Clean Development Mechanism in Coal Bed Methane Projects

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Abstract

The Kyoto Protocol specifies legal binding commitments by most industrialized countries to reduce their collective greenhouse gas (GHG) emissions by atleast 5% below 1990 levels by the period 2008-2012. One of the mechanisms provided for this is Clean Development Mechanism (CDM), which is expected to benefit both developed and developing countries as it gives opportunities for additional investment and transfer of efficient technologies to the developing countries and reduce costs for the developed ones. Coal Bed Methane (CBM) is being proposed as a non-conventional source of energy in India. This paper, therefore, discusses the developments in global climate change regime and CDM and their applicability to Coal Bed Methane Projects.

Key Words

Coal Bed Methane, Methane, Clean Development Mechanism, Green House Gas

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INTRODUCTION

Global Climate became a major concern for the countries of the planet with the discovery of the ozone hole. Prior to that, perhaps, James Lovelock who postulated the Gaia theory was one of the first thinkers on the issues of global climate and changes occuring. Concrete steps towards protection against Global Climate Changes took place under different protocols and treaties at different times, as listed below:

- "Montreal Protocol" means the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Montreal on 16 September 1987 and as subsequently adjusted and amended. [1]
- "Intergovernmental Panel on Climate Change" means the Intergovernmental Panel on Climate Change established in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme. [2]
- The very first steps taken in relation to the present day global climate regime was the UN Framework on Conventional Climate Change (UNFCCC) adopted in New York on 9th May 1992. It set a very generic framework but did not specify any concrete measures. There were voluntary targets for the industrialised countries to stabilise the emission of CO_2 until 2000 but then in 1995, it seemed that this target would be difficult to reach so a more stringent target was negotiated for the period 2008-2012. The targets set by the budget and commitment period were legally binding, and so, stronger than the voluntary targets. [3]
- In 1997 at the Kyoto Protocol, basing on the earlier skeletal framework developments were suggested
- Till day the process has been going on with the meeting of Conference of Parties (COP).

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Clean Development Mechanism (CDM)

Article 12 of the Kyoto Protocol specifies that developing countries are to benefit from CDM projects resulting in 'certified emission reductions' (CERs) and that industrialised countries may use CERs to comply with their quantified emissions reduction commitments under the Kyoto Protocol. CDM consists of bilateral agreement between two entities to complete a GHG mitigation project. The investor is from an Annex B industrialised country and must reduce its emissions under the Protocol. The project will be hosted in non-Annex B country. CDM potentially can provide credit for emissions abatement to the investor at lower cost than domestic abatement. In other words, this can be expressed as 'emissions trading'. [4]

Prototype Carbon Funding (PCF)

Recognizing that climate change will have the most impact on its borrowing client countries, on July 20th, 1999 the Executive Directors of the World Bank approved the establishment of the Prototype Carbon Fund (PCF). The PCF, with the operational objective of combating climate change, aspires to promote the Bank's tenet of sustainable development, demonstrate the possibilities of public/private partnerships, and offer a "learning-by-doing" opportunity to its stakeholders. The major three objectives being High-Quality Emission Reductions, Knowledge Dissemination and Public-Private Partnerships.

Six governments and 17 companies—including power and oil companies from Japan and Europe, and leading global banks—all from industrialized countries, have contributed US$180 million in funds to the PCF. The PCF will pilot production of Emission Reductions within the framework of Joint Implementation (JI) and the Clean Development Mechanism (CDM). The PCF will invest contributions made by companies and governments in projects designed to produce Emission Reductions fully consistent with the Kyoto Protocol and the emerging framework for JI and the CDM. Contributors, or "Participants" in the PCF, will receive a pro rata share of the Emission Reductions, verified and certified in accordance with agreements reached with the respective countries "hosting" the projects. [5]

Role of Developing Countries

If there were no CDM, many of the developing countries would not have heard about this debate because they don't have to reduce emissions. But CDM gives them this interesting possibility of participating in something different [6]. This is so because it is much cheaper, on the margin, for developing countries to abate GHG emissions. Hence, this arrangement theoretically facilitates cost-effective achievement of any target for GHG reduction. For instance, Ellerman *et al.* (1998) find that the global costs of achieving the Kyoto Protocol targets are $120 billion when each nation must satisfy its commitments purely through domestic actions, but drop to $54 billion if trading is permitted among Annex I countries and further to $11 billion if CER transfers are permitted and efficiently supplied [7].

