Enhancing Coal Mine Methane Utilisation in China

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by

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EXECUTIVE SUMMARY

The objectives of the work

The main objective of this project was to enhance coal mine methane (CMM) utilisation in China and reduce emissions of greenhouse gases from the coal mining sector. This project aimed to achieve this overall objective through the development of a pioneering methodology and replicable Model Project Concept for using the Clean Development Mechanism (CDM) for CMM utilisation projects in China. The existence of a model concept will present a way to overcome barriers for CMM utilisation, result in market opportunities for the UK industry in China and bring together Chinese and UK expertise.

Background to and need for the work

Increasing international recognition of the threat of climate change and the desire to reduce greenhouse gas emissions has seen the establishment of the CDM under the Kyoto Protocol. There now exists an opportunity for the UK to become a world leader and establish a CDM methodology for CMM utilisation schemes. Such CDM methodology would stimulate a rapid expansion of CMM utilisation schemes and create demand for specialist UK equipment and services. This would enable the UK to gain competitive advantage over the USA and other countries such as Japan and Australia.

The DTI-supported UK-China gas control technology (GCT) transfer project\(^1\) showed that a reduction of up to 2.5 billion m\(^3\) of methane emissions, a potent greenhouse gas with 21 times\(^2\) the impact of CO\(_2\) on global warming, may be possible in China. This project has built on the information, experience and contacts gained from the GCT project.

Gassy mines in China are required to drain gas to improve mine safety. More than 95% of the coal mined in China comes from underground workings. Assuming an average specific emission of 10 m\(^3\) of methane per tonne of coal mined, Chinese mines liberate about 10.6 billion m\(^3\) of methane annually. Some 300 of the key mines are classified as gassy. By 2002 there were 193 coal mines with methane drainage systems draining about 1.1 billion m\(^3\) of gas, of which only around 0.6 billion m\(^3\) is used. The growth potential for CMM utilisation schemes is therefore large.

Some 0.6 billion m\(^3\) of CMM (pure basis) was used in 2002, mainly for domestic cooking. Some is also used in colliery boilers. There would be environmental advantages in using CMM for district heating and CHP in cities, and also as a clean fuel for industry displacing coal as a fuel.

\(^{1}\) Methane Control Technology for Improved Gas Use in Coal Mines, Report No.COAL R257 DTI/Pub URN 04/1019.

\(^{2}\) Under the Kyoto Protocol the global warming potential for methane has been set for the period 2008-2012 at 21, while the IPCC in it’s latest report suggested a value of 23.
The development of CMM schemes in China has been slow, mainly as a result of financing difficulties due to the marginality of many projects. CDM financing could be the key to launching a large number of projects and hence rapidly expanding the market for UK equipment and services in this specialist area.

A summary of the work carried out

Sub divided into six tasks, the project developed a CDM model concept for enhancing CMM utilisation. The following tasks were carried out to develop this model and promote its usage in China:

- Task 1 Initial project start up meetings and on-going project management
- Task 2 Project identification
- Task 3 Pre-feasibility study
- Task 4 Develop CDM model concept and methodology
- Task 5 Inward mission
- Task 6 Information dissemination

First, a suitable case study project was identified by the project participants. Pansan Mine of the Huainan Coal Mining Group (HCMG), Anhui Province, was selected after reviewing a series of mines in a number of mining areas. This choice was made for several reasons, in particular the suitability of the mine and proposed utilisation scheme, but also the full co-operation by the staff from the mining group was important.

Secondly, a pre-feasibility study was carried out to ensure the selection of suitable CMM utilisation technologies to achieve the project potential. This study showed a great variability of CMM volumes and quality throughout the years. This directly impacted the project team’s recommended utilisation options, in particular the need for flaring.

Thirdly, a model concept for CDM projects was developed based on the case study of Pansan. As the pre-feasibility study showed great potential for this project, the project partners and HCMG took additional steps, which were outside the direct scope of this project but a very useful extension to it, and submitted a formal new baseline and monitoring methodology to the CDM Executive Board.

Fourthly, the results of this work have been disseminated in various ways, including an inward mission from the Chinese coal mining industry to the UK, publication of papers and presentations at various conferences. The submission of the methodology to the CDM Executive Board also resulted in exposure of the work to world-wide CDM experts.

A summary of the main results

The main result from this study has been the publication of the CDM model concept for CMM utilisation projects (in China). The methodology was developed and
submitted to the CDM Executive Board, and will hopefully result in an approved CDM methodology for the coal mining sector in mid-2005, and an officially registered CDM project before the end of 2005. Approval of the methodology will result in a strong incentive for the coal mining sector in China (and elsewhere) to implement CMM utilisation projects through the additional finance that will be available through the CDM.

The methodology, which has not yet been approved but received only a few comments from the methodology reviewers, emphasised utilisation of the energy content of CMM and maximum destruction of harmful emissions, without compromising on safety.

The study found wide support for CMM utilisation projects. Indeed, in response to a series of mining accidents caused by CMM, the Chinese government is taking steps to further promote utilisation of CMM as part of the safety provisions at mines. Without additional funding from the CDM, however, it may be difficult to finance such utilisation projects at a time when coal production needs to be increased to compensate for closure of smaller and less-safe mines.

Destruction of CMM through flaring is a new concept in China and the Pansan mine needed special dispensation to be allowed to install flares. Traditionally, flaring would not be considered as it introduces open flames in an area where methane gas is present and instantaneous combustion possible. However, modern flaring installations are safe, tried and tested, including in China for landfill gas projects. Additionally, without environmental regulation requiring emission reductions, and without the financial incentives that are given by the CDM, no reason exists in China to invest in this technology.

Conclusions drawn from the results

Emissions of methane from the coal mining sector in China are large. However, practical, proven and commercial technologies exist for utilisation of the energy content of coal mine methane, as well as for the destruction of the excess methane gas. Both the utilisation and destruction of CMM will dramatically reduce greenhouse gas emissions from coal mining activities, by converting methane to CO₂.

The Kyoto Protocol is aimed at reducing greenhouse gas emissions. Several instruments exist that encourage investments in projects that achieve such emission reductions. The CDM potentially offers significant additional finance for projects in developing countries, such as China, that result in emission reductions. The model concept, developed as part of this project, can help industry to seize these opportunities and make such projects more economically attractive for investors and developers.

By and large, the model concept aims to minimise the environmentally harmful emissions of CMM from coal mining activities, while improving the economic
The attractiveness of CMM utilisation. This model promotes economically and environmentally attractive projects through two steps:

- First, utilisation of CMM is promoted. This helps generate a relatively clean energy provision, as it is based on gas as opposed to coal. Such energy provision may be in the form of electricity generation for the mine, gas supply to a nearby town, or other appropriate forms of energy for the circumstances. This is limited by the actual local energy demands, as demand in some sparsely populated, or under developed areas is small. This is further limited by the unavailability of consistently high-quality CMM. In the mines investigated, gas flow and quality varied strongly over the year.
- This leads directly to the second step, which is the promotion of maximum reasonable destruction. As gas flows are variable both in volume and quality, much gas will necessarily remain unused by utilisation technologies (e.g. gas engines). This model concept therefore promotes the installation of flares to destroy any surplus CMM and any CMM of a quality too low for utilisation, but high enough for destruction.

The utilisation of the energy content of CMM emitted from the mine serves to increase local energy provision, improve energy security in the region and reduce wastage. Additionally, CMM utilisation reduces the use of other energy sources, therefore minimising environmental harm that would have resulted from those sources. The maximum destruction minimises the environmental harm from the CMM released which cannot be avoided when mining coal.

**Recommendations**

CDM-supported CMM projects have the potential to be replicated at a large number of mines throughout China. It is envisaged that the methodology from this project will become the basis for other CDM-supported CMM projects. This presents very good opportunities for UK equipment and service suppliers. As a result of the project, additional opportunities have been identified, such as the sale of electrical generation packages, gas flow monitoring and flare systems. The impact of the project could be further enhanced by:

(i) Encouraging a UK industry team to visit China to observe first hand actual operational conditions, assess technology needs, understand performance requirements and establish strong links with potential buyers.

(ii) Organising a dedicated dissemination workshop in China to promote UK skills, services, technologies and equipment highly relevant to China’s current interests and needs, as identified by the project collaborators. Presentations could be given detailing the project findings, problems and solutions, and how UK technology can be used to progress a CMM scheme using CDM. Such a workshop would also present the opportunity to update the findings after CDM Executive Board discussions regarding the methodology.

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3 The environmental properties of methane in comparison to coal are not only better in terms of its CO₂ emissions, but also with respect to sulphur and particulate matter which cause serious environmental and health concerns.
(iii) Updating and expanding the methodology to include further and more advanced utilisation and destruction options, increasing both the environmental benefits and potential opportunities for UK industry for involvement in Chinese CMM projects.
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### ABREVIATIONS AND ACCRONYMS

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AAU</td>
<td>Assigned amount unit, unit of emissions used for IET</td>
</tr>
<tr>
<td>ADB</td>
<td>Asian Development Bank</td>
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<tr>
<td>AIJ</td>
<td>Activities implemented jointly. The pilot phase of the CDM</td>
</tr>
<tr>
<td>AMM</td>
<td>Abandoned mine methane</td>
</tr>
<tr>
<td>Annex B</td>
<td>Industrialised countries with an emission reduction obligation listed in Annex B to the Kyoto Protocol</td>
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<tr>
<td>Annex I</td>
<td>Industrialised countries as listed in Annex I to the Framework Convention on Climate Change</td>
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<td>CBM</td>
<td>Coal bed methane</td>
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<tr>
<td>CCII</td>
<td>China Coal Information Institute</td>
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<tr>
<td>CCRI</td>
<td>China Coal Research Institute</td>
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<tr>
<td>CDM</td>
<td>Clean development mechanism. The CDM is defined in Article 12 of the Kyoto Protocol, and allows emission reduction projects to take place in developing countries and to be credited to the target of an Annex B country – assuming both countries are party to the Kyoto Protocol</td>
</tr>
<tr>
<td>CER</td>
<td>Certified emission reduction. Emission reduction unit for CDM</td>
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<tr>
<td>CH₄</td>
<td>Methane (GWP is 21)</td>
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<tr>
<td>CHP</td>
<td>Combined heat and power. Installation that allows the generation of useful heat and electricity at the same time</td>
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<tr>
<td>CICETE</td>
<td>China International Centre for Economic and Technical Exchanges</td>
</tr>
<tr>
<td>CMM</td>
<td>Coal mine methane</td>
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<tr>
<td>CO₂</td>
<td>Carbon dioxide (GWP is 1)</td>
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<tr>
<td>CO₂e</td>
<td>Carbon dioxide equivalent (measure for all greenhouse gases)</td>
</tr>
<tr>
<td>COP</td>
<td>Conference of Parties</td>
</tr>
<tr>
<td>DNA</td>
<td>Designated national authority. A country’s CDM authority</td>
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<tr>
<td>DOE</td>
<td>Designated operational entity. A verification and certification body approved by the CDM Executive Board</td>
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<tr>
<td>DTI</td>
<td>Department of Trade and Industry</td>
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<td>EB</td>
<td>Executive Board of the CDM</td>
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<tr>
<td>ERPA</td>
<td>Emission Reduction Procurement Agreement</td>
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<tr>
<td>ERUs</td>
<td>Emission Reduction Units. Emission reduction unit for JI</td>
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<tr>
<td>ETS</td>
<td>Emissions trading scheme</td>
</tr>
<tr>
<td>EUR</td>
<td>Euro</td>
</tr>
<tr>
<td>Gassy mines</td>
<td>A gassy mine is one with a specific emission of greater than 10 m³/t</td>
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<tr>
<td>GBP</td>
<td>Pound Sterling</td>
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<tr>
<td>GCT project</td>
<td>The UK-China DTI sponsored gas control technology (GCT) transfer project. See “Methane Control Technology for Improved Gas Use in Coal Mines”, Report No.COAL R257 DTI/Pub URN 04/1019</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
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<tr>
<td>GWP</td>
<td>Global warming potential. Measure of the impact of a greenhouse gas compared with CO₂, for example, methane has a GWP of 21.</td>
</tr>
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</table>
Through the use of GWPs it is possible to compare emissions of all greenhouse gases using the same unit: CO$_2$ equivalent (CO$_2$e)

h Hour
HCMG Huainan Coal Mining Group, Anhui Province, which owns the Pansan Mine
IET International emissions trading. IET is defined in Article 17 of the Kyoto Protocol
IPCC Intergovernmental Panel on Climate Change. Institution established in 1988 to provide authoritative assessment of the state of knowledge on climate change
IRR Internal rate of return
ITP IT Power
JI Joint implementation. JI is defined in Article 6 of the Kyoto Protocol, and allows emission reduction projects to take place in one Annex B country and to be credited to the target of an Annex B country – assuming both countries are party to the Kyoto Protocol
kPa kiloPascal, measure for pressure/suction
l Litre
m Meter/million
m$^3$ Cubic meter
m$^3$/t Cubic meters per tonne, measure of specific emissions of coal seams
Methodology Methodology for calculating the baseline for CDM projects and carrying out the monitoring of emissions and emission reductions for these CDM projects
min minutes
mm Millimetre
mmH$_2$O Millimetre water pressure
MSW Municipal solid waste.
Mt million metric tonnes
MtCO$_2$e Million metric tonne of CO$_2$e
MW MegaWatt
MWe MegaWatt electric output
N$\textsubscript{2}$O Nitrous oxide (GWP is 210)
NC4 National Climate Change Co-ordination Committee, China’s DNA
NDRC National Development and Reform Commission
OD Orifice diameter, i.e. half internal pipe diameter
PDD Project design document
RMB Yuan Renminbi, Chinese currency (USD 1 = 8.27650 RMB fixed rate)
s second
 t Metric tonne
tCO$_2$e Metric tonne of CO$_2$ equivalent
UNFCCC see FCCC
USD US dollar
VAM Ventilation air methane
VCBM Virgin coal bed methane
WA Wardell Armstrong
y Year
1 INTRODUCTION

1.1 Background

Methane emissions from China’s coal mines are increasing annually as coal production rises. Coal mine methane (CMM) utilisation provide a means of mitigating these emissions, which have a high global warming potential (GWP), but there are too few schemes and development is slow. A methodology has therefore been developed to facilitate the application of Clean Development Mechanism (CDM) financing to stimulate the construction of more CMM utilisation schemes and encourage maximum methane destruction in a cost-effective manner. The approach relies on technology, which has been demonstrated and proven in the UK and elsewhere. It recognises the need for flexibility and low business risk while satisfying the requirement for ‘environmental additionality’. The project was sponsored by the UK government’s Department of Trade and Industry under its Cleaner Fossil Fuels technology transfer programme.

This report describes the final results of the project “UK initiative to enhance the use of coal mine methane (CMM) in China, developing a model CDM project concept”. The report describes CMM utilisation options, the clean development mechanism (CDM), and reviews the progress made by the project in the development of a CDM model concept and methodology. The process has drawn on research undertaken at a coal mine methane utilisation scheme in Anhui province and from experience of other coal mines in China and elsewhere in the world.

The purpose of the project was to develop a methodology that will encourage the clean production of electricity and heat for domestic and industrial use from CMM and the reduction of greenhouse gas emissions from coal mining activity through the destruction of surplus methane by flaring. The successful implementation of CMM schemes under the CDM would help overcome the existing barriers through the provision of additional finance.

Gas capture and use at coal mines can often be enhanced through improvements in the management of existing technologies and control practices at a mine. The CDM will positively encourage this process thus benefiting safety as well as the environment.

The CDM project was targeted at China’s coal mining sector as a major emitter of greenhouse gases but the principles incorporated in the methodology will be applicable in other developing (and industrialised) countries.

1.2 Methane emissions from coal mines in China

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 or outburst prone. By 2002 there were 193 coal mines with methane drainage systems draining about 1.12 billion m$^3$ of gas, of which only around 0.6 billion m$^3$ is used (Table 1.1).
The coal sector in China has undergone substantial reform to improve efficiency, safety and price stability. Large numbers of small illegal and financially irrational mines have been closed and returns-to-scale are being achieved by larger mining enterprises formed by merger and acquisition. Initial estimations indicate that CMM emissions could have increased by more than 1 billion m$^3$ as a result of replacing small mine capacity with large longwall operations. This is due to the greater extent of strata disturbance and hence gas release around a longwall compared with the room-and-pillar methods employed in small mines.

The total emissions from all coal mines in China is not directly measured, but has been estimated in a previous study for the DTI.$^4$ The emissions estimated from the data available and assumptions made are shown in Table 1.1, along with estimates for potential capture and utilisation.

| Table 1.1 Estimated methane emissions from coal mines in China (billion m$^3$/y) |
|---------------------------------------------|------------------|----------------|
| Total coal production (billion tonnes/year) | 2002              | 2003          |
| Estimated total release                     | 9.5               | 10.6          |
| Estimated potential for capture             | 2.9               | 3.2           |
| Actual capture                              | 1.1               | Not available |
| Actual utilisation                          | 0.6               | Not available |


As shown in Table 1.1, actual capture and utilisation of CMM falls far short of the potential. The growth potential for CMM utilisation schemes is therefore large. Additionally, coal production is expected to rise steadily, with at least 1.7 billion tonnes being mined in 2004 with a corresponding increase in gas emission.

1.3 CMM utilisation

Despite the potential, however, the utilisation of drained mine gas in China remains low with more than half of the total gas extracted by gas drainage stations released directly into the atmosphere. CMM utilisation prospects for many mines in China are financially marginal and gas quality is often low limiting the utilisation options. In many instances there may be no economically utilisation prospect and the gas will be vented to atmosphere.

Historically, gas has been used for domestic supply distributed through local pipe networks. Such local networks usually incorporate gas storage holders which help with short terms variations in demand and supply. Other uses have been as fuel for industrial boilers, chemical processes and some power generation. By the end of 1999 about 20 coal mining groups were operating some 60 utilisation schemes.

Various gas drainage techniques are used throughout China but underground post drainage capture methods are most common. Methane concentration are variable but are reported to be typically between 30–50% methane purity. Information gathered during this study suggests methane purity in a lower range of around 25–35% is not uncommon. The problem of maintaining methane purity at high enough levels is a significant factor in maximising gas use.

1.4 **Carbon finance through the CDM**

In response to concerns about global climate change, the UN Framework Convention on Climate Change (FCCC) and the Kyoto Protocol were negotiated. The Kyoto Protocol set greenhouse gas emission reduction targets for the industrialised countries. In order to help meet these targets, the protocol also adopted market mechanisms, including the clean development mechanism (CDM). Through these mechanisms, additional finance has become available for emission reduction projects worldwide. Industrialised countries can achieve their promised emission reduction targets globally, wherever they are cheapest. Thus, a global market for emission reductions has been created by the Kyoto Protocol.

