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COOPERATIVE PROJECT ON METHANE CAPTURE AND USE: BEST PRACTICE GUIDANCE ON EFFECTIVE METHANE DRAINAGE AND USE IN COAL MINES

Note by the secretariat

I. INTRODUCTION

1. The results of the "Extra-budgetary Project to Facilitate Financing of Coal Mine Methane (CMM) Projects in Central and Eastern Europe and Commonwealth of Independent States (CIS) countries" (2005-2008) were reported at the twentieth session of the Steering Committee of the Energy Efficiency 21 (EE21) Project in June 2009 (ECE/ENERGY/GE.4/2009/9).

2. As a follow up to this project, the "Cooperative Project on Methane Capture and Use: Best Practice Guidance on Effective Methane Drainage and Use in Coal Mines" was launched at the fourth session of the Ad Hoc Group of Experts (AHGE) on CMM in October 2008 (ECE/ENERGY/GE.4/2008/2). It is proposed to include the current CMM project in the Project Plan of the Energy Efficiency 21 Project (ECE /ENERGY/2009/8). Description of the project is in the Annex.

II. BACKGROUND

3. The global coal mining industry lacks a set of recommended principles and standards to guide decision-makers at all levels, including mine owners and operators, government officials and technical professionals, to more effectively manage their methane problems, especially in emerging economies. The supporting organizations, United Nations Economic Commission for Europe (UNECE) and Methane to Markets (M2M) Partnership, have come together to address this deficiency through producing a publication "Best Practices Guidance on Effective Methane Drainage and Use in Coal Mines". The publication details the benefits, objectives and principles of coal mine methane drainage and utilization in order to reduce fatalities and injuries of mine workers, protect mine property, reduce greenhouse gas (GHG) emissions and efficiently utilize valuable energy resources. A key message is that adequate investment in methane capture infrastructure and operations delivers important safety and environmental benefits, but also supports the economic health of the mine leading to more profitable operations.

4. The world has relied upon coal for a significant portion of its primary energy production since the Industrial Revolution. The world's major industrialized, emerging, and transitional economies – and hence, the global economy – will be dependent on coal energy resources for the foreseeable future.

5. Today, coal supplies 25% of global primary energy, 40% of global electricity, and almost 70% of the world's steel and aluminium industry. The International Energy Agency (IEA) projects that emerging economies will see energy demand grow by 93% by 2030, driven largely by demand growth in China and India, and coal is expected to be the leading fuel to meet this growing demand.

6. With the continued dependence on coal production, coal extraction is expected to become increasingly challenging in many parts of the world as shallow reserves are exhausted and deeper and more gassy seams are mined. Yet societies are demanding and expecting safer mine working conditions, and greater environmental stewardship from the coal industry.

7. The application of best practices for methane drainage and use is critical to reduce methane-related accidents and explosions that all too often accompany coal mining, while also contributing to environmental protection through reduction of GHG emissions.

III. COAL MINE METHANE POSES SAFETY AND ENVIRONMENTAL CHALLENGES

8. The global coal industry, national governments, trade unions, and worker safety advocates are concerned that the frequency and severity of methane explosions, especially in emerging economies, are unacceptably high. Good mining practices need to be transferred to all countries to ensure that risks are managed professionally and effectively. No mine, even in the most developed countries, is free from safety risks. Regardless of location or mining conditions, it is possible to significantly reduce the risk of methane accidents.

9. Methane is an explosive gas in the range of 5% to 15% methane in air. Its transport, collection, or use within this range, or indeed within a factor of safety of at least 2.5 times lower than

the lower explosive limit and at least two times higher than the upper limit, is generally considered unacceptable because of the inherent explosion risks.

10. Effective management of methane risks at coal mines can also have the benefit of contributing to reduced or minimized GHG emissions. Coal mines are a significant emissions source of methane, a potent GHG with a global warming potential (GWP) of more than 20 times that of carbon dioxide. Methane totals 14% of global anthropogenic GHG emissions and coal mines release 6% of global anthropogenic methane emissions, or about 400 million tonnes of carbon dioxide equivalent ($MtCO_2e$) per year. CMM emissions are projected to increase through 2020, with estimates as high as 793 $MtCO_2e$ by 2020.

IV. METHANE OCCURRENCE AND CONTROL

11. Methane-rich gases, generally containing 80% to 95% methane at underground mining depths, occur naturally in coal seams and are released as CMM when coal seams are disturbed by mining activities. CMM only becomes flammable and creates an explosion hazard when allowed to mix with air.

