGTEC Systems AB from Sweden. With over 100 participants, including many international experts, the workshop addressed newly-developed technologies in coalmine methane drainage and utilization, project financing options, and project management and integration. There was a comprehensive agenda for the two-day event. The workshop covered a wide range of technical and financial issues related to coalmine methane capture and use, with the following 11 sessions:

1. Opening remarks and welcome
2. Introduction to the workshop
3. Key aspects of a successful CMM project
4. Current developments in methane degasification
5. Methane production and gathering systems
6. Use of CMM from methane drainage systems
7. Financing options
8. Ventilation air methane (VAM)
9. Project integration and execution
10. Roundtable on barriers to implementation
11. Mini-workshop on financing CMM projects
12. Other presentations, including flaring and abandoned mine methane
13. Closing remarks

The presentations delivered at the workshop are available at <http://www.imf.net.pl/node/28>; the programme is available at <http://www.imf.net.pl/node/26>

1. Opening Remarks and Welcome

The workshop was opened by Professor Jozef Dubinski of the Central Mining Institute. He thanked all the participants, in particular those from the USA, Canada, Romania, the United Kingdom, Czech Republic, Turkey, Russia, Ukraine, Sweden, Germany, France, and Switzerland. He expressed appreciation to Dr. Jayne Somers of the USEPA and Mr. Clark Talkington of the UNECE for their outstanding contributions to the workshop. Prof. Dubinski also briefly reviewed the history of coalmine methane capture and use in Poland.

The total methane geological resources in Poland are estimated at 254 billion m³. Potentially recoverable resources of methane amounted to 95 billion m³, including 29.8 billion m³ from mining areas. This is a source of clean energy and potential carbon credit generation. So far, the greatest challenge in Poland in coalmine capture and utilization is how to deal with the large volume of ventilation air methane, which contains less than 1% methane and is currently emitted into the atmosphere.

2. Introduction to the workshop

Mr Clark Talkington updated the workshop on UNECE's activities. There are currently 56 UNECE membership countries including the USA, Canada, Israel, Turkey, and countries in Europe and the CIS. Talkington noted that coal has been and will continue to be a major primary energy resource globally and in the UNECE region, and will continue as the dominant fuel in power generation. Thus, coalmine methane emissions and their impact on climate change will continue to grow. The UNECE region accounts for about 40% of global coal mine methane emissions, and coal will remain an increasingly important fuel in the region. With the growth of coal demand, methane emissions in this region are likely to increase.

The UNECE maintains an ongoing dialogue on CMM issues through the Ad Hoc Group of Experts on Coal Mine Methane (<http://www.unece.org/ie/se/cmm.html>). The overall objective of the UNECE's Group of Experts is to bring CMM stakeholders together for a global dialogue on CMM and to support the Methane to Markets Partnership. More specifically, the UNECE focuses on cooperation with international organizations, including other UN organizations such as UNDP and ILO, promotion of mine safety through more effective methane drainage and use, and catalyzing CMM project development.



Dr. Jayne Somers of the USEPA presented several key points: (1) the USEPA's activities in the USA for coal mine methane utilisation; (2) an overview of what is happening in CMM globally; and (3) what is happening in Poland. Coal mine methane contributes to 8%-10% of man-made methane emissions worldwide and coal mines are key sources of the emissions. The US EPA has been implementing a voluntary program since 1994 to encourage the capture and use of coal mine methane worldwide. The USEPA's program only covers coalmine methane, not coalbed methane. Dr. Somers stressed a number of benefits of coal mine methane capture and use: (1) providing local clean energy sources; (2) increasing productivity of coal mines; (3) improving air quality and coalmine safety; (4) mitigating GHGs; and (5) generating additional revenues to the coalmines. Coal mine methane capture and recovery covers a wide range of activities, from a newly opened coal mine to an abandoned mine. Dr. Somers discussed a number of technologies for capturing and using coal mine methane.

Currently, over 200 CMM projects developed in 14 countries are capturing 3 billion m³ per annum. China is currently the largest country in coal production and coalmine methane emissions. The Chinese people are aggressively pursuing CMM projects. Now, about 200 mines have drainage systems and about 60 projects are active in China. In Jincheng, Shanxi Province, the Chinese have installed so far the largest coalmine methane to power plant with 120 MWe. They are going to double this figure. The USA is the second largest country in coal production and coalmine methane emissions. The USA ranks the best in coal mine capture and use, with over 10 coal mine methane projects. Most of the captured gas is injected to natural gas pipes. There is only one coalmine methane to power project in the USA. The USA has another 20 projects on closed mines. Dr. Somers briefly reviewed the CMM projects and activities in other countries, including Ukraine (10 CMM projects), Russia, Australia (6 MW VAM project), and India (no projects yet).