METHODOLOGY

Certified Emission Reductions (CERs)

A certified emission reduction or CER is a unit pursuant to Article 12 and requirements thereunder, as well as the relevant provisions in the CDM modalities and procedures, and is equal to one metric tonne of carbon dioxide equivalent, calculated using global warming potentials defined by decision 2/CP.3 or as subsequently revised in accordance with Article 5 of the Kyoto Protocol. [8]

Considerations for CER and carbon projects

The following considerations are there for CER, the most important of which is additionality:

- ***Additionality*:** Establishing the status of environment had the emissions reductions not taken place in the absence of the project
- ***Baseline and systems boundaries (leakage)*:** Establishing the 'business-as-usual' emissions in the absence of the project and compare with-project and without-project emissions. The spatial and temporal boundaries of the system we are looking at have to be also established.
- ***Measurement*:** The accuracy of measurement the actual levels of emissions when the project comes into existence
- ***Permanence*:** The consequences of all these will then be evaluated as whether the project will have a long-lasting mitigating effect on atmospheric GHG concentration and on the economic and social consequences of global warming
- ***Local social and environmental impact*:** Establishing the environmental impacts of the project and the socio-economic benefits to the local and neighbouring population

RESULTS

CDM Projects in the Indian Context

Most of the proposals which are coming up from India as a result of CDM mechanism are related to small renewable energy sources such as wind, hydros and biomass. There are some ideas about industry related proposals such as retrofitting in power sector and waste energy recovery in sponge iron plants. Here is a very brief look at the revenues from CDM, assuming rate per tonnes of CO_2 emission reduction as US$ 4 :

Table 1 : Proposed CDM Projects in India (upto 2003)

Type of Project	Production	Estimated revenue from CDM (Rs. Crores)
Biomass energy project	5 MW	4.6
Bagasse power plant	5 MW	3.1
Wind energy project	5 MW	1.5
Micro Hydro power project	5 MW	3.8
Power plant- shift from naptha to gas		7.8
Sponge Iron- (a) Hot metal	800,000 tpa	4
(b) Waste heat recovery	848 GWH.p.a.	13

[Adapted from : "CDM- Case Studies in India", Surojit Bose, 2003 presented at India Energy Meet on Climate Change and Clean Development Mechanism]

India has great potential to earn CDM revenue through renewable energy projects. Table 2 reflects the potential in various renewable energy sectors and percentage potential realised so far.

Table 2 : Potential for Renewable Energy Projects

Renewable Energy Source	Potential (MW)	%age Realised
Wind	45,000	3.8
Biomass	19,500	1.8
Mini-hydro electric	15,000	9.5

[Adapted from "Renewable energy policy statement soon", article in Deccan Herald, February 22, 2003]

Coal Bed Methane

CDM projects in the India context reflect the great potential for energy generation and CDM revenue from it in the renewable energy sector. A new alternative source of energy being envisaged in our country is Coal Bed Methane (CBM), which might prove more successful in achieving high CO_2 emission reductions.

Coal Bed Methane

When plants are converted into coal, natural gas (mostly methane) is released. In many places the plant material is buried by impermeable rocks, such as shale, and methane may be left in the pores and fractures of the coal. Some of this gas is released when coal is mined. Methane emissions in mining come from [9]:

- Natural ventilation (cracks in coal layers and adjoining rocks)
- Coal mine emissions
- Underground mines
  - Ventilation (methane: 0.2-1%)
  - Degasification
  - Vertical wells of surface degasification in advance of mining (CH_4 concentration 80-98%)
  - Gob-wells from the surface (CH_4 concentration 20-60%)
  - Horizontal and cross-measure boreholes of underground degasification (CH_4 concentration 20-60%)
- Surface coal mining
- Coal enrichment, transportation and usage

Methane is colorless, odorless and tasteless, so it is difficult to detect. When 5 to 10 percent of methane is mixed with air, it becomes highly combustible. Many of worst mine disasters were caused by explosions of ignited methane gas. Therefore, methane recovery from coal seams provides a number of benefits [10]. Recovered methane can be sold, which will not only significantly reduce greenhouse gas emissions, but could also be a substitute for fuel, which is currently being imported from outside the country.