The Kyoto Protocol entered into force on 16 February 2005, after ratification by some 140 countries. Despite the absence of the United States and Australia, demand for emission reductions is soaring, and ‘carbon finance’ is available for ‘clean’ projects, including CMM utilisation schemes. This project has helped develop a model concept for CMM schemes under the CDM with some success.
2 THE CLEAN DEVELOPMENT MECHANISM

2.1 Introduction

Coal mine methane (CMM) attracts considerable interest in coal mining countries throughout the World, including China, as a potentially important clean energy source. While CMM resources in China are estimated to be about 10 billion cubic metres per year at current mining production rates, gas extraction and utilisation have been limited at about 0.6 billion m\(^3\)/y. Reasons for the limited take-up of CMM utilisation include the lack of technical understanding and experience, insufficient training and skills, lack of suitable technology and little understanding of market conditions and commercial aspects.

This project aimed at helping to overcome some of the barriers to utilisation of CMM and emission reductions from coal mining activities in China. This project has looked at opportunities for CMM utilisation and emission reduction schemes within the scope of the clean development mechanism (CDM). This chapter summarises the history and important aspects of the CDM.

2.2 The Kyoto Protocol

After ten years of international negotiations the UN Framework Convention on Climate Change, the Kyoto Protocol, and the Marrakesh Accords, which enforces the Kyoto Protocol, have all been agreed. On 16 February 2005, the Kyoto Protocol entered into force, when about 140 countries had ratified the treaty, and became international law. The future is thus ‘carbon constrained’.

Greenhouse gas (GHG) emissions in every sector and every country will have to be reduced in the long term. In the shorter term only the industrialised countries are affected. The Kyoto Protocol has set out GHG emission targets for the period 2008 to 2012 for industrialised countries, called ‘Annex B countries’. The Protocol also contains agreements on technology transfer, emission inventories, administrative issues, etc.\(^5\)

The targets of the Kyoto Protocol apply to a number of gases, including carbon dioxide (CO\(_2\)), methane (CH\(_4\)) and nitrous oxide (N\(_2\)O), weighted according to their GWP. Methane, for example, has a GWP 21 times stronger than CO\(_2\).

The Protocol allows the GHG emission targets to be met in the most economically efficient way, including through a wide range of policies and measures that can be designed by the countries themselves, or the so-called Kyoto mechanisms. These Kyoto mechanisms allow for emission reductions to take place in one country but credited towards the emissions target of another country (upon payment for these emission reductions).

The Kyoto mechanisms, thus, establish a trading mechanism for emission reductions in such a way that reductions can be achieved wherever they are cheapest. As a consequence a market price for greenhouse gas emission reductions is established. This should, in theory, lead to the cheapest solution to meeting the 5.2% overall reduction in greenhouse gas emissions in industrialised countries from the 1990 baseline.

The Kyoto Protocol adopted three such mechanisms: Joint Implementation, the Clean Development Mechanism, and Emission Trading.

- Joint Implementation (JI) allows Annex B countries to achieve part of their Kyoto target by purchasing Emission Reduction Units (ERUs) from greenhouse gas reducing projects in other Annex B countries. The project needs to comply with the Kyoto rules, be approved by the Parties involved, and is validated among others on the basis of a baseline scenario. Only emissions reduced during the Kyoto commitment period(s) are accredited.

- The Clean Development Mechanism (CDM) is a means for Annex B countries to achieve part of their Kyoto target by purchasing Certified Emission Reductions (CERs) from greenhouse gas reducing projects in non-Annex B countries. The main difference with JI is that the emissions reductions can be banked and used in the commitment period of Kyoto, 2008–2012. For example if a project starts in 2003, the CERs generated from 2003 until 2007 can also count towards achieving the 2008–2012 Kyoto target of the Annex B country. A prerequisite for a CDM project is that it should contribute to sustainable development in the host country. Each host country government can define the criteria for sustainable development for projects in their own territories. The CDM Executive Board decides on the validity of the methodology of generating CERs, and needs to approve each project.

- International emission trading (IET) is the free trading of emission allowances among Annex B countries. IET is not project related, but is based on the emissions target for 2008–2012. The unit of trade in IET is the AAU – Assigned Amount Unit.

Even several years before the start of the Kyoto target period (2008-2012) an active market in emission reductions, in particular through the CDM, has already emerged. Hundreds of projects have already been identified, representing a market value of the underlying emission reductions of at least one billion dollars. With Russia’s ratification of the Kyoto Protocol, the market will grow further and could reach USD 5 billion per year by the start of the commitment period.

### 2.2.1 Current Status of Ratification of the Protocol

The Kyoto Protocol has been open for signature from March 1998. The Fiji Government was the first to ratify the Kyoto Protocol in September 1998. As of 7 March 2005, 144 Parties have ratified the Protocol. With Russia’s ratification in November 2004 the conditions for entry into force were fulfilled, and Kyoto entered into force on 16 February 2005. The Kyoto targets have become binding when the Kyoto Protocol entered into force.
A brief account on recent developments with regard to the Kyoto process is given below.

The European Union and the 15 Member States ratified the Protocol on 31 May 2002. The different member countries have set out their own strategies to reach their national targets. While some countries aim to achieve the emission reductions mainly through domestic measures, others indicated that they would make full use of the Kyoto mechanisms to reduce the costs of achieving targets. The EU interpretation of the Kyoto rules is that a 50% minimum of the emission reduction targets should be achieved domestically. Several countries, notably the Netherlands and Italy, have indicated that they will seek 50% of the emission reductions to be achieved from abroad. In July 2003, the European Council and Parliament agreed a Directive to establish a mandatory EU emission trading system (EU ETS) in the year 2005, as a way to reach the Kyoto target. The trading system will be introduced in 2005 for a three-year mandatory ‘warm-up’ phase. The second phase is in parallel with the Kyoto commitment period from 2008 to 2012. Because a big market with sufficient number of sellers and buyers is one of the preconditions for a well functioning trading system, the EU system is mandatory with limited opt-outs. A penalty is imposed for every tonne of emissions that is not covered by an allowance of EUR 40 in 2005 to 2007 (EUR 100 thereafter), as well as the requirement to make good the shortfall. Other conditions for a well functioning market are clear and transparent rules as well as a strong framework to ensure compliance. To provide more flexibility and certainty to participants the EU ETS allows for the linking of project credits from JI and CDM. This means that JI/CDM credits can be used by entities to fulfil their obligations. Participants in the EU ETS deliver JI/CDM project credits to their National Authority and get issued an EU allowance in exchange for it. The European Commission expects that some 10,000–15,000 companies will participate in the scheme from the start.
The United States have declared that they will not ratify the Kyoto Protocol. The Bush administration is opposed to the Protocol because it says it exempts 80 percent of the world population, including major population centres such as China and India, from compliance, and would cause serious harm to the US economy. In October 2002, the US department of State officially released the US Global Climate Change Policy. The main elements of the policy are: a reduction of the CO₂ intensity, emissions per unit of economic activity, by 18% over the next ten years; increased funding for climate change-related programmes such as the Global Environment Facility; and working together with other nations to develop an effective and efficient global response.

After a long period of hesitation, the Russian government submitted the Kyoto Protocol in September 2004 to the Duma, which approved it. Formal notification of ratification of the protocol took place in November 2004. Ratifying Kyoto became less beneficial for Russia after the withdrawal of the US from the Protocol, but many other issues have played a role in Russia’s initial hesitance.

China ratified the Protocol in August, 2002. The Government of China has been active in the Kyoto mechanisms for a long time, having contracted their first projects with the Dutch Government in 2000-2001, and being involved with other projects with the World Bank. However, the Government has indicated that it will not take up any target commitments for the foreseeable future.

2.3 The rules of the CDM

As mentioned earlier, three different mechanisms have been established under the Kyoto Protocol, the most important of these for the purpose of this report, is the Clean Development Mechanism, which allows trading of reductions between developing and industrialised countries. However, the CDM is not a simple trading instrument, but the result of difficult political negotiations.

Any trading of emission reductions between two countries, who have committed to specific absolute targets, as under the Kyoto Protocol, does not change the aggregate emissions. However, as developing countries do not have emission targets, trading of reductions between such parties need additional safeguards to prevent inflated claims for reductions. This has therefore called for specific methodologies for calculating a baseline and any emission reductions achieved.

Other complications to the CDM have arisen from the complex political negotiations before the agreement was reached in Kyoto. For example, the call for host government approval, verification of emissions, limited crediting times, technology transfer, the adaptation levy - all complicate the process of establishing a CDM project.

However, after several years of international negotiations, the Marrakesh Accords, agreed in 2001, finalised the rules for the CDM which should have been operational from 2000. Immediately following the agreement of the Marrakesh Accords, the CDM executive Board was elected and started its work of promoting the CDM and
implementing the regulations. Within a short number of years the CDM has already attracted a large number of projects.

On the UNFCCC CDM website already some 95 different project methodologies have been proposed, and over 40 projects have been registered. There are many more projects awaiting approval of the methodologies. One well informed source\(^6\) suggests that more than 1400 projects have been proposed (for CDM and JI together), with nearly 300 projects already having detailed documentation. Emission reductions associated with these projects already exceed 460 million tonnes of CO\(_2\) equivalent (tCO\(_2\)e) by 2012.

The agreements reached in Bonn during COP-6 and the Marrakesh Accords drawn up at COP-7 determine the modalities and institutional set up of the CDM. The institutional organisation of the CDM comprises the following range of official bodies that will implement the CDM:

- **The Meeting of the Parties (COP – before entry into force):** the MOP provides guidance on the rules and procedures of the CDM and is ultimately responsible for agreeing the modalities of the CDM.

- **Executive Board (EB):** the EB is responsible for the overall supervision of the CDM under the authority and guidance of the COP/MOP and for accreditation of the operational entities. It will keep a registry of CERs and a database of all CDM projects, which will be publicly available. The EB has established three panels to assist in the performance of its functions: 1) the CDM Accreditation Panel; 2) the Methodology Panel; and 3) small scale CDM Panel. The EB consists of ten members from Annex I and non-Annex I countries that are elected by the COP/MOP for a period of two years.

- **Designated National Authorities (DNA):** all Parties participating in the CDM must establish a Designated National Authority. In the host country, the DNA's responsibility is to evaluate the proposed CDM project according to the criteria for national sustainable development. The DNA may also be tasked to promote CDM through capacity building and marketing activities.

- **Designated Operational Entity (DOE):** designated operational entities are independent bodies accredited by the EB whose main responsibilities are (1) to validate and request for registration of proposed CDM projects, and (2) to verify the emission reductions of registered CDM projects. The EB has approved 4 organisations as DOE to-date, and is currently reviewing another 20 or so organisations.

The principal requirements for CDM projects are:

- Non-Annex B Parties (host countries) must benefit from the project activities resulting in certified emission reductions (CERs), through, for example, technology transfer;

- Projects must assist host countries in achieving sustainable development and contributing to the ultimate objective of the FCCC;

- Projects must result in real, measurable and long-term benefits related to the mitigation of climate change; and

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6 PointCarbon.
Projects must result in reduction in emissions that are additional to any that would occur in the absence of the certified project activity.

The various activities required to design and implement a CDM project and to claim certified emissions reduction units are presented in Figure 2.2.

Figure 2.2: CDM project cycle

<table>
<thead>
<tr>
<th>CDM Project Cycle</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Design</td>
<td></td>
</tr>
<tr>
<td>Project design documents, baseline study, estimation of emissions reduction, environmental impact, monitoring plan, stakeholder comments</td>
<td>Project participants, including stakeholders who can comment</td>
</tr>
<tr>
<td>Validation of project design document</td>
<td>Designated Operating Entity; Project approval from Designated National Authority</td>
</tr>
<tr>
<td>Comments on validation</td>
<td>UNFCCC stakeholders, including accredited NGOs</td>
</tr>
<tr>
<td>Registration</td>
<td>Executive Board</td>
</tr>
<tr>
<td>Project Implementation</td>
<td></td>
</tr>
<tr>
<td>Implementation of the project</td>
<td>Project participants</td>
</tr>
<tr>
<td>Monitoring emission reductions &amp; reporting</td>
<td>Project participants</td>
</tr>
<tr>
<td>Verification of monitoring report (resulting in verification report)</td>
<td>Designated Operating Entity</td>
</tr>
<tr>
<td>Issuance of CERs (based on verification report of the DOE)</td>
<td>Executive Board</td>
</tr>
<tr>
<td>Project Revenues</td>
<td></td>
</tr>
<tr>
<td>CERs sold or banked</td>
<td>Project participants</td>
</tr>
</tbody>
</table>

The first step in the CDM project cycle involves the preparation by the project participants of the Project Design Document (PDD). The components of the PDD include:

- A general description of the project;

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• Proposed baseline methodology;
• Statement of the operational lifetime of the project and crediting period;
• Description of the additionality of the project;
• Calculation of the net greenhouse gas emission reductions of the project;
• Environmental impacts of the project; and
• Stakeholder comments received on the project.

After approval of the proposed CDM project by the Designated National Authority and after validation of the PDD by the Designated Operational Entity, the project is automatically registered by the Executive Board unless a review is requested within eight weeks by one Party involved or three Executive Board members. Next, the project is implemented and the emission reductions are monitored by the project participants and verified by the Designated Operational Entity. The verification report prepared by the DOE is submitted to the Executive Board and is a request for issuance which will take place 15 days after the submission if no request for review has been expressed. Finally, the CDM registry administrator issues the CERs and withholds a share of the proceeds for administration and adaptation (2% of CERs). Figure 2.2 above shows these major steps in the CDM project cycle and indicates the party that would be responsible for implementing each step.

2.4 Early experiences with the Kyoto mechanisms

Although the Kyoto Protocol has only recently come into effect, several initiatives have already been ongoing for some time with the aim to start the implementation of the flexible mechanisms. A brief overview of some of the existing programmes in this regard is given below. There are many more initiatives set up recently, including by the private sector, but there is limited information available on some of these new initiatives. China’s involvement in these schemes is reviewed in the next section.

2.4.1 World Bank: the Prototype Carbon Fund

The Prototype Carbon Fund (PCF) was established in July 1999 by the World Bank with the objective to invest in CDM and JI projects that generate greenhouse gases emission reductions eligible under the Kyoto Protocol. The PCF is a public-private partnership consisting of six governments (Canada, Finland, Norway, Sweden, Netherlands, and Japan) and seventeen private-sector companies (thirteen energy companies, two financial institutions, and two trading companies), with a total budget of USD 180m.

2.4.2 World Bank: Netherlands Clean Development Facility

An agreement between the WB and the Netherlands was reached in May 2002 on the establishment of a facility to purchase greenhouse gas emission reduction credits. The Facility will support CDM projects in exchange for credits and the target is to invest some EUR 35m in a wide range of projects (except sequestration) for each of 4 years. It is expected that in total about 32 MtCO$_2$e can be reduced (average price EUR 4.37/tCO$_2$e. Projects with a purchase price above EUR 5.50/tCO$_2$e are not eligible, unless they are expected, in the opinion of the Dutch government, to make a very significant contribution to sustainable development in the host country.
2.4.3 International Finance Corporation
The IFC Netherlands Carbon Facility is an arrangement under which the IFC will purchase GHG emission reductions using the CDM of the Kyoto Protocol. The Netherlands has allocated USD 46m for this facility for the period 2002 to 2004. The facility will provide additional revenues to eligible projects that reduce GHG emissions in developing countries.

2.4.4 World Bank: Community Development Carbon Fund
The Community Development Carbon Fund (CDCF) focuses on small-scale projects in least developed countries and poorer areas of the developing world. The fund was launched by the WB in collaboration with the International Emissions Trading Association in September 2002 at the World Summit on Sustainable Development in Johannesburg. Canada and Italy have signed an agreement to contribute USD 2.5m and USD 7.7m, respectively, to the fund. The target size for the fund is USD 100m. By working through local intermediaries and applying the simplified procedures for small-scale CDM projects, the CDCF will seek to lower transaction costs and risks associated with these projects.

2.4.5 World Bank: BioCarbon Fund
The BioCarbon Fund of the World Bank has been operational since the start of 2004. The fund focuses on projects that sequester or conserve carbon in forest and agro-ecosystems. The fund will be a public-private initiative similar to the PCF and the target size of the Fund is USD 100m.

2.4.6 Dutch Government: ERUPT and CERUPT
The Emission Reduction Unit Purchasing Tender (ERUPT) programme was set up by the Dutch government with the aim to purchase carbon credits through the implementation of JI projects. JI is aimed at countries that also have a reduction target under the Kyoto Protocol, mainly Central and Eastern European countries.

The CERUPT programme under the Clean Development Mechanism aims to purchase carbon credits from projects in the area of renewable energy, energy efficiency, fuel switch and waste management in non-Annex B countries. It has been established by the Dutch government in parallel with the ERUPT tender and has a lot of characteristics in common in terms of procedural matters. In principle no specific project portfolio has been defined for the CERUPT programme but different prices are accepted for different technologies. The highest price accepted by Senter, the Agency in charge of ERUPT and CERUPT on behalf of the Dutch government, for CERUPT projects is EUR 5.50/tCO$_2$e. The price for renewable technology forms the reference price. The accepted price for clean sustainably grown biomass (excluding waste) is 25% lower; the price of energy efficiency improvements is also 25% lower; and the price of other technologies, among which fuel switch and methane recovery, is 67% lower.

2.4.7 Singapore-ASEAN Carbon Fund
The Singapore-ASEAN Carbon Fund has been established in 2003, and is to be administered through Electric Eye Pte Ltd in Singapore. It is an independent
initiative that seeks to kick-start CDM projects under the Kyoto Protocol. The fund will be a 5-year closed-end investment fund, with a target capitalisation of USD 120m. It will target energy efficiency and renewable energy in the ASEAN countries, and aims at 200,000 tCO₂e in CERs per year. If successful it will function as model for a larger Asian carbon fund.

2.4.8 Government of Finland
Finland has a commitment to stabilise emissions of greenhouse gases under the EU burden sharing agreement. The Ministry of Foreign Affairs (Development Co-operation) is using the Kyoto mechanisms as one way of meeting the country’s targets. The government of Finland published an invitation to submit project proposals. Finland’s portfolio currently consists of 5 JI and 7 CDM projects.

2.5 CDM in China

China signed the FCCC on 6 November 1992 and ratified on 1 May 1993. Under the FCCC, developing countries such as China do not have binding GHG mitigation commitments, in recognition of their small contribution to the greenhouse problem as well as low financial and technical capacities. The Ministry of Foreign Affairs is the national focal point for climate change issues in China. The National Development and Reform Commission (NDRC), through the National Climate Change Co-ordination Committee (NC4), is the DNA on the CDM.