Poland has significant coal mine methane gas resources and there are several existing CMM projects in operation. Poland has also capable experts in CMM who are assisting other countries with their projects development.

Mr Jacek Skiba from Central Mining Institute of Katowice in Poland reviewed briefly coalmine methane resources, gas capture and its utilisation in Poland. There are three major coal resources in Poland: (1) the Upper Silesian Coal Basin (USCB); (2) Lower Silesia Coal Basin (fully abandoned at present); and (3) Lublin Coal Basin (only one active mine). There are also three major coalmine operators in Poland. He described all the coalmines in details. Currently, there are 33 active coal mines including 29 gassy coalmine mines in the country. Twenty of the mines are equipped with drainage systems, and 14 of them are using CMM. Geologically, coalmine methane resource is about 250 billion m³ with the exploitable gas resource of 95 billion m³. Total methane released by the mines in Poland was about 870 million m³ in 2006; about 30% of above gas was captured by drainage systems and 70% was emitted into the atmosphere via the

ventilation air. The number of coalmines in Poland has been decreasing over the past two decades. Despite of drop of gassy coal mines number by 48% from 1989 – 2005, drop of absolute gassiness for above period was only 19%. It means that the share of gassy coalmines in Poland has been increasing, and that their gas potential is growing, which will provide significant opportunities and challenges in CMM.

3. Key Aspects of a Successful CMM Projects

Dr Cameron Davies, Chief Executive of Alkane Energy PLC of the United Kingdom, presented key aspects of a successful CMM project. In the UK, coalmine methane contains approximately 70% methane, 15% CO₂ and 15% N₂. In CDM or JI projects, to reduce one ton of methane may get from 18-23 CERs depending on the methodologies. Internationally, CMM could provide a huge amount of energy with potential in excess of 1 GW of power generation. Coalmine methane power to date has reached more than 250 MW worldwide in response to renewable energy laws and CDM/JI project developments. There are about 25 coalmine methane projects currently in operation in the UK but more than 1,000 abandoned coalmines. Thus, there is a great potential to use coalmine methane as a strategic local source of clean energy and to save up to 4.5 million tons of CO₂ emissions per annum. Ten years ago, there were 20 deep working coalmines in the UK but this number is now reduced to five. There are two other companies in addition to Alkane operating and constructing CMM electricity generation plants in the UK. In 2004/5, the wholesale electricity price in the UK fell to about £15 per MWh and only the CCM projects already operating were economically attractive. The typical production costs of power from coalmine methane including capital costs are around £13 per MWh but from 2005 as electricity prices began to rise more and more projects became economically viable. By February 2008, the electricity price had risen to over £50 per MWh giving a strong impetus to build more CMM plants. In order to get projects up and running, the economics must be underlined by firm electricity prices, a clear regulatory and legal framework, premium prices for renewable energy and helpful policies such as feed-in-tariffs and easy-connection-to-grid rules for methane power plants. Dr Davies then described CMM technologies developed by his company and installed on abandoned coalmines in the UK and Germany.

4. Current Developments in Methane Degasification

A new horizontal hole drilling technology for CBM capture was presented by Mr Jerzy Hadro of the EurEnergy Resources Poland. He concluded a few key points: (1) CBM drainage by using vertical drainage technologies was not successful in some part of Poland; (2) A key to success in this county is to use a new horizontal, multilateral, and underground-balanced drilling technology; and (3) High skilled personnel is needed to manage this technology in Poland.

Mr Jonathan Kelafant's presentation was on Current Developments in Methane Degasification, with a focus on New Trends in Coal Mine Methane Recovery and Utilization in the USA. His speech covered drainage technologies, including surface wells and in-mine drainage. Mr. Kelafant described in detail pre-drainage via vertical wells, gob wells, in-seam/in-mine horizontal boreholes, and cross-measure boreholes.

