Analysis and evaluation of CDM prospects for coal bed methane (CBM) projects in India

Deliverable 1
The potential for CBM projects in India

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EXECUTIVE SUMMARY

India’s expected continuing rapid economic growth will be fuelled mainly by domestically produced coal. Expanding clean energy sources will also contribute significantly. CBM may be able to play its role in this sector, providing a clean energy source with a large domestic resource.

Indeed, GOI has identified VCBM as having a vital role in meeting this energy shortfall. This has been clearly demonstrated by the strong support given to DGH in promoting and awarding some 16 VCBM blocks for exploration and development. A further indication of intent to produce VCBM is shown by the third round of bidding for CBM blocks. Exploration programmes are well advanced in a number of blocks and foreign involvement and co-operation is reported for technical support and specialist services.

The use of CDM to support CBM development is an option. VCBM development would lead to a fuel switch away from coal usage, which will be readily available in the coal mining areas where VCBM can take place, to gas use. As such VCBM project will help reduce India’s greenhouse gas emissions significantly.

However, VCBM activities are leading the way but these are not linked to any foreseeable coal mining operations and therefore could not be construed as pre draining the gas. Therefore, as will be explained in other reports, the current CDM methodology does not allow for VCBM, so a new methodology would need to be developed. Its value is in providing a clean fuel to displace use of polluting coal.

CBM in India is at an early stage of development with both public and private companies vying to develop in-country skills and services and thus achieve market position. There are vast resources of methane available in India, but until commercial production has been demonstrated the reserve potential is largely unknown.
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1 INTRODUCTION

This report is the first deliverable of the GOF-funded project “Analysis and evaluation of CDM prospects of CBM projects in India”. This first report briefly assesses the potential for Coal Bed Methane projects in India, some of which is now starting to be exploited.

The report briefly clarifies the various forms of methane that may be derived from coal in Chapter 3. Chapter 4 describes the specific Indian policy context for CBM projects. The total potential is assessed in Chapter 5, including some cost aspects. Chapter 6 touches briefly on the CDM aspects, which will be further explored in deliverables 2 and 4, before drawing conclusions in Chapter 7. CBM is the generic name applied to the naturally occurring gas found in coal seams. It is recovered from coal seams as:

- Virgin coal bed methane (VCBM) from unmined coal using surface boreholes;
- Abandoned mine methane (AMM) from disused coal mines;
- Coal mine methane (CMM) which is captured in working coal mines to allow safe working.

In addition, very dilute gas mixed with ventilation air, known as ventilation air methane (VAM), is emitted from coal mines.

2 BACKGROUND TO THE PROJECT

India is third largest producer of coal in the world. If effectively recovered, methane associated with coal reserves and emitted during coal mining could be a significant potential source of energy in coal-rich but often economically poor regions. Utilisation of coal bed methane would introduce a clean energy source and reduce local pollution and emissions of greenhouse gases.

The potential for utilisation of coal mine methane (CMM) and maximisation of emission reductions from utilisation schemes is very large globally, with some opportunities in India. The benefits for the global environment from reduced emissions can be substantial. The benefits in terms of local environment and economy can be similarly large, reducing emissions of pollutants and providing a clean and local energy source to rural communities.

The Government of India (GOI) has recognised the potential of coal bed methane extracted from virgin coal seams (VCBM), independently of mining, to increase sources of domestic energy supply and as an environmental friendly fuel. A number of CBM blocks have already been awarded to industry, and production from the first few wells has started. In addition, GOI, UNDP and GEF have initiated a coal mine methane recovery & commercial utilisation project1 to further encourage uptake of CBM and CMM in India.

However, coal bed methane projects are often capital intensive projects and are likely to need additional support from mechanism such as the CDM. This project will be a major impetus to ongoing private sector involvement and international co-operation in the CBM sector in India. The project is the first attempt to address CDM issues in the CBM sector in India.2 It will also strengthen the Government of India’s efforts to promote clean energy options.

1 See http://www cmpdi.co.in/cmpdi/CBM.htm.
2 A number of CDM methodologies for coal mine methane and coal bed methane have been submitted to the CDM Executive Board. All of these methodologies are based on projects in China,
2.1 Objectives of the project

This project has a number of inter-related objectives. The key objectives for the GOF Climate Change and Energy Programme, through which the project is funded, are (i) the international response to climate change under the UN Framework Convention on Climate Change and (ii) promoting greater uptake of renewable energy and more efficient use of energy to help address climate change and enhance energy security.

The project specific objectives are to (i) enhance the utilisation of CBM as a local energy source in India, (ii) reduce global greenhouse gas emissions, (iii) increase the understanding of the issues surrounding CBM and CDM, and (iv) build institutional capacity in this sector. The project will look specifically at the role that CDM finance can play, and will aim to prepare a number of “project concept notes” as a first step towards implementing a CDM project in this sector.

2.2 Components

The project will deliver a number of short reports, presenting a solid background to CBM and CDM that is used to build capacity in the sector in India. A computer-based pre-feasibility model will be developed which will allow prospective project developers to assess the feasibility of their project and the CDM potential. One project will be described in detail and act as a case study.

A workshop will be organised for all stakeholders, including government, industry and financiers, as well as CDM developers. After the workshop, developers will be invited to contribute “project concept notes” or information to the project team for CBM projects for possible investors and buyers for purchase of carbon credits from UK. These prospective projects will be submitted to UK Climate Change Project Office for consideration.

Findings from the project are being disseminated widely through various channels, including the CBM India website: www.cbmindia.org.

Key deliverables are:

- Report on the CDM potential of CBM projects in India;
- Report on the baseline, additionality and costs involved in Coal Bed Methane projects;
- Computer-based pre-feasibility analysis model for analysing the attractiveness of Coal Bed Methane CDM projects;
- Review of approved and proposed CDM methodologies for CBM projects in India, and addressing acceptability and additionality of such projects in India;
- Case study;
- Stakeholder workshop;
- Project concept notes (PCN) from CBM projects for possible investors and buyers of carbon credits from UK;
- Dissemination through the www.cbmindia.org website.

where the project partners have been carrying out a number of CDM-focused CBM project over the last few years. One methodology has been approved and will be described in detail in report 4.
2.3 Beneficiaries and target audience

The project aims to enhance the understanding and build capacity in order to increase the utilisation of the Indian CBM resource. The target audience for this project, therefore, includes the relevant departments of Government of India, including local or regional government, industry and financiers. As the project looks to the CDM to stimulate CBM utilisation, foreign investors and buyers of emission reductions are also stakeholders. The project team also invites local NGOs to get involved and help increase the sustainable development benefits of these CBM projects.