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2.5.3 The Chinese institutional framework for CDM projects
The CDM is still a relatively new instrument, and much learning by doing is required both in government and in industry. A few research and non-governmental organisations in China have built some expertise in the CDM. Many sponsored
workshops, capacity building activities, and other projects have already been implemented in China, often sponsored by industrialised country governments or the commercial sector looking for emission reductions from the country, and also by the Asian Development Bank and the Chinese Government itself.

Given the potential size and number of CDM projects, the capacity and activity in China is lagging compared to many other countries. Rather than being the key player in the market, which it could be, few CDM projects have yet received approval. However, procedures and rules have recently been clarified for projects within China. Unfortunately, some of these rules are not conducive for CDM project development adding to the perceived difficulties of doing business in China, including restrictions on foreign ownership of CDM projects, minimum prices for CER contracts, and the possibility of a government tax on CER sales.

While these procedures and rules are limiting activity, the current relative clarity is expected to greatly stimulate project development as the potential is vast.

2.5.4 Activities Implemented Jointly (AIJ)

Launched in 1995, Activities Implemented Jointly (AIJ) was pursued mainly with the objective of gaining experience with the joint implementation process (the term joint implementation at that time included projects in developing countries, which became the CDM under the Kyoto Protocol).

In total China approved four projects under AIJ, one with Norway and three with Japan. These projects were mostly focused on energy efficiency measures: CHP, electric furnace in the steel sector, waste heat recovery from Municipal Solid Waste (MSW) burning, and dry-quenching of coke.

2.5.5 Certified Emission Reduction Unit Procurement Tender (CERUPT)

The Dutch Government’s CERUPT programme received 80 expressions of interest during its first call, from which 26 projects were selected. One project in China was approved to participate in the CERUPT tender, the Huitengxile Wind Farm. A contract for the sale of the CERs is currently under negotiation. With total reductions of over 500,000 tCO₂e and a price of around EUR 5.00 per CER, this contract could provide a significant share of total revenues for the project.

2.5.6 Prototype Carbon Fund (PCF)

The Government of China approved a Coal Bed Methane (CBM) project for submission to the PCF. The project will be implemented at the Sihe mine of the Jincheng Mining Group, Shanxi Province, and comprises of 120 MW electric power generation from CBM. The whole project is expected to reduce emissions by nearly 50 MtCO₂e over its lifetime. The PCF’s 4 MtCO₂e contract alone should bring USD 17m into the country.

A second project, 98 MW run of river hydro, is currently under development with the PCF. This project reduces emissions by nearly 3 MtCO₂e, of which the PCF has contracted 2 MtCO₂e for an aggregate of about USD 9m.
The World Bank has also started a fund aimed at forestry projects, the BioCarbon Fund. One of the projects proposed for this fund is based in the Guangxi Zhuang Autonomous Region, which includes half of the Pearl River basin.

2.5.7 Private sector projects
A number of projects have been put forward to the CDM Executive Board by private sector participants in the carbon market. These have not yet been registered, and have not yet received full host government approval, but shows growing confidence in the Chinese CDM capabilities. The projects put forward for new methodologies are in the coal mining and cement sectors. However, the project partners are aware of a number of further projects nearing completion, both from the private sector and institutional investors such as the World Bank.

2.6 CDM procedures in China
In order to enhance effective management of CDM project activities by the Government of China, and ensure an orderly implementation of CDM projects, the Tentative Rule on Operations and Management of CDM Projects was developed by the National Development and Reform Commission, the Ministry of Science and Technology and the Ministry of Foreign Affairs. The rules were implemented from 30 June 2004. The most important rules are given below.

2.6.1 General articles
• Conduction of CDM projects in China shall be approved by relevant departments of the State Council.
• The priority areas for CDM projects in China will focus mainly projects which increase energy efficiency, development and use of new energy and renewable energy, and the recycled use of methane and CBM.
• In accordance with relevant decisions of the signatory parties meeting, the implementation of CDM projects should ensure transparency, high efficiency and accountable responsibilities.

2.6.2 Permission Conditions
• Implementation of CDM projects shall be in consistent with laws and regulations of China, sustainable development strategies and policies and the overall requirement for national economic and social development planning.
• Implementation of CDM projects will not make China undertake any new obligations beyond the regulations contained in the Convention and the Protocol.
• CDM project activities shall be beneficial to technology transfer in an environmental friendly way.
• The enterprises within the territory of China, with sole Chinese investment and with Chinese investment as the dominating resource, can conduct CDM projects with the foreign parties.
• The enterprises which implement CDM projects must submit CDM project design paper, qualification evidence document of the enterprises, project brief and fund raising briefing.
2.6.3 Management and Implementation Agencies

- The joint leader of the Project Review Council consists of the National Development and Reform Commission, Ministry of Science and Technology, while the deputy leader is the Ministry of Foreign Affairs. The members include State Environmental Protection Administration, Meteorological Bureau of China, Ministry of Finance and Ministry of Agriculture.
- The National Development and Reform Commission is the organisation in charge of the CDM project activities in China. Its main responsibilities include accepting CDM project applications; and issuing CDM project approval documents on behalf of the Government of China.

2.6.4 Miscellaneous

- The benefits generated by the transfer of greenhouse gas reduction volume in the projects belong to the Government of China and the enterprises which implement the projects. The benefits distribution percentage is decided by the Government of China. Before such a decision is made, the benefits are owned by the enterprises.

2.7 Barriers and opportunities in China

2.7.1 Barriers
The key barrier in implementation of any environmental improvement is lack of both financial and technical resources. Renewable energy projects are considered to be of high risk by financing institutions. These institutions also do not always have staffs that have sufficient expertise to evaluate small scale renewable energy and energy efficiency projects. This leads to reluctance to even consider getting involved in these types of projects, particularly as the amount of effort to evaluate such projects is high in proportion to their value. If a project does not reach a certain investment value, lenders are unwilling to consider it. Other barriers include:

- A lack of awareness among industries about the CDM. Awareness programmes and workshops have focused on policy makers, large industries, as well as a few prominent research and academic institutions. There has been little effort made to raise the awareness of small scale project developers and state level governments.
- High transaction costs associated with the CDM project cycle is a major barrier to the take-up of small scale CDM projects. Despite the fact that there are simplified rules and modalities for small scale CDM projects the transaction cost are still very high, particularly in view of the current low prices of credits in the international market (typically USD 3–6/tCO₂e).
- A lack of a policy framework for the promotion of small scale CDM projects. There is little information available on the market potential of small scale CDM projects.
- A lack of institutional capacity. Despite the fact that there is a network of financial and professional institutions, no organisation is working specifically to support small scale CDM projects. There is no clear understanding how small scale CDM projects can be bundled to reduce transaction cost.
- Historically, the uncertainty associated with the Kyoto Protocol coming into force also played a major part, but Russia’s ratification has removed this uncertainty.
2.7.2 Opportunities

As a rapidly developing economy, and as one of the largest economies in the world, China has a vast potential for emission reduction projects in all sector. As indicated above, energy efficiency, renewable energy and coal mine methane are priority areas for the Chinese government.

2.8 CDM baseline methodologies for the coal mining sector

No baseline methodologies have been approved to-date that are applicable to CBM. However, the last round of proposals has seen two new methodologies being proposed for the coal mining sector. Both of these methodologies were specifically aimed at the utilisation of coal mine methane (CMM) at working coal mines. Projects including utilisation of methane from coal mines should in principle be eligible under the CDM. This potential for CDM projects is an exciting prospect for the coal mining sector, as this would allow tapping into a new market and providing additional income that would support cleaner and safer production.

The CDM is still a relatively new instrument, and further experience is required to make a more certain judgement on the eligibility of individual types of projects. We believe that projects which include the capturing and subsequent destruction of methane released from abandoned mines or vented from working mines for safety reasons should be eligible under the CDM. The sustainable development aspect of these projects would be increased if the methane were actually utilised for energy purposes, such as electricity production or gas supply to nearby towns. Both methodologies submitted to-date fall in this category.

The additionality of such projects is relatively easy to argue. Methane is emitted, either when the mine is already abandoned or still working. While there is often a need to drain gas for safety reasons, there is no regulation to utilise or destroy the gas. The two first methodologies submitted are summarised below. Please note that both of these methodologies have yet to be approved! Further methodologies have been submitted in the following round, but these have not yet been studied in any detail.

Both of the submitted methodologies apply to CMM from working coal mines. However, extending the eligibility to abandoned mine methane (AMM) utilisation for closed mines is not expected to be a problem. Eligibility of CBM and VCBM projects, however, is more complicated and may depend on a large number of reasons, including the certainty of prospects about mining the coal seams from which the gas is extracted. If a coal seam is mined the associated methane will be released and may be vented to the atmosphere. However, if the seam is not disturbed the methane will remain sequestered underground. Thus, if the coal is not mined, emissions are only reduced by switching from using coal to gas. If the coal is mined in the near future when gas would still normally be vented to the atmosphere

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8 These methodologies and project documents are available on http://cdm.unfccc.int.
emissions would be significantly reduced: both substituting coal use in the short term, and destroying gas that would have been released in the long term.

A VCBM project, for example, reduces emissions significantly if the coal seam would be mined without gas capture technology (i.e. in the relatively near future). If the coal would not be mined in the near future the emission reductions achieved are only equivalent to the difference in emission intensity of coal and gas, which would limit achieved reductions substantially.

Without the development of detailed baseline and monitoring methodologies and the submission of these methodologies to the CDM Executive Board it is impossible to say with any certainty whether the CDM can be successfully applied to CBM and VCBM. However, similar uncertainty has been overcome with regards to land use, land-use change and forestry projects. Solutions were suggested using insurance and temporary credits.

2.8.1 NM0066: grid-connected CMM power generation at an active coal mine
This baseline methodology uses existing actual or historic emissions as a baseline. It applies to projects that use CMM to produce electricity at a mine where CMM is already extracted and partially used for thermal energy (heat) production. The methodology applies to the CMM over and above that used for thermal energy purposes. Without power generation, the methane would be vented to the atmosphere.

The proposed methodology includes a correction in case any CMM used for power generation is diverted from the thermal energy uses. An appropriate emissions factor is calculated to estimate the emission reductions associated with the electricity generated.

The methodology consists of four steps:
(i) Determining that the project is different than business as usual
(ii) Determining that no comparable emission reduction activities will occur under business as usual
(iii) Determining the amount of methane that would be emitted in the baseline, taking into account uncertainty and volatility
(iv) Determining the appropriate CO₂ emissions factor for electricity supplied to the grid.

2.8.2 NM0075: CMM utilisation and destruction at a working coal mine
Coal mining releases gas from any coal seams disturbed by the mining activity. The gas flow into a mine district depends on the gas contents, number and thickness of coal seams (and any other gas bearing strata), the proximity of the seams to the workings, the length of time the district has been working and the rate of coal extraction. For safety reasons in gassy underground mines, a proportion of the gas is captured and piped to the surface. Once at the surface the gas is vented to the atmosphere. Until recently no coal mines anywhere in the world were flaring.

9 See http://cdm.unfccc.int.
10 See http://cdm.unfccc.int.
drained gas. However, safe flaring designs for CMM have now been demonstrated in some highly industrialised countries. CDM project activities using flaring will assist in transferring this technology to developing countries where flaring could make a rapid, cost effective and significant reduction to greenhouse gas emissions from gassy coal mines.

This methodology is applied to CMM utilisation and destruction projects in the following three steps.

Step 1: Confirmation of applicability and additionality test

In a series of 5 questions this methodology will confirm whether or not it is applicable to the project activity. The methodology applies to CMM utilisation and destruction project activities at a working coal mine, where the baseline is the partial or total atmospheric release of the gas and the project activities include situations such as:

- The captured gas is destroyed through flaring; and/or
- The captured gas is destroyed through utilisation to produce energy (e.g. electricity/thermal energy) with emission reductions may or may not be claimed for displacing or avoiding energy from other sources.

A further 5 questions will explore the additionality of the project activity, including:

- Legal requirements for utilisation and destruction of CMM
- Economically attractive actions
- Barriers and common practice

Step 2: Description of the baseline

The baseline is the atmospheric release of the coal mine methane gas, as the most economically attractive course of action. The baseline includes the consideration that some of the methane drained may be captured and utilised or destroyed, for example to comply with regulations or contractual requirements.

The first part of this methodology calculates the CMM releases and emissions without the project activity. Please note that CMM is not of biological origin, unlike landfill gas, and CO₂ emissions from utilisation and/or destruction need to be taken into account.

The second part of the baseline with respect to CMM utilisation for energy production (e.g. electricity/thermal energy/gas supply), where emission reductions are claimed, follows an appropriate approved methodology. Please note that any CO₂ emissions have already been taken into account under the first part of the baseline, and the energy production can thus be considered to be from a zero-emission source.
Step 3: Determination of the emission reductions

The greenhouse gas emission reduction achieved by the project activity during a given year is the difference between the mass of methane actually destroyed/combusted during the year and the mass of methane destroyed/combusted in the baseline, times the Global Warming Potential of methane, and corrected for the resulting CO₂ emissions from the methane destruction. Additionally, the project proponent may claim emissions reductions from electricity, thermal energy, and gas supply. The total reductions need to be corrected for any emissions from internal energy use of the project; and any emissions from energy inputs and losses in the CMM supply grid, power generator and monitoring system are taken into account in the calculations above.

2.9 Conclusions

National support options for CMM exist, but are rather limited at present. However, projects including utilisation of methane from coal mines are in principle eligible under the CDM, and are listed as priority areas by the government. This potential for CDM projects is an exciting prospect for the coal mining sector, as this would allow tapping into a new market and providing additional income that would support cleaner and safer production.

The CDM is still a relatively new instrument, and further experience is required to make a more certain judgement on the eligibility of individual types of projects. However, the instrument has been accepted in China, both in industry and government. The Government of China has recently become more active with respect to the CDM, and has supported capacity building activities throughout the country and for a large number of industrial sectors.

We believe that projects which include the capturing and subsequent destruction of methane released from abandoned mines or vented from working mines for safety reasons should be eligible under the CDM. The sustainable development aspect of these projects would be increased if the methane were actually utilised for energy purposes, such as electricity production or gas supply to nearby towns.

Eligibility of CMM projects may depend on a number of reasons, but the development of detailed baseline and monitoring methodologies, as well as the submission of these methodologies to the CDM Executive Board is a first step towards greater certainty as to whether or not the CDM can be successfully applied to CMM.
3 CMM UTILISATION TECHNOLOGIES

3.1 Introduction

Coal mining releases gas from coal seams when disturbed by mining activity. The gas flow into a longwall mining district depends on the gas contents, number and thickness of coal seams (and any other gas bearing strata) in the de-stressed zone around the working face, the proximity of the seams to the workings, the length of time the district has been working and the rate of coal extraction. As coal production is not constant due to breakdowns, geological problems, planned breaks and the stopping and starting of new mining panels, gas flows inevitably will show variations. Where seams have been previously under or overworked, a proportion of the gas has already been lost and emission rates are attenuated. This can lead to wide variations in gas flow.

For safety reasons in gassy underground mines, a proportion of the gas is captured to prevent it entering the mine airways and is piped to the surface. Once at the surface the gas is vented to the atmosphere. In some mines where only low capacity gas extraction is needed, drained gas is discharged underground.

At some mines a proportion of the drained gas is utilised for power generation or distributed to domestic and industrial consumers. As drained gas flows are variable, it is usually impracticable to design a feasible utilisation scheme which will use all of the gas. The unused gas is vented to the atmosphere. Until recently no coal mines anywhere in the world were flaring drained gas. However, in the UK three mines are now flaring CMM surplus to utilisation requirements and more installations are planned – a recent innovation driven by the UK’s ambitious carbon emissions reduction programme. Safe flaring designs for CMM have also been demonstrated in Australia and the USA. This CDM project will assist in transferring this technology to China where flaring could make a rapid, cost effective and significant reduction to greenhouse gas emissions from gassy coal mines.

CMM drainage technologies only capture a proportion of the gas released into mine workings. Any gas not captured by the methane drainage system enters the mine roadways where it is diluted with ventilation air. Captures achieved in individual mining panels can typically range from 30% to 80% depending on the drainage technology used, the geology and the mining conditions. Gas capture and use can often be enhanced significantly through improvements in the management of existing technologies and control practices at a mine. CDM will positively encourage this process thus benefiting safety as well as the environment.

Technologies also exist for removing the diluted methane from mine ventilation air but these are not yet commercially viable and have not yet been demonstrated at full scale. Furthermore, these technologies may not be commercially viable without additional financial support. All methane destroyed in ventilation air methane (VAM) scheme would be additional. If usable energy was also produced then its contribution could be assessed in terms of coal displacement. However, ventilation
air methane (VAM) technology could have a negative impact on mine safety in that it would reduce the impetus to increase CMM capture. VAM is not being considered as an option at Pansan in this particular CDM project.

3.1.1 Methane emissions from coal mines in China
The total emission from all coal mines in China is not directly measured, but was estimated in a previous study for the DTI, and explained in Chapter 2. The total estimated release of CMM in 2003 was at least 10.6 billion m$^3$/y, with approximately 30% available for potential capture and utilisation. Current utilisation is only about 0.6 billion m$^3$/y, less than 20% of the potential for capture. The growth potential for CMM utilisation schemes is therefore large. Additionally, coal production is expected to rise steadily in the next few years, with a corresponding increase in gas emission.

3.2 CMM drainage technology
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. The methods used for capturing CMM are conventionally classified into one of two categories according to their temporal relationship with mining activities:

There are two basic types of gas drainage:
(i) Pre drainage which involves draining gas from the worked seam before mining;
(ii) Post drainage which involves capturing gas emitted from coal seams in strata above and below a longwall coalface which have been de-stressed by the mining operation.

Pre drainage involves removing methane from coal seams in advance of mining, while post drainage involves capturing methane and other gases released as a consequence of the strata movement induced by mining. Underground pre drainage is applied predominantly to the seam to be worked in contrast to post drainage which targets gas from adjacent seams. The applicability of the fundamentally different approaches depends chiefly on the natural permeability of the coal seams.

The objective of pre drainage is to remove as much gas as possible from the strata likely to be disturbed by mining before coal extraction commences. A continuous and open cleat fracture network within the coal appears to be a pre-requisite for satisfactory rates of recovery of methane from virgin coal seams. The objective of post drainage, irrespective of the method employed, is to maximise the rate of gas removal from the underground mining districts and hence minimise the gas flow into the mine airways to ensure that requisite coal production targets can be safely attained.
Gassy mines in China are required to practice both methods but pre drainage is only effective where coal seams are relatively permeable. It is also the only method available where non-caving methods of mining (e.g. room-and-pillar) are used.

3.2.1 Pre drainage
Pre drainage can involve drilling boreholes or wells from the surface into one or more unworked coal seams and using hydraulic pressure to fracture the coal and stimulate the release of methane. Coalbed methane drainage from surface boreholes using this method is often practised independently of mining operations as a commercial gas production operation. Only at a few locations is such activity linked to coal mining.