5. Methane Production and Gathering Systems

Dr Eugeniusz Krause from the Experimental Mine Barbara, Central Mining Institute of Katowice presented "Technologies of methane capturing in Polish coal mines – experiments and prospects". He showed a few interesting slides: (1) the course of changes of coal seams permeability according to the depth of deposition, (2) zones of permeability in the surroundings of extraction, (3) a range of fissuring area of the rock mass vs. long-wall advance, (4) distribution of gas pressure and permeability in an extracted seam, (5) location of the methane drainage boreholes in an area of a long-wall, and (6) location of methane drainage gallery in a long-wall environment.

6. Use of CMM from Methane Drainage Systems

Dr Tor of the Jastrzebska Coal Company presented the use of CMM from methane drainage systems from a perspective of a leading coal company in Poland.

7. Financing Options

The workshop received two perspectives during the discussion on financing CMM projects.

Mr Karl Schultz, a private consultant, spoke more generally on the current state of the carbon markets and the position of CMM projects in these markets. Generally, he provided a positive view. The capital markets have clearly provided sufficient liquidity to finance CMM and other greenhouse gas mitigation projects with around US\$11 billion available from carbon funds in 2007 and approximately US \$70 billion in clean energy funds. The global CMM resource base is quite large at 450 million tonnes of CO₂ equivalent per year and is expected to grow to around 530 million tonnes per year by 2020, most of which will be VAM. In today's markets, CMM projects are proving to be an attractive asset class. Many commercial technologies are well-established and in use, and monitoring and verifying emission reductions in CMM projects is generally easy. Individual projects have ability to deliver relatively large emission reductions compared to many other types of offsets, and VAM technologies are now commercially creating a significant new market. One of the more compelling aspects of CMM projects is the mine safety benefits which make the projects especially attractive in emerging economies. Mr. Schultz then outlined the

minimum requirements to successful carbon financing include: (1) sufficient gas resources; (2) the size of the project should be reasonably large; (3) firmly established revenue streams not only from carbon credits but also from energy sales; (4) sufficient financial equity to support the project; (5) permits and license on place; and (6) a dedicated and capable team. However, he also noted some key barriers that continue to limit project implementation, notably the continuing inadequacy of the legal and regulatory frameworks in some countries, uncertainty after 2012 in the carbon credit markets; other priorities within the mining companies, and differing objectives between the mines and project developers. Still the outlook is positive. Mr. Schultz quoted a survey by *Environmental Finance* in 2007 that showed 88% of carbon funds see growth in CMM projects in 2008 and 64% believe the CEE/CIS region will be a key growth area for carbon projects.

Mr Friso de Jong of the European Bank for Reconstruction and Development (EBRD) delivered a presentation: "Generating Carbon Credits through Coal Mine Methane Capture and Flaring/Utilisation". He focused on four areas in his presentation: (1) rationale for the Bank's involvement; (2) introduction to emissions trading; (3) opportunities of emissions trading; and (4) EBRD's role in carbon financing. The Bank has committed to scale up its sustainable energy investments over 2006-2008 to €1.5 billion, a target that was already exceeded by the end of 2007.

Thus far, 11 coalmine/bed methane projects are being developed under the Kyoto Protocol's Joint Implementation mechanism, which are anticipated to reduce as much as 25 million (metric) tons of CO₂e by 2012. Prices for such emission reductions are dependent on (distribution) of risk and currently range from €7 to €11/tCO₂e. Current monetary value of the JI CMM projects in the pipeline is approximately €100 million – 250 million. Carbon credits may provide up to 75% of project finance needs.

8. Ventilation Air Methane

Mr Peter Carothers of BCS Consulting in the USA presented: "Mitigation of Methane Emissions from Coal Mine Ventilation Air". His speech covered (1) increasing VAM concentration with CMM; (2) optimizing utilization of CMM and VAM assets; (3) Technologies for utilizing VAM, such as VAM oxidation with energy recovery; and (4) VAM opportunities in Poland. Now, 70% of coal mine methane is emitted with VAM globally. Challenges in this area include large airflows and low concentrations (0.1 to 1.0%, typically 0.3 to 0.5%). Projects that use VAM as combustion air would not normally mix the ventilation airflow with ambient air. Under "Oxidation", Mr Carothers introduced three systems: MEGTEC's VOCSIDIZER, BioThermica's VAMOX, and the Catalytic oxidizer developed by the Canadian laboratory, CANMET. He stressed the success of the VAM to power generation project in Australia using oxidizing technology. Other

VAM technologies include (1) VAMCAT lean-fuel generation technology by CSIRO of Australia using VAM with 1% concentration to generate electrical power. A prototype of the technology with a capacity of 30 kW is still being built in China; (2) lean-fuel micro-turbine by Ingersoll-Rand (IR); and (3) Lean-fuel micro-turbine by FlexEnergy. The demonstrated and still emerging technologies are very promising, and several of these technologies are expected to have wide applications in the coming years.