12. Emissions of large volumes of carbon dioxide also occur from coal mines in some geologic environments (e.g., Australia, France, South Africa and Central Europe). This coal seam carbon dioxide can have important implications for overall mine degasification management strategies. Good safety practice in coal mines is to reduce explosion risk by preventing the occurrence of explosive mixtures where practical, and by rapidly diluting them to safe concentrations (i.e., through ventilation systems). Where gas flows are so high that they exceed the capacity of the mine ventilation system to ensure adequate dilution of methane in the mine air, gas should be collected through a mine drainage system before it can enter the mine airways.

13. Good practice for mine methane drainage systems means both selection of a suitable gas capture method and proper implementation and execution of the mine drainage system. Following good practice will ensure that CMM can be safely captured, transported, and (if appropriate) utilized, at a concentration at least twice that of the upper explosive limit (i.e., at or over 30% methane).

V. REGULATORY APPROACHES TO METHANE CONTROL

14. A risk assessment approach to minimizing explosion risks combined with strong enforcement of robust ventilation and utilization safety regulations can lead to substantially improved quantities and qualities of captured gas. Furthermore, establishment and enforcement of safety regulations governing gas extraction, transport, and utilization will encourage higher methane drainage standards, increased clean energy production, and greater emission reductions.

VI. PREDICTION OF UNDERGROUND METHANE RELEASES

15. Gas flows into underground coal mines under normal, steady-state conditions are relatively predictable in certain geological and mining conditions, although there is significant variation from country to country. Lack of reliable gas emission prediction methods for deep and multiple-seam

mining continues to be a significant challenge due to the complex mining-induced interactions between strata, groundwater, and gas. Nonetheless, proven methods for projecting gas flows, gas capture, ventilation requirements, and utilization potential are widely available and should be used routinely in mine planning.

16. By their very nature, unusual emission and outburst events are not easily predicted, but the conditions under which they can occur are reasonably well known. Therefore, following good practice allows for more effective management of these risks. Any mining activity can sometimes disturb adjacent natural gas reservoirs, leading to unwanted methane releases that can be as much as twice those expected from coal seam sources alone. Such situations can be identified at an early stage by comparing measured and predicted data.

VII. THE ROLE OF VENTILATION SYSTEMS

17. The maximum rate of coal extraction that can be safely achieved on a gassy working coalface is determined primarily by the combination of two factors: 1) the mine ventilation system's capacity to dilute gaseous pollutants to acceptable concentrations; and 2) the efficiency of the mine's methane drainage system.

18. Operating costs are a key driver in designing the overall mine degasification scheme. The power consumed in providing underground mine ventilation is among the most costly operational expenses at a mine; it is proportional to the airflow volume cubed. Therefore, introducing a gas drainage system or increasing its effectiveness often represents a lower-cost option than increasing ventilation air volumes.

VIII. METHANE DRAINAGE

19. The purpose of methane drainage is to capture gas at high purity from its source before it can enter the mine airways. From a strictly regulatory perspective, only enough gas needs to be captured to ensure that the capacity of the ventilation air to dilute gaseous pollutants is not exceeded. However, there is a strong case for maximizing gas capture to achieve enhanced safety, environmental mitigation, and energy recovery.

20. Methane can be captured before and after mining by pre- and post-drainage techniques, respectively. Pre-drainage is the only means of reducing gas flow directly from the mined seam. For this reason, pre-drainage is especially important if the seam being extracted is the main gas emission source, but it is generally only feasible in seams of medium- to high-permeability. Post-drainage methods involve intercepting methane that has been released by mining disturbance before it can enter a mine airway. Post-drainage techniques all involve accessing the zone of disturbance above – and also sometimes below – the worked coal seam. Post-drainage may involve drilling from the surface or from underground.

21. Low capture efficiencies of the drainage system and excessive ingress of air to the mine workings result from the selection of unsuitable gas drainage methods and from the poor implementation of these methods. These, in turn, negatively affect both gas transport and utilization by producing gas concentrations sometimes at levels that are not considered safe (e.g., below 30% methane).

22. The performance of methane drainage systems can be significantly improved through a combination of proper installation and maintenance, regular monitoring, and systematic drilling. There is a strong business case for installing and operating high-efficiency methane gas drainage systems. Successful methane control is a key factor in achieving profitability of gassy underground coal mines.

