U.S. EPA Coalbed Methane Outreach Program

ANALYSIS OF INTERNATIONAL BEST PRACTICES FOR COAL MINE METHANE RECOVERY AND UTILIZATION

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INTRODUCTION

According to Webster's New Millennium Dictionary of English, a "best practice" is a "…technique or methodology that, through experience and research, has reliably led to a desired or optimum result." To a certain extent, the concept of "best practice" can be understood as "best policy measures" or (in a broader context) "best policy and measures" to secure the recovery and use of coal associated gases, primarily coal mine methane (CMM) and coalbed methane (CBM), which are obtained through pre-mine drainage at active coal mines[1]. This report is not intended to provide a detailed analysis of polices and measures, or to come to a univocal conclusion about best policies and measures. Determining "best" policy can always be controversial due to significant differences between the socio-economic, political and other conditions in different countries. Rather, this paper suggests considering similarities between different countries' successful polices and institutional choices that have led to significant reductions in CMM emissions.

1. GENERAL OVERVIEW OF POLICIES AND MEASURES TO SUPPORT CMM UTILIZATION

Many different parameters can characterize development of CMM recovery and utilization projects in a particular country. These parameters can be grouped as follows:

- Existence of major stakeholder categories;
- Institutional development;
- Increased use of new technologies;
- Utilization of existing economic incentives;
- Defined gas property rights;
- Unsubsidized free gas market; and
- Education and information dissemination.

The recent status of implementing policies and measures to support CMM recovery and utilization is different for every country, which is demonstrated in Table 1.

[1] CMM refers to methane derived from existing mines, while CBM refers to methane derived from coal seams that are not actively being exploited (and which typically would not be emitted without human intervention).

Table 1. Recent status of implementation of policies and measures to support CMM recovery and utilization

	Existence of major stakeholder categories	Institutional develop-ment	Increased use of new technologies	Utilization of existing economic incentives						Defined gas property rights	Unsubsidized free gas market	Education and information dissemi-nation
				Feed-in Tariff	Obligations	Utilize Existing Economic Incentives (except tax privileges)	Tax Incentives	Grants	Lowering or eliminating tariffs and/or VAT for CAG imported equipment			
Australia	+	+	+	-	+	+	-	+	-	+	+	+
Canada	+	+	+	-	-	+	+	-	-	+	+	+
China	-	-	+	-	n.a.	+	+	-	+	+	-	+
Germany	+	+	+	+	-	+	-	-	-	+	-	+
India	-	-	-	-	-	+	-	-	-[2]	-	+	+
Poland	-	-	+	-	-	+	-	-	-	+[2]	+[2]	+
Russia	-	-	-	-	-	+	+	-	+	+	-	+
United Kingdom	+	+	+	-	-	+	+	-	-	+	+	+
United States of America	+	+	+	-	-	+	+[1]	-	-	+	+	+

Sources: 1) Global Overview of CMM Opportunities, Coalbed Methane Outreach Program, U.S. Environmental Protection Agency, September 2008.

2) Recent Trends in Recovery and Use of Coal Mine Methane, Raymond C. Pilcher, Michael M. Cote, Ronald C. Collings and James S. Marshall, Raven Ridge Resources, 3-rd International Methane & Nitrous Oxide Mitigation Conference, November 17, 2003.

[1] Tax incentive is no longer applicable.

[2] Authors' assessment

2. REGULATORY PROVISIONS

Ill-defined gas property rights, lack of clarity regarding the ownership of the CBM/CMM and permitting process in many developed countries serve as obstacles to the development of gas utilization projects. CBM/CMM ownership issues also acquire much significance in the course of methane recovery and utilization in transition countries. The entities engaged in CMM project development need to have a uniform regulatory framework establishing CMM ownership. For example, in Ukraine CMM falls into a mineral resource category regulated at the national level, as it falls under the Code of Ukraine on Mineral Resources. The code states that the people of Ukraine own the country's mineral wealth. Thus, the standard mineral licensing procedure has to be applied to CMM.