Mr Nicolas Duplessis of Biothermica Technologies presented potential benefits of VAM projects from his company. Biothermica is a newly emerging carbon project developer specializing in burning VAM but with a solid background as a landfill gas CDM project developer. An outstanding feature of the company is the integration of all carbon-credit-to-market activities internally, including project identification, feasibility study, financing, construction, operation, management, registering CDM or JI projects and sell credits in markets. The company takes all project risks. Stakeholders of coalmines if they go with Biothermica do not need to invest any capital in projects. Rather they will receive royalty in hard currency from Biothermica if they allow Biothermica to oxidize their VAM.

Mr Richard Mattus of MEGTEC Systems presented “Converting VAM to Energy”. With demonstration plants, he presented a new technology developed by MEGTEC Systems using ceramics to efficiently oxidize VAM with no open flame, and without any generation of NO_x. In particular, he stressed a project at WestVAMP at the WestCliff Colliery of BHP Billiton in Australia. The power plant is equipped with MEGTEC’s oxidizing technology to utilize the energy of 250 000 Nm³/h (150 000 scfm) of ventilation air with 0.9% methane concentration (VAM + drainage gas) generating high pressure, superheated steam driving a conventional 6 MWe steam turbine. The power plant has been in full operation since April 2007. He described the technology in detail and announced that an on-site workshop and study will take place on 10th April 2008 at the WestVAMP installation. Mr Mattus invited all the participants to attend his workshop.

9. Project Integration and Execution

Mr Alexander Hoffmann of Green Gas International introduced his company’s activities in putting together the up-stream and downstream stakeholders of coalmines. Historically, the coal developers concerns more about coal production and safety while the CMM project developers concern about gas quantity and quality. He stressed the importance of bringing together the gas upstream and downstream stakeholders. Lack of underground information may cause high costs and over estimated the capacity of a power plant at the downstream stakeholders. As a result, a company may lose a lot of revenue if it only focuses on production of electricity. To avoid it, a firm has to take into account resources, environment in mitigating methane, He stated and explained measures on how Green Gas International had bring coal producers, power producers, and carbon credit producers together, optimizing the opportunities for all the participants. The

key to success in project integration is to combine coalmine safety and project profitability.

10. Roundtable on Barriers to Implementation

At the beginning of the roundtable discussion, Dr. Jayne Somers of the USEPA presented a number of general barriers to CMM project development:

1. Ownership issues. A piece of land may be owned by a number of stakeholders: coal, gas and surface owners. This multiple ownership can sometimes complicate or delay project development.
2. Due to existing policies and regulations, it might be difficult to introduce technologies such as VAM oxidation or flaring to active mines.
3. Project financing mechanisms such as carbon credits are new to some people.
4. Lack of green power pricing or other incentives in some countries.

Mr Jacek Skiba also added some major barriers in Poland:

1. Lack of government incentives/legislation to develop CMM as a clean energy source;
2. Lack of technology as far as VAM utilisation is concerned;
3. Complicated structure of electricity tariffs in Poland. Dominant role of coal as the primary fuel for power generation.
4. Due to geological conditions and low-permeability of coal, new technologies are needed to drain coal mine methane in Poland by the vertical wells from the ground surface.

Mr Eugeniusz Postolski, Undersecretary of State for the Ministry of Economy, made a brief speech. In Poland, 94% of power plants use coal as primary fuel. Gas and oil resources in Poland are not sufficient to meet the demand. In 2006, domestic production of gas could only meet 40% of the demand; the rest was imported from Russia. Poland produced 783,000 tons of crude oil, and oil imports amounted to 19.5 million tons. To comply with the European regime on climate change, Poland needs to have 20% of their energy supply from renewables. It is a huge challenge for the government. Therefore, the Polish government is very interested in capturing and using coal mine and coal bed methane. On behalf of the Polish parliament, he thanked all the participants.

The participants actively engaged in the ensuing discussion on barriers and other issues related to CMM. Beyond the barriers noted above, it was suggested that many mining company executives do not see CMM utilization as part of their core business, and a shift in attitudes is necessary to see full utilization of CMM.