23. Based on experiences in coal mines worldwide, investment in "good practice" gas drainage systems results in less downtime from gas emission problems, safer mining environments, and the opportunity to utilize more gas and reduce emissions.

IX. METHANE UTILISATION AND ABATEMENT

24. Captured CMM is a clean energy resource for which there are a variety of uses. Figure 1 summarizes the distribution of known CMM projects globally that are operating, under development, planned, or were operating previously. These figures are based on a database of more than 240 projects globally, compiled by the Methane to Markets Partnership. As the figure indicates, power generation, natural gas pipeline injection, and boilers are the dominant project types (based on number of projects).

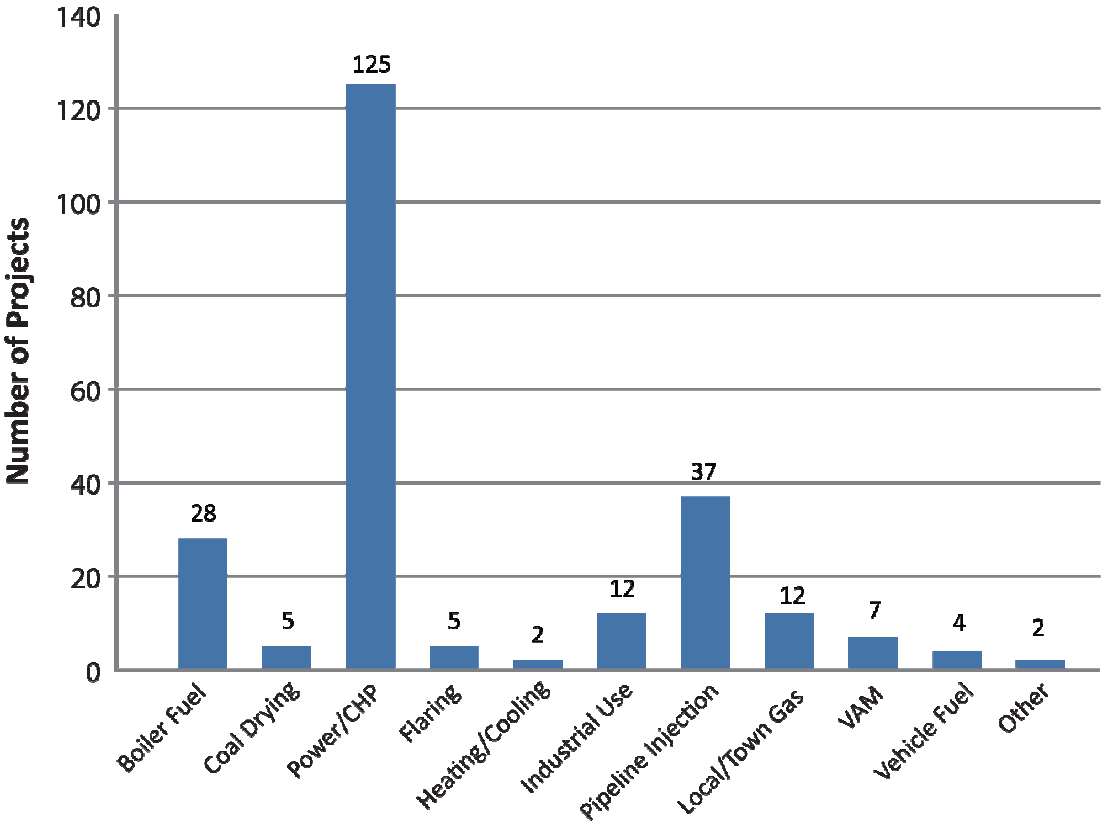

Figure 1: Distribution of CMM Uses in Global Projects. This figure represents the total number of CMM projects reported to Methane to Markets that are active or under development globally, based on type of end use.

25. Purification technologies have been developed and are extensively used (e.g., in the United States) to remove any contaminants from high-quality CMM – typically produced from pre-drainage – to meet stringent pipeline-quality standards. For many other gas end-use applications, the high costs associated with purifying drained gas may be unnecessary and can be avoided by improving underground methane drainage standards.

26. With the proper equipment and procedures, unused drained gas can be safely flared to minimize GHG emissions. Flaring converts methane, which has a GWP of more than 20 compared to carbon dioxide, which has a GWP of one.