Most pre drainage operations in coal mines involve horizontal boreholes drilled in the worked seam from underground roadways or, occasionally, from shafts. The benefits sought from application of these techniques include the reduction of some, or all, of the following:
- Gas emissions into development headings;
- The gas content of coal seams to prevent outbursts;
- Gas emissions from the worked seam which can be high for thick, high gas content seams.

Pre drainage is generally only beneficial when applied in seams with relatively high gas pressures and moderate to high permeability. Many of the large coal mines in China work thick coal seams, typically up to 4 m. Pre drainage may be necessary to reduce the gas.

Surface pre drainage techniques are primarily used in the "coalbed methane" industry for recovering gas from virgin coal seams independently of mining. They are not widely used by the coal mining industry although this technology is receiving increased attention in China.

3.2.2 Post drainage
All methods for intercepting methane released by mining disturbance before it can enter a mine airway involve obtaining access, by some means or other, to the zone of disturbance above and also sometimes below, the worked seam. Access is gained by drilling from the underground roadways, drilling from the surface, driving roadways into the disturbed zone or exploiting old workings which lie within the disturbed zone. Irrespective of the method of access, the aim is to consistently capture sufficient gas to ensure that the mine ventilation can satisfactorily dilute any remaining emissions at the planned rate of coal production. The choice of method is determined by practicality, safety and cost.

3.3 Use of coal mine methane in China
Drainage of gas in underground coal mines has been practised in China since the 1950s. Now, as a result of environmental concerns, coal mines are now encouraged to use the gas where practicable, but it is not mandatory and there are relatively few schemes.
Projects have involved supplying mine gas to household consumers, industrial concerns and small-scale gas-fired power generation schemes with some CMM used in colliery boilers. Household use predominates and there are few power generation schemes due to the capital cost of the plant.

The exception is a large power generation project being developed at Jincheng in Shanxi Province as a demonstration project. This CMM project based at Sihe mine will use an ADB loan to develop a 120 MWe power plant to generate electricity for local distribution. Additional gas may need to be collected from neighbouring mines to ensure the generation plant runs at capacity. The geological situation is unique and few if any other schemes of such magnitude are likely to be built elsewhere in China.

There have been some relatively short-lived CMM power generation schemes at coal mines which suffered from lack of finance for spare parts. For example, a gas-fired power generation plant was installed at the Laohutai mine in Fushun. The plant, which uses a Kongsberg Dresser KG2 gas turbine, was constructed in 1990 with a nominal installed capacity of 1.5 MWe. It operated for about six years, burning gas in summer when there was a surplus, until a gear broke and attempts to machine a replacement failed. Four similar gas turbine sets were imported into China for CMM applications at the same time and all have stopped because of a lack of spares.\(^\text{11}\) It is unlikely that the power generation was ever profitable due to the intermittent use of the capital equipment.

The utilisation of drained mine gas in China remains low with more than half of the total gas extracted by gas drainage stations released directly into the atmosphere. In developing a more sustainable, environmentally responsible coal mining industry more effort is needed to increase both the amount of gas captured and the quantity used.

The demand from domestic consumers varies widely both daily and seasonally, 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 as more gas will be used. There are few CMM power generation schemes in China because local authorities and mining enterprises for social reasons often consider domestic consumers as a priority. In addition, achieving an electrical grid connection is problematic at present, as the electricity sector is focused on large scale generation. However, there is potential to develop more CMM schemes to supply power to the mines themselves as they have a predictable base electrical load.

Financing of CMM utilisation schemes can be a problem. After years of poor performance and large losses, many mines have poor credit ratings with banks.

\(^{11}\) The breakdown and attrition of imported energy technology and the subsequent demise of its operation has been widely reported in developing countries. These problems can be attenuated by appropriate after-sales service/maintenance contracts or appropriate training of local staff in successfully maintaining and operating foreign equipment.
Many schemes are too small to interest international financing institutions and private investors.

Measurement, monitoring and control procedures and technologies – integral to an effective utilisation scheme – tend to be basic, mainly due to financial constraints. Domestic users are tolerant of gas pressure and quality fluctuations but as energy prices rise they are likely to become more discerning. The Pansan scheme will introduce more sophisticated controls than those in general use elsewhere. Pansan mine intend to install gas meters in households and charge per unit volume supplied basis (at a nominal heat value).

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.

3.4 Developing CMM utilisation in China

Although there are favourable policies to promote CMM projects in China, development of the resource is slow. Lack of funds in Chinese enterprises hinders local investment, and bureaucratic processes, safety issues and market concerns deter foreign investors.

Those foreign companies actively seeking projects sometimes find the amount of information provided is inadequate and insufficiently detailed. Mining enterprises and other Chinese organisations seeking to promote their projects need to do more to increase the chances of attracting external funding. Overseas investors will need a great deal of information before they will consider investing in a project in China. They need to satisfy themselves that a project is both technically and financially feasible and will need to conduct due diligence investigations to confirm the authenticity of information, its completeness and its interpretation. There must be a potential to generate profit to attract foreign interest. In contrast, Chinese engineers first explore the technology and what can be technically achieved, rather than evaluating a project on the grounds of financial and economic attractiveness. For this reason many projects viewed as exciting and noteworthy by their Chinese proponents may attract little interest from overseas investors or financial institutions.

China’s recognition of the Kyoto Protocol paves the way for the introduction of incentives to encourage reduction of emissions of greenhouse gases. One of these processes, the Clean Development Mechanism (CDM), may assist the financing of CMM schemes.

3.4.1 Ingredients of good CMM projects
As a rule of thumb, attractive projects are those where:

- the aims are clearly defined, understood and achievable
- there is a clear management structure and key decision-makers have been identified
• local or central government approval has been obtained and the applicability of any tax incentives confirmed
• technical risks are quantifiable and controllable
• the requisite technology is suitable and applicable to the location and within the skills base of the community
• revenue can be generated at an early stage
• customers have been identified and firm supply contracts negotiated
• prices are firm and set to rise (a difficult one to forecast)
• there are significant environmental and social benefits
• the return on investment is commensurate with the risk
• payback of capital is possible in 2 or 3 years
• there are long-term gas sales prospects
• there are quantifiable environmental and social benefits
• success can be replicated elsewhere.

Additionally, economy-of-scale is important for CMM projects due to the high transaction costs involved with the CDM, which limits the profitable operation of small scale projects.

3.5 Further issues to be considered

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 pre drained in advance of mining would not otherwise have been released until the coal seam was mined. The time difference between pre draining and working of the coal seam could be as much as two years. In some instances, an area could be pre drained but not necessarily worked due to geological reasons.

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, 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.

Lack of capital usually limits mine utilisation schemes to relatively simple gas distribution systems to supply gas for domestic uses, any surplus being vented. Use tends to be seasonal with large volumes of drained gas being vented during the summer months. This may represent the baseline case at some sites. However,
many sites have no utilisation and the baseline case is presumably straightforward with all the gas used eligible for credits.

3.6 UK experience with coal mine methane

The UK has a long history of gas use from working mines. An example of this is the North Staffordshire Gas Grid (NSGG) initiated in the 1970’s and operated for over 25 years. Gas from a number of mines was fed into a local distribution pipeline and supplied to local industry. Other examples include the use of gas for space heating, boilers and for electricity generation.

CMM schemes are located at deep, gassy coal mines practising longwall mining methods where underground methane drainage is needed for safety reasons. Recent change to the electricity market has enabled mines to consider on-site power generation and currently all CMM utilisation schemes are for power generation. Additionally, the introduction of the innovative UK emissions trading scheme in 2001 introduced further financial incentives to reduce emissions from coal mining activities. New equipment has been installed since the introduction of this scheme, which like the CDM rewards emission reductions from a baseline scenario. There are a number of schemes with a generating capacity of some 30 MWe in aggregate.

3.6.1 Case study – CMM utilisation at Maltby colliery

UK coal has recently developed a number of CMM schemes including the power generation and flare system at Maltby colliery, which was visited by the Chinese industry delegation in August 2004 as part of this project. Key points of the Maltby CMM scheme are:

- The power station and flare system is operated by a subsidiary company of UK Coal. They financed the construction of the scheme and receive revenue from UK Coal; they also receive monies for reduction in greenhouse gas emissions through a government supported scheme.
- The whole set-up consists of 3 containerised gas engines of 1.3 MWe each, and 2 flare stacks. This was installed by Biogas Technology Limited, and is based on waste sector technology.
- UK mining legislation prohibits the ignition of methane at a mine unless the gas is burnt in a boiler or engine. However, UK Coal has been granted an exemption from this legislation to flare drained gas at its working coal mines.
- Installed flare units are rated at 2000 m³/h (555 l/s) but are able to operate at lower flow rates. The flare units installed by UK Coal are enclosed ground units as used by the waste industry. Additional safety features have been incorporated within the design to prevent the risk of an ignition travelling back in to the mine. Typical costs (in the UK) for the installation and operation of a ground flares of this rating are GBP 55,000, plus costs for safety features for use at a mine of GBP 25,000.
- Enclosed ground flares have been developed primarily to control emissions from landfill sites; flares used for CMM are modified units. The Environment Agency provides guidance on environmental standards for the installation and operation of such units when installed at a landfill site. The general guidance given is considered appropriate to CMM applications. The additionally installed safety features have been
developed and agreed with the Health and Safety Executive (HSE) Mines Inspectors. An automatic monitoring system, including emissions, has been developed as part of the safety system.
4 PTIMISING THE DESTRUCTION OF METHANE AT PANSAN

In order to reduce emissions from coal mining activity through CMM utilisation, it is important to optimise utilisation and destruction of methane at the mine. Local energy demand and CMM supply from the mine are independently variable. It would be difficult, if not impossible, to cope with such variations without some form of storage or buffering capacity. However, this is unlikely to be satisfactory, as storage may have to be uneconomically large to cope with these variations, and also because the quality of the CMM varies and may be too low for utilisation (although as discussed later, short-term storage can mitigate these problems to some extent). The model project concept case study at Pansan mine highlighted these issues. As described in this chapter, therefore, the project partners urge the introduction of flares to destroy any excess or low quality CMM.

4.1 Gas availability at Pansan

4.1.1 Gas Resource
The gas resource comprises all the seams that will be disturbed by mining and hence will lose some, or all, of their gas content. The gas resource therefore depends on the volume of coal in the mining area and its gas content.

Pansan, like many of the large state-owned coal mines, has extensive coal resources. A new mine can only be approved for construction if the design meets the criteria specified by the government of China and administered by the National Development and Reform Commission (NDRC). One of the criteria is the lifetime of the mine. There must be sufficient coal reserves for the proposed production capacity to be achieved for a minimum number of years, typically around 80 (depending on production capacity). The downside of this is the large volume of coal tied up that cannot be accessed for exploitation in the near future. The benefit for CMM is the potentially, large gas resource. By extending to a depth of 910 m, Pansan can access workable seam nos. 13, 11, 8, 5, 4, 3 and 1 to achieve an 80-year life. Gas content tends to increase with depth so significant CMM flows are likely to continue for the foreseeable future. A quantitative resource assessment for all of the mining area allocated to Pansan was not considered necessary as the crediting period for Certified Emission Reductions (CERs) is relatively short compared with the design life of the mine, and because a conservative baseline approach is being proposed. The assessment of gas availability in this study was made on the basis of the proposed mining plan.

4.1.2 Gas Sources
The CDM study required a prediction of the likely gas availability over the crediting period for CERs. Considerable effort has therefore been expended on ascertaining the accuracy and reliability of current data measured at the mine and also examining mining and geological factors that will influence future gas supply.
Pansan mine generally operates three longwall retreat coalfaces. Those in production at the time of the May 2004 visit are reviewed below and the gas drainage arrangements on each are summarised.

**Face 1781** (No 13 seam east) – 4.5 m thick seam, mining method reported as longwall top coal caving (LTCC). Gas drainage was from:

- Boreholes drilling in front of the retreating coal face angled back over the goaf area. Gas drained from this source was typically 17.5 m$^3$/min (292 l/s) pure;
- Gas collection pipe left in the goaf. This gas was not drained to the surface but discharged underground;
- A bleeder roadway has been used in the past but was not available at the time of the visit;
- A small flow of gas was also drained from an old face (opposite) and put into the drainage pipework but the quantity was not measured.

**Face 1782** (No 11 seam east) – 1.7 m thick, mining method reported to be full height extraction. Gas drainage was from a super adjacent roadway driven some 50 m above No 11 seam (20–25 m below No 13 seam) and involves:

- Boreholes drilled up to insect No 13 seam. Gas drained from this source was about 16.4 m$^3$/min (273 l/s) pure;
- Floor boreholes. Gas drained from this source was 7 m$^3$/min which was not drained to the surface but discharged underground.

**Face 1452** (No 13 seam west) – 3.6 m thick seam, mining method reported to be full seam extraction. Gas drainage involved boreholes drilled over the face and also the use of a pipe laid in the goaf. Gas was discharged underground and not put in the collection pipework.

**Development drivage 1261** (No 13 seam west) - pre drainage in advance of development (drilling about 70 m in advance). Gas drained from this source was 0.7 m$^3$/min (12 l/s) pure.

**Development drivage** (No 8 seam west) - pre drainage in advance of development. Gas drained from this source was 0.7 m$^3$/min (12 l/s) pure.

A surprisingly close parity was found between the sum of underground drained gas flows measured at the four underground stations and the total volume measured at the surface extraction plant (28.2 m$^3$/min was measured both at surface and underground on 5 May, and 35.3 m$^3$/min was measured at surface and underground on 10 May 2004). Some discrepancy would be expected due to temperature and pressure differences, and cumulative error. Nevertheless, the scale of emissions measured at the surface was satisfactorily corroborated by underground observations.
The total flow of methane that could be diluted to within permissible limits (1%) by the total volume of ventilation air (4120 m$^3$/min) supplied to the three working longwalls is 41.2 m$^3$/min.

4.1.3 Gas flow predictions

Gas emission prediction calculations were made using a British Coal model modified by Wardell Armstrong (Table 4.1). Requisite geological, gas content and mining input data were obtained from the mine.

A plan of the mine was inspected which showed longwall face layouts, specific emission and gas content contours. Specific gas emission (relative emission per tonne of coal mined) ranged typically from 10 m$^3$/t to 22 m$^3$/t, being highest in the east. Coal seam gas content was also identified from a review of gas content contours on the mine plan. This indicated a range of 4 m$^3$/t to 10 m$^3$/t. Gas contents values were measured on samples from exploration boreholes. Other underground samples are sent to Chongqing Branch CCRI for measurement. There are no measured data for seams below No 13, but gas content is expected to increase with depth. Seam gas contents are lower in the western part of the mine than the east.

Run-of-mine coal production on the No13 seam, west working district visited in February 2004 (1452) was 30,000 t/week (typically containing 20% ash) and the retreat rate was 28 m/week.

The longwall in No 11 seam cuts full seam thickness of 1.8 m with a retreat rate of 25.2 m/week. An increase to 34 m/week retreat is planned.

Future coal production plans envisage a single longwall in each of the following seams: No.13 (2.2 Mt), No. 11 (1 Mt) and No. 8 (1.5 Mt). The mine has two sets of face equipment for each unit so there are no delays during face change over.

<table>
<thead>
<tr>
<th>District</th>
<th>Coal output (t/week)</th>
<th>Gas content (m$^3$/t ash free)</th>
<th>Total methane emitted (l/s)</th>
<th>Total methane emitted (m$^3$/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 13 seam, west, not underworked in seam No.11</td>
<td>30,000</td>
<td>6</td>
<td>339</td>
<td>20.3</td>
</tr>
<tr>
<td>No. 13 seam, east underworked in seam No.11</td>
<td>30,000</td>
<td>10</td>
<td>343</td>
<td>20.6</td>
</tr>
<tr>
<td>No. 11 seam</td>
<td>11,500</td>
<td>10</td>
<td>416</td>
<td>25.0</td>
</tr>
<tr>
<td>Total</td>
<td>71,500</td>
<td></td>
<td>1098</td>
<td>65.9</td>
</tr>
</tbody>
</table>


The total pure methane drained in No. 13 seam, west was quoted by a mine official as 20 m$^3$/min. This gas was discharged into the main return outbye of the district.
District ventilation in the return of the 13 seam longwall visited was reported as 1800 m³/min with an average gas concentration of 0.8%. Intake pollution was noted at 0.1%. The measured airway methane was therefore 12.6 m³/min and the total measured methane released by the longwall operation was 32.6 m³/min which is substantially higher than the predicted value. The reason for the discrepancy could be measurement values are too high or an error in selecting appropriate input parameters for the prediction model.

Overall, the emission model predicted a total gas flow (pure methane equivalent) during continuous coal production of 65.9 m³/min) using current longwall data. Analysis of mine data indicated that, on average, about 32% of the gas was captured by methane drainage and piped to the surface (some drained gas was vented underground), thus the drained gas flow derived from the prediction calculation would be 21.1 m³/min. This was very close to the average surface drained methane flow of 22.1 m³/min calculated using 18 months data (see baseline studies). The above study demonstrates a close similarity between the calculated quantity of gas released from coal seam sources and overall measured quantities. Thus, the origin of the gas can be satisfactorily accounted for and the prediction model can be used to assess the implications on gas availability of planned future changes in coal production rates.

4.1.4 Gas drainage methods
Gas at Pansan is captured by a combination of boreholes drilled upwards from a roadway driven in rock beneath the worked seam and from boreholes drilled in advance of the retreating coal face at a shallow angle of about 20 m back over the face. These boreholes are drilled to a length of some 125 m every 5 m (cost per borehole 2000 RBM or 16 RMB/m). There are plans to increase gas capture in No 13 seam by the use of super adjacent roadways driven 20 m above No 13 in rock. This new method offers advantages over the existing system although there are some possible disadvantages (Table 4.2). The method has proven successful at other mines in the Group and is reported to be in use in No 11 seam east workings at Pansan.
Table 4.2 Advantages and disadvantages of proposed super-adjacent roadway gas drainage method compared with the angled, cross measures drilling method currently used

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No drilling in difficult roadway conditions</td>
<td>• Higher operating cost (3000 RMB/m to construct rock gallery compared with 2000 RMB/borehole at 5 m spacings)</td>
</tr>
<tr>
<td>• Removes risk of coalface shearer striking standpipe and causing frictional ignition</td>
<td>• Additional rock for surface disposal</td>
</tr>
<tr>
<td>• Removes risk of igniting gas flowing from intercepted borehole</td>
<td>• If heating occurs (CO increases) then all drainage lost</td>
</tr>
<tr>
<td>• Higher gas purity attainable</td>
<td>• Low purity gas could be produced if fractured ground encountered and air ingress occurs</td>
</tr>
<tr>
<td>• Consistently higher capture achievable</td>
<td></td>
</tr>
<tr>
<td>• Demonstrated successfully in nearby mines</td>
<td></td>
</tr>
</tbody>
</table>

A standpipe is inserted for the first 10 m of the borehole and sealed in place, although this was not evident during the site visit. There were three gas drainage collection pipes in the longwall district visited as detailed in Table 4.3 below.