Key stakeholders are:
- Directorate General of Hydrocarbons (Under Ministry of Petroleum & Natural Gas, GOI);
- Ministry of Coal and Mines (GOI);
- Ministry of Environment and Forests (GOI);
- Ministry of Non-Conventional Energy Sources (GOI);
- Ministry of Power (GOI);
- CBM project developers in India (and elsewhere);
- CBM capture and utilisation technology providers;
- Carbon investors in the UK.

2.4 Project team

IT Power and Wardell Armstrong have formed a strong partnership over the last few years working on emission reduction projects and CDM methodologies in the coal mining sectors of in particular India, China and Russia. IT Power led the development of the proposed new CDM methodology NM0075, which has formed the basis of the combined methodology that was approved by the CDM Executive Board. Wardell Armstrong provided the technical knowledge to deliver high quality utilisation schemes and improve operational safety at the mines.

2.4.1 IT Power

IT Power is a leading global sustainable energy consultancy company specialising in all aspects of sustainable energy and emission reduction projects. The company’s work ranges from technology development to project finance and energy and environmental policy advice. IT Power’s engineering, economic, financial, commercial and environmental specialists are developing Clean Development Mechanism (CDM) projects and other renewable energy projects world-wide. In the last 25 years, IT Power has completed over 900 projects in some 100 countries.

2.4.2 Wardell Armstrong

Wardell Armstrong is a major mining, minerals, environmental and engineering consultancy. With more than a century of experience in the coal mining sector it has been instrumental in the implementation of CMM, AMM and CBM projects in the UK, China and many other countries. Over the last fifty years, its original mining, minerals and geology base has also been extended into ground and civil engineering, environmental sciences, waste management, etc.

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3 MOEF also hosts the Indian Designated National Authority for the CDM.
management, land use planning, health and safety, landscape and renewable energy/sustainable development.

### 2.4.3 IT Power India

IT Power India is a renewable energy and environmental management consultancy company. The company has been looking at sustainable development, renewable energy and environmental policies and has already carried out projects in over 30 countries throughout Asia and Africa. IT Power India was founded 10 years ago, and is part of the global IT Power Group of companies.

### 3 GAS FROM COAL

Coalbed methane (CBM) is a natural gas formed by geological, or biological, processes in coal seams. CBM consists predominantly of methane. Lower concentrations of higher alkanes and non combustible gases are also often present.

CBM was primarily formed in coal seams as a result of the chemical reactions taking place as the coal was buried at depth. The greater the temperature and duration of burial, the higher the coal maturity (rank) and hence the greater the amount of gas produced. Much more gas was produced during the "coalification" process than is now found in the seams. The lost gas has been emitted at ancient land surfaces, dissipated into the pores of surrounding rocks, removed in solution, and some will have migrated into reservoir structures forming natural gas deposits.

CBM tends to remains firmly locked in the coal at the prevailing pore fluid pressure until released as a result of mining disturbance or by specific gas production activities conducted in boreholes.

If effectively recovered, coal bed methane associated with coal reserves and emitted during coal mining could be a significant potential source of energy.

#### Methane as a greenhouse gas

Methane is a powerful greenhouse gas, and one of the basket of gases covered by the Kyoto Protocol. It has a relatively short residence time in the atmosphere before it disappears. However, it has a very high global warming potential (GWP), 21 times that of CO₂.

It is important to distinguish different categories of methane from coal as explained below.

### 3.1 Coal Mine Methane (CMM)

Methane is released as a result of mining activity when a coal seam is mined out and if not controlled to prevent the accumulation of flammable mixtures of methane in air (5-15%) it presents a serious hazard. Gas drainage techniques are used to enable planned coal production rates to be achieved safely by reducing gas emissions into longwall mining districts to a flow that can be satisfactorily diluted by the available fresh air. In some instances gas drainage is also needed to reduce the risk of sudden, uncontrolled emissions of gas into working districts. In well managed mines, in favourable geological and mining conditions, the methane concentrations in drained CMM can reach 70% or more. CMM of such quality may be utilised. However, poorly drained mines will only achieve methane concentrations that are much lower, and may be too low for conventional utilisation purposes.

Methane capture and its utilisation from coal mines is generally not practiced in India as current levels of coal production in gassy mines are generally achievable using ventilation...
controls but even where there may be some safety benefit there is some resistance to introducing gas drainage due to a lack of technology, expertise and experience. Additionally, there is the perception that CMM utilisation is not commercially viable.

3.1.1 Ventilation Air Methane (VAM)

Methane released from coal seams into the ventilation air of the active coal mine is called Ventilation Air Methane (VAM). Concentrations of methane in the ventilation air is generally limited by law, for safety reasons, at 0.5 to 2% in different parts of a mine with variations depending on the country. Concentrations can be controlled by the volume of ventilation air circulated (dilution) or through special drainage (CMM). The concentration of methane in VAM is typically 0.8% or less and is too low for conventional utilisation purposes. However, technologies are being developed to remove the methane, and where additional gas is available to generate electricity using the thermal energy recovered.

3.1.2 Abandoned Mine Methane (AMM)

When an active coal mine is closed and abandoned, methane continues to be emitted from all the coal seams disturbed by mining, decaying gradually over time unless arrested by flooding due to groundwater recovery. Depending on the methane concentrations, local regulations and the geology it may be possible, or required for public safety reasons to continue draining or venting this Abandoned Mine Methane (AMM). AMM extraction and utilisation schemes aim to recover the gas left behind in unmined coal above and below goaf (worked-out) areas formed by longwall mining methods. The gas can either be transported by pipeline to a nearby user consumer for combustion in boilers or used on-site to generate electricity for local use or sale to the grid. AMM reservoirs consist of groups of coal seams that have been de-stressed, and therefore of enhanced permeability, but only partially degassed by longwall working. Favourable project sites are those where a market for the gas exists, the AMM reservoir is of substantial size and not affected by flooding and the gas can be extracted at reasonably high purity. A number of schemes are in place in countries such as the UK and Germany. No AMM schemes are in place in India and initial investigations show limited promise.