27. Methane that is not captured by the drainage system is diluted in the mine ventilation air and is emitted to the atmosphere as dilute ventilation air methane (VAM), typically at concentrations of 1% or less methane. Despite this low concentration, collectively VAM is the single largest source of mine methane emissions globally. Thermal oxidation technologies have been introduced at demonstration and commercial scales at several sites globally (e.g., Australia, China, and the United States) to abate these emissions (and in one case, to produce electricity from the dilute methane). Other technologies to mitigate VAM emissions (e.g., catalytic oxidation) are emerging and under development.

X. COST AND ECONOMIC ISSUES

28. Effective gas drainage reduces the risks of explosions, and hence accident risks. Reducing these risks in turn reduces their associated costs. Costs of methane-related accidents vary widely from country to country but are significant. For example, a 10% work stoppage or idling at a given mine due to a gas-related incident or accident could lead to US $8 million to US $16 million per year in lost revenues at a typical high-production longwall mine. Additional costs of a single fatal accident to a large mining operation could range from US $2 million to more than US $8 million through lost production, legal costs, compensation, and punitive fines. At the same time, gas drainage creates an opportunity for gas recovery and utilization. Such energy-recovery projects can be economical in their own right through sale of the gas or its conversion to electricity, vehicle fuel, or other valuable gas feed stocks.

29. Gas recovery and utilization projects are increasingly also including revenue streams from carbon emission reduction credits in the form of Verified Emission Reductions (VERs), Certified Emission Reductions (CERs), or other credits such as emission reduction units (ERUs). These potential carbon financing options may be a critical factor in making some CMM utilization projects economically viable that would be otherwise financially unattractive. In addition, carbon financing may provide the only revenue streams for abatement-only projects, such as VAM oxidation (without energy recovery) or CMM flaring. VAM can also be used for power generation. At this time, VAM-derived power generation is not commercially feasible without carbon revenues or other incentives, such as preferential electricity pricing or portfolio standards.

30. Currently, investment decisions at most mines are likely to favour expansion in coal production rather than developing CMM utilization projects (particularly power generation) due to the high opportunity cost of investing in power generation capital equipment and infrastructure. To

meet environmental protection targets in the future, however, mine owners may be required to improve gas drainage performance beyond the level strictly required to meet the mines' safety needs. Such improvements in the drainage system that yield relatively high-quality gas may provide an additional incentive for investment in gas recovery and utilization projects.

XI. CONCLUSIONS

31. A holistic approach to managing methane releases into coal mine workings and subsequent emissions into the atmosphere will have a number of beneficial impacts on overall mine safety, mine productivity, and environmental impacts, particularly with regard to GHG emissions:

(a) Global application of the accumulated knowledge on methane occurrence, prediction, control, and management that is currently available will improve mine safety. Implementation of good practices for methane drainage could substantially reduce explosion risks resulting from methane in coal mines;

(b) There is a strong business case for installing and operating high-efficiency gas drainage systems based on their contributions to increase mine productivity. Because such systems will increase the availability of good-quality CMM, there can also be a strong business case for exploiting and recovering energy from the captured gas;

(c) Emissions of methane, an important GHG, from underground coal mines can be significantly reduced by utilizing the drained gas, flaring the gas that cannot be used, and mitigating VAM emissions by oxidation.

ANNEX

Project Description

Project Title:	Cooperative Project on Methane Capture and Use: Best Practice Guidance on Effective Methane Drainage and Use in Coal Mines
Countries:	Kazakhstan, Ukraine and China
Duration:	12-18 months
National Implementing Agencies:	Ministries, companies, organizations and institutions from energy, coal and industry sectors of the participating countries
Executing Agency:	United Nations Economic Commission for Europe (UNECE)
Budget Available:	US$ 100,000
Supporting Institutions:	Methane to Market (M2M) Partnership of the United States Environmental Protection Agency (EPA) and UNECE

Brief Description: At its third and fourth sessions, the UNECE Ad Hoc Group of Experts (AHGE) on CMM agreed that the global coal mining industry lacked a set of recommended (accepted) principles and standards to guide mine operators, regulators, government officials and technical professionals in more effectively managing their methane problems, especially in emerging economies. In this respect the Cooperative Project on Methane Capture and Use to Improve Mine Safety was launched at the 4th session of the AHGE on CMM (October 2008). The organizations supporting the initiative (UNECE and M2M Partnership) aim to contribute to improving mine safety practices through the development of a publication providing "Best Practices Guidance on Effective Methane Drainage and Use in Coal Mines". The publication would detail the benefits, objectives and principles of coal mine methane drainage and utilization in order to reduce fatalities and injuries of mine workers, protect mine property, reduce greenhouse gas emissions and efficiently utilize valuable energy resources. The supporting organizations are planning to launch the best practice guidance at a high-level event at the M2M Partnership Expo in India in March 2010 involving senior corporate, government and international officials.

