

CDM, A TRIGGER FOR COAL MINE METHANE EMISSION REDUCTIONS IN CHINA

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ABSTRACT

A UK-China consortium is developing a methodology and Model Project Concept for using the Clean Development Mechanism (CDM) for Coal Mine Methane (CMM) and Abandoned Mine Methane (AMM) utilisation projects in China. It is anticipated that the financing barriers currently stalling the introduction of mine gas utilisation schemes at many mines in China can be significantly reduced by the use of CDM financing.

Combined CMM/AMM schemes could have significant positive impact on reducing anthropogenic greenhouse gas emissions, as methane is a potent greenhouse gas with high global warming impact. An estimated reduction of up to 2.5 billion m³ of methane emissions is possible in China alone, and the developed approach has significant replication potential elsewhere in non-Annex I countries.

Successful application of the CDM will create opportunities throughout China for local and international companies with interests in developing CMM and AMM utilisation schemes. The most financially attractive schemes are likely to be those where gas flows from a number of working and/or abandoned mines can be combined and be used to supplement peak demand, especially in winter. Surplus drained gas that would otherwise be vented to the atmosphere could be flared to further reduce emissions.

1.0 INTRODUCTION

The methane, which occurs naturally in coal seams, is released by mining and emitted to the atmosphere unless specific efforts are made to capture and use the gas. Almost 30 per cent of global industrial greenhouse gas emissions may be attributed to underground coal mining. Emissions are expected to rise to 28 million tonnes per annum (Mtpa) by the year 2010 as world coal production rises¹.

Gas drainage in gassy, working coal mines is an important safety measure as well as a source of clean fuel. These two aspects are intimately linked and both have a high profile in China due to an unacceptably high number of gas explosions, a shortage of clean energy, and a desire to reduce greenhouse gas emission from coal mines. More utilisation of the drained gas means lower greenhouse gas emissions, reduced energy costs and the potential to displace coal.

Gas emissions from coal mines in China

¹ Greenhouse Issues, No 41, March 1999, IEA Greenhouse Gas R&D Programme.

More than 95% of the coal mined in China comes from underground operations. Some 300 of the key state-owned coal mines are classified as gassy. Assuming an average specific emission of 10 m³ of methane per tonne of coal mined, Chinese mines would emit about 9 billion m³ of methane annually. Assuming that on average 30% of the gas could be captured in drainage systems, some 3 billion m³ of gas is theoretically available each year. By 2000 there were 184 coal mines with methane drainage systems draining about 0.9 billion m³ of gas of which only around 0.5 billion m³ is used. Therefore, an additional methane mitigation potential of 2.5 billion m³ annually may be available. The growth potential for CMM utilisation schemes therefore is large. The total potential revenue, assuming half of the gas can be commercially exploited and a price of 1.0Yuan/m³ of pure methane, is approximately US\$180m per year. China is the world's largest CMM source awaiting commercial exploitation.

CMM drainage technologies only capture a proportion of the gas released into mine workings. Capture rates achieved in individual mining panels can typically range from 30% to 80% depending on the drainage technology used, the geology and the mining conditions. Technologies exist for removing diluted methane from mine ventilation air, but these are not yet commercially viable. The potentially drainable CMM resource in China using tried and tested technology is currently so large that treatment of mine ventilation air is not yet warranted. Gas capture and use could be enhanced significantly through improvements in the management of existing technologies and control practices.

Table 1. Mine gas classification of state-owned key coal mines (1998)

Mine gas classification	Number of mines		Total gas		Max. gas inflow (m ³ /min)
	Number	%	m ³ /min	%	
Total	634		9418		
Coal-gas outburst	130	21	3757	40	430
Highly gaseous	184	29	4416	47	365
Low methane	320	50	1245	13	52

Mines in China are classified as highly gaseous (see Table 1) when they emit more than 10m³ of methane per tonne of coal mined and the total gas flow rate exceeds 40m³/min. Coal and gas outburst prone mines require special treatment to control risk which can limit coal production. Provided records at the mine indicate the risks are controllable these may be suitable candidates for CMM schemes. However, the highly gaseous mines are the preferred targets. If 50% of the gas released from the 184 highly gaseous mines could be captured and used this would represent a total of about 400MW_e equivalent. However, the gas flows at some mines will be too low to support commercial utilisation even with CDM financing, although the possibility of flaring may still be considered.