Process of coal bed methane recovery

CBM extraction involves drilling wells down to target coal beds. Desorption, diffusion, and production of methane are accomplished with the reduction in reservoir pressure by dewatering the coal seams. [11]

DISCUSSION

CBM potential in India

As per geological assessment of coal/lignite basins in India, carried out by Reliance Gas, around 20 000 square kilometers of area has been identified as prospective for CBM exploitation. Recoverable CBM reserves are estimated at 800 billion cubic meters with gas production potential of 105 million cubic meters a day over a period of 20 years. Based on the geological assessment carried out by Reliance, the bituminous coal basins found prospective for CBM are Damodar-Rajmahal in West Bengal and Bihar, Sone-Mahanadi, and Narmada-Pranhita-Godavari in Madhya Pradesh, Orissa, Andhra Pradesh, and Maharashtra. Tertiary lignito-bituminous coal basins having CBM potential are Cambay in Gujarat, Barmer in Rajasthan, and Cauvery in Tamil Nadu. Separately in 1997, Reliance Gas identified rich CBM prospects in the Banaskantha district of Gujarat, Tanjore district of Tamil Nadu, and Birbhum district of West Bengal. [11]

CBM and CDM

The way to analyse suitability of CBM projects for CDM would be to evaluate them on the considerations discussed under CER and Carbon projects.

It is a well-accepted fact that methane has a 23 times [12] green house warming potential (GWP) than carbon dioxide. For different time periods the GWP varies as seen in Table 3.

Table 3 : Global Warming Potential (GWP) [13]

Green House Gas	Time Horizon		
	20 years	**100 years**	**500 years**
Carbon dioxide	1	1	1
Methane	62	23	7

Additionality

Coal bed methane would have escaped into the atmosphere when mining would begin in the coal beds. Sometimes, before mining, wells are sunk into the coal seams to allow the methane to escape and create safe working conditions. In absence of any coal bed methane recovery measures, the methane would escape into the atmosphere and each tonne of CH_4 entering the atmosphere would create a global warming equivalent to 23 tonnes of CO_2. Moreover, in absence of any coal bed methane, other fossil fuels would be in usage and contributing to global warming in additional to the leaking methane. In presence of the project, the fuel will be replaced by methane; a situation whereby the GWP of methane will be drastically reduced on combustion and CO_2 releases from fossil fuels will not be there. Hence, there will be a two-pronged reduction in GHG release.

Baseline

The baseline for any area will constitute of usage of fuels such as kerosene, LPG, propane, Residual Fuel Oil (RFO), Bituminous Coal, Wood, etc. Hence, to establish the baseline, the energy available from these fuels as well as the CO_2 emission are summarised in Table 4.

Table 4 : Available Energy and CO_2 Generated on Combustion of Fuels

Fuel	Higher Heating Value (HHV) GJ/tonnes	Fuel required to generate energy equal to that from 1 tonne CH_4	Emission in Kg CO_2/ tonne of fuel used	Emission in kg CO_2 on burning fuel required to generate energy equal to that from 1 tonne CH_4
Methane	70.886	1.000	2750.00	2750.00
Kerosene	46.448	1.526	3150.00	4807.342
LPG	48.394	1.465	2842.99	4164.350
Propane	49.630	1.428	2991.37	4272.515
RFO	42.139	1.682	2828.00	5243.404
Bit. Coal	30.236	2.344	2465.61	5780.462
Wood	17.000	4.169	1906.97	7951.625

[Adapted from Francis [14]; IPCC Guidelines for National Greenhouse Gas Inventories, 1996, Volume 2, Section 1; Energy Information Administration (EIA), 2001, Appendix B]

Measurement

In light of the GWP potential of CH_4, the conversion of methane to carbon dioxide becomes very important. The basic equation on combustion of methane would be:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

Mol. Wt. 16 44

The above equation demonstrates very clearly that each methane molecule gives rise to one carbon dioxide molecule. Thereby, the very act of combustion or oxidation the green house warming potential of methane has reduced to 1/23. At the same time, the combustion of 1 tonne of CH_4 will generate 2.75 tonnes of CO_2. Therefore, the cumulative effect will save 20.25 tonnes of CO_2 equivalents per tonnes of CH_4. The net savings are 88.04%.