Table 4.3 Methane drainage flows in the No.13 seam district, west

<table>
<thead>
<tr>
<th>Purity</th>
<th>Pipe size (mm)</th>
<th>Gas source</th>
<th>Methane (%)</th>
<th>Suction (kPa)</th>
<th>Flow DP across orifice (mmH₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>150</td>
<td>Boreholes distant from the face</td>
<td>76</td>
<td>24</td>
<td>470</td>
</tr>
<tr>
<td>Medium</td>
<td>200</td>
<td>Boreholes close to the face</td>
<td>44</td>
<td>30</td>
<td>270</td>
</tr>
<tr>
<td>Low</td>
<td>150</td>
<td>Pipe in goaf area</td>
<td>25</td>
<td>20</td>
<td>650</td>
</tr>
</tbody>
</table>

Note: Orifice plate sizes are Chinese standard as supplied by Fushun Branch of CCRI.

In addition to surface gas extraction, temporary methane drainage (portable underground pump) is used to collect low concentration gas from the goaf which is discharged to the main return airway. This is probably of little benefit for gas control purposes and a ventilation solution at the return end of the face would be more beneficial.

4.1.5 Methane capture efficiency

It is impractical to capture all the gas released by mining using conventional gas drainage technology. However, a measure of both the captured and uncaptured gas provides a means of assessing the effectiveness of the gas drainage system and helps to identify opportunities for improvement. Methane not captured by the mine, and drained gas discharged underground, is emitted to the atmosphere in the
ventilation air. Check measurements were made of the quantity of methane emitted in ventilation air. Some of this gas may be available for capture and use, subject to further refinement of the gas drainage and collection system.

Methane capture efficiency can be calculated on a longwall by longwall basis or on a mine-wide basis but the values are not interchangeable. The latter basis was used here as it provides a good indicator of the overall gas drainage performance. It was calculated as the total drained methane flow divided by the total gas flow in the mine and expressed as a percentage.

4.1.6 Gas emitted in ventilation air
The mine has a “through” ventilation system with the three service shafts located on the mine site used as intakes and two remote ventilation upcast shafts located about 4 km away. At the time of the February 2004 visit, data provided by the mine showed the east ventilation shaft had an airflow of 11,600 m³/min and a methane concentration of 0.3%. The airflow in the west ventilation shaft was 10,800 m³/min at 0.2% methane. The total airflow was therefore 373 m³/s and the pure gas flow 56.3 m³/min.

Check measurements were made of the ventilation air methane by Wardell Armstrong on 11 and 12 May 2004 to ensure a consistent basis for assessing methane capture efficiency. Both shaft pit bottom areas were visited and airflow measurements and air samples taken in Gresham tubes for laboratory analysis. The airflow ventilation measurements were undertaken in accordance with British Coal Ventilation Mines – A Handbook for Colliery Ventilation Offices. Prior to the visit the Anemometer (AM500) was calibrated.

During the visit, a Pansan mine ventilation engineer took airflow velocity readings using an anemometer and these were compared with those obtained by Wardell Armstrong. Routine ventilation measurements are taken at weekly intervals.

The total airflow exhausted at the two upcast shafts was measured by Wardell Armstrong as 20,553 m³/min. The mine obtained a total airflow 9.1% higher. The difference arose because mine personnel do not use anemometer rods so are unable to traverse full roadway height and thus obtain a too high average velocity value in large roadways. Tube samples were taken for laboratory analysis of the methane concentration in the air. The airway methane flow was subsequently calculated as 47 m³/min. Using the average of two spot readings (35.6 and 40.5 m³/min), one for each day, at the methane plant of 38 m³/min, yields a methane capture of 45%. However, drained flows of such magnitude are uncommon. Using the average drained methane flow of 22.1 m³/min, and assuming the methane concentration in air is reasonably constant, a probably more representative capture efficiency of 32% is obtained.

An average whole mine capture efficiency of 40% would be a reasonable target. The required improvement could be obtained by piping all the gas to the surface rather than venting some underground, as well as by raising methane drainage
management standards. A consistent 40% capture would increase the average
drained methane flow to 31.3 m³/min, 16.5 million m³/y.

4.1.7 Mine gas supply risks
There are two major potential technical risks associated with the supply of mine gas.

- Premature closure of the mine – there are social, political and coal supply
  reasons which should favour the longevity of the mine, provided operating costs
  can be controlled. There are sufficient coal resources to support a life in excess
  of 80 years at current planned production levels. In any event, the mine would
  continue to produce gas for some time after closure (abandoned mine methane),
  until it became flooded.

- Loss of longwall faces due to geological or mining problems – there are three
  faces and the loss of one would reduce gas availability by around one third until
  the problem was resolved or a replacement face started. Assuming new
  longwall panels are under continuous development, such an interruption would
  not be expected to last more than approximately three months and could be a
  one in ten year event (data needed to confirm). It is unclear as to the level of
  exploration that has been undertaken in the seams below No 13. The use of
  retreat mining methods will reduce the risk associated with local geological
  features.

The availability of an additional set of face equipment for each unit will mean that
there should be little risk of lost production from face change over. The replacement
face could be prepared sometime in advance and capable of making up for shortfalls
in coal production.

4.2 Gas extraction at Pansan

4.2.1 Gas drainage plant
The gas extraction plant is operated primarily to allow safe coal mining and would
be installed irrespective of any gas utilisation proposals. It was therefore considered
to lie outside the boundaries of the CDM project.

Gas is routed to the surface from the underground gas drainage network through
boreholes drilled into the workings (borehole depths about 670 m). There are two
pipes in use at present bringing the gas to the surface and a third will be completed
and linked shortly. Borehole diameters are 14” and 12” for the east and west
respectively. The surface to underground pipes (377 mm OD\textsuperscript{12} diameter) are
connected in parallel.

Flow into the extraction plant was measured using an orifice plate inserted in the
344 mm OD diameter pipe. Tappings to measure the differential pressure across the
orifice plate were confirmed as D and D/2 where D is the pipe diameter consistent
with the ISO 5167 standard. Orifice plates used both surface and underground are

\textsuperscript{12} Orifice Diameter, half internal pipe diameter.
supplied by Fushun Branch CCRI and are to a Chinese standard size. Inspection of a spare orifice plate indicated these are good quality but the orifice plate sizes used are inconsistent with BS 1042 and ISO 5167.

4.2.2 Flow calculation method used by the mine
Pansan mine staff provided details of the formula used to calculate gas flow across the orifice plate at surface and underground drainage measuring stations:

\[
Q = k \times 0.621 \times \sqrt{P} \times \sqrt{760 + \left(\frac{7500.7 \times P_s}{273 + G_t}\right)} (1 - 0.00446 \times CH_4\%)
\]

Where

- \(Q\) = \(m^3/min\)
- \(k\) = constant for orifice plate (for surface is 3.6263)
- \(P\) = differential pressure across orifice plate in mmH₂O
- \(P_s\) = suction pressure in MPa (negative value)
- 760 = constant in mmHg
- 7500.7 = constant
- \(G_t\) = gas temperature
- \(CH_4\%\) = methane concentration

The above approach is adequate for methane management at the mine but insufficiently precise for CDM monitoring purposes. For the CDM monitoring and verification plan, a flow measurement method must be used that is consistent with international standards and which can be checked but will only need to be applied to the measurement of methane destruction at the surface.

Plant staff record relevant methane extraction information in a book on a hourly basis, including:
- Suction pressure of workings pumps (MPa)
- Vacuum on mine inbye of pumps (mmHg)
- Differential pressure across the orifice plate (mmH₂O)
- Methane concentration on the discharge side of the pumps (interferometer)

A continuous methane reading is also displayed on the discharge side of the pumps. A further continuous methane concentration reading is taken immediately after the vent. If methane purity falls below a pre-defined concentration (currently set at 30%) an automatic valve operates and diverts gas from the utilisation plant to the vent. This is reasonably consistent with international safety practice at coal mines. Should a flare system be installed the automatic venting setting should be reduced to 25% subject to approval by the safety inspection department.

A schematic of the gas extraction plant layout is shown in Figure 4.1 below, including proposed additional connections to utilisation plant.
Additional continuous monitoring equipment has been installed by the mine for testing purposes in a pipe limb parallel to that with the orifice plate. The equipment was designed to measure methane concentration, gas pressure, flow and temperature but it was not used as the data were considered unreliable. It would be a matter of concern if similar equipment were to be used for the utilisation scheme. This pipe limb was normally isolated.

Two new large extraction pumps (one operational, one standby) are planned to be installed adjacent to the current surface plant. The addition of more pumps will not increase gas recovery significantly unless some of the drained gas currently vented underground is connected to the system. In fact, increased suction will tend to increase the volume of ventilation air drawn into the system and could reduce methane purity and hence reduce gas availability for utilisation.

The current gas extraction performance was inhibited by the high resistance of the undersize orifice plate in the flow measurement section.

4.3 Gas utilisation scheme

A new 30,000 m³ gas holder had been constructed together with a control room and pump house. Tenders have been let for the gas engines, which include a performance specification. Only Chinese companies were invited to tender on this occasion, two having been selected for further evaluation. Further engineering procurement will be open to international companies.
Construction had started on the foundations for the Power Generation Station. Two units of 1.2 MW generator sets arrived in July–August 2004 with the other two 1.2 MW sets in Autumn 2004. The engines require 400 Nm³/h of gas to generate 1.2 MW. Gas delivery pressure to the engines is 2–3 kPa at a minimum methane concentration of 30%. Gas leakage (unburned hydrocarbons) from the engines is to E-2 standard. The capital cost of the power generation plant is 18m RMB (approx. GBP 1.2 million).

HCMG confirmed no gas will be used for the mine boilers, but hot exhaust gases from the engines will be fed to the mine for heating. Gas will be supplied from the gas extraction station to the gas-holder from which it can be sent either for local residential use or to the power generation station.

A scale drawing of the utilisation scheme provided by the mine shows, schematically, a CMM pipeline from the adjacent Panyi mine connecting to the Pansan utilisation system. As gas could be transferred in either direction between the mines, account must be taken of the quantities involved in the CDM scheme.

The utilisation system incorporates automatic monitoring at three locations. Monitoring involves gas flow, methane, pressure and temperature. The three monitoring locations are:

(i) Between the vent and automatic slam shut valve (surface extraction plant) and the gas holder
(ii) Between the gas holder and residential supply
(iii) Between the gas holder and power generation station

In practice, a utilisation scheme will not use all of the gas supplied by a mine for various reasons:

- Captured methane flows will vary as a result of varying mining and geological factors and it would be inappropriate to design a scheme with sufficient utilisation capacity to consume peak gas flows.
- Power generation equipment cannot run continuously (best schemes assume 90% to 95% availability but this is with full manufacturers O&M support and is unlikely to be the case here) and efficiently without regular attention necessitating planned maintenance stoppages. Plant breakdowns can also occur. The performance of the domestically manufactured gas engines has yet to be established (unsure of ability of domestic engine fuel management and control systems to deal with variable gas quality. Failure to exclude water vapour can lead to damage to pistons.
- Mining induced breaks in the roof around cross measures methane drainage boreholes, or gas drainage galleries, inevitably lead to loss of purity due to excessive air entering the methane drainage system. Air will also enter the drainage system when new pipes and boreholes are connected. At times, therefore, the concentration of gas arriving at the surface will be too low to use. Where the problem is short-lived, gas can be drawn from the gas holder.
Flaring of low concentration gas (< 25%) is not advisable for safety reasons and this gas would either be vented or enriched by blending with gas from the gas-holder. This would require additional pipework and control and is not in the current design.

Gas surplus to power generation and domestic use together with any gas of less than 30% purity but greater than 25% should be flared.

4.3.1 Environmental impacts
The wider adoption of the superadjacent roadway drainage method will result in increased rock disposal on the surface from driving a gas drainage gallery above each longwall panel (Nos 11 and 13 seam). The mine also reported that they drain gas from boreholes drilled from a gallery driven below the face panel.

The gas drainage method was being changed primarily for underground safety reasons and would take place irrespective of the CDM project.

The proposed gas utilisation scheme will not use all of the gas drained and unless a flaring option is included, substantial gas volumes will continue to be vented to atmosphere.

Water, air and noise impacts of the gas utilisation scheme have been assessed and are not significant relative to the industrial activity associated with mining operations themselves.

4.3.2 Operational health and safety risk assessment
The gas-related ignition, explosion, fire and asphyxiation hazards have been assessed and risk mitigation measures designed, but the details have yet to be confirmed:

- Ignition of gas in pumps (extraction station and gas distribution plant) – water seal extractors in surface extraction station, use of non incendive materials for dry extractors
- Flashback to gas storage - slam shut valves and flashback arrestors (must be regularly serviced)
- Flashback to mine – slam shut valves and flashback arrestors (must be regularly serviced)
- Gas leakage in the extraction plant – monitoring and alarms, good standard of building ventilation
- Leakage from distribution pipes – undertake regular “sniffer” surveys
- Leakage from gas storage – stand-off zone, monitoring, controlled access
- Asphyxiation at industrial and domestic sites by displacement of air – natural ventilation, low supply pressure, information and education for users
- Restoring household gas after interruption – risk of domestic rings being left on
- Impact of extraction pump failure on mine safety (standby pump, facility to open vent drainage pipe to atmosphere if power outage or total failure – check in place)
- Compression of gases containing oxygen for engines – monitor oxygen and auto shut off if maximum permitted oxygen level exceeded.
4.3.3 Surface safety provisions
A number of safety measures have been recommended for incorporation within the Pansan extraction and utilisation scheme, these include:
- The gas storage and control system is located in a controlled area.
- Methane detectors within the surface buildings
- Use of water sealed extraction pumps
- Methane purity sensor which will automatically close the slam shut control valve to direct gas to the vent if gas purity falls below 35%
- Methane sensor in the control room for gas to residential property blocks
- Metering of gas supply to each property
- Gas bottle (LPG) or electricity to be used if gas not available. WA have expressed concerns about the use of LPG unless directly switched without any need to disconnect and connect gas supplies
- Emergency and service call out numbers given to users
- Electric spark lighters for gas users
- Gas used for hot water and cooking. Option to use for heating at a later date

4.4 Variabilities and uncertainties in predicted gas flows
The mine has a manual monitoring system which ensures gas flow and purity is measured at hourly intervals. Remote monitoring equipment has been installed but is not yet fully operational. Expected CMM delivery by the extraction plant has been assessed from a review of historical data, future mining plans, check gas flow and concentration measurements and methane emission prediction calculations.

4.4.1 Quantity and quality of drained gas
Gas drainage measurements were examined and analysed. Methane concentration and flow data were provided by the mine for a period of 18 months (Jan 2003-June 2004) consisting of daily spot readings and comprising 546 data points. The statistical distributions of data were examined and the results summarised in Tables 4.4 and 4.5.

Table 4.4 Distribution of methane concentration values

<table>
<thead>
<tr>
<th>Methane purity (%)</th>
<th>Time above or equal to indicated purity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>91</td>
</tr>
<tr>
<td>30</td>
<td>79</td>
</tr>
<tr>
<td>35</td>
<td>62</td>
</tr>
<tr>
<td>40</td>
<td>51</td>
</tr>
<tr>
<td>45</td>
<td>24</td>
</tr>
<tr>
<td>50</td>
<td>8</td>
</tr>
</tbody>
</table>

Note: Average methane concentration = 37.8%; standard deviation = 8.9.

Table 4.4 indicates that methane of sufficient purity to flare (> 25%) was available 91% of the time. The engines for power generation require methane of at least 30% purity and would have had gas of the appropriate quality for 79% of the time.
Table 4.5 Distribution of methane flow (pure basis)

<table>
<thead>
<tr>
<th>Methane flow (m³/min)</th>
<th>Methane flow (Million m³/y)</th>
<th>Time above or equal to indicated flow (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2.6</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>5.3</td>
<td>92.3</td>
</tr>
<tr>
<td>15</td>
<td>7.9</td>
<td>71.0</td>
</tr>
<tr>
<td>20</td>
<td>10.5</td>
<td>55.5</td>
</tr>
<tr>
<td>25</td>
<td>13.1</td>
<td>49.5</td>
</tr>
<tr>
<td>30</td>
<td>15.8</td>
<td>19.0</td>
</tr>
<tr>
<td>35</td>
<td>18.4</td>
<td>5.5</td>
</tr>
<tr>
<td>40</td>
<td>21.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: Average methane flow = 22.1 m³/min (11.6 million m³/y); standard deviation = 8.6.

The average pure methane flow of 22.1 m³/min (Table 4.5) is substantially lower than the 180 m³/min reported at our February 2004 visit to the mine which must be considered erroneous – perhaps it may be representative of the gas extraction station pump capacity at atmospheric pressure.

Check spot measurements of drained gas flow were made by Wardell Armstrong using a pitot tube during a visit to the mine in May 2004. A pure flow of 56 m³/min was measured by WA and the mine recorded 39 m³/min across an orifice plate. Some difference between mine measurements (orifice plate) and check measurements (pitot tube) would be expected as these measurements were made in two separate, parallel pipe limbs. The limb not in use was isolated by valves while measurements are made in the other. The mine measurement involved use of an undersize orifice plate which adds up to 6 kPa resistance to the drainage system. The plate size was consistent with the Chinese standard of half the internal pipe diameter but not with the ISO standard. The ISO flow standard requires an orifice diameter to be sufficiently large to limit differential pressure to less than 2 kPa, and typically about two thirds of pipe diameter (British Coal guidance suggested an orifice plate diameter should be selected so differential pressure is in the range 0.5–1.0 kPa). The check measurement was made using a pitot tube in the lower resistance pipe limb after isolating the limb with the orifice set. Less suction pressure and a higher flow, possibly about 5% more, would therefore be expected in the pipe limb which does not contain the orifice plate. These findings also indicate that some improvement in drainage flow might be obtained by replacing the existing orifice set with one designed to an international standard.

4.4.2 Trends
Trends of various key parameters over the 18 month period were examined.

Mixture flow showed a generally rising trend for 16 months then a fall. The implication is that either the system resistance decreased or pump capacity was increased. If the latter was true then methane concentration would have fallen. As this did not happen the former is the most likely explanation. The rising trend could therefore reflect the effect of improvements to the gas drainage infrastructure and gas capture methods employed.
Methane concentration showed two distinct populations, one centred around 25% and the other around 45% with a general spread of around ± 10%. By improving operational practices and methane capture design it should be possible to eliminate the lower suite of values.