At the same time, coal seam degassing is performed during coal production (following compliance with mining safety rules). These safety rules do not relate methane extraction to mineral wealth extraction. Therefore, degassing system methane emissions can be regarded as production waste owned either by the mine owner, or nobody. This legal peculiarity creates some uncertainty towards methane ownership and has a negative impact on resolution of the issue of licensing CMM extraction. Since CMM's legal status and usage procedure are not properly regulated, the activity of companies that could utilize the CMM from operating mines is hampered (for example, when coal mines are not capable or do not wish to engage in this activity).

As mentioned in the Coalbed Methane Extra [1], "the question of who "owns" or has rights to the methane adsorbed to a particular coal estate does not have a straightforward answer." Thus, one can see a large variety of legal forms and instruments in this sphere, adapted to specific conditions throughout countries that are the largest producers of coal in the world. Disputes or judicial examination may take place if existing laws do not legibly regulate the arising legal relationship between stakeholders (surface and project owners, the government and gas leaseholders), and that fact impedes CMM project development.

For example, in the UK the government owns the methane associated with coal and regulates the rights to the gas. The government passes its ownership to the licensee when methane is recovered. According to the UK Department for Business Enterprise and Regulatory Reform [2], mine gas is considered a petroleum product, thus the regulation of rights did not rest with the Coal Authority. Under the Petroleum Act of 1998, the Department of Business Enterprise & Regulatory Reform awards Petroleum Exploration and Development Licenses (PEDLs) which cover coal associated methane. Notwithstanding that "technically, capturing the drained methane requires a License under the Petroleum Act 1998" [2] the Government issues a Methane Drainage License (MDL) to regulate methane drainage for safety reasons as safety is its first priority. The operating mines normally are the MDL holders. The U.S. Environmental Protection Agency (EPA)'s Overview of Global CMM Opportunities notes that MDL usually covers smaller areas than PEDLs and it does not grant "exclusive rights, so it can overlap geographically with one or more PEDLs" [3]. In practice, this kind of licensing arrangement may to lead to situations when several interested parties are likely to have pretensions of methane extraction and its recovery in the same area.

In the United States there is a controversy regarding the ownership of methane produced from coal seams as carbon-based mineral rights come under different jurisdictions. The coal lessee has the right to capture and discharge methane without holding a gas lease supplementary to the coal lease. Also, there is no need to pay royalties if mine gas is vented to the atmosphere to keep mining operating conditions safe. If a mining company wants to utilize extracted CMM, it must follow the federal leasing procedures and pay royalties to the government. The review [3] concluded that "although some states have attempted to clarify the ownership issue through legislation, the U.S. government has not done so. Therefore, these disputes are settled on a case-by-case basis".

Today some coal mining countries that have federal forms of government lack a national legislative framework regulating CMM extraction and recovery activities. For example, in Australia, "each state of the country has its own legislation and licensing arrangements" [3]. A similar situation can be observed in Canada "where the provinces own and can sell the rights to develop CBM at their discretion" [3].

By contrast in Germany, according to the legal framework adopted at the federal level, the Federal Mining Authority is responsible for the administration of activity related to CMM exploration, extraction, and processing. CMM ownership rights are transferred to a coal mining company for the duration of a coal mining license, after which "the capture of mine gas requires a renewed license in its own right for at least another 30 years" [3]. The Federal Mining Authority considers an application for license after the applicant has submitted the respective program which clearly demonstrates that "planned activities are sufficient and within an acceptable time frame for the type, scope and purpose of the methane extraction" [4]. A license can be refused or withdrawn if found to be inadequate with respect to legislatively fixed factors, including the availability of sufficient funds, feasibility of a proposed extraction technology within a given timeframe and public interests [4].

The review above shows that, in most countries, a coal leaseholder does not obtain rights to CMM automatically, and licensing for mine gas recovery and utilization is required. Usually governments impose royalties on the capture and beneficial utilization of CMM. However, in some cases exceptions are made. In New South Wales (Australia) the local government has not been imposing royalties to facilitate the development of deep coal seams [3].

It is important to take into account the differences in each country, particularly differences due to varying political traditions, institutions and level of government centralization. However, with this caveat in mind, it seems that the legal framework in Germany provides a particularly noteworthy solution to the CMM ownership issue. Publicly available sources indicate that there are no endemic disputes over ownership of methane recovered from coal seams in Germany. This country developed an effective and non-controversial way to resolve the managerial and administrative problems that may arise in the course of CMM exploration, extraction, and processing/utilization. This is likely a key reason why Germany takes a leading place in the world in utilized CMM as a percent of its total mine-related methane emissions.