11. Mini-Workshop on Financing CMM Projects

Mr Clark Talkington briefly introduced the UNECE's program to support CMM project development in the UNECE region. The objective of the project is to facilitate financing of CMM projects. He stressed that the UNECE's objective is not to finance projects. Rather, it is to provide technical assistance by working with mines and other project sponsors to prepare early-stage investment-grade documents and facilitate a path-way to further financing through UNECE-based mechanisms, or other institutions including international financial institutions, bilateral organizations or private sector financing. In addition, the UNECE is attempting to convey lessons learned through capacity-building workshops.

Mr Karl Schultz presented the slides prepared by Mr Deltcho Vitchev who were absent to the workshop. The presentation was entitled: "Facilitating CMM Finance: Presenting your Project to Financial Institutions". The slides covered (1) Main Mechanisms for CMM/CBM Investments, (2) Proper Business Plan, and (3) A checklist of supporting documents typically required as appendices to a project agreement.

Mr Karl Schultz stressed the market elements that will influence the finance of CMM projects: (1) good design of the project; (2) stability of the electricity market; and (3) the global carbon credit market. To avoid project financing failure, one needs to involve in part of planning process for project, taking into account the possibility to assess to customers, the grid and the pipeline systems. Customers' willing to pay and the electricity prices are key to project cash flow. Company's equity, debt, and capability to generate carbon credits, etc. should all be considered in project financing. There is a significant uncertainty regarding the value of the credits. At the end of 2012, there is no treaty in place saying that an ERU will continue to have value. If the UNFCCC does not have such a treaty to value the EURs, banks may not be willing to finance CMM projects. With a case study, he explained how to incorporate all the elements together in project development.

12. Other presentations

A couple of short presentations on CMM and CBM capture and use were added to the second-day workshop agenda.

Dr Rafal Lewicki of Biogas presented "Power Generation Experience from Abandoned Coalmine Methane". In 2003, Biogas started its activities in CMM by developing flaring gas systems for coal industry. Biogas have been the biggest landfill gas flare manufacturer in the UK and the firm installed over 150 units in the country. Other project areas of the firm include: harnessing (capture and utilization) of methane from landfills, anaerobic digesters, waste water treatment plants, CMM, abandoned mines methane, CBM, and VAM. With a number of case studies, Dr Lewicki demonstrated Biogas' major services: flaring equipment

design, construction and sales, CMM / CBM production testing, and bespoke systems from wellhead to flare, and management.

Other presentations included scope of the activities of the company *LENNETAL Stahlhandel GmbH* by Rüdiger Weber (presented in German).

13. Closing remarks:

On behalf of the USEPA, Dr. Jayne Somers thanked all the excellent speakers for their presentations. In particular, she thanked the staff of the Central Mining Institute for organizing the workshop, specially Mr Jacek Skiba and Mr Postolski of the Ministry of Economy.

She reiterated that the purpose of the USEPA M2M partnership is similar to that of this current workshop: to develop and facilitate CMM projects. There are 25 member countries in the partnership and Poland is a new member. Apart from the partnership (which is open to governments), the USEPA offers the Methane to Markets Partnership (www.methanetomarkets.org), which is open to private companies, NGOs, and individuals. There is no fee to join the network. Any interested person can join the network at the USEPA's website. Once he or she does so, he/she will regularly receive newsletters from the USEPA on CMM. For example, the USEPA will hold an M2M coal sub-committee meeting April 2008 in Italy, and the IEA will organize a CMM workshop in China in September 2008. All this information can be obtained from the USEPA newsletters. In addition, a registered individual can access data from the USEPA's CMM database. The EPA highly encourages the private sector to join the network and take advantage of the free information.

Mr Clark Talkington thanked again all the workshop organizers, participants, speakers, and interpreters. From the perspective of the UNECE, he especially noted the high quality of presentations and corresponding strong level interest by the participants and the excellent and professional execution of the organizers during the proceedings.

In his closing speech, Mr Jacek Skiba stated that the workshop achieved its goal. He thanked all the participants and presenters for contributing knowledge to CMM utilization. In particular, Mr Skiba thanked Ms Jayne Somers and Mr Clark Talkington for their active assistance in and their contribution to the workshop.

The workshop presentations are available on the following websites: www.teberia.pl and <http://www.imf.net.pl/node/28>

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