Methane flow, pure basis, (Figure 4.2) showed a similar trend to methane concentration. Two distinct populations are exhibited. These lie in the ranges 10–15 m³/min and 25–35 m³/min. This shows that gas availability in the drainage system was closely dependent on the quality of the drainage operation, and presumably the method of gas capture employed. For a period of about 9 months a consistently high flow performance was obtained but recently flows have fallen significantly. Data have therefore been requested for July to see if the recent fall was transient and short-lived. If it was, and if the low results can be satisfactorily explained, then there may be a case for accepting the higher population as a baseline. If not, then the baseline must assume that the variability exhibited in the 18 month sample period will be replicated in the future and current utilisation expectations must be down rated.

There is likely to be some scope for treating the deficiencies and improving the design, practise and management of the system to obtain consistently higher methane recovery.

Methane capture efficiency and methane concentration showed a close correlation, once again confirming the diagnosis of a deficiency in the drainage method.
4.4.3 Results of data analysis

Using data representing an 18 month period, the average methane flow is 11.6 million m³/y. However, at only 91% of the spot checks, representing 495 out of the 546 days, did the gas concentration exceed 25%, which would allow it to be safely burned (flared). At 79% of the time was the concentration high enough for utilisation in the gas engines, above 30%. Using these numbers the maximum potential for methane destruction is about 10.6 million m³/y (reducing emissions by 160,000 tCO₂e/y).

However, concentration and flow were correlated (see Figure 4.2.): days with higher CMM concentrations also show higher gas flows. This means that during the 79% of days that the concentration exceed 30%, 90% of the gas is emitted; 96% of the gas is emitted during days when concentrations exceed 25%. Total methane destruction could thus exceed 160,000 tCO₂e/y.

A further analysis, using these data points, and allowing for the utilisation by the four engines within their utilisation range of 5 to 6 m³/min, the total gas utilisation would reach about 70%. During the nine months of consistent high concentration (and high flow) all four engines would be working and spare gas would be available for flaring. During some of the rest of the time one, two or three engines may be working, with the remainder being flared, or concentrations may be too low for utilisation, and all gas is flared or vented. In aggregate, this analysis shows that some 26% of the available gas in the year may be flared.

Figure 4.3 below show the result of this further analysis. During the first few months of data, gas concentrations were within the 20-30% range. However, concentrations were highly volatile during this time, resulting in a succession of venting, flaring and utilisation of gas flows. The data shows a slow improvement with concentrations staying above 30% most days in the last ten months of data, although flow was reduced in the last month. In this period, concentrations were high enough for utilisation most days, but not enough capacity would be available to use all gas, thus leading to flaring of the excess gas.

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13 This analysis ignores, for simplicity, the relatively small CMM utilisation rate for domestic supply.
14 The mining group indicated that the engines would be running at 1 MWe rather than at their rated capacity of 1.2 MWe.
However, if the improved performance consistently achieved for a nine month period within the data set were sustained in the future then a best case average of 29 m$^3$/min, which equates to 15.2 million m$^3$/y, could be available (about 229,000 tCO$_2$e). However, recent results obtained from the mine indicate that the variability shown over the preceding 18 months is probably representative of what may be expected in the future. There is therefore no justification for revising the above estimate at present.

The mine has set a target to improve drainage to a consistent 40% capture which would increase the average drained methane flow to 31.3 m$^3$/min, 16.5 million m$^3$/y, but there are no firm indications of how this will be achieved.

4.4.4 Gas availability over the life of the CDM project

A CDM feasibility appraisal requires a prediction of the likely gas availability over the term of the CERs. This involves ascertaining the accuracy and reliability of current data measured at the study mine, examining mining and geological factors that will influence future gas supply and confirming that there is sufficient gas resource in place. The gas resource comprises all the seams that will be disturbed by mining and hence will lose some, or all, of their gas content. The gas resource therefore depends on the volume of coal in the mining area and its gas content.

The impacts and likelihood of premature mine closure and loss of longwall faces due to geological or mining problems should also be assessed. A gas emission prediction model is useful for this.
Impact of variations in CMM flow and quality
The study mine provided an example of how customarily used average flow values can give an unrealistically optimistic value of CMM utilisation potential. Methane concentration and flow data representing over a period of 18 months were examined. The average methane concentration was 37.8% and this had been misinterpreted as indicating all the gas was usable. However, analysis of the data distributions by Wardell Armstrong showed that methane of sufficient purity for power generation (> 30%) was only available for 79% of the time but flaring would be possible (> 25% purity) for 91% of the time. Flaring will not only destroy some of the gas that the engines cannot use but also surplus gas that cannot be stored or used during engine maintenance and breakdown.

Some CMM scheme design criteria
To maximise energy efficiency, waste heat from the engines used for power generation should, where practicable, be used for heating mine buildings and water.

Flaring of low concentration gas (< 25% perhaps) is not advisable for safety reasons and this gas should either be vented or enriched by blending with gas from a gas-holder and then flared or used.

Gas surplus to power generation and domestic use, together with any gas of less than 30% purity but greater than 25% should be flared (subject to local regulations).

Domestic gas use tends to be seasonal and account should be taken of this in assessing variability in total CMM demand, utilisation and flare capacity.

4.4.5 Measurement Uncertainties

Gas composition
UK laboratory gas analyses on samples of the drained gas yielded methane concentrations of 81.4% and 89.8% for samples of drained gas, taken in February and May 2004 respectively, adjusted to an air-free basis. There were no significant concentrations of higher alkanes so the heat value depended wholly on the methane concentration in the gas. Any concerns about cross sensitivity of methane detectors which can lead to measurement errors were also removed. As methane concentration is measured directly, and mixture flow converted to pure methane flow, any variability in source gas composition is automatically compensated for.

Methane concentration measurement
In a calibration check of the gas detector used for measuring the methane concentration in the drained gas, the following readings were obtained: mine gauge 53%, portable interferometer 55% and laboratory gas sample 46%. The relatively low value from the laboratory sample may have been due to possible air in-leakage in the sampling system. It is recommended that an independent sampling system with new tubing and a short, direct connection to the discharge side of the drainage pumps is used in any future calibration exercise. The parity between the mine gauge and the interferometer is taken as indicative of instrument calibration within + 5% of gauge reading.
Gas mixture flow measurement
No satisfactory calibrations were obtained of the mine’s orifice plate system using a pitot tube. Reasons included measurements undertaken in parallel limbs, unstable flow conditions, possible contaminants within the pipe reducing its effective diameter, inconsistent pipe diameter data supplied by the mine and uncertainty by the mine in the actual orifice plate size. The only satisfactory solution would be to install an orifice set compliant with BS 1042 (used internationally) and revise the flow calculation method used at the mine accordingly. A different monitoring technology (air velocity measurement using a vortex-shedding device) will be used for the utilisation scheme that, hopefully, will be tested and calibrated in a wind-tunnel before installation.

Calculation of gas flow
The mine did not adjust flow to a standard temperature. The gas temperature measured by WA at a spot check was 34°C but the mine record lower temperatures of 10-24°C, probably ambient air, for a reason that was not clear. The true mine gas temperature would not be expected to vary greatly, but the mixture temperature would decline with increasing leakage of the cooler ventilation air into the drainage system.

No correction is applied to absolute pressure to account for variation in barometric pressure but any error will be small due to the relatively the high suction pressure of around 58 kPa. Neither is delivered flow adjusted to standard atmospheric pressure.

Data supplied by the mine were used to calculate flow using a computer programme based on BS 1042 and the results were compared with those calculated using the mine’s formula after correcting them to a common temperature (15°C) and assuming a gas mixture temperature of 34°C (Table 4.6).

Table 4.6 Comparison of flows calculated by the mine and by a standard calculation method, adjusted to standard temperature

<table>
<thead>
<tr>
<th>Data set</th>
<th>Mine formula</th>
<th>WA (based on BS 1042)</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>14.1</td>
<td>13.4</td>
<td>5.0</td>
</tr>
<tr>
<td>221</td>
<td>28.1</td>
<td>26.0</td>
<td>7.5</td>
</tr>
</tbody>
</table>

China’s standard for orifice plates for flow measurement is not consistent with ISO. The high resistance of the under-size orifice could reduce flow by 5% and therefore flows available for utilisation, assuming an undersize orifice plate is not used, may be understated by this amount.

Overall uncertainty
Taking into account the above factors, the methane flow delivered for utilisation should be close to the values calculated by the mine. The estimated overall uncertainty is +10%.
4.5 Variability and uncertainty in gas utilisation rates and optimisation through flaring

4.5.1 Gas used by engines
According to the mine, the engines will each consume 400 Nm$^3$/h at full load to produce 1.2 MW. Four engines would use 14 million m$^3$/y if fully operational all the time but this will not happen as engines will have to be stopped for maintenance and also if methane concentration falls below 30%. In addition, it is believed that the mine only intend to run three engines at any one time. Assuming 85% availability of three engines and for 79% of the time gas is usable this will equate to 7.0 million m$^3$/y. This is substantially less than the 12 million m$^3$/y of methane used for power generation estimated by the mine operators.

4.5.2 Domestic use of gas
At present, gas was supplied to domestic users comprising some 400 (other reports state 300) miners homes. The aim was to expand the domestic consumer distribution network to a total of 4,000 homes and ultimately 10,000 (pending approval and operational support by local government).

The proposed gas use by domestic consumers according to Pansan mine is 3 million m$^3$/y. On this basis the anticipated average annual demand per household per year equates to 750 m$^3$/y but annual demand per household in other mine CMM schemes range from 146 to 373 m$^3$/y (Table 4.7). The projected domestic gas use at Pansan based on 4,000 homes would therefore appear to be too optimistic, the actual demand could be half that proposed.

<table>
<thead>
<tr>
<th>Mine</th>
<th>Total gas used (million m$^3$/y)</th>
<th>Total number of households connected</th>
<th>Average consumption per household (m$^3$/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiefa</td>
<td>28</td>
<td>191,000</td>
<td>146.5</td>
</tr>
<tr>
<td>Yangquan</td>
<td>50</td>
<td>134,000</td>
<td>373.1</td>
</tr>
<tr>
<td>Songzao</td>
<td>36.5</td>
<td>222,000</td>
<td>164.4</td>
</tr>
<tr>
<td>Hegang</td>
<td>10</td>
<td>28,000</td>
<td>357.1</td>
</tr>
</tbody>
</table>

Source: Wardell Armstrong

The uncertainty in the amount of gas that will be used domestically is not critical as surplus gas can be flared.

Domestic use has been assessed on the basis of reported results from operational schemes elsewhere and not the predictions made by the mine for which there is no reliable historical basis. A consumption of 0.9 million m$^3$/y was proposed as a practical estimate.

4.5.3 Optimisation through flaring
A flare unit would need to have a minimum capacity of 2000 m$^3$/h (17.5 million m$^3$/y at 100% availability and utilisation) and be operable at a concentration of methane of 25% or higher, which corresponds to 91% of the drained gas (15.9 million m$^3$/y.
capacity at 100% availability). Such a large flare unit is essential in the event of total power generation engine failure at a time peak flows are being drained which can reach 40 m³/min. The 5:1 turndown capability of the unit allows flows as low as 7 m³/min to be flared. The flare will destroy about 2.7 million m³/y of methane that is not utilised.

There would be little cost saving opting for a smaller flare – about GBP 5,000 less for half the size, but this could result in loss of emission credits in the event of a failure of the generation plant.

4.6 Business as usual (BAU) and baseline scenarios

4.6.1 Utilisation

In the absence of the Pansan CDM project, about 0.9 m³/min of the drained gas would have been used in the colliery boilers, equating to an annual pure methane flow of 473,000 m³.

In the absence of the CDM project, domestic gas use would have been limited to 400 miner’s homes. Annual consumption per household based on an analysis of four domestic distribution networks elsewhere in China averages 217 m³/y. The miners’ households would therefore have consumed around 86,800 m³ each year.

No power generation and no flaring would take place without CDM.

4.6.2 Leaks

Potential uncontrolled emissions needed to be identified for health and safety, environmental and CDM specific reasons.

Emissions could arise from the following sources within the project at Pansan:
- CMM transmission leakages
- Unburned gas in engine exhausts
- Fugitive losses from pressure relief valves in pipelines and storage facilities
- Unburned gas in the flare stack
- Gas emitted from domestic gas rings prior to ignition
- Emergency venting and venting of low concentration gas
- Gas vented during normal measurement and maintenance activities

Studies performed by the natural gas industry in various countries indicate 1% as typical for fugitive losses from pipelines. Taking into account the range of possible fugitive emission sources, low transmission pressure and proposed maintenance procedures an overall loss of around 2% might be expected at Pansan.

CMM vented when the concentration is too low to flare, or CMM flows exceeding the total utilisation and flare capacity, are accounted for in the monitoring process and are therefore excluded from the consideration of leakage. Electricity is used by the CMM extraction pumps but as they are operated as an essential part of the mining process, irrespective of whether gas is used or not, this would not be considered a leakage and the gas extraction plant would lie outside the CDM project.
However, power consumed by compressors, pumps, valves, instruments, lighting and other equipment downstream of the extraction plant all represent leakages to the energy system. An estimated overall leakage of 2% would compensate conservatively for the above losses.

These leakages are increased internal project emissions, and should not be confused with the usual CDM project leakage concept – environmentally negative activities potentially encouraged as a result of implementation of the project.

4.6.3 Baseline result
An estimate of the BAU scenario is 0.56 million m$^3$ methane pure (consumption from the boiler plus households). The methane emission reductions after subtraction of BAU utilisation, before leakages are 10.04 million m$^3$ methane pure. Correcting for 2% leakage gives 9.8 million m$^3$ methane per year against which CERs should be allowable which corresponds to 148,180 tonnes per year of CO$_2$.

4.7 Conclusion

In any future scheme it would be rational to flare first and use the monitored data to assess the scale of feasible power generation.

The mine was considering installing a pipeline connection to bring gas from the neighbouring mine. There may now be a strong case for examining such a scheme and allowing for its inclusion in the PDD.

Gas flows in a coal mine are variable depending on which faces are in production, which combinations of seams are being worked, coal production rate, geological and gas content variations. For operational reasons, both the quantities of gas drained and gas quality will vary. Not all of the gas may be of high enough purity to use, therefore only a proportion of the drained gas may be available for utilisation. Thus, only a proportion of the drained methane can be destroyed using conventional means.

As both drained CMM flows and CMM compositions are variable, it is impracticable to design a commercially feasible utilisation scheme which will use all of the gas. The unused gas is conventionally vented to the atmosphere although a substantial proportion of it could be safely flared. However, in the UK three mines are now flaring CMM surplus to utilisation requirements and more installations are planned. Motivation comes from a national carbon-trading scheme. Safe flaring designs for CMM have also been demonstrated in Australia and the USA.

Flaring is a cost to mining operations and is not mandatory in China, neither is it prohibited for operational safety reasons. CDM will, however, provide financial justification for its introduction and assist in transferring this technology to China where flaring could make a rapid, cost effective and significant reduction to greenhouse gas emissions from coal mines. There is no obligation in Chinese law to use drained CMM but it is mandatory to attempt to drain gas if the mine is classified...
as gassy. CDM will therefore be a positive driver for encouraging investment in gas drainage and use at coal mines.
5  MODEL CDM PROJECT CONCEPT FOR ENHANCING CMM UTILISATION

The model concept discussed below follows the new methodology form of the CDM Executive Board.

5.1 Identification of methodology

5.1.1 Proposed methodology title
Baseline methodology for coal mine methane (CMM) utilisation and destruction at a working coal mine.

5.1.2 List of category(ies) of project activity to which the methodology may apply
The principle category of the project activity, coal mine methane utilisation and destruction, is number 10: fugitive emissions from fuels (solid, oil and gas). Other scopes could be mining/mineral production, energy industries (renewable – / non-renewable sources), and energy demand.

5.1.3 Conditions under which the methodology is applicable to CDM project activities
This proposed methodology is applicable to coal mine methane utilisation and destruction project activities at a working coal mine, where the baseline is the partial or total atmospheric release of the gas and the project activities include the following situations:

- The captured gas is destroyed through flaring; and/or
- The captured gas is destroyed through utilisation to produce usable energy (e.g. electricity/thermal energy), emission reductions may or may not be claimed for displacing or avoiding energy from other sources.

CMM utilisation schemes are not usually designed to capture and utilise the full CMM flow occurring at the mines. The reason is that CMM flow rate, CMM quality and utilisation are variable, and that they vary independently of each other. Therefore, in order to minimise the amounts of CMM vented, flaring should be considered to destroy most of the excess CMM that can not be utilised for energy production (e.g. electricity/thermal energy).

There are currently no approved methodologies which may apply to this project activity.

5.1.4 What are the potential strengths and weaknesses of this proposed new methodology?
This proposed methodology is applicable to CMM utilisation and destruction project activities. The methodology is developed to be flexible so that it can be used by a wide range of project activities, and is not limited to the particular project activity proposed by the project participant.
Utilisation of the energy content of CMM is clearly preferential. There may be situations, for example where there is very limited local energy demand, in which energy utilisation is not feasible. However, the methodology has a preference for utilisation and requires an explanation if no energy is utilised.

At the same time, it is unlikely that (local) demand matches the supply of CMM from the mine, because the CMM extraction is managed to ensure the safe operation of the mine and is (and should be) independent of any demand for the gas. Therefore, it is unlikely that the CMM utilisation schemes will be designed to capture and utilise the maximum CMM flow rates occurring at the mines. Therefore, in order to minimise the amounts of CMM vented and minimise total greenhouse gas emissions, flaring should be considered to destroy most of the excess CMM that can not be utilised for energy production (e.g. electricity/thermal energy). If no flares are installed, an explanation needs to be given.

However, while utilisation of the energy content of CMM is clearly preferential, the additional requirements for the baseline may be burdensome. Additionally, higher leakage estimates for energy utilisation, in particular for gas supply to end users, as compared to flaring may, from a pure CER perspective, lead to a choice for flaring over energy utilisation. The possibility of using existing and approved methodologies, potentially including simplified methodologies for small-scale CDM project activities, for any emission reductions from energy utilisation as part of the project activity would reduce such costs. Additionally, the requirement for an explanation why energy utilisation is not part of the project activity should prevent this.

The methodology proposed includes the basis for claiming emission reductions for a number of different energy utilisation options. These claims are based on existing approved baseline methodologies for electricity generation and thermal energy use.