Gas capture in coal mines

There are two basic approaches to capturing methane in coal mines: removal of gas ahead of mining (pre drainage), and removal of gas from coal seams disturbed by mining (post drainage).

Gassy mines in China are required to practice both methods, but pre drainage is only effective where coal seams are relatively permeable. Pre drainage is the only method available where non-caving methods of mining (e.g. room-and-pillar) are used.

Post drainage techniques are aimed at capturing gas from coal seams that have been disturbed by the mining operations. In typical coal measure strata, this gas will come from seams above and below the workings, but not from the mined seam itself. Where unusually thick seams are worked by sub level caving methods, for example at Fushun, gas from the worked seam may also be captured using post-drainage techniques.

There are a wide variety of post drainage methods but all of them involve either drilling boreholes or driving headings into the de-stressed areas (goaf) created by coal extraction. Thus, some of the gas released from adjacent coal seams is captured before it enters the mine airways. The effectiveness of gas capture depends on the geology and also on the design, implementation and management of the gas drainage system. For any given geology and mining geometry, the rate of gas release from seams in adjacent strata is directly related to the rate of retreat of the longwall face.

Commercially feasible mine gas utilisation requires consistent availability of gas of sufficiently high purity and flow. Improved planning, training, equipment reliability, monitoring and management invariably lead to gains in performance.

Utilisation of Coal Mine Methane

Most of the CMM used in China is distributed via pipelines to mining communities and neighbouring cities for domestic use, mainly cooking. Some CMM is used in colliery boilers and for small-scale power generation. Additional uses being considered include vehicle fuel and chemical feedstock. Gas flows supplied to CMM utilisation schemes typically lie in the range 5 million m³/year to 200 million m³/year. The demand from domestic consumers varies widely, on daily and seasonal timescales, leading to gas often being vented in summer. In comparison, a power generation scheme can consume gas at a steady base load rate, all year round, offering higher returns on investment and greater reductions in greenhouse gas emissions. There are few CMM power generation schemes in China because local authorities and mining enterprises for social reasons often consider domestic consumers a priority. Additionally, achieving an electrical grid connection is problematic at present. However, there is potential to develop more CMM schemes to supply power to mines as they have a predictable base load and offer a number of advantages as a customer for the generated power.

The flaring option

A very rapid reduction in mining related emissions could be achieved by introducing flaring. This low-cost, low-risk option could be implemented at almost all mines that drain gas, irrespective of the quantities involved. Gas utilisation schemes would still be developed where they are financially attractive

A proven model could encourage mining companies to install flares where there are inadequate markets. Even where gas is used, flaring could be introduced for the excess gas at times of low demand.

Gas can be flared safely, but lobbying would be required to convince the mining regulatory authorities of this. In essence flaring is no different than any other combustion process at the mine. The technology has been demonstrated and accepted in Australia and the UK, but has not yet been introduced into China.

Financing of CMM schemes

Financing of CMM utilisation schemes is a problem. After years of poor performance and large losses, many mines have poor credit ratings with banks. Many schemes are too small to interest international financing institutions and private investors. There are, however, some notable exceptions, the largest being the Jincheng CMM project based at Sihe mine which will use an ADB loan to develop a 120MW_e power plant to generate electricity for local consumption. The commercial feasibility of CMM projects can be improved by combining schemes to increase scale, and selecting the gas use for which there is a market and which brings the highest returns. Increased transparency, streamlining of approval procedures, and gas price stability will help to create an environment to attract both domestic and foreign investors. The Clean Development Mechanism may become an important financing mechanism for assisting marginal utilisation schemes to be brought into operation.

2.0 CDM FINANCING FOR CMM SCHEMES

A UK-China consortium has been formed with the aim of stimulating the reduction of methane emissions from China's coal mining industry (in both working and abandoned mines) using the Clean Development Mechanism as a means to secure financing of such projects.

