Recent Trends in Recovery and Use of Coal Mine Methane

Coal Mine Methane Emissions

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ABSTRACT

Coal mine methane (CMM) has been used on a local basis for decades in many parts of the world, but the commercial scale development of this resource in the USA and elsewhere during the 1990s has contributed to the interest in development of the resource in China, Russia, Eastern Europe, and India. Investment in international CMM development projects began slowly with projects that were really CBM projects designed to drain gas from the virgin coal in the proximity of gassy mines. In the early 1990's, with impetus and investment provided by bilateral and multilateral grants and soft loans, successful demonstration projects of mine gas recovery began to pave the way for private investment in CMM projects. Public sector funding of projects is still important in a number of countries due to a variety of institutional and technical barriers; but in some countries the barriers have been overcome, leading to successful commercial projects that may be replicated elsewhere.

Now, at the turn of the 21st century, emissions from active and closed coal mines represent an under-utilized resource in the major coal producing countries. Gas drainage is increasingly necessary for ensuring safe mining in some coal basins, and not only is there an increase in the volume of gas produced, but in some cases there is an associated increase in gas drainage efficiency. Unfortunately, for countries with economies in transition, the rate of increased use is not commensurate with the increasing availability of gas. Because of this disparity in rate of growth in demand with respect to supply, large volumes of medium heating value gas are vented to the atmosphere annually. In addition, even larger volumes of very low heating value gas are routinely discharged from mine ventilation systems. This paper examines the trends in recovery and use of this resource, and the impact of changes in mining conditions, markets, and technology on the future commercial viability of CMM.

1.0 INTRODUCTION

The recovery and utilization of methane from both active and abandoned coal mines has increased in recent years, with several new projects operating in North America, Australia, and Europe. The economic value of this resource as a fuel is becoming more apparent with the recent increase in natural gas prices. The emerging GHG emissions reduction market may provide additional revenues to organizations that recover and either utilize or destroy methane before it enters the atmosphere. Although leveraged by international CBM development, CMM investment and policy development has advanced slowly. As a result, the development potential of CMM varies widely between countries.

2.0 CAN CMM DEVELOPMENT REACH ITS COMMERCIAL POTENTIAL?

Conceptually, the inclusion of CMM development into the gas and methane mitigation markets is dependent on overcoming a set of multi-tiered barriers, several of which have been breached during recent years. **Figure 1** depicts five different aspects of development potential for the CMM industry: market, economic, socioeconomic, technological, and physical potentials. **Figure 2** is an example of a path that full resource development can take, in this case, the path CBM resource development took in the US,. CMM development could take a similar path to full development in many coal producing countries. Through the use of current technologies, incentives, multi-lateral agreements and sound practices, development of CMM has achieved *market or economic potential* in most countries, but to advance toward the upper-bound, or limits of *physical potential*, (meaning using all of the technically recoverable resources), CMM development must still surmount many obstacles.

To reach the 2nd component after market potential, or its *economic potential*, entities involved in CMM development must prevail over several issues such as ill-defined gas property rights, increased financial transfers and credit, creation of markets, and reducing risk and failure rates of projects. These issues still exist in countries like Russia, Ukraine, Czech Republic, and Poland where the state-owned gas companies control the market.

The next component of achievement is the *socioeconomic potential*. Through education, institutional reform, industry involvement in policy making, and changes in attitudes, this development potential can be reached. Australia, for example, is eliminating some of these barriers through activities of its Australia Greenhouse Gas Office such as climate change education and by funding CMM demonstration projects. Likewise, the U.S. EPA's Coalbed Methane Outreach Program has been promoting CMM recovery and use for over a decade in the U.S. as well as major coal producing countries of Central and Eastern Europe and Asia. More recently, the Coalbed Methane Clearinghouse in China and Uglemetan in Russia have offered services and provided information and assistance to companies interested in developing the CMM resources in their respective countries.