3.2 (Virgin) Coal Bed Methane (VCBM)

Coal Bed Methane (CBM) and Virgin Coal Bed Methane (VCBM) are terms conventionally used for methane drained and captured directly from the coal seams. CBM is generally reserved (in addition to its use as a generic term for all coal seam gas) to describe the gas produced from surface boreholes ahead of mining for coal mine safety and coal production reasons. VCBM is produced by a similar process but completely independently of mining activity. Methane concentrations in VCBM are generally very high, around 99%, and can be used as a replacement for natural gas supplies.

For clarity, this report will use the term VCBM for methane recovered from unmined coal seams using surface boreholes.

Underground Coal Gasification

Underground coal gasification is the in-situ gasification of coal in the seam. It is achieved by injecting oxidants, gasifying the coal deposit itself and bringing the produced gas to surface through boreholes drilled from the surface rather than the gas already present in the coal bed. Underground coal gasification, therefore, is a completely different form of energy source and is not referred to in this report.
4 THE INDIAN CONTEXT FOR CBM

4.1 CBM institutional set-up

The Ministry of Petroleum & Natural Gas is entrusted with the responsibility of exploration and exploitation of petroleum resources, including natural gas and coal bed methane, their refining, distribution and marketing, import, export, and conservation of petroleum products and Liquified Natural Gas. The Ministry is headed by a Cabinet Minister and a Minister of State. The bureaucracy is headed by a Secretary.

The Ministry comprises of five different wings, namely administration; exploration; refinery; marketing; and finance.

4.1.1 Administrative structure

India ranks seventh in the world in terms of coal resources, and 10th in CBM resources. India has a good resource base for CBM with an estimated resource of 2,000 billion cubic meters (bcm) in 2,000 square kilometres out of which recoverable reserves are about 800 bcm. The Government of India broadly supports efforts to enhance the utilisation of CBM. Subsidies are available for some projects, and the Government is currently carrying out a demonstration project costing 768 million rupees in conjunction with UNDP to promote the commercialisation of CBM utilisation projects. The Central Mine Planning and Design Institute Ltd, a subsidiary of Coal India Ltd, is the main local implementing agency. Additionally, the Government of India has been very actively promoting the use of the CDM as additional finance for ‘clean’ energy projects and rural electrification.

The GOI has formulated a Coal Bed Methane (CBM) policy in 1997 for exploration and production of CBM from coal/lignite bearing areas. Under this policy the government identified 16 blocks located in West Bengal, Jharkhand, Madhya Pradesh, Maharashtra, Chhattisgarh, Rajasthan and Gujarat for E&P of CBM. All these blocks have been allotted to various companies, both in public and private sector. In private sector, Reliance Industries, Essar Oil and Great Eastern Energy Corporation are the major players. In public sector, Oil and Natural Gas Corporation Limited (ONGC) is the major player exploring CBM in India.

Ministry of Coal and Mines

The Ministry of Coal and Mines has the overall responsibility for determining policies and strategies in respect of exploration and development of coal and lignite reserves, sanctioning of important projects of high value and for deciding all related issues. Under the administrative control of the Ministry, these key functions are exercised through the Public Sector Undertakings, namely, Coal India Ltd. and its subsidiaries and Neyveli Lignite Corporation Limited. The Ministry of Coal and Mines also has a joint venture with Government of Andhra Pradesh called Singareni Collieries Company Limited.

Given their responsibility regarding the further development of the coal mining sector in India, the Ministry of Coal and Mines encourages new developments, opportunities for growth, and environmental improvements in the sector. Such new developments include the use of coal bed methane (CBM), exploitation of virgin coal bed methane (VCBM), coal mine methane from working mines (CMM), and abandoned mine methane (AMM). Some subsidies are available for projects aimed at further development and commercialisation of these technologies and methodologies.
Directorate General of Hydrocarbons

The Ministry of Petroleum and Natural gas is responsible for the petroleum and natural gas sector in India, including the exploitation, distribution and consumption of these fuels. As part of that responsibility the Ministry also aims to increase availability of gas supply throughout the country. Given that gas reserves in India are limited, and imports expensive, the potential utilisation of methane from coal mining could facilitate one of the objectives of the Ministry of Petroleum and Natural Gas.

Industry

A number of potential CBM developers in India have been approached and have shown an interest in the project, including the Great Eastern Energy Corporation Ltd and Reliance Industries Ltd. The latter, Reliance, has also indicated that it considering offering to act as the pilot CBM utilisation CDM project. However, decision is not yet taken on the pilot site and will be selected after discussion with major players in CBM in India and formal expression of interest.

Non-financial support may be available from the Confederation of Indian Industries (CII) or Federation of Indian Chambers of Commerce and Industries (FICCI). Both these organisations are very active on climate change issues, particularly related to the CDM.

4.1.2 Policy framework

The main laws governing CBM exploration and production in India are listed below.

- Oilfields (Regulation and Development) Act, 1948;
- Petroleum and Natural Gas Rules, 1959;
- Environment Protection Act, 1986;
- Arbitration and Conciliation Act, 1996;
- Income Tax Act, 1961;
- Customs Act, 1962.

The exploration of CBM is time-consuming and capital-intensive. Unless fiscal and other incentives are in place, the possibility of investors getting interested is remote. Keeping this in mind, many fiscal incentives have been offered as listed below.

- No signature bonus;
- No upfront payments;
- No import duties;
- Unincorporated joint ventures permitted;
- No limitation on cost recovery;
- Free to market gas in the domestic market at market-determined prices;
- Securitization of participating interests allowed for raising project finance;
- No bank guarantee required for work programme at development stage;
- 7-year tax holiday;
- Liberal set-off and accelerated deductions for income-tax purposes ;
- No ring fencing.

In a document presented by GOI during COP8 in October 2002 indicates that CBM is one of
the priority sectors for GOI for achieving GHG reductions (see: http://envfor.nic.in/cc/cop8/moefbk/use.pdf). Proposed projects also fits in the interim sustainable development indicators laid down by GOI for providing Host Country approval for CDM projects (see: http://envfor.nic.in/cdm/host_approval_criteria.htm). This project, therefore, would fit with the priorities in the coal mining sector as well as the environmental and developmental policies identified by the Government of India.