The efficient licensing systems in developed countries provide an in-depth examination of the applicants' intention and availability of funds and allow for market competition, thus expediting CMM project development. Licenses cannot be easily extended in case of unjustified delays in CMM project implementation.

Usually, achieving access rights to electrical grids and natural gas pipelines is not problematic in developed countries if methane is of sufficient quality to meet the natural gas pipeline quality specifications.

3. INSTITUTIONAL FRAMEWORK

National and local authorities in developed countries play the most important role in the CMM industry ensuring regulation of methane rights, project approval for leasing land, licensing and permitting processes. These activities aim at facilitating interaction between various stakeholders: between the coal leaseholder (which usually does not have automatic rights to CMM) on one side, and surface land owners, the gas leaseholder, power generators and pipeline operators on the other side. Table 2 identifies existing authorities and regulatory agencies in CMM development, their roles and levels of responsibility over the developed countries profiled.

Designated CMM authorities and regulatory agencies identify the policy measures and technical barriers that need to be addressed, and suggest actions that the governments need to take to scale up the development and utilization of CMM. The governments introduce and implement specific policy measures and institutional changes to achieve desirable results while trying to avoid excessive dispersion of responsibilities between numerous organizations and departments to benefit the CMM project hosts.

Table 2. Overview of CMM authorities and regulatory agencies in the countries profiled

Country	CMM authorities and regulatory agencies	Functions	State/ local level
Australia	Department of Industry, Tourism, and Resources; Australian Greenhouse Gas Office; Department of Environment, Water, Heritage, and the Arts	Licensing and permitting	Federal
	Queensland Department of Natural Resources and Mines; New South Wales Department of Primary Industries Minerals	Arrangement of licenses for CBM/CMM extraction and royalty payments; project identification and assessment support	State
Canada	Natural Resources Canada	Permitting and licensing trade and commerce in natural resources	Federal
	Alberta Ministry of Energy; British Columbia Ministry of Energy, Mines, and Petroleum Resources	Permitting and licensing	Provincial
Germany	Arnsberg Local Government / Dept. 8 Mining Industry and Energy	Mining authorization; designation of mine gas property rights; administration of exploration, extraction, and processing of mine associated gas	State
	State Ministry for the Environment Nature Conservation and Reactor Safety	Project identification and assessment support	Federal

United States of America	Bureau of Land Management within the U.S. Department of the Interior	Management of U.S. public lands and leases on federal land	Federal
	U.S. Forest Service within U.S. Department of Agriculture	Administration of the national forests and leases on federal forest land. (*Does not address projects on private lands.*)	Federal
United Kingdom	Department for Business Enterprise & Regulatory Reform	Regulation of methane rights	National

Source: Global Overview of CMM Opportunities, Coalbed Methane Outreach Program, U.S. EPA, September 2008.

Generally, key CMM stakeholders aside from government bodies include:

- Mining companies (operator of hard coal mines and project hosts);
- Equipment manufacturers (methane treatment and utilization equipment, and power generation equipment supplier);
- Project developers (project opportunity identification and planning);
- Engineering and consultancy (technical assistance, i.e. testing, consulting and engineering);
- Universities and research establishments (research and technical assistance);
- Engineering and construction companies (CHPs, power plant engineering and construction companies, and drilling contractors);
- Natural gas transmission and distribution companies, and power companies (pipeline sales for power generation); and
- Professional associations (establishing project networks, and advising members on technical, economic and legal issues).

Development of CMM recovery and utilization projects is highly dependant on the demand side of the methane market, the availability of CMM and project financing. Most of CMM demand potential comes from natural gas markets (for example, in the U.S. most CMM is sold via natural gas pipeline), electricity markets (for example, in the UK new CMM utilization projects tend to be power generation projects), and heat generation and combined heat and power generation (potential CMM end usage in Germany). Emerging carbon markets also provide significant potential for CMM recovery and utilization projects.