Full *technological potential* can only be reached by applying new technologies that have been successfully demonstrated to be commercially viable. A comprehensive national energy policies and CMM development and use initiatives, the networking and synergism among coal and gas companies, and continued research and development toward optimizing technological potential, and demonstration of new technologies, advances the process. Most CMM emissions worldwide are produced through ventilation air methane (VAM). New technology is being developed and tested to use this otherwise wasted resource. Australia's CISRO is currently funding lean-fuel technologies such as turbines that can use 1-2% CH_4 from ventilation air. U.S. EPA and DOE are funding a demonstration project with Consol Energy using MEGTEC's VOCSIDIZER to destroy ventilation air methane (VAM).

The barriers and obstacles to achieving the development potentials listed above can only be overcome through planning, policy development, and concerted action on the part of government and industry. The theoretical

upper-bound or *physical potential* of CMM development may shift over time, but steps necessary to reach that level of development remain unchanged. Progress is being made reducing barriers at different components of development in different countries. In the end, technology transfer between nations with the highest CMM potential will be essential to the success of the worldwide industry.

3.0 TRENDS IN GLOBAL CMM EMISSIONS

Global CMM emissions increased approximately 20% from 1990 to 2000, and are expected to increase another 20% by 2010. Not all countries are experiencing increases in CMM emissions however. CMM emissions from Russia and Ukraine dropped nearly 50% during the 1990s, while significant reductions occurred in the United States, Germany, South Africa, Kazakhstan, and the United Kingdom. The most notable increases were seen in China, Australia, and India. **Figure 3** summarizes the CMM emissions from 1990 and 2000 for the twelve countries producing the greatest amounts of CMM emissions.

Forecasts of CMM emissions for the year 2010 are also shown in **Figure 3**. Significant increases are expected to occur in China, United States, Australia, and India. Russia and Ukraine are expected to produce nearly constant levels of CMM emissions. **Table 1** summarizes the state of CMM development of each country based on the components discussed in the previous section. Each country has been evaluated based on its achievements in CMM development. Based on this evaluation scheme, China, U.S., Russia, Germany, and the U.K have made substantial progress.

4.0 THE MARKETS: PRODUCTION VS. COMSUMPTION OF NATURAL GAS IN CMM-PRODUCING COUNTRIES

Six of the twelve countries producing the largest amounts of CMM emissions actually needed to import natural gas to meet their countries' demand in 2001 (**Figure 4**). They are the United States, Ukraine, Poland, Germany, Kazakhstan, and the Czech Republic. Of these countries, the United States, Poland, Kazakhstan, and Czech Republic all expect to see significant increases in demand in the near future (with respect to their current demand). With the exception of Russia and Ukraine, all the other countries expect to see consumption of natural gas increase by 20-50% by 2010. The largest expected incremental increase for gas use is the United States with 125 billion cubic meters (Bcm), followed by China (35 Bcm), Kazakhstan (31 Bcm), and India (29 Bcm).

In comparing the 2010 forecasts for CMM emissions with the gas use forecast, it appears that China and the United States offer the greatest potential for the CMM industry. Large resources do exist in Russia and Ukraine, but new demand is not expected in Russia while Ukraine's state-owned gas industry limits the market opportunities there. Moreover, tremendous CMM opportunities will continue in countries like Australia, Poland, Germany, India, and Kazakhstan.

5.0 COUNTRY OVERVIEWS

CHINA

Historically, natural gas has not been a major fuel in China, but given its domestic reserves of natural gas, China has embarked on a major expansion of its gas infrastructure. China has the "West-to-East Pipeline" under construction fto deliver natural gas produced in the Xinjiang province to Shanghai. As a result, China is experiencing heightened CBM development interest and activity in coal basins that also offer the greatest opportunities for CMM development.