A number of gassy mine sites which could benefit from CDM project finance have been identified and talks held with representatives of short-listed mines to ascertain their interests and willingness to collaborate. The benefits, constraints and current uncertainties in the CDM process have been discussed with the mining companies and possible buyers of Certified Emission Reductions are being sought. As not only the CDM process is relatively new, but also the application of CDM to coal mine methane (CMM) utilisation schemes is novel, early projects will be closely monitored by the government of China. Attempts so far to initiate CDM support for CMM schemes without identifying funding sources have resulted in a loss of credibility and the national authority is now exercising caution in its

endorsement of proposed schemes. The consortium is liaising with the appropriate bodies to help map a way forward and to ensure suitable protocols are established. The aims of the consortium are to:

- Develop a pioneering methodology and replicable Model Project Concept for using the Clean Development Mechanism (CDM) for Coal Mine Methane (CMM) utilisation projects in China.
- Use the CDM to overcome the financing barriers currently stalling the introduction of gas utilisation schemes at many mines in China.
- Bring together leading national and international experts in the field of CMM and CDM to achieve a robust and practical methodology, which is approved by the relevant authorities.
- Develop the Model Project Concept into a state whereby financing can be secured and CDM approval is obtained from the Designated National Authority for the CDM.
- Lodge the CDM Model Project Concept and Methodology with the CDM Executive Board to be used as a reference by other non-Annex I countries.

Other benefits of utilisation of gas from mines that may be relevant under the Kyoto mechanisms are fuel substitution leading to greenhouse gas emission reductions, e.g. a boiler conversion from coal to CMM.

In order to cover set-up and administrative costs, and provide some financial benefit to the CMM scheme developers, assuming a price of \$3 per tonne of CO₂, it is estimated that a scheme needs to create CO₂ emission reductions of at least 50,000tCO₂ over 10 years. This equates to a scheme which has a pure methane flow of roughly 1000m³/day.

CMM factors relevant to CDM assessments

There are various issues relating to *additionality* and the establishment of rational methodologies to be used in appraising and evaluating CMM schemes for CDM support, some of which are discussed below. These and other issues are currently a matter for debate. The philosophy of the consortium is to encourage a free exchange of views, seek a consensus and promote pragmatic solutions. Some key issues include:

- Would the project have occurred anyway without CDM funding?
- What are the demonstrable and verifiable additional greenhouse gas emissions versus the baseline scenario?
- Is it possible to demonstrate investment additionality?
- What is the technological additionality, i.e. the introduction/transfer of new technology?
- Does the project meet the sustainable development criteria of the host country?
- Furthermore, the boundary of the project must be clearly defined, and the project leakage (i.e. the net change of anthropogenic emissions by sources of greenhouse gases outside the project boundary that are attributable to the project activity) estimated.

Many CMM projects in China are likely to meet the additionality criteria – the key question is how to define the baseline.

Baseline conditions

Although gas drainage may be installed in a coal mine for safety reasons, and increasingly this is being mandated in China, a CMM utilisation plant is not an essential part of initial mine construction and is rarely, if at all, developed until the mine has been operating for a few years. A major reason is the need to limit capital expenditure and borrowing to project items relating directly to the mainline business which is coal extraction. In the ensuing time, actual gas flows can be measured thus reducing performance risk, but at the same time substantial volumes of methane are vented to the atmosphere. Flaring of the drained gas could be introduced as an intermediate step but there is no precedence for this practice in China. CMM utilisation schemes are not usually designed and constructed in any country as part of the initial mining phase. For this reason, it could be argued that, in the absence of an existing scheme at an existing mine, the baseline is zero utilisation of methane. However the project team may have to take a conservative approach and assume that even for mines with no existing scheme, a scheme may be introduced at some time in the future as part of the baseline scenario. For mines with existing gas utilisation schemes, the project team will be establishing what is a typical utilisation rate for local usage, e.g. residential, to develop a conservative baseline.

Gas emission rates are reasonably predictable and the expected gas production profile can be estimated using gas content information, geology, mine panel geometry and the coal production schedules. Gas drained in advance of mining would not otherwise have been released until the coal seam was mined. The time elapsed between pre draining and working of the coal seam could be two years or more. In some instances, an area could be pre drained but not necessarily worked due to geological reasons. However, pre drained gas would be vented if no utilisation scheme was in place, so it could be argued that these gas flows should be allowed as part of the baseline case (the arguments for this will be further refined during the Project as will the methodology for estimating how to include this gas in the baseline). The quantities of gas being pre drained can be measured and the area from which the gas is collected can be recorded. In many coal mines in China, the pre drained gas flows are low and of poor quality due to inadequate drilling equipment, poor sealing of boreholes and low coal seam permeability.