Strengthenes
- Applicable to a wide variety of projects (completeness)
- Minimises greenhouse gas emissions, despite variabilities in gas flow, gas quality and utilisation
- Energy utilisation encouraged
- Flaring of excess CMM encouraged
- Inclusive of the emission reductions from energy use
- Conservative

Weakness
- Destruction (flaring) of CMM may be easier than utilisation of the energy content if already-existing methodologies are not allowed for the utilisation part of the project

5.2 Overall summary description

Coal mining releases gas from any coal seams disturbed by the mining activity. The gas flow into a mine district depends on the gas contents, number and thickness of coal seams (and any other gas bearing strata), the proximity of the seams to the workings, the length of time the district has been working and the rate of coal
extraction. For safety reasons in gassy underground mines, a proportion of the gas is captured and piped to the surface. Once at the surface the gas is vented to the atmosphere. Until recently no coal mines anywhere in the world were flaring drained gas. However, safe flaring designs for CMM have now been demonstrated in some highly industrialised countries. CDM project activities using flaring will assist in transferring this technology to developing countries where flaring could make a rapid, cost effective and significant reduction to greenhouse gas emissions from gassy coal mines.

This methodology is applied to CMM utilisation and destruction projects in the following three steps.

**Step 1: Confirmation of applicability and additionality test**

In a series of five questions (see section 5.4.3) this methodology will confirm whether it is applicable to the project activity. The methodology applies to coal mine methane utilisation and destruction project activities at a working coal mine, where the baseline is the partial or total atmospheric release of the gas and the project activities include situations such as:

- The captured gas is destroyed through flaring; and/or
- The captured gas is destroyed through utilisation to produce energy (e.g. electricity/thermal energy), emission reductions may or may not be claimed for displacing or avoiding energy from other sources.

A further 5 questions (see section 5.4.3) will explore the additionality of the project activity, including:

(i) Legal requirements for utilisation and destruction of CMM
(ii) Economically attractive actions
(iii) Barriers and common practice

**Step 2: Description of the baseline**

The baseline is the atmospheric release of the CMM gas, as the most economically attractive course of action. The baseline includes the consideration that some of the methane drained may be captured and utilised or destroyed, for example to comply with regulations or contractual requirements.

The first part of this methodology calculates the CMM releases and emissions without the project activity. Please note that CMM is not of biological origin, unlike landfill gas, and CO₂ emissions from utilisation and/or destruction need to be taken into account.

The second part of the baseline with respect to CMM utilisation for energy production (e.g. electricity/thermal energy/gas supply), where emission reductions are claimed, follows an appropriate approved methodology, for example, AMS-I.D or ACM0002. Please note that any CO₂ emissions have already been taken into account under the first part of the baseline, and the energy production can thus be considered to be from a zero-emission source.
Step 3: Determination of the emission reductions

The greenhouse gas emission reduction achieved by the project activity during a given year is the difference between the mass of methane actually destroyed/combusted during the year and the mass of methane destroyed/combusted in the baseline, times the Global Warming Potential of methane, and corrected for the resulting CO₂ emissions from the methane destruction. Additionally, the project proponent may claim emissions reductions from electricity, thermal energy, and gas supply. The total reductions need to be corrected for any emissions from internal energy use of the project, and any emissions from energy inputs and losses in the CMM supply grid, power generator and monitoring system are taken into account in the calculations above.

5.3 Choice of and justification of the baseline approach

5.3.1 General baseline approach
Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment.

5.3.2 Justification of why the approach chosen is considered the most appropriate
Approach 48(b) “emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment” is chosen.

The proposed baseline methodology has been developed for projects, which involve new investments in already-existing and operating mines. The economically attractive course of action is to continue current practise of venting the drained coal mine methane, which is standard practise at coal mines across the world, and any utilisation/destruction to comply with regulations or contractual arrangements.

Actual or historical emissions, approach 48(a), would not properly take into account any changes in CMM releases from the mine. The releases from the mine are heavily dependent on the evolution of the mining process: new coalfaces may have different gas contents, and production changes will impact on the volume of gas emitted. Additionally, historical data of CMM emissions in proposed project activities are unlikely to be verifiably accurate. Prior to implementation as a CDM project, accurate measurements of CMM flows were not relevant, as only changes in gas flow and concentrations need to be monitored for safety reasons.

Average emissions from similar projects, approach 48(c), would not be appropriate because the CMM releases are very specific for each mine. The destruction element of the project activity proposed is one of the first in China and one of the first globally.

Approach 48(b), therefore, is the most appropriate approach for this new baseline methodology, as it does not rely on non-existent or inaccurate historical data, or non-existent or too few similar projects. Instead, the approach would use accurate
measurements of CMM actually destroyed, using newly installed technology that would not have been installed as the economically most attractive course of action.

5.4 **Explanation and justification of the proposed new baseline methodology**

5.4.1 **Explanation of how the methodology determines the baseline scenario (that is, indicate the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases (GHG) that would occur in the absence of the proposed project activity)**

The baseline methodology consists of three steps. The first step confirms the applicability of the methodology to the project, and proves the additionality of the project. The second step describes the baseline scenario, including the emissions from the project, and the emissions associated with the energy utilisation of the project.

As part of the first step of the baseline methodology, the project participant needs to describe the legal requirements for the project, the economically attractive course of action, and assess any existing barriers to implementation of the project.

The baseline scenario is the full or partial atmospheric release of the coal mine methane gas, as this is the most economically attractive course of action for a working coal mine. The baseline methodology considers that some of the methane drained may be captured and utilised and/or destroyed, for example to comply with regulations or contractual requirements.

Ex-ante projections for future CMM emissions of the coal mine are made for reference purposes, but emission reductions will be determined (ex-post) by metering the actual methane flow once the project activity is operational. It is difficult to project accurately what volumes of CMM will be released in future years, as this is dependent on coal production, and evolution of the coal mine. Different coal faces have different CMM profiles, and so the level of production from each coal face and possible new coal faces will have an impact on the production of CMM. Similarly, the quality of the CMM, i.e. the concentration of methane, is variable. This will have an impact on both the overall volume of methane and on the uses for the CMM. Some uses require higher concentrations of methane in CMM, even flaring needs a minimum amount of methane and some venting may be required for safety reasons. While projections of CMM volumes are made, the CMM flow actually monitored over the crediting time of the project is being used to determine the baseline scenario and emission reductions achieved by the project ex-post.

Part of the CMM may have been destroyed/combusted during the year in the absence of the project activity, for example to comply with regulations or contractual requirements, or the existence of utilisation equipment. The baseline is the atmospheric release of the amount of methane actually drained minus the CMM that would have been destroyed in the absence of the project activity. The amount that would have been destroyed could be a given absolute quantity, share of the total amount, or zero, depending on the economically attractive course of action, existing regulation, contractual requirement or industry practice.
The greenhouse gas emission from the methane in the baseline is made up of two parts. First the CO₂ emissions from the destruction of methane in the baseline scenario. Secondly, the methane not destroyed/combusted in the baseline.

The approved Global Warming Potential value for methane for the first commitment period is 21. The amount of CO₂ emissions resulting from the destruction of methane is equal to the amount of methane destroyed multiplied by the CO₂ emissions factor for methane. Given molecular weights and the chemical reaction when methane is combusted, each tonne of methane results in 44/16 tonnes of CO₂; thus the CO₂ emissions factor for methane is 2.75.

The second part of the baseline scenario includes the emissions related to any energy utilisation as part of the project, such as electricity generation, thermal energy generation, and gas supply. The emissions from the internal energy used for these energy utilisation purposes has already been taken into account under the project emissions, and is netted out in the emission reduction calculations. It may be that (limited) energy utilisation is part of the baseline, and this has to be corrected for. These baseline energy utilisation figures would need to be corrected for energy use in the baseline scenario, depending on the economically attractive course of action. Representative CO₂ emission factors (CEF) are used to calculate the greenhouse gas emissions in the baseline.

The total greenhouse gas emissions in the baseline are equivalent to the emissions from the methane plus the emissions from energy use.

5.4.2 Criteria used in developing the proposed baseline methodology
Capture of CMM is an effective way to reduce emissions from a working coal mine. However, it is difficult to project accurately what volumes of CMM will be released in future years, as this is dependent on coal production, and evolution of the coal mine. Different coal faces have different CMM profiles, and so the level of production from each coal face and possible new coal faces will have an impact on the production of CMM. Similarly, the quality of the CMM, i.e. the concentration of methane, is variable. This will have an impact on both the overall volume of methane captured and destroyed, and on the uses for the CMM. Some uses require higher concentrations of methane in CMM, even flaring needs a minimum amount of methane and venting may be required for safety reasons.

This methodology has been developed specifically to be applicable to a wide range of projects in the coal mining sector, accurately reflect reductions made, and maximise the emission reductions achieved.

This methodology, therefore, encourages energy utilisation as the first and best option. However, not all mines may have local energy demand to absorb energy from CMM, or this may be prohibitively expensive.

CMM flaring is not currently considered normal practice in any coal mining sector in the world, but this methodology aims to minimise the amount of methane vented to
the atmosphere through the introduction of flaring. Until recently, flaring was not considered as a viable option, as it may introduce an additional risk. However, new and safe technology is now available and is currently operational at a number of mines. Widespread introduction of this technology would dramatically reduce GHG emissions from the coal mining sector. This methodology encourages the installation of flares to destroy any excess methane; however, there may be valid reasons why this is not possible.

This methodology takes account of any regulations or contractual requirements, or industry practice to determine the amount of CMM destruction in the baseline scenario.

5.4.3 Explanation of how, through the methodology, it can be demonstrated that a project activity is additional and therefore not the baseline scenario

This methodology is applied to coal mine methane utilisation and destruction projects in the following way.

Step 1(a) Confirmation of applicability

This proposed methodology is applicable to coal mine methane utilisation and destruction project activities at a working coal mine, where the baseline is the partial or total atmospheric release of the gas and the project activities include situations such as:

- The captured gas is destroyed through flaring; and/or
- The captured gas is destroyed through utilisation to produce energy (e.g. electricity/thermal energy); emission reductions may or may not be claimed for displacing or avoiding energy from other sources.

It is unlikely that the CMM utilisation scheme would be designed to capture and utilise the maximum CMM flow rates occurring at the mines because these flow rates are variable and the utilisation is likely to be variable as well. It is therefore strongly recommended that flares be installed to capture most of the excess CMM that can not be utilised for energy production (e.g. electricity/thermal energy), and minimise the amounts vented. Flares are also required for situations when the methane concentration in the CMM falls below the working range of the engines. If possible CMM utilisation should have priority over pure destruction.

Applicability of this baseline methodology can be confirmed using the following questions:

Q1. Is this project being implemented at a working coal mine? If no, not applicable.
Q2. Is the baseline partial or total atmospheric release of the CMM? If no, not applicable.
Q3. Does the project include CMM utilisation and destruction equipment? If no, not applicable. If yes, list installations.
Q4. Are flares going to be installed as part of the project? If no, explain why not.
Q5. Is the CMM released used for energy production? If no, explain why not.
Step 1(b) Additionality test

The additionality test for coal mine methane utilisation and destruction project activities at a working coal mine comprises three assessments described below. The project is additional if the amount of methane destroyed/utilised is greater than the amount of methane destroyed/utilised in the baseline scenario. A number of questions are formulated to guide the additionality test.

Assessment of legal requirements

A CMM utilisation and destruction project is not additional if it complies with any existing or expected legislation requiring such utilisation or destruction. This does not include legal and safety requirements to drain CMM from gassy mines. The project developer must state whether capturing, utilisation and/or destruction of CMM from coal mines in any way is prescribed by legislation or is expected to be prescribed in the foreseeable future. Thorough research on likely future legislation needs to be carried out, preferably by a consultant in the host country. If, e.g. such research shows that in 2010 legislation comes into force that makes CMM utilisation and destruction obligatory, the project is no longer additional from that date, and thus only generate credits until 2010, if the legislation is enforced and becomes normal industry practice. This can be substantiated by a statement by the local regulator and/or a statement by a relevant professional body.

The assessment of legal requirements can be confirmed using the following questions:
Q6. Is there any legislation or regulation – existing or expected in the foreseeable future – requiring CMM drainage at this mine? If yes, explain these requirements.
Q7. Is there any requirement – existing or expected in the foreseeable future – to utilise or destroy CMM released from the mine? If yes, explain these requirements, e.g. what percentage needs to be destroyed, or how does the CMM need to be utilised. If the project does little more than fulfil these requirements, the project is not additional. If no, the project is probably additional, subject to the economic and barrier assessments below.

Assessment of economic attractive course of action

The project developer must show that the situation without the project would have implied partial or full atmospheric release of the CMM. Scenarios to be considered are dependent on the existing or future requirements identified, and the project scenario.

These scenarios must then be compared by making a long-term cost calculation, excluding potential income from CERs. If the economic or financial analysis shows that the proposed CDM project activity has higher cost or a lower Internal Rate of Return (IRR) than one of the other scenarios, it is considered to be additional.
The assessment of the economically attractive course of action can be confirmed using the following question:

**Q8.** Does the economic or financial analysis show that the proposed CDM project activity has higher cost or a lower IRR than one of the other scenarios? If yes, the project is additional. If no, the project may still be additional depending on the barrier analysis below.

**Assessment of barriers and common industry practice**

In cases where the CDM project activity raises income from the CMM utilisation scheme(s), the financial analysis might point out that the project scenario has a higher IRR than one of the other scenarios. However, situations exist that justify that the proposed CDM project activity is additional even if it is the most attractive course of action based on the economic or financial analysis. This barrier and common practice assessment may determine that without the ability to register under the CDM, the proposed project activity would be, or would have been, unlikely to occur.

The barrier analysis should demonstrate that the barriers/risks considered may be mitigated by the CDM project activity. Some of the possible barriers that may be considered are:

- **Investment barrier:** The absence of access to capital in undeveloped markets for incremental financing of the proposed project activity means the project would not go ahead without CER revenue;
- **Technological barrier:** Where technology proposed for the project activity has low market share and involves risks due to the performance and management uncertainty;
- **Barrier due to prevailing practice:** Prevailing practice or existing regulatory or policy requirements would have led to implementation of a technology with higher emissions;
- **Other barriers:** Without the project activity, for another specific reason identified by the project participant, such as institutional barriers or limited information, managerial resources, organisational capacity, financial resources, or capacity to absorb new technologies.

The additionality analysis could also demonstrate that the project type is not common practice (e.g. occurs in less than five percent of similar cases) in the proposed area of implementation, and is not required by recent/pending legislation/regulations.

The barrier and common practice assessment can be confirmed using the following questions:

**Q9.** Do barriers exist that would have prevented the project from being implemented despite its IRR? If no, this project is not additional. If yes, describe these barriers and explain how registration as a CDM project may help overcome these barriers?

**Q10.** Is this project different from common practice in the host country? If yes, this project is additional.
5.4.4 How national and/or sectoral policies and circumstances can be taken into account by the methodology
The additionality test includes the legal requirements, barriers and common industry practice in the host country that apply to the project activity. Any national requirements or common industry practice in the host country resulting in lower emissions would be used as the baseline scenario.

5.4.5 Project boundary (gases and sources included, physical delineation)
The project boundary (Figure 5.1) of a project using this baseline methodology encloses the CMM utilisation and destruction plant. Installations within the project boundary may include flares, storage tank, power generator, thermal energy use and gas supply trunk pipelines.

Not included within the project boundary is the gas drainage pumping station, as this is an integral and necessary part of the mine, and is required for operational safety reasons (and often by law). The operation of the gas drainage pumping station is driven by the requirements for the mine and is not impacted by the implementation of the project.

The CMM utilisation installations within the project boundary, such as power generation and gas supply to the end user, result in the destruction of the methane and emission of CO₂. The main purpose of the flares is to transform the high-GWP methane into low-GWP CO₂.

While utilisation of the CMM by an end user for thermal energy purposes may be an important part of a CMM utilisation and destruction project, it would not be appropriate to include the entire gas distribution grid within the project boundary. Reference values of leakage from gas distribution grids in the host country can serve as appropriate estimates. However, the supply grid and trunk pipelines must be run efficiently and with low leakage. The conversion efficiency of CMM into CO₂ by the end users for thermal energy uses can also be estimated.

Any energy usage or emissions resulting from the installations in the project boundary, including the gas distribution grid, must be taken into account as project emissions.
5.4.6 Elaborate and justify formulae/algorithms used to determine the baseline scenario. Variables, fixed parameters and values have to be reported (e.g., fuel(s) used, fuel consumption rates):

The baseline scenario is the full or partial atmospheric release of the coal mine methane gas. The baseline methodology considers that some of the methane drained may be captured and utilised and/or destroyed, for example to comply with regulations or contractual requirements.

Ex-ante projections for future CMM emissions of the coal mine are made for reference purposes, but emission reductions will be determined (ex-post) by metering the actual methane flow once the project activity is operational.

Part of the CMM may have been destroyed/combusted during the year in the absence of the project activity, for example to comply with regulations or contractual requirements, or the existence of utilisation equipment in the economically attractive scenario. The baseline is the atmospheric release of the amount of methane actually drained (MM_drained) minus the CMM that would have been destroyed in the absence of the project activity. The amount that would have been destroyed (MD_bau) could be a given absolute quantity, share of the total amount, or zero, depending on the economically attractive course of action, existing regulation, contractual requirement or industry practice.

The methane emissions released in the baseline (MD_released) [tCH₄ pure] is thus:

\[ MD_{\text{released}} = MM_{\text{drained}} - MD_{\text{bau}} \]
Note that monitoring equipment will measure CMM flow in m³, temperature and pressure. The pure methane fraction will also be monitored on a continuous basis. This will allow the calculation of flow at standard temperature and pressure of pure methane. All this can be done automatically by the monitoring equipment. Using the standard conversion factor of 0.7168kgCH₄/m³, the amount of methane can be derived.

The greenhouse gas emission from the methane in the baseline (EM_baseline) [tCO₂e] is made up of two parts. First the CO₂ emissions from the destruction of methane in the baseline scenario (EM_bau). Secondly, the methane not destroyed/combusted in the baseline (EM_released).

EM_baseline = EM_bau + EM_released

The approved Global Warming Potential value for methane (GWP_CH4) for the first commitment period is 21. The amount of CO₂ emissions resulting from the destruction of methane [tCO₂e] is equal to the amount of methane destroyed multiplied by the CO₂ emissions factor for methane (CEF_CH4). Given molecular weights and the chemical reaction when methane is combusted, each tonne of methane results in 44/16 tonnes of CO₂; thus the CO₂ emissions factor for methane is 2.75.

EM_bau = MD_bau * CEF_CH4
(with CEF_CH4 = 2.75)

EM_released = MD_released * GWP_CH4
(with GWP_CH4 = 21)

Using the above formulae, the baseline emissions from the coal mine methane (EM_baseline) can now be written as:

EM_baseline = MM_drained * GWP_CH4 – MD_bau * (GWP_CH4 – CEF_CH4)

The second part of the baseline scenario includes the emissions related to any energy utilisation as part of the project (EE_baseline) [tCO₂e], such as electricity generation (EG) [MWh], thermal energy generation (ET) [GJ], and gas supply (GS) [m³ pure CH₄]. The emissions from the internal energy used for these energy utilisation purposes has already been taken into account under the project emissions, and is netted out in the emission reduction calculations. It may be that (limited) energy utilisation is part of the baseline, and this has to be corrected for. These baseline energy utilisation figures would need to be corrected for energy use in the baseline scenario, depending on the economically attractive course of action. Representative CO₂ emission factors (CEF) are used to calculate the greenhouse gas emissions in the baseline.