In the early 1990s, UNDP, through the Global Environmental Facility, funded successful demonstration projects at three gassy coal mine complexes. The GEF project accelerated the technological and socio-economic development of CMM resources in China. In 1994, China Coalbed Methane Clearinghouse was established to enhance understanding and awareness of China's CBM/CMM resource development potential. Located in Beijing, the Clearinghouse provides information and logistical support to private businesses and foreign and domestic government agencies interested in CBM/CMM development in China. Their work supports the economic, socio-economic, and technological components of CMM industry.

UNITED STATES

The total volume of CMM liberated in the U.S. in 2001 was 5.4 Bcm, with underground mining activities liberating the largest source with 3.8 Bcm (or 71% of the total). Of the 3.8 Bcm of CMM liberated from underground mines in 2001, about 1.4 Bcm was emitted through drainage systems, while the remainder was emitted as ventilation air. Nearly 80%, or 1.1 Bcm, of the gas liberated through drainage systems was recovered at ten coal mines. The largest share, 0.7 Bcm, is recovered from two Consol Energy mines.

While drainage efficiencies have increased at existing projects recently, no new CMM recovery and use projects have been implemented at active coal mines in the U.S. since 1997. As a result, recovery and use quantities have been increasing only slightly. Conversely, many new abandoned coal mine methane projects have begun operating during the past few years. EPA’s CMOP continues to advance the socio-economic and technical potential of the CMM industry through their outreach program.

RUSSIA

Gazprom, Russia's state-run natural gas monopoly is seriously encumbered by domestic regulation. According to the Russian Gas Law of 1999, Gazprom must supply the Russian natural gas market, regardless of profitability, at government-regulated prices. The Russian government has recognized this problem and has stipulated that domestic natural gas prices will be freed sometime after 2010. Uglemetan headquartered in Kemerovo, Russia, was established in April 2002 on the foundation created by the work of the Russian Coalbed Methane Center. Uglemetan is organized as an autonomous not-for-profit organization dedicated to promoting coalbed methane (CBM) recovery and utilization in Russia and other countries of the Former Soviet Union. Uglemetan offers a package of services and expertise that aid in identifying

and developing CMM project opportunities, including definition and development of investment projects, technical translation, and communications and office services.

In October 2002, the United Nations Development Programme and the Global Environmental Facility (UNDP/GEF) approved a coal mine methane recovery and utilization project in Russia. The purpose of the project is to mitigate greenhouse gas emissions by removing barriers to the financing and implementation of coal mine methane (CMM) recovery and utilization projects in the Kuzbass Basin of Russia. The total project cost is US$8 million, with the UNDP/GEF contributing US$3.1 million. This project will further the expansion of all CMM development potentials in Russia.

UKRAINE

During 2000, Ukrainian coal mines captured 260 million cubic meters (Mcm) which was 12.4% of the total methane liberated. Only 73 Mcm (or 28%) of the captured methane was utilized. The low percentage is due to the lack of funds in the coal industry for proper maintenance in the collection systems and for new development projects. Forty-five mines in Ukraine used degasification systems but only twelve mines utilized the captured methane; primarily for use in their mine boilers.

The greatest barrier to CMM development in Ukraine has been the lack of comprehensive governmental support and a legal environment that promotes outside investment in energy. The Cabinet of Ministers of Ukraine has considered a new national energy program that includes a goal to have 8 Bcm of methane produced by the year 2010. In addition, new laws have been enacted to promote CMM development; these include the Law on Alternative Fuels, the Production Sharing Agreement, and the establishment of Free Economic Zones. The U.S. Agency for International Development (U.S. AID), with support from U.S. EPA, is funding a project of introducing further legislation in support of CMM development in Ukraine.