4.2 Energy Economy of India

4.2.1 Energy scenario

The energy sector has emerged as one of the important pillars of the modern economy. Since independence, and especially after the oil crisis of 1973, energy policy became inseparable from the national development strategy. A large number of ministries and organisations are responsible for various functions concerning energy development, as shown in Figure 1 below.

**Figure 1 Organisation of India’s energy sector**

Energy and environment-related concerns in India include the growing gap between the demand and supply of energy and the environmental externalities associated with energy use. High growth in the major energy-intensive sectors, such as power generation, steel, cement, refineries, chemicals, fertiliser, and transport, has resulted in a high elasticity of energy consumption and environmental emissions with respect to GDP.
The consumption of commercial fuels (coal, oil, natural gas, and power) has been steadily rising over the years, with coal continuing to be the dominant source. Coal meets about 63% of India's total energy requirement, followed by petroleum products (30%) and natural gas. The total coal reserve in India is 211 billion tonnes, and by current estimates the reserves are enough to meet India's power needs for at least another 100 years. The agriculture, industry, transport, domestic, and other sectors are the major consumers of commercial energy/power in India. India imports around 70% of its total crude oil requirements. In regards to natural gas, the Hydrocarbon Vision 2025 indicates that India's total gas reserves will decline by 16 bcm by 2011/12, based on its consumption of 22.5 bcm in 1998/99. Total energy use in India has increased substantially during the past five decades, with a shift from non-commercial (such as fire wood) to commercial sources of energy. As a result, the production of commercial sources of energy has increased significantly. The following table indicates the production trends of various primary energy resources, including renewable energy sources.

**Table 1 Trends in primary energy production**

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<th>1980/1</th>
<th>1990/1</th>
<th>2001/2</th>
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<tbody>
<tr>
<td>Coal</td>
<td>Mt</td>
<td>55.67</td>
<td>72.95</td>
<td>114.01</td>
<td>211.73</td>
<td>325.65</td>
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<tr>
<td>Lignite</td>
<td>Mt</td>
<td>0.05</td>
<td>3.39</td>
<td>4.80</td>
<td>14.07</td>
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</tr>
<tr>
<td>Crude oil</td>
<td>Mt</td>
<td>0.45</td>
<td>6.82</td>
<td>10.51</td>
<td>33.02</td>
<td>32.03</td>
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<tr>
<td>Natural gas</td>
<td>Bcm</td>
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<td>1.44</td>
<td>2.35</td>
<td>17.90</td>
<td>29.69</td>
</tr>
<tr>
<td>Hydro</td>
<td>TWh</td>
<td>7.84</td>
<td>25.25</td>
<td>46.54</td>
<td>71.66</td>
<td>82.80</td>
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<tr>
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<td>2.42</td>
<td>3.00</td>
<td>6.14</td>
<td>16.92</td>
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<td>0</td>
<td>0</td>
<td>0.03</td>
<td>1.70</td>
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</table>

*Source: GOI Planning Commission 2002.*

Between 1953 and 2001, the total primary energy supply grew at an annual rate of 3.4 percent, reaching a level of 437.7 million tonnes of oil equivalent (Mtoe) in 2001. This growth has been mainly contributed by commercial energy supply, which grew at 5.3 percent per annum, whereas, non-commercial energy grew at 1.6 percent per annum. Due to this high growth rate, the share of commercial energy has increased from 28 percent in 1953/54 to 68 percent in 2001/02.
Coal is the dominant fuel in India's energy mix, with a share of 31% (26% in 1953/54). Petroleum products have also gained prominence during this period, increasing to about 27% in 2001/02 from a share of just 2% in 1953/54 (all petroleum products were imported at that time). The share of natural gas has also increased from virtually nil to 6% in 2001/02.

The share of commercial fuels in the total energy supply in India has risen from 41% in 1970/71 to approximately 70% in 2003/04, despite the dominance of the traditional fuels in the energy sector in India. The total domestic primary commercial energy supply in India has risen from 147.05 million tonnes of oil equivalent (Mtoe) in 1970/71 to 248 Mtoe in 2003. The energy demand for non-commercial fuels is estimated to rise overtime from 151.3 Mtoe in 2006/07 to 170.25 Mtoe in 2011/12.

The domestic demand for coal is estimated to grow from 340.1 million tonnes (Mt) in 2002/03 to 460.5 Mt by 2006/07, and 620 Mt by 2011/12. As against this demand, the availability of indigenous coal is estimated to grow from 341.3 Mt in 2002/03 to 405 Mt in 2006/07 and 515 Mt in 2011/12, thereby leaving a gap of 55 Mt in 2006/07 and this gap is expected to increase to 105 Mt in 2011/12. The production of crude oil in the country has increased marginally from 32.03 Mt in 2001/02 to 33.05 Mt in 2002/03, and to 33.38 Mt in 2003/04. The production of natural gas has increased from 29.71 bcm in 2001/02 to 31.395 bcm in 2002/03 and to 31.95 bcm in 2003/04.

The total primary commercial energy supply in India has been projected to grow at an average rate of 3.2% over the period 2002-25. Though the share of coal is expected to decline from 55% to 50% in 2025, it still remains the largest energy source in India's energy matrix. The share of natural gas and nuclear are also expected to constitute 20% and 3% of the energy mix, respectively, in 2025.

### 4.2.2 Environmental concerns

India's ongoing population explosion has placed great strain on the country's environment. This rapidly growing population, along with a move toward urbanisation and
industrialisation, has placed significant pressure on India's infrastructure and its natural resources. Deforestation, soil erosion, water pollution and land degradation continue to worsen and are hindering economic development in rural India, while the rapid industrialisation and urbanisation in India's booming metropolises are straining the limits of municipal services and causing serious air pollution problems.

Following the 1984 Bhopal disaster – in which a toxic leak from the city's Union Carbide chemical plant resulted in the deaths of more than 3,000 people – environmental awareness and activism in India increased significantly. The Environment Protection Act was passed in 1986, creating the Ministry of Environment and Forests (MoEF) and strengthening India's commitment to the environment, which was enshrined in the 42nd amendment to country's constitution in 1976. Under the 1986 Environmental Protection Act, the MoEF is tasked with the overall responsibility for administering and enforcing environmental laws and policies. The MoEF established the importance of integrating environmental strategies into any development plan for the country.