Although the benefit of developing and publishing the best practice guidance is obvious, the value of the project will be maximised only if the content of the document is exposed to a wide audience that subsequently adopts the best practices as a part of the normal course of coal mining. Therefore the project intents to disseminate the best practices guidance to a targeted audience through a series of regional workshops that are held at locations central to coal mines that frequently experience accidents caused by methane gas emissions into the coal mines. Globally recognized experts will present topics that are directly taken from the best practice guidance in a way that allows the audience to understand the technical and other benefits and potential ways of adopting these practices within the existing mining environment.

The workshops will also serve as a method of assessing the potential of follow-on work that will be accomplished by local workshops, which will be held for the benefit of mines willing to cooperate. These workshops will be focused on the problems that local mines are experiencing, will include analysis of safety issues related to CMM, and presentation of potential options for resolving the issues in a cost effective manner. In addition to increasing safety the project will also contribute to CMM market creation.

Objective: The objective of the project is to reach out, train, create awareness and spread the knowledge of best practice guidance on effective methane drainage and use in coal mines and to foster continuous improvements in this field in the emerging economies.

The main output is to perform the necessary work to plan and hold three workshops; in conjunction with them assessments of mining conditions and of extant gas drainage and recovery practices will be performed by a team of experts. The output will comprise recommendations that can lead to improvement of gas drainage and use practices at mining areas in selected countries of the UNECE region (Kazakhstan and Ukraine) and China. Coal mining companies within these regions that indicate willingness to cooperate will be selected for additional follow-up in the form of a focused consultation at which the experts will present material useful to the mining professionals wishing to implement best practices for drainage and use of methane. The UNECE project manager will identify international CMM experts and work with them for selection of coal mining companies that will be good targets for the analysis and follow-up workshops. Development of these criteria will be done in concert with development of an analysis template and workshop framework. These outputs and the resulting documents will be published by the UNECE.

A project website, available to the public, will be developed using the existing UNECE website (http://www.unece.org/energy/cmm/Welcome.html), which will encourage efficient project replication and make available the work products derived from this project by routinely updating the website with reports and other materials produced during the project. The website will function as a mode of contact and solicitation for expert assistance and will be linked to the M2M Partnership Project Database.

For these activities the UNECE and the AHGE on CMM will identify and secure candidate sites for workshops and encourage the participation of coal mines, in which methane related mine safety problems continue to plague the industry.

Expected Accomplishments: The main outcome of this project is the dissemination of the best practice guidance, in order to encourage the adoption of those practices by industries to improve safety, environmental, and economic conditions within coal mining areas that continue to experience costly methane related accidents.

As CMM is captured, it could be consumed or sold as energy fuel and thus will contribute to CMM market formation. Members of the project team will conduct a series of workshops in the project countries (Ukraine, Kazakhstan and China) to explain and publicize the best practice guidance documents and convey the information in the document within the relevant UNECE member countries. In addition to holding workshops to explain best practices, these experts, with the help of national experts, will conduct assessments of the conditions and practices existing in the project country's coal mining regions that hamper achievement of optimal recovery and use of coal mine methane. The existing practice may result in unsafe work conditions. The experts will present the results of their assessment at the workshops and recommend practices that could lead to higher methane recovery and use and improved safety. Where possible, individual mines in the project country will be identified where the project team will provide consultation focused on specific issues hampering optimal methane recovery and use.

Main Activities:

(a) Conducting assessments of the conditions and practices that are unique to the project county's coal basins and coal fields. These assessments will identify problems that hamper improvement in recovery and use of coal mine methane and in turn negatively impact mine safety;

(b) Suggesting best guidance practices that will lead to increased methane recovery and utilization and improved mine safety. Key representatives of the mining industry and local government will be invited and encouraged to participate in these workshops;

(c) Providing recommendations on ways to assure adoption of best practices, identifying sources of training relevant to mining conditions. Where possible, individual mines will be identified and invited to participate in a focused consultation by the team experts. The consultation will provide specific suggestions for improving methane recovery and use at the selected mine.