Investment costs for CMM projects vary widely depending on the project characteristics, and can be financed through equity investments, loans, grants, carbon financing, or a combination of these sources. Some degree of equity financing is generally required for loans in order to demonstrate that the developer is confident in the project's success and shares in its risks. International experience shows "that debt to equity ratios of 60:40 (debt:equity) or 75:20 are not uncommon for international CMM projects under consideration in China. The actual ratio preferred by any given lender usually reflects the project's perceived risk as well as the borrower's financial stability" [1]. Table 3 provides an overview of key government bodies, private institutions and international organizations that provide loans, carbon financing and/or assistance for CMM recovery and utilization projects worldwide.

Table 3. Organizations providing loans, carbon financing and/or related assistance to CMM recovery and utilization projects

Financing	Government bodies	Private institutions	International organizations
Loans and/or assistance in debt financing	• BISNIS Finance Link – U.S. Department of Commerce • Overseas Private Investment Corporation • Trade Information Center, International Trade Administration • U.S. Trade and Development Agency • U.S. Export-Import Bank	• ABB Financial Services • Caterpillar Financial Services Corporation • GE Capital Global Energy • Global Environment Fund Group • Global Finance Corporation • Heller Financial • Monarch Financial Corporation • Siemens Financial Services	• Asian Development Bank • European Bank for Reconstruction and Development • Global Environment Facility • World Bank
Carbon financing and/or assistance in carbon financing	• Austrian JI/CDM Program • Belgian JI/CDM Program • Danish Carbon Tender • Finnish Drive for Emission Reductions	• European Carbon Fund • Natsource GHG Credit Aggregation Pool • Icecap Carbon Portfolio • Japan Greenhouse Gas Reduction Fund • KfW Carbon Fund	• Baltic Sea Region Testing Ground Facility • ADB Clean Development Mechanism • IFC-Netherlands Carbon Facility • Multilateral Carbon Credit Fund • World Bank Carbon Funds

Sources: 1) Coalbed Methane Extra: A publication of the Coalbed Methane Outreach Program, U.S. EPA, Fall 2007. 2) Catalog of Coal Mine Methane Project Finance Sources. Coalbed Methane Outreach Program, July 2002.

There are plenty of opportunities for financing CMM recovery and utilization projects in developing and transition countries that arise from both carbon and clean energy funds. It is important to mention that minimum project requirements to successful carbon or/and institutional financing include more or less significant project size with sufficient CMM resources, suitable revenue stream, equity co-financing, "permits and license in place; and a dedicated and capable team" [5]. This means that in spite of the potential availability of financial resources for CMM recovery and utilization projects, project owners must undertake considerable effort for successful project implementation.

4. ECONOMIC AND FINANCIAL INCENTIVES

A variety of economic and financial incentives have been developed to foster CMM and CBM utilization projects. The domestic incentives described below include: feed-in tariffs (France and Germany), obligations and grants (Australia), and tax incentives (UK).

Feed-in tariffs can promote renewable energy through higher prices for renewable electricity on the electricity market. Both France and Germany employ this practice; France created the mechanism for feed-in tariffs through its Electricity Act of 2000, while Germany relies on its Renewable Energy Sources Act of 2004. Feed-in tariffs proved to be very effective in creating incentives for development of the renewable energy sector (including CMM projects) in these countries [3 and 6].

To decrease the share of electricity generated from coal in Australia, the government developed a program called Gas Electricity Certificates (GECs). According to the scheme of the program, which is authorized under the Electricity Act of 1994, "electricity suppliers are required to source GECs from generators of electricity using natural gas, coal seam, landfill, or sewage gas to comply with their obligation" [4]; otherwise, the government imposes a penalty. Under this scheme, accredited generators receive an additional source of income through a market-linked mechanism. In addition to the obligations, the Australian government provides grants that cover up to 50% of CMM/CBM project costs.

In 2001, to reduce GHGs emissions and improve energy efficiency, the UK introduced the Climate Change Levy under the Finance Act of 2000. The levy applies to energy suppliers. Electricity generated from renewable energy and CMM does not fall under the Act, which effectively decreases the expenditures of the relevant generators compared to their competitors.

Financial incentives for foreign investment in CMM projects include lowering or eliminating tariffs and value added taxes for CMM equipment. According to the Coal Mine Methane Global Overview by the Methane to Markets Partnership, China, India and Ukraine have all implemented such policies.