Industrialisation and urbanisation have resulted in a profound deterioration of India's air quality. India has more than 20 cities with populations of at least 1 million, and some of them – including New Delhi, Mumbai, Chennai, and Kolkata – are among the world's most polluted. Urban air quality ranks among the world's worst. Of the 3 million premature deaths in the world that occur each year due to outdoor and indoor air pollution, the highest number are assessed to occur in India. Sources of air pollution, India's most severe environmental problem, come in several forms, including vehicular emissions and untreated industrial smoke.

Carbon intensity (carbon emissions per unit of GDP) in India also is relatively high compared to its neighbours. In 2001, India's carbon intensity measured 0.5 tonnes of carbon per thousand $1995. In Asia, only China's carbon intensity (0.75 tC/thousand $1995) was higher than that of India, but whereas China has become less carbon intensive over the past 20 years, India's carbon intensity has remained at virtually the same level as in 1980.

India's heavy reliance on coal, much of it low-quality, goes a long way towards explaining the country's relatively high carbon intensity level. Indian economic policies such as high import tariffs on high-quality coal and subsidies on low-quality domestic coal also have contributed to increased use of low-quality coal, although initiatives to encourage the use of higher-quality coal, such as reducing the tariff on imported coal, may help in reducing the country's carbon intensity. The introduction and adoption of technologies to reduce coal consumption and/or improve the efficiency of the coal that is combusted is an important government priority, given that the majority of India's power generation is coal-fired.

Methane emissions from coal mines are increasing annually as coal production rises. Coal mine methane (CMM) and Abandoned Mine Methane (AMM) utilisation provide a means of mitigating these emissions, which have a high global warming potential (GWP). However, there are few schemes at present and development is slow.

Various reasons can be given for the lack of CMM/AMM developments. This project addresses these reasons in the various reports. Important reasons include the recent transition from a state-owned and government-run to privatised and (partially) liberalised coal mining industry, as well as a lack of regulation, technology and institutional capacity and experience. Additionally, historically little incentive existed for implementing these type of schemes. This report describes how 'carbon finance' now provides that incentive.
4.2.3 CBM/CMM as an energy option

CBM/CMM has attracted considerable interest throughout the coal mining countries of the world, including India, as a potentially important clean energy source. Estimated global CBM resources (gas in place) are between 84 and 281 trillion cubic metres (tcm), although actual recoverable reserves will be substantially less. CBM resources in India are estimated to be about 1 tcm.

Most of the coal-derived methane which is commercially exploited outside the USA and Australia, is drained from underground longwall coalfaces (CMM). Gas captured as part of the mining cycle has traditionally been seen as a waste product by the mining industry. However, increasing environmental awareness of the need to reduce greenhouse gas emissions and the opportunity to generate revenue from the gas has seen a re-evaluation of gas drainage and use in coal mines. Many countries are looking at opportunities to maximise gas capture and use. The Clean Development Mechanism (CDM), applicable in developing countries, may enable additional revenue to be generated through carbon trading. Lesser quantities of gas are recovered from abandoned mine workings as AMM. In addition to the reduction in emission from CMM and AMM projects the environmental benefits of VCBM are recognised as the use of this clean fuel is likely to replace coal burn.

5 CBM POTENTIAL

Many coal mining countries, like India, claim extensive CBM resources (mainly VCBM). Development of CBM in India has been restricted by a number of factors including, lack of technical understanding and experience, insufficient training and education of skills, lack of advanced technology suited to mining and geological conditions and little understanding of market conditions and commercial issues.

The Indian energy market is dominated by coal, currently about 65%. Forecasts suggest coal use will remain at about 65% with demand for natural gas increasing from 8% to over 10%. However, the gap between gas demand and supply will probably continue to widen. According to some reports, CBM could be capable of contributing up to 15% of India’s natural gas production and reducing India’s reliance on imports.

DGH in India is currently offering 10 blocks for CBM bidding (VCBM). This is the third round of offers and under the previous two rounds a total of 16 blocks were awarded. The previous awards covered an area of 7,800 sq. km with an estimated CBM resource of 820 BCM. To date it is reported that a total of 50 core holes have been drilled and there are 20 Test/pilot wells. The blocks on offer are in the states of Jharkhand, West Bengal, Chattisgarh, Madhya Pradesh, Andhra Pradesh and Rajasthan.

One of the expected outcomes of this project is to undertake a case study and discussions were held with ONGC regarding their Jharia project. In particular, ONGC has already drilled a number of boreholes and a site visit to the well field was undertaken. The case study, therefore, is in respect of ONGC’s prospect in the Jharia coalfield.

5.1 Coal Mine Methane in India

The projected coal production in India for 2004/05 is 369 Mt out of which some 80% will come from opencast surface mining methods. Coal production is anticipated to rise in the coming years to meet economic growth but will come predominantly from opencast mines. The coal produced from underground mines (74 Mt) is expected to remain fairly constant over the next decade thereafter increasing gradually as shallow opencast deposits become exhausted. The increase in underground coal production and need for high quality coal will lead to mining operations at greater depths, therefore, gas emissions (specific emission) per
tonne of coal mined will increase. Eastern Coalfields Limited report underground production will increase by about 60% over the next seven years with production from Continuous Miners increasing some 20% (2.1 Mt) and production from longwalls by 15% (1.5 Mt).

Coal production in India is largely administered by the MoC who control Coal India Ltd (CIL) and its eight coal producing companies. CIL is the world's largest single coal mining company and produces about 87% of India's coal; the other main producer is Singareni Collieries Co limited. Technical support to the industry is provided by Central Mine Planning and Design Institute Limited (CMPDIL) which has 8 regional institutes attached to the coal producing companies.

Most underground mines are at depths of less than 300m and work coal seams from 2 to 3m thick although a small number (about 10) operate at depths of between 300 to 600m. Typical mining methods are manual and semi-mechanised room and pillar workings (accounting for 90% of underground coal production) although 5 to 6 mines are reported to be using longwall methods. Conventional and mechanised longwall mining methods are used in mines operated by Eastern Coalfields Limited, Bharat Coking Coal Limited and South Eastern Coalfields Limited. Longwall production in CIL equates to about 5% of underground coal output. Mechanised longwall extraction was first introduced at Moonidih mine in 1978. Since then some 20 longwall equipment sets have been imported although the effective use of this equipment has been limited.