Post drained gas if not captured would have immediately entered the mine airway. The quantities of gas post drained can be measured independently of the pre drainage system although some changes may need to be made to the underground collection pipe-work to achieve this. In some instances, seams being pre drained are over or under-worked by a longwall panel. Consequently, the gas flow in the original pre drainage collection system increases as it becomes a post drainage operation.

Furthermore in China, with a traditional heavy reliance on coal for electricity generation, a CMM utilisation scheme that generates electricity can also claim emissions reduction in the baseline for displaced electricity production from coal. A typical factor for displaced grid generation in China today is around 0.9

kg CO₂ per kWh generated. This factor will vary during the project life and is one of the baseline issues to be determined for a given project site containing an element of generation.

Leakage issues

There is an argument that the increased drainage of gas from a mine and the increased profitability from the inclusion of the utilisation scheme, means that more coal may be extracted as a result of the project activity and that this should be included as leakage within the calculation for emissions reductions. The project team will investigate whether this is a likely scenario and whether this can be estimated reliably.

Cost of gas supplied by the mine

Account is rarely taken of the true cost of extracting the gas when analysing the financial feasibility of a CMM utilisation scheme. This is because gas drainage is considered an essential part of the mining process and therefore an integral component of the coal production cost. Some scheme designers assume zero cost for the methane delivered to the gas extraction plant, and the gas utilisation process is often operated by a separate company which accepts the gas as delivered. There is therefore no immediate financial incentive for the operation of the mine to be improved to increase the quantity of gas captured or to better maintain the quality of the gas to ensure as much as possible can be used.

It is the authors' view that a CMM utilisation study should take account of the production cost of the gas in assessing the feasibility of a CDM project. Revenue from gas supplied to a utilisation scheme, if re-invested in the mine, could enable higher gas captures to be achieved which in turn could bring further advantages in terms of increased coal production without exceeding statutory gas emission concentrations in airways, reduced ventilation costs and increased coal reserves by enabling more gassy coals to be worked economically. Thus, the CDM scheme can indirectly promote energy savings and improved resource exploitation at the mine.

Investigative Approach

It is envisaged that the following investigative steps would be involved in a CDM project appraisal:

1. Accessible methane resources – A description of the mining and geological setting, typical geological strata section, seam gas content data and CMM resource estimation.
2. Gas Drainage – Analysis of the gas drainage methods, gas quantities and qualities and the potential to improve drainage performance.
3. Gas Predictions – A prediction of future gas availability based on the mining plan and taking account of underground pre and post drainage of gas. It may be difficult to justify including any gas pre drained from surface wells unless they are drilled into longwall panels likely to be mined within

the crediting time of the CDM project. Evaluation of this would be included in the verification plan.

4. Monitoring Standards – Establishing equipment specification, calibration and maintenance for verification of methane destruction.
5. The Utilisation Scheme – The scheme, technology, benefits, quantities of methane to be consumed, and turndown potential.
6. Risk Factors – The risks involved with the gas assessment and the utilisation scheme and suggested mitigation measures. This would include an assessment of the likely geological, mining and market risks which could impinge on the volumes of gas produced over the period of the proposed CDM project as well as the life of the mine.
7. Financial Analysis – Development of a financial model to demonstrate the financial *additionality* of the project and to be used to convey the value of the scheme to investors.
8. Social Environmental and Safety Assessment – A preliminary assessment of the social, environmental and safety aspects of the proposed utilisation scheme sufficiently detailed for CDM registration of the project.
9. Land and permitting – Establish ownership of resources, land and permitting issues as well as boundary settings for CDM.

3.0 CONCLUSIONS

Lack of capital usually limits mine utilisation schemes in China to relatively simple gas distribution systems supplying gas for domestic uses, with the surpluses being vented, causing considerable anthropogenic greenhouse gas emissions. The CDM could trigger project activities which reduce these emissions. Developing the documentation and Model Project Concept for CMM projects under the CDM is a key next step in unlocking this potential. However in developing the documentation and designing the concept, the approach for this should be conservative but remain pragmatic, simple to apply, and be developed with consensus agreement.