In summary, policies to promote CMM utilization have proven to be successful in the above mentioned countries. It is very important to note that incentives concerning renewable energy projects and GHG mitigation measures have been developed in a package rather than separately for each type of alternative energy source and CMM. Moreover, different categories of incentives are not used simultaneously (except in Australia). Feed-in tariffs are employed in Germany and France, and tax incentives in the UK.

5. EDUCATION AND INFORMATION DISSEMINATION

Education and information dissemination play an important role in the development of CMM recovery and utilization projects in developing countries and countries in transition. Developed countries have considerable experience in successful CMM project implementation. That is one reason why international institutions and government bodies of developed countries have been actively fostering CMM education and dissemination practices in developing countries and countries in transition. These practices include CMM clearinghouses and information centers, CMM technology transfer programs, and international cooperation programs.

There are CMM clearinghouses and information centers in such countries as China, India, Russia. In 1994, the Chinese government founded the first of these institutions, the China Coalbed Methane Clearinghouse [7]. The Russian International Coal and Methane Research Center (Uglemetan) began operating in 2002 [8] and the India CMM Clearinghouse – in 2008 [9]. Polish institutions that play important roles in CMM dissemination practices include the Central Mining Institute of Katowice, AGH University of Science & Technology, and the Mineral & Energy Economy Research Institute of the Polish Academy of Sciences. Many organizations such as the Methane to Markets Partnership, the International Energy Agency, and the United Nations (UN) Economic Commission for Europe as well as the U.S. EPA have been actively participating in the development of CMM recovery dissemination practices in China, India, Poland and Russia. The main function of clearinghouses and information centers in the countries mentioned above is to promote CMM recovery by providing information and assistance on technical, economic, financial and policy issues to interested companies and government agencies.

Two organizations particularly active in promoting CMM recovery and utilization globally include EPA's Coalbed Methane Outreach Program (CMOP) and the Methane to Markets Partnership. CMOP is a voluntary government program aimed at reducing methane emissions from coal mining. CMOP promotes the profitable recovery and utilization of coal mine methane. It works cooperatively with the coal mining industry in the U.S. and internationally to reduce CMM emissions. CMOP's website states that "By helping to identify and implement methods to recover and use CMM instead of emitting it to the atmosphere, CMOP has played a key role in the United States' efforts to reduce greenhouse gas emissions and address global climate change" [10]. The Methane to Markets Partnership's website states that "it is a voluntary, non-binding framework for international cooperation to advance the recovery and use of methane as a valuable clean energy source. The role of the Partnership is to bring diverse organizations together with international governments to catalyze the development of methane projects" [11].

The UN has several programs that promote coal mine methane recovery and use, including a specialized group in the UN's Economic Commission for Europe. The UN Development Programme, Environment Programme and other departments have also worked to promote coal mine methane projects. Likewise, some international development banks work on the issue, either through specific investment projects or through technical assistance programs like the World Bank's Energy Sector Management Assistance Program.

Bilateral CMM technology transfer programs have also been successful at disseminating information. Examples of technology transfer projects include the UK-China Coalbed Methane Technology Transfer Project (2001), the Methane Extraction and Utilization from Abandoned Coal Mines: UK-China Technology Transfer Project (2001 to 2002), the UK–India CBM Technology Transfer Project (2003 to 2005), the UK-Russia AMM/CMM[3] Technology Transfer Project (2005 to 2006), and the Development of China's Coalbed Methane Technology/Canada Carbon Dioxide Sequestration Project (2002 to 2007) [12, 13]. In these projects, China, India, and Russia were the host parties while the UK and Canada served as project developers. The main objectives pursued by these projects were as follows:

[3] AMM – Abandoned mine methane.

- To promote sustainable development by reducing GHG emissions and improving exploitation of local energy resources;
- To investigate the regulatory framework of CMM industry and the current state of CMM recovery and utilization technology in a host country;
- To develop economic cooperation between countries involved in the project and CMM related industries of these countries; and
- To determine market opportunities for UK or Canada companies and to promote the usage of UK or Canada technologies in a host country.

This list of organizations promoting CMM internationally is by no means exhaustive, but it does provide a flavor for the type of assistance and cooperation available.