Some success is reported at Jhanjra mine in Eastern Coalfields Limited. Production at the mine is currently concentrated in three seams (RN-4, RN-4 bottom and RN-3). Some 19 longwall panels (7.5 Mt) have been taken in RN-4 and RN-4 bottom seams since 1989/90. These panels are typically 120 to 150m wide, up to 1000m in length with an extraction height of 3.0 to 3.4m. The depth of cover at Jhanjra is very shallow, with hard cover typically 15 to 65m. Average daily production rates are about 1500 t/d with a maximum output up to 5100 t/d (face W1), average advance rates are 2 to 5 m/d. Annual production touched 1 Mt in 1998/99 with figures for 2003/04 reported at 0.8 Mt.

Coal mines in India are classified according to their methane hazard, category III being the gassiest. There are about 20 category III (>0.1% methane in the ventilation air and a specific emission >10 m³/t) gassy mines in India but Moonidih coal mine is the only fully mechanised longwall mine in this category. Moonidih was therefore chosen as the case study mine for this project. At present there are few gassy mines in India. It is likely that future deeper coal workings will be gassier, particular in the Jharia coalfield were 45% of India's high rank coals are deposited. The need to access coal at greater depth will also exist elsewhere as the higher grader coals are at a greater depth. Gassy mines are found in the Damodar valley coalfields of Jharia, Raniganj and Bokaro in the eastern part of India.

The current lack of interest in deep mining means the near-term potential for CMM recovery and use is limited. However, in the long-term India will have to pay greater attention to underground mining as opencast deposits become exhausted and surface workings reach uneconomic depths. Greater pressure to control greenhouse gas emissions such as the methane released in the ventilation air will also encourage CMM use. As the cost of production from underground mines is much greater than from opencast mines, any expansion in the former would require the introduction of efficient, highly mechanised mining. The concentration of production would create conditions in which higher than current gas emissions would be expected. It is therefore important that Indian mining engineers are aware of these implications and particularly of the technology for both controlling and exploiting the methane.

The gas released from coal seams during underground mining is a hazard to the miner and needs to be controlled to allow the safe working of coal. Generally, the faster the rate of
coal extraction the higher the flow of gas released. Initially, control is achieved by diluting the gas with ventilation air. Where this cannot be achieved gas drainage can be introduced to reduce the gas flow into the mine ventilation air. Gas drainage may involve the capture of gas from the worked coal seam or the adjoining strata before it enters the underground airways. Gas-related problems can become particularly acute in underground mines where high-production longwall methods are used, which disturb a much greater volume of gas bearing strata than room-and-pillar methods.

Underground coal mining in India involves predominantly room-and-pillar workings at shallow depth. Problems with gas emissions are reported to be associated with the worked seam indicating that pre-drainage techniques may be needed to drain gas in advance of mining. Pre-drainage involves drilling into the target coal seam some time (perhaps 2 to 5 years) in advance of coal mining from either the surface or underground. Successful pre-drainage requires a relatively permeable coal seam that will allow gas to flow ensuring the time lag between drilling of boreholes and the start of coal production is not too excessive.

Gas can be pre-drained through vertical boreholes drilled from the surface, guided surface to in-seam boreholes, or in-seam boreholes drilled underground. The use of underground guided in-seam drilling equipment, including the use of downhole motors, has been successfully demonstrated in both the USA and Australia allowing boreholes over 1000m to be routinely drilled. Attempts to introduce such technology to other countries, eg, China and UK have had mixed success. Growing pressure to reduce gas emissions from coal mines, the need for clean energy and advancements in drilling services and experiences has seen renewed interest in the application of this technology. A number of coal mining and energy companies are currently reviewing the commercial benefits of adopting such methods.

Other more simple methods of pre-drainage involve the use of conventional rotary drilling equipment to install boreholes up to 100m in length. This advanced technology intermediate depth drilling (ATIDD) may be more suited to Indian mining and cultural conditions than the longhole equipment. The application of UK equipment of this type to pre-drainage, supported by the UK government DTI CFFT programme, is currently under review at Luling coal mine, Anhui Province in China.

India’s lack of CMM experience is thus a result of:
1. Ventilation quantities are capable of controlling gas emission in most instances.
2. The relatively shallow depth of most underground mines, less than 300m.
4. Moderate to low coal productivity.
5. Relatively low gas content coals.

Current Status of CBM in India

In 1997 the Government of India (GOI) formulated a policy for the utilisation of CBM and a memorandum of understanding was signed between the Ministry of Petroleum and Natural Gas and the Ministry of Coal (MOC) to facilitate the implementation of the policy.

Since that time a total of sixteen CBM blocks have been awarded by Directorate General Hydrocarbons (DGH) in coal seams that are >300m below surface as follows:

**Table 2 Current CBM block ownership distribution**

<table>
<thead>
<tr>
<th>Company</th>
<th>Number of block</th>
</tr>
</thead>
<tbody>
<tr>
<td>ONGC</td>
<td>9</td>
</tr>
</tbody>
</table>
Phase 1 exploration (to be defined) is complete in five of the blocks and in four dewatering is complete or substantially complete and gas is being flared. Reliance has drilled five wells with a combined flow of 6,000 m$^3$/d, Essar is collecting 2,000 – 3,000 m$^3$/d from three wells in the Raniganj coal field.

Coal mines are operational within the various coal field areas and current government policy is not to allow CBM in areas where coal is <300m below surface. However, those areas where coal is present from 300m – 1200m below surface have been allocated for CBM. There is an overlap where coal mines can operate at depths greater than 300m depth where CBM has been allocated. Accordingly, there would appear to be a conflict regarding the ownership of the rights to the gas within this depth range.

With the current mining technology in India and due to the large opencast reserves, it is unlikely that coal will be mined at depths greater than 800m for the foreseeable future. It is known that Moonidih Mine and North Amlabad Mine have shafts up to 461m and 458m depth respectively.

There will, therefore, have to be agreement between DGH and the Ministry of Coal with respect to the area of overlap and a policy developed to enable the resources to be extracted to maximum benefit. CBM should not affect the mineability of the coal provided that there is proper abandonment of the wells (fully cemented, recorded accurately on plans).

A recent article in The Times states that GEEC will announce its intention to list on the AIM. The article goes on to state that £17.8 million has been raised to extract gas from undeveloped coalfields. GEEC is looking to exploit a 210 km$^2$ block in the Raniganj coalfield in West Bengal.