AUSTRALIA

Outside of the U.S., Australia has the most commercially advanced CMM/CBM industry and is home to the largest CMM power project in the world. In New South Wales, the Appin and Tower Collieries, operated by BHP Billiton, produce electric power by using drained CMM to fuel 94 MW of power from 651,000 m^3/day of CMM. In addition, the 54 engines located at the Appin site also consume mine ventilation air as combustion air, thereby utilizing ventilation air methane. BHP Billiton is also currently working with MEGTEC Systems to further reduce its methane emissions by using low quality (<1%) ventilation air for heating and possibly power generation. A demonstration project using MEGTEC's Vocsidizer™ system was recently conducted at BHP's Appin Colliery beginning January 2001. The goal of the one-year project was to confirm the ability of the Vocsidizer™ to destroy methane in mine ventilation air and evaluate its stability at low methane concentrations.

In October, 2001, the Australian government announced awards for AUS $30 million (U.S. $15 million) to three coal CMM projects expected to cut greenhouse gas emissions by 7.2 million tonnes CO_2e between 2008 – 2012.

BHP Billiton has been offered up to $6 million towards a $10.7 million project to install a specialized combustion unit that can burn low concentration ventilation air methane at the West Cliff colliery; Powercoal has been offered up to $15 million towards a $26 million project to link the air intake of Vales Point power station to the mine ventilation systems of Endeavour and Munmorah collieries; and Envirogen will be offered up to $9 million toward a $16 million project to install 10 gas engine generators at Bellambi mine. With its abundant gas reserves, Australia's weakest component of CMM development may be its ability to create new markets.

POLAND

Polish mines currently employ cross-measure boreholes to produce gas in advance of mining and in-mine gob wells to drain mined-out areas. Implementation of a CBM utilization program in Jastrzebska Spolka Weglowa SA from 1996-2000 established the basis for increased capture and use of methane at several mines. The overall percentage of CMM utilized from the degasification systems at six coal mines is high, generally in excess of 70%. Since the majority of gas contains methane concentrations between 50-60%, the end use is usually industrial rather than pipeline sales (due to the enrichment costs). In addition, only the Jas-Mos, Pniowek, and Zofiowka coal mines have access to nearby pipelines. As a result, end-uses for the gas include power generation, heating, coal drying and industrial boilers, and CHP projects. In 2001, over 70 Mcm of CMM was utilized at Polish coal mines.

Although state-owned companies currently control the gas market, Poland and other Visegrad countries are striving to meet EU membership criteria, which includes liberalizing their gas markets and increasing use of natural gas. Meeting the EU milestones should help CMM development potential.

GERMANY

Germany is the European Union's second largest consumer of natural gas after the United Kingdom and meets most of its demand through imports. Recently, CMM has established itself as an important clean energy resource in Germany with the passage of a new energy law. In 2000, the German Federal Government adopted an Act on Granting Priority to Renewable Energy Sources for the environmental protection as well as guaranteeing a reliable energy supply. This objective is related to the German Federal Government's planned commitment to reduce greenhouse gas emissions by 21 per cent by the year 2010. Under this act, because CMM is included as a renewable resource, and compensation is being paid for electricity generation installations (< 500 kilowatts) using gas from coal mines in the amount of 15 pfennigs (~US$0.07) per kilowatt-hour.

G.A.S. Energietechnik GmbH together with their partners, RAG Aktiengesellschaft, Essen, and LAMBDA Gesellschaft fur Deponiegastechnik mbH, Wuppertal has recently founded the joint venture company called Minegas GmbH. The aim of Minegas GmbH is the development of CMM from abandoned coal mines in the Ruhr area for the generation of energy that will be used in the electricity and heat market. The company expects to build 50 MW of capacity using CMM-fueled gas engine-based CHP power plants. Germany remains the only EU member yet to have established a regulatory

agency for natural gas and electricity markets; however, the government announced that it would create an agency by mid-2004. This has not been a significant barrier thus far since existing policies and initiatives favor CMM as an energy source, and Germany is approaching its technological potential.

INDIA

Gas Authority of India Limited (GAIL), a government-owned entity, is in the process of doubling the throughput capacity on its main Hazira-Bijaipur-Jagdishpur (HBJ) Pipeline. India's government has been considering reforms in its natural gas pricing mechanism, which is currently set by the government. Deregulation has been delayed several times, and the recent increase in domestic reserves may lead to a tilt toward less regulation of prices.