6. TECHNOLOGIES TO CAPTURE AND UTILIZE CMM AND CBM

The experience of coal producing countries, where the utilization of coal methane is well developed, shows that extraction of methane is possible and reasonable at three stages of coal mine development: before mining takes place (pre-drainage CBM extraction), in an abandoned or closed mine (AMM extraction), and in an operating mine (CMM extraction).

Pre-drainage CBM, AMM, and CMM can be extracted through drainage systems. Drainage systems “remove the gas from coal-bearing strata before, during, and after mining, depending on the particular needs of the mine” [14]. Following the terminology developed by the UNECE Ad Hoc Group of Experts on Coal Mine Methane, a “drainage system is a system that drains methane from coal seams and/or surrounding rock strata. These systems include vertical pre-mine wells, gob wells and in-mine boreholes”. [11]

1) Vertical pre-mine wells

If a mine owner uses vertical pre-mine wells for CBM extraction before putting a mine into operation or before developing a coal seam of an operating mine, the methane concentration in the mine can be considerably lower than without pre-mining CBM extraction. Pre-mining CBM extraction increases safety, reduces mining delays, and decreases ventilation costs and methane emissions in the operating mine.

Without applying additional measures to enhance CBM extraction, it is impossible to produce CBM before the seam is de-stressed during coal mining. It is important to mention that CBM development can cause negative impacts on the environment, most significant of which are the destruction of land and wildlife.

Vertical pre-mine wells are used for CBM extraction, the methane content of which is usually over 90%. Most common CBM usage is injection into the natural gas pipeline or electricity generation.

2) Gob wells

At abandoned or closed mines, gas with methane content fills the fracture zone caused by the collapsed strata after mining has been completed. In this case, methane is produced using existing drainage systems or gob wells drilled especially for this purpose.

Gob wells are used for AMM extraction; the methane content of this AMM is usually 20-80%. The most common use of AMM is as a fuel for heating and power generation.

3) In-mine boreholes

At operating mines, methane is extracted using the existing degasification systems, after mining de-stresses the coal carrying strata and the methane loses its close absorption connection with coal media.

It is important to note that “CMM drainage is an essential part of mining of coal seams where the gas emissions from the seams, disturbed by mining, are higher than can practicably be diluted by ventilation air. Various methane drainage techniques have been developed to capture as much CMM as possible before it enters the airways of underground coal mines” [15].

In-mine boreholes include “underground horizontal boreholes drilled along the mined coal seam and cross-measure boreholes drilled through the coal seam and surrounding rock” [16]. In-mine boreholes are used for CMM extraction, the methane content of which is usually over 90% for horizontal boreholes and 30-80% for cross-measure boreholes. The most common CMM usage is heat and power generation.

It should be noted that variations of the drainage techniques described above may be used for methane production, which can result in methane content and methane recovery levels different from the ones mentioned above. These variations mostly depend on the mining techniques used for coal production, the geological conditions of the mining area and the particular needs of the mine.

Key prerequisites for successful CMM utilization include:

- Adherence of mine owners to methane recovery and utilization;
- Existing, carefully managed methane drainage system providing well-controlled air intrusion;
- Sustainable gas capture; and
- Appropriate infrastructure.

On-site CMM combustion technologies include: decentralized or centralized combined heat and power units (CHP), internal combustion engines or gas turbines, and boilers that can burn CMM or co-fire CMM and coal.

CHP plants generate heat and power simultaneously through cogeneration. In decentralized CHP, each CHP unit supplies heat to cover individually connected heat loads and deliver power for local needs, while any surplus is sold into the public grid. Centralized CHPs supply electricity to the mine and the rest to the public grid, and provide heat to the mine and municipal heating system. Combined heat and power units are used for electric power and heat generation via combustion of CMM with a methane concentration of 25-30%.

Internal combustion engines and gas turbines produce electricity, which is used for on site consumption or/and grid-connected power transmission. Electricity is generated via combustion of CMM with a methane concentration of about 45% for internal combustion engines and above 35% (with minimal variability) for gas turbines.

Boilers burning CMM, or CMM and coal provide space heating and hot water production via combustion of CMM with a methane concentration of 25-30%.

Some applications of methane combustion technologies may need additional equipment for gas enrichment and/or purification to ensure continuity of power generation, especially if the generated power has to be sold to the public electric grid.

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