**5.2 Coal Bed Methane in India**

There is no commercial surface CBM, CMM or VCBM extraction and utilisation from any source, although there is currently a number of exploration programmes on going in various coalfields by different operators and CMM demonstration projects at two working coal mines to capture and use the gas. Historically mining companies have chosen to invest in mining activities rather than gas recovery. However, increasing awareness of the environmental and safety benefits together with the opportunity to sell greenhouse gas emission reduction is forcing a change of attitude. This position is been further strengthened by the emergence of energy companies willing to invest in projects where financial support mechanisms and pro-active government policy are adopted for clean energy projects.

One potential support mechanism to assist the development for CBM in India is through the Koyoto Protocol which provides support to “additional” projects that reduce atmospheric emissions either through direct use of an alternative clean energy fuel or through indirect routes such as a replacement for coal burning for power generation.

To ascertain an understanding and to determine the potential for CBM it is necessary to:
1. Prepare a realistic geological model;
2. Obtain coal parameters such as seam thickness, ash content, permeability and gas content;
3. Drill trial wells to provide a preliminary indication of the reservoir characteristics and CBM potential;
4. Undertake monitoring and sampling over at least a twelve month trial production period to ascertain water and gas flow trends;
5. Assess production costs, market and price. There must be an end user available to take and use the gas.

5.3 ONGC Jharia Prospect

The Jharia coalfield is located in the Dhanbad/Bokaro area of Jharkhand State. The CBM block is bisected by the Damodar Valley and the topography is generally flat and slightly undulating throughout. The CBM block is approximately 84 km² of which 45-50 km² has been classified by ONGC as providing a good to moderate prospect for VCBM. In the order of 18 km² of the good to moderate prospect is situated in the Parbatpur area and ONGC are currently undertaking field trials for CBM production in a 6 km² area of the prospect.

5.4 Jharia Coalfield

The Jharia coalfield comprises exposed (where coal seams outcrop at surface) and concealed (seams at depth overlain by non-coal bearing strata). It is understood that ONGC has prepared a comprehensive geological model for the area due to the following:

- Mining has been undertaken in the coalfield over a considerable number of years;
- Many boreholes have been drilled by mine operators and GSI;
- The existing information has been supplemented with drilling undertaken by ONGC. Further drilling along the southern boundary of the block is proposed;
- The coal bearing strata have been drilled to the base of the sequence thereby providing a complete geological section through the coal seams.

The coal bearing strata are Permian in age and are part of the Gondwana Basin. The southern part of the block is defined by a boundary fault and the northern part by the upper coal seams. Within the coal sequence there are in the order of 45 coal seams of varying thickness. The sequence has been split into top, middle and bottom containing seams that are generally <3m, 3-5m and 10-30m in thickness respectively. Within the sequence it is possible to correlate 18 seams throughout the coalfield.

5.5 Parbatpur

In the Parbatpur trial CBM area, ONGC has drilled four exploration wells to depths varying between 500-1100m. Nine to ten coal seams have been intersected in Jharia No 2 (J2) and Jharia No 3 (J3) wells and in J2 the coal seams encountered fall in the middle and bottom categories. Gas is currently being flared at each of the well sites. The four wells that have been drilled intersect the range of seams that will be accessed for CBM. Water is currently being pumped from J2 and J3 and gas flow and methane content is being monitored on an hourly basis.
5.6 Coal Characteristics

The principal characteristics to be considered in a CBM programme are permeability and gas content. The permeability of the coal seams are understood to be low and are generally in the region of 1-3 md. Permeability decreases with depth and the lower the permeability the more difficult it is for the gas to be extracted. Methane contents of the various seams encountered can be as high 20m³/t but in general the gas content is between 12-15 m³/t (daf) at 0°C. As the seams have high ash contents the actual gas contents (in situ basis) will be less than half these values.

5.7 Purged Water

Water is removed from the coal seams to reduce pressure until gas begins to desorb and flow. Water that is pumped from the wells is piped to a setting tank before being released to a larger pond. It is understood that the water quality has been sampled and that it would be acceptable for agricultural use.

5.8 Well Construction

Specific well construction details have not been provided however, it is understood that drilling commences to the topmost seam that will be accessed for gas. Casing is then inserted to the seam (having taken core samples for geotechnical and chemical analysis). The well is perforated and hydrofractured as well as being tested i.e. injection-fall off test to determine permeability. Thereafter the well is extended to the next seam and casing of a smaller diameter inserted. The process continues as before. Following well completion the well head infrastructure and pump is installed prior to water abstraction. During drilling it is normal to use a drilling mud (bentonite based) but some Gel's are also understood to be used. The possibility of formation damage reducing well performance cannot therefore be excluded.

5.9 Preliminary Results

The gas flows measured at J2 and J3 are currently in the order of 85 m³/h (5,000 m³/d) and 42 m³/h (2,520 m³/d) respectively. J2 recorded in excess of 8,000 m³/d during dewatering but has since reached a current steady flow of 85 m³/d. J3 is expected to increase as the water is pumped out before reaching a steady state.

5.10 Proposed Method of Gas Capture

The results obtained to date have not formally been made available and should therefore be considered as preliminary. However, ONGC intend to develop the Parbatpur test area further into a small scale pilot study. Currently, well spacings vary up to in the order of approximately 500m but ONGC have determined the well layout for the study area and they have included for the use of inseam directional drilling to overcome the low permeability of the coal.

It is proposed to drill wells vertically until the upper most target seam is intersected after which the drilling will be sub-vertical until the desired seams have been intersected.

The borehole will be cased for its full depth before cutting a window in the casing at the various seam horizons allowing directional drilling, inseam, for up to 1000m depending on geology and continuity of the seam. Each directionally drilled hole will have a number of boreholes off it containing in seam. Upon completion of the drilling an electrical submersible
pump will be installed in the base of the borehole and de-watering undertaken. However, short-radius drilling technology is not yet readily available so ONGC will be advised to examine medium radius drilling (MRD), an established Australian technology also used in China.

Directional drilling is not available in-house to ONGC and it is understood that expressions of interest have been sought from third parties. There will be a significant amount of drilling required to drill one well with associated in seam drilling and the cost is likely to be substantial.

Within the study area it is proposed to construct seven drilling pads from which up to three wells could be drilled. It is anticipated that the total number of wells will be in the order of 21.