India recently initiated its first CMM recovery and utilization program. The $18 million project, funded by the GEF, UNIDO, and the Government of India, seeks to demonstrate the technology for producing methane in advance of and during the mining process. The recovered methane will be used to generate electricity and as a fuel for CNG in mine trucks.

UNITED KINGDOM

Three UK companies, Alkane Energy, Octagon Energy, and StrataGas are aggressively pursuing opportunities in CMM development from abandoned mines. Octagon Energy recently installed a 5 MW plant in South Yorkshire using previously vented methane from abandoned mine workings. Octagon Gas, owns and operates a production, distribution, and storage system in the Stoke-on-Trent area where the methane is used by a 10 MW power station.

Alkane Energy of the U.K is developing a series of Green Energy Parks based on CMM extracted from abandoned mine workings. The company currently has five Green Energy parks in operation: Shirebrook fuels a 9 MW on-site power station; Markham supplies gas for industrial heat applications; Steetley, feeds a 6 MW power station; Wheldale, supplies a 10 MW power station; and Monk Bretton, provides gas for process heat at a glass manufacturer.

In January 1999, StrataGas began to supply gas from the closed Silverdale Colliery to industrial customers in the Stoke-on-Trent region. In June 1999 it had signed contracts with Octagon Gas Limited to take an operating lease of the site and all the mines gas produced, and in June 2003 sold the project to Octagon Gas. StrataGas, completed the commissioning of the Bentinck CMM gas plant in Nottinghamshire in January 2002. The project was designed to be able to pump up to 3,300m3 per hour of gas to the adjacent 10MW electricity generating plant. StrataGas recently announced the sale of this project to Warwick Energy Ltd. in August 2003.

6.0 CONCLUSIONS

Worldwide development potential for CMM can be realized to its fullest extent in the near term, but many formidable barriers remain. The most common barrier to development is the lack comprehensive policies that not only encourage the development of CMM using the technology that is available

presently, but policies and funding that cause new approaches to be taken and new technologies to be developed and used. Development of CMM projects can be encouraged by facilitating financial incentives gained through GHG emissions trading and from tax credits associated with unconventional energy resource development.

7.0 FIGURES

Figure 1 – Steps to Realizing CMM Development Potential (derived from Climate Change 2001: Mitigation, a report of IPCC Working Group III)