The CO₂ emission factors may be derived from, for example, ACM0002 in the case of electricity generation: the CO₂ emission factor (CEF_electricity) is calculated as a
combined margin (CM), consisting of the combination of operating margin (OM) and build margin (BM) factors according to the three steps described in ACM0002.

$$EE_{\text{baseline}} = (\text{EG}_{\text{project}} - \text{EG}_{\text{bau}}) \times CEF_{\text{electricity}} + (\text{ET}_{\text{project}} - \text{ET}_{\text{bau}}) \times CEF_{\text{thermalenergy}} + (\text{GS}_{\text{project}} - \text{GS}_{\text{bau}}) \times CEF_{\text{gassupply}}$$

CEF_electricity is given in tCO2e/MWh. CEF_thermalenergy is given in tCO2e/GJ. CEF_gassupply is given in tCO2e/m3 pure CH4. CEF_gassupply may be calculated from the amount of fuel displaced and the CO2 emission factor of that fuel. Any internal energy use of the project is netted out of the energy production. Any emissions from this energy production are part of the first part of the baseline.

The total greenhouse gas emissions in the baseline (DE_baseline) [tCO2e] are equivalent to the emissions from the methane plus the emissions from energy use.

$$DE_{\text{baseline}} = EM_{\text{baseline}} + EE_{\text{baseline}}$$

5.4.7 Elaborate and justify formulae/algorithms used to determine the emissions from the project activity. Variables, fixed parameters and values have to be reported (e.g. fuel(s) used, fuel consumption rates)

Emissions from the project include all CO2 from the destruction (through flare or utilisation for energy production or gas supply) of the methane in the CMM, and any methane not destroyed. Please note that CMM is not of (recent) biological origin, unlike landfill gas, and CO2 emissions from utilisation and/or destruction need to be taken into account. Any internal energy use for supply grid pressure and pumping, the power generation plant and for monitoring has to be subtracted from the energy volumes generated. The calculation of the project emissions is described below in four steps.

(1) The methane destroyed by the project activity (MD_project) [tCH4 pure] during a year is determined by monitoring the quantity of CMM actually destroyed/combusted in each of the installations. Ex-ante projections for future CMM emissions of the coal mine are made for reference purposes and are presented in the relevant sections of the PDD. However, emission reductions will be determined (ex-post) by metering the actual quantity of methane captured and destroyed once the project activity is operational.

$$MD_{\text{project}} = MD_{\text{flared}} + MD_{\text{electricity}} + MD_{\text{thermalenergy}} + MD_{\text{gassupply}}$$

The monitoring equipment will measure gas flows in m³, concentrations of methane, pressure and temperature. This data will allow computation of each of these amounts in tCH4 pure.

(2) The CO2 emissions resulting from the destruction/combustion of methane by the project (EM_project) [tCO2e] is equal to the amount of methane destroyed/combusted multiplied by the CO2 emissions factor for methane. Given molecular weights and the chemical reaction when methane is combusted, each
tonne of methane results in 44/16 tonnes of CO₂; thus the CO₂ emissions factor for methane is equal to 2.75.

\[ EM\_project = MD\_project \times CEF\_CH4 \]
\[ \text{(with } CEF\_CH4 = 2.75) \]

(3) A second part of the project emissions are those related to any internal energy use for the elements of the project (EE\_project) [tCO₂e], such as supply grid pressure and pumping, power generation plant and monitoring equipment. The internal use of electricity (EG\_use) [MWh], thermal energy (ET\_use) [GJ], and gas supply (GS\_use) [m³ pure CH₄] may be offset by the project’s energy production if it exceeds internal use. Representative CO₂ emission factors (CEF) are used to calculate the greenhouse gas emissions associated with the internal energy use.

\[ EE\_project = EG\_use \times CEF\_electricity + ET\_use \times CEF\_thermalenergy + GS\_use \times CEF\_gassupply \]

CEF\_electricity is given in tCO₂e/MWh. CEF\_thermalenergy is given in tCO₂e/GJ. CEF\_gassupply is given in tCO₂e/m³ pure CH₄. CEF\_gassupply may be calculated from the amount of fuel displaced and the CO₂ emission factor of that fuel.

However, energy production should be larger than internal energy use, and thus production may be netted out to take account of internal energy use. EE\_project therefore should be zero.

(4) The direct emissions from the project (DE\_project) [tCO₂e] are equivalent to the emissions from the methane, plus the emissions from energy use, and emissions of any methane not destroyed and other corrections (EM\_adjust).

\[ DE\_project = EM\_project + EE\_project + EM\_adjust \]

**Calculation of losses and corrections**

Some CMM leakage will occur as a result of losses in the CMM system, and incomplete destruction/combustion in flaring, power generation and thermal energy utilisation. Additionally, some methane drained may be of a concentration that is close to the explosive range for a methane-air mixture, and thus too low for utilisation. Venting CMM in these circumstances can not be avoided for safety reasons. Such losses must be taken into account in the calculations and the following steps are therefore required for accurate estimation of the project emissions.

Losses due to incomplete destruction/combustion of CMM take place at each installation. The methane measured at each of these installations, therefore, has to be corrected for incomplete destruction.

In the case of flaring, the methane measured (MM\_flare) is corrected by the flare efficiency (FE) [%]. Similarly, for electricity generation and thermal energy
utilisation, methane measured (MM_i) is corrected by the combustion efficiency (CE_i) [%].

These efficiencies are estimated using the manufacturers’ data or IPCC reference values\textsuperscript{15}, whichever is lower (more conservative).

In the case of CMM supply through a gas grid, losses may occur at two stages: first in the grid, second at combustion at the end user. The overall gas supply efficiency (CE\textsubscript{gassupply}) [%] is calculated from the efficiency of the grid and of the end-consumer combustion. These efficiencies are estimated using IPCC national reference values for grid supplied gas, gas grid efficiency, and combustion efficiency.\textsuperscript{16} Regular measurements of leakage from the gas grid also need to be carried out. Whichever leakage rate is higher (more conservative) is chosen.

As stated above, venting of CMM is still likely to be required from a safety perspective. The amounts of methane vented will not be monitored directly, as they fall outside the project boundary, but they can be derived from the flows monitored.

Because the CMM system is small and compact, directly centred around the working coal mine, any methane leakage from the system is negligibly small.

In all of these situations it is important to monitor the composition of CMM, which consists of mainly of methane and CO\textsubscript{2}, but may also contain and other gases. Non-methane hydrocarbons (NMHC) such as ethane and propane are mostly contained in CMM. These NMHC have short lifetimes in the atmosphere and do not contribute to radiative forcing. However, they are classified as volatile organic compounds (VOC) which may contribute to smog formation. No emission reductions can be claimed for the destruction of these NMHC, but they may contribute to higher energy yields in case of utilisation. Using this monitoring data the CO\textsubscript{2} emissions factor from NMHC for the CMM (CEF\textsubscript{NMHC}) can be calculated. Any CO\textsubscript{2} emitted from the combustion of these NMHC is added to the project emissions to be more conservative. This, of course, also applies to any CMM destroyed in the baseline.

5.5 Description of how the methodology addresses potential leakage

No significant change in anthropogenic emissions by sources of greenhouse gases outside the project boundary is identified that is not already part of the baseline. The baseline includes the energy displaced from utilisation of the energy content of CMM; however, the project developer may decide not to claim all such displacement. Any energy displacement, which may or may not be claimed, is likely to be small compared to the overall energy market in which the project is developed,

\textsuperscript{15}The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidised for gas combustion of 99.5%.

\textsuperscript{16}The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidised for gas combustion of 99.5%. It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the grid. These emissions are given as 118,000kgCH\textsubscript{4}/PJ, which is 0.6%. Leakage in the residential and commercial sectors is given as 0 to 87,000kgCH\textsubscript{4}/PJ, which is 0.4%. CE\textsubscript{gassupply} can now be calculated as the product of these three efficiency factors, giving a total efficiency of 98.5%, i.e. CE\textsubscript{gassupply} = 0.985.
and will not lead to significant changes of anthropogenic emissions outside the project boundary.

A small source of emissions not accounted for in the baseline or project emissions is transport. In the baseline scenario energy may be generated from coal, which is displaced in the project scenario by CMM utilisation. Any emissions from transport fuel required for distribution of the coal in the baseline scenario has not been counted, while the energy required for the operation of the CMM supply grid is included in the calculations.

The gas drainage pumping station is not included within the project boundary. This equipment is an integral and necessary part of the mine, and is required for operational safety reasons (and often by law). The operation of the gas drainage pumping station is driven by the requirements for the mine and is not impacted by the implementation of the project. Therefore, no leakage occurs as a result of the CMM utilisation and destruction project.

However, the successful implementation of the CDM project activity and a royalty payment for high quality and quantity gas may result in an incentive for the mine to improve its methane drainage system and help pay for it. Such improved drainage would improve the safety of the coal mining operation, and may result in higher coal production. However, improved drainage and safety in coal mines is one of the sustainable development goals of the Chinese government within the mining sector. Additionally, it could be argued that coal production from gassy mines is best concentrated at mines with effective capture and methane destruction.

Any methane losses and internal energy usage of the project activity are taken into account in the project emissions calculations.

5.6 Elaborate and justify formulae/algorithms used to determine emission reductions

The greenhouse gas emission reduction (ER) achieved by the project activity during a given year is the difference between the total greenhouse gas emissions in the baseline in that year (DE_baseline) and the direct emissions of the project in that year (DE_project).

\[ ER = DE_{\text{baseline}} - DE_{\text{project}} \]

Ex-ante emission reduction estimates are made by projecting the future CMM emissions of the coal mine. These estimates are for reference purposes only, since emission reductions will be determined (ex-post) by metering the actual quantity of methane captured and destroyed once the project activity is operational. The projections need to take into account variability of quantity and quality (methane concentration) of CMM flow during the year.
6  CONCLUSIONS

There is increasing international recognition of the threat of climate change. The Kyoto Protocol and the Clean Development Mechanism under it have been established to help reduce greenhouse gas emissions globally. Coal mining activity emits large amounts of methane, a potent greenhouse gas. Coal mine methane utilisation and destruction could contribute to significant emission reduction through the CDM. This project, therefore, established a model project concept for CMM utilisation projects in China to obtain additional financing from the CDM and overcome the existing barriers to their implementation.

The methodology developed encourages utilisation of the energy content of CMM, which leads to emission reductions, and greater energy security. It also helps wider energy provision and has other environmental benefits, thus contributing to sustainable development.

However, most, if not all, conventional CMM utilisation schemes will be unable to use all of the gas drained. This utilisation is limited by various factors, including local energy demand and quality and quantity variations. The methodology therefore encourages maximum destruction through flaring for any excess CMM released. This addition has great benefits for the global environment, as it could represent a large percentage of the total emission reductions from a project. Unless a flaring option is included, substantial gas volumes will continue to be vented to atmosphere.

It is likely that there will be many gassy coal mines in China, and by implication in other developing countries at which methane use will not be commercially viable without CDM support.

6.1  CDM primer for CMM projects

- Coal mining releases gas from coal seams disturbed by the mining activity. Some of this coal mine methane gas is captured and piped to the surface to prevent it entering the mine airways. This process of gas drainage is practised primarily as a safety precaution. Once at the surface the gas is vented to the atmosphere.
- In some mines, some gas is drained from the worked seam before mining (pre drainage). Longwall mining disturbs coal seams in roof and floor strata which emit gas, some of which can be captured using post drainage technologies.
- Any gas not captured enters the mine roadways where it is diluted with the ventilation air. Such ventilation air methane (VAM) must be of a very low concentration for safety reasons.
- At some mines a proportion of the drained gas is utilised for power generation or distributed to domestic and industrial consumers.
- In some industrialised countries, drained gas for which there is no immediate use may be flared for environmental reasons.
Technologies have been developed that are theoretically capable of removing the ventilation air methane but have not yet been demonstrated at full scale. These technologies may not be commercially viable without additional financial support. All methane destroyed in a VAM scheme, therefore, would be additional from the CDM perspective. If usable energy is also produced then its contribution could be assessed in terms of coal displacement.

The baseline scenario for the mine is to drain sufficient gas to ensure the planned coal production can be safely achieved. Sometimes, due to lack of need, inadequate equipment or inappropriate practices the gas quality is highly variable or consistently low thus precluding its utilisation. Improvements in the underground gas drainage system are likely to be required as part of any CMM scheme. In these instances, all the used CMM would be additional.

A gas utilisation plant would not normally be constructed until a newly constructed mine has achieved a period of satisfactory coal production and the gas flows have been characterised. The most feasible utilisation scenarios are generally on-site power generation or flaring, although the latter is purely dependent on carbon finance or legal requirements.

Owners of an existing, ageing mine may be reluctant to invest in a CMM scheme and may not have the resources or credit facilities. The baseline scenario in this instance would be no utilisation involving investment in new technology, such as gas engines and power generation, but could include an extension to a local gas distribution system as an affordable option.

Methane can be drained from virgin coal seams ahead of mining. Virgin coalbed methane (VCBM) is usually produced as a clean energy source. However, VCBM utilisation may not be counted as emission reductions without additional guidance from the CDM Executive Board.

Gas flows in coal mines will not necessarily remain constant for the duration of the CDM project. They will vary with geology and the rate of retreat/advance of coalfaces. Where more than one seam is worked in a geological sequence, depending on the vertical separation, the working of one seam can partially de-gas another. This can lead to decreasing gas flows and less gas for utilisation. These factors are predictable and should be considered in the CDM project feasibility study.

6.2 Practical lessons from the field study

The gas concentration and flow data collected from 18 months of operation of the Pansan mine showed the challenges and difficulties for successful CMM utilisation and destruction schemes. Figure 4.2 and 4.3 showed a wide variety of concentrations and flow during the observation period and proved the importance of long-term monitoring.

The data was analysed for the utilisation scheme, showing that the mine’s objective for the utilisation scheme were initially out of reach. While concentrations have been high for much of the observation period, they were not consistently high, and fell back on a number of days in the Summer of 2004 at the end of the period. Similarly, gas flow was high during some nine months, but fell back at the end of the period to levels below that required to run all four gas engines. The reasons for this behaviour need to be investigated as the
causes are likely to be able to be remedied, increasing the economics of the utilisation scheme.

- The installation of a flaring system alongside more traditional CMM utilisation technology – in the case of Pansan over the 18 months monitored and analysed – would have destroyed about a quarter of the total gas drained. Thus, because this CMM would otherwise have been vented, the installation of the flare would have contributed significantly to the emission reductions achieved.

- The installation of a flaring system is not only beneficial to the global environment, but also helps the economic of the whole utilisation scheme as a CDM project. The flaring system is able to act as a backstop generator of emission reductions. Given the terms of Emission Reduction Procurement Agreements (ERPA) contracts to date, it is important for suppliers of emission reductions to be able to generate enough CERs at all times. Additionally, the income from the CDM is likely to be very significant for these projects, and the target generation of emission reductions should be achieved for the successful running of the project.

- Improvements in the monitoring equipment are likely to be required in order to become a CDM project. The monitoring in place for normal and safe mining operation would not be approved under the CDM rules as greater accuracy is required. This new monitoring regime will add costs to the utilisation scheme, but this should be easily recouped from the CDM income.

6.3 The role of the UK industry

- UK industry is well positioned to exploit the opportunities emerging on CMM utilisation in China. The UK industry is able to deliver high quality technology for all aspects of CMM projects, including drilling and drainage technology, gas engines, flares and monitoring equipment.

- The UK finance and services industry also has good opportunities to exploit this new market in China. CMM projects have taken place in the UK for several years, giving valuable experience for developers, consultants and financiers. Additionally, London is centre of the global greenhouse gas market at present, giving additional advantage to both consultants and financiers.

- During the project all relevant industry sectors were involved, and met with Chinese industry on the UK visit. The best potential identified by the project for technology suppliers exists in drilling technology, containerised gas engines, flares, and monitoring equipment. Regarding services the best potential exists in project development (possibly as part of a technology supply contract), gas and CDM consulting, and CDM financing.
7 RECOMMENDATIONS

CDM-supported CMM projects have the potential to be replicated at a large number of mines throughout China. It is envisaged that the methodology from this project will become the basis for other CDM-supported CMM projects. This presents very good opportunities for UK equipment and service suppliers. As a result of the project, additional opportunities have been identified, such as the sale of electrical generation packages, gas flow monitoring and flare systems. Of course, a market for consulting services by coal mining experts and CDM experts has also been created.

The impact of the project on UK industry opportunities could be further enhanced by:

- Encouraging a UK industry team visit to China to observe operational conditions, assess technology needs, and establish links with potential technology and service buyers.
- Organising a dedicated workshop in China to promote UK skills, services, technologies and equipment highly relevant to China’s current interests and needs.
- Assess the decisions of the CDM Executive Board regarding the methodology proposed by this project. Update and expand the methodology to include further utilisation and destruction options, increasing both the environmental benefits and potential opportunities for UK industry for involvement in Chinese CMM projects.

More general recommendations can also be given to project developers, which are likely to help UK industry gain foothold, as well as improve projects they are involved in:

- Independent investigations of gas availability and potential for use should be undertaken to ensure a CDM for CMM project is realistically scaled and viable. CDM for CMM projects that fail to perform as projected could deter future buyers of CERs and hence reduce investment in CMM schemes. Thus, the important leverage on emission reductions from coal mining would be lost to the detriment of the global environment.
- Due to the risk of over-estimating gas availability and use (a common problem in all coal mining countries), the relatively small-scale of most CMM schemes and the substantial capital cost of power generation, flaring is recommended as a key component of a CMM utilisation scheme to minimise greenhouse gas emissions while gathering enough data to make a thorough commercial evaluation. While we believe this would be the most economical and environmentally beneficial way, however, it is important to follow the methodology approval process of the CDM Executive Board to see whether such an approach will be accepted.
- Accurate estimates of the quantity of CERs generated by the project are important for being able to conclude beneficial contracts for buyers and sellers of reductions. Buyers need to know the quantity of CERs they can expect to receive, because they require them for compliance with (EU) emission targets.
Sellers require an accurate assessment of the quantity of reductions achieved, as ERPA contracts generally contain penalties for missing the agreed volumes.

- The installation of a flaring system is able to act as a backstop when CMM consumption from the other utilisation options is low, for example because of breakdown of the engines, or seasonal variations of domestic gas use. Additionally, the volume and quality of CMM drained varies as a result of the mining operations. A flare acts both as backup and is able to generate additional reductions from the CMM for which no demand exists.
8 REFERENCES

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