5.11 UNDP/GEF project

In order to control methane emission related to coal mining activity, Department of Coal, Ministry of Mines and Minerals, GOI, in collaboration with Global Environment Facility (GEF) / United Nations Development Programme (UNDP) have taken up a Demonstration Project to recover Methane during mining and use recovered methane for Power Generation. The objectives of this project are to control greenhouse gas emissions and demonstrate the economic viability of harnessing coalbed methane, an important greenhouse gas, in the Indian coal mining sector. The full project is intended to build national capacity in the field of coalbed methane recovery and utilisation.

Central Mine Planning and Design Institute Limited (CMPDI) on behalf of GOI is the main local implementing agency. The Preparatory Assistance lead to the development of the project document for the full project aimed to demonstrate the commercial feasibility of utilizing methane recovered during coal mining activities from coal and surrounding strata before, during and after extraction of coal. Recovered methane will be used as fuel in a 1MW internal combustion generator and in 50t mine dumper trucks that are powered by converted bi-fuel engines. The full project is intended to build national capacity in the field of coal-bed methane recovery and utilization. This project has been implemented.

6 BARRIERS TO CBM EXPLOITATION

6.1 Technology needs

During the course of this study and previous work associated with UK India CBM projects has identified a number of needs in the development of Indian VCBM resources. India is reliant on imported technologies, services and technical assistance but response to international tender invitations have sometimes been poor due to impractical tight timetables. The quantity and quality of available data is invariably unsatisfactory. Technology is needed to improve exploration data acquisition and interpretation, modelling, resource estimation, borehole completion designs and gas well production rates. Directional drilling and medium radius drilling (MRD) technology which is quickly becoming the standard approach in medium to low permeability coal has yet to be attempted.

In respect of CMM from underground mines, there is a paucity of technical knowledge as well as technology. Technology needs include:

- Collection pipe work design;
- Gas concentration and flow monitoring equipment;
• Effective design and management of gas drainage systems;
• Surface wet and dry sealed extraction pumps;
• Surface gas cleaning and mass flow monitoring equipment;
• Technologies for gas use;
• Gas flaring technologies to control emissions;
• Software systems to record and manage data;
• Drilling technologies and borehole design.

6.2 Costs

There is too little information available to be able to comment on the likely costs for VCBM exploration, testing, well completions and production drilling as there has been too little activity and cost data are treated as commercially sensitive. VCBM completion costs vary from country to country and also with technology. When services are derived predominantly from the petroleum sector costs tend to be higher than those serviced by the coal sector or those developed specifically for CBM.

6.3 Other barriers

Indirect barriers to the development of gas recovery and utilisation projects are apparent when considering the use of supporting mechanisms such as CDM. These “clean” energy projects are considered to be of high risk by financing institutions. One of the reasons is the likely relatively small scale of some schemes. Other issues are related to the lack of skilled and experienced staff capable of evaluating such schemes. Other barriers that have been identified are:

• A lack of industry awareness about CDM and in particular the process of project development, preparation of documentation and investor needs;
• Efforts to promote CDM has focused on policy makers, large industries and prominent research and academic institutions;
• High transaction costs associated with the CDM project cycle, particularly in view of the current low prices of credits in the international market;
• A lack of a policy framework for the promotion of smaller CDM projects;
• A lack of institutional capacity. Despite the fact that there is network of financial and professional institutions, no organisation is working specifically to support smaller CDM projects. There is no clear understanding how smaller CDM projects can be bundled together to bring down transaction cost.

Due to the high incremental costs, only large-scale renewable energy projects are presently considered viable options under the CDM in India. This experience can be built on and adapted to CBM related projects. There is strong GoI support to reduce methane emission from its operational and closed mining operations and the exploration of VCBM provides potential to replace coal burn with a clean fuel.

7 CDM POSSIBILITIES FOR CBM PROJECTS

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 - in principle - CMM/CBM utilisation schemes.

A number of methodologies have been developed to facilitate the application of Clean Development Mechanism (CDM) financing to stimulate the construction of CMM/CBM utilisation schemes and encourage methane destruction in a cost-effective manner. The approaches rely on technology, which has been demonstrated and proven in industrialised countries.

In addition to these projects proposed under the CDM, further projects have also been proposed and implemented in industrialised countries. In the UK, a number of projects have been implemented as part of the UK emissions trading scheme. In Germany a project was proposed for producing power and heat, with the emission reductions contracted to the Dutch government under JI4.

Possibilities for CBM under the Kyoto Protocol’s Clean Development Mechanism will be discussed in much more detail in the reports for deliverables 2 and 4. To date, CBM is only eligible when followed by mining within the crediting period of the project as discussed in deliverable 4. This would make each CBM project in India ineligible.

In the further reports of this project we will be recommending action to widen the applicability of the existing methodology, or to propose a new methodology, for CBM projects under the CDM. With a shortage of natural gas resources domestically, CBM is key to making fuel switching in India possible. If the environmental benefits of increased gas use, displacing coal, could be claimed under the CDM, then the additional financial resources available to CBM developers may stimulate significant growth.

8 CONCLUSIONS AND RECOMMENDATIONS

India’s expected continuing rapid economic growth will be fuelled mainly by domestically produced coal. Expanding clean energy sources will also contribute significantly. CBM may be able to play its role in this sector, providing a clean energy source with a large domestic resource.

Indeed, GOI has identified VCBM as having a vital role in meeting this energy shortfall. This has been clearly demonstrated by the strong support given to DGH in promoting and awarding some 16 VCBM blocks for exploration and development. A further indication of intent to produce VCBM is shown by the third round of bidding for CBM blocks. Exploration programmes are well advanced in a number of blocks and foreign involvement and co-operation is reported for technical support and specialist services.

The use of CDM to support CBM development is an option. VCBM development would lead to a fuel switch away from coal usage, which will be readily available in the coal mining areas

4 JI is similar to the CDM, and will be explained further in report 2.
where VCBM can take place, to gas use. As such VCBM project will help reduce India’s greenhouse gas emissions significantly.

However, VCBM activities are leading the way but these are not linked to any foreseeable coal mining operations and therefore could not be construed as pre draining the gas. Therefore, as will be explained in other reports, the current CDM methodology does not allow for VCBM, so a new methodology would need to be developed. Its value is in providing a clean fuel to displace use of polluting coal.

CBM in India is at an early stage of development with both public and private companies vying to develop in-country skills and services and thus achieve market position. There are vast resources of methane available in India, but until commercial production has been demonstrated the reserve potential is largely unknown.