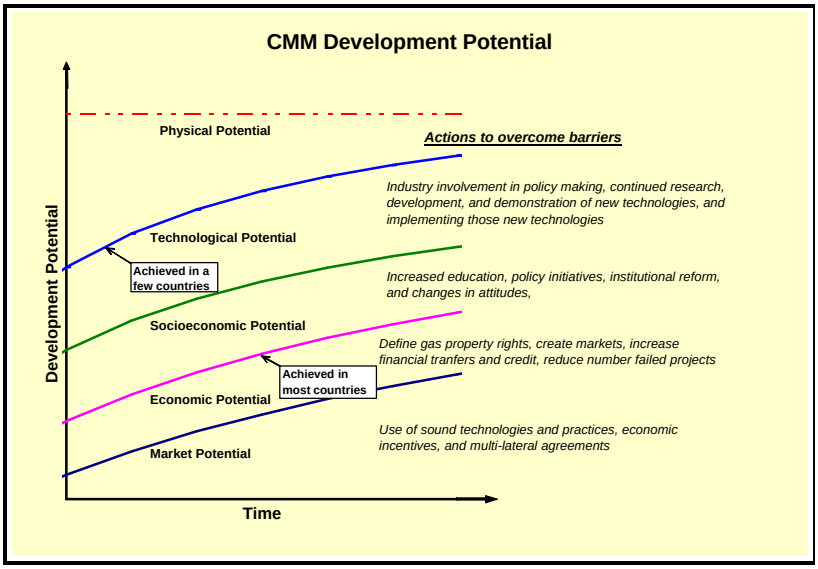

Table 1 – Ranking Countries with the Largest CMM Development Potential

	Market Potential			Economic Potential			Socio-Economic Potential			Technical Potential			Physical Potential		
	Use of sound technologies and practices	*Utilize existing economic incentives*	*Bi-lateral or multi-lateral agreements*	*Define gas property rights; Create and expand markets*	*Reduce risk and failure rates of projects*	*Unsubsidized, free gas market*	*Educational and institutional reform*	*Changes in attitudes*	*Industry involvement in policy making*	*Government initiates, CBM energy plan*	*Continued research development and demonstration of new technologies*	*Implemeting new technologies*	*Increased use of new technologies*	*Widespread use of new technologies*	*New technologies commonplace*
China	X	X		X			X	X					X		
USA	X	X	X	X	X	X	X			X			X		
Russia	X	X	X	X			X	X							
Ukraine	X	X													
Australia	X	X	X	X	X	X	X	X	X	X	X		X		
Poland	X	X	X										X		
Germany	X	X	X	X	X		X	X	X	X	X		X		
India	X	X	X												
South Africa	X	X													
Kazakhstan	X	X													
UK	X	X	X	X	X	X	X						X		
Czech Republic	X	X											X		

Figure 2 – CBM Development in the U.S. as Example of CMM Development Potential

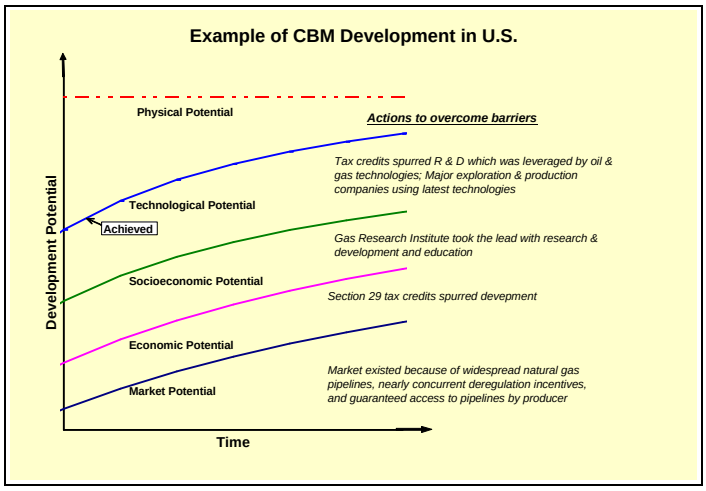

Figure 3 – Trends in Global CMM Emissions 1990-2010

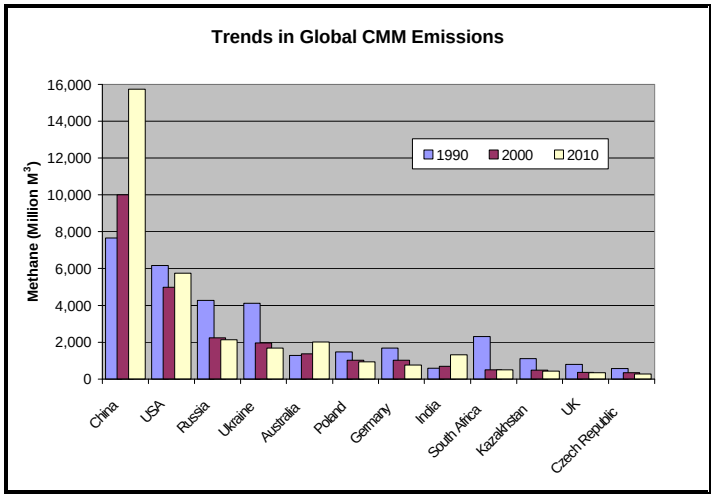

Figure 4 – Production & Consumption of Natural Gas By Largest CMM Producing Countries