Similarly, combustion of other fuels compared to CH_4 will generate excess CO_2 equivalents as demonstrated by Table 5.

Table 5 : Net Savings in CO_2 equivalents when using CH_4 in lieu of conventional fuels

Conventional Fuel	Emission in kg CO_2 on burning fuel` required to generate energy equal to that from 1 tonne CH_4	Emission in kg CO_2 on burning 1 tonne CH_4	Emission Saving in kg CO_2/ tonne of methane on 100% substitution of conventional fuel
Kerosene	4807.342	2750	2057.342
LPG	4164.350	2750	1414.351
Propane	4272.515	2750	1522.515
RFO	5243.404	2750	2493.404
Bit. Coal	5780.462	2750	3030.462
Wood	7951.625	2750	5201.625

The above table clearly demonstrates that the maximum saving is by substitution of wood and coal by methane gas. LPG has been considered as 30% propane and 70% butane. From table 4 and 5 it becomes convenient that for a given area, if the fuel utilisation is known, then the savings in CO_2 emissions can be calculated by substituting conventional fuel masses with energy equivalent mass of CH_4.

Permanence, Local Social and Environmental Impact

CBM utilisation has long-term consequences as it speaks of an alternative source of fuel, thereby reducing load on fossil fuels. The local social consequences are in terms of employment opportunities and revenue generating activities. Multiple environmental advantages in form of possible shift from fuel wood in rural areas to methane, thereby reducing household pollution, protection of forests, reduction in usage of kerosene, RFO, LPG, wood and coal and contribution to the global green house gas emission reduction.

CONCLUSION

There is immense potential to gain from sale of CER for coal bed methane projects. It is apparent through simplified calculations that using methane as the energy source can save 88.04% of the global warming which would otherwise occur due to direct releases. Hence, project developers and project investors should consider CDM as a revenue source for CBM projects. So far no Indian CBM project has submitted their project idea note to the Executive Board of the CDM. China, on the other hand, has started work on not only CBM recovery but also CO_2 sequestration through into coal beds through the same boreholes. The basic calculations in this paper should be able to give some ideas to CBM project developers. There is room for more in depth study regarding energy source which are used in traditional rural India which include cow dung cakes and agricultural wastes. GHG Protocol Initiatives have not yet given emission factors for these kinds of fuel, which creates some limitations.

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Methane in Coal (CO-11)
When plants are converted into coal, natural gas (mostly methane) is released. In many places the plant material is buried by impermeable rocks, such as shale, and methane may be left in the pores and fractures of the coal. Some of this gas is released when coal is mined.
Methane is colorless, odorless and tasteless, so it is difficult to detect. When 5 to 10 percent of methane is mixed with air, it becomes highly combustible. Many of Indiana's worst mine disasters were caused by explosions of ignited methane gas.
In some places experimental drilling has removed methane from the coal before it is mined. The recovered methane can be used if the volume is large and a need or a market exists. Some of Indiana's coal has about 90 cubic feet of gas per ton. Large mines may release more than a million cubic feet of gas each day -enough to supply heat for 3,000 homes if it could be collected.
Source: *Our Hoosier State Beneath Us:* Coal
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Coal-bed methane: a bed of roses?

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The basic assumption for calculations in reduction of carbon emissions or its equivalent is that there is an enclosed space within which any releases are taking place and their utilisation, is any. Matter can come into the enclosed space through well defined routes such as fossil fuels through tankers/trucks. Similarly leakage can occur from within the enclosed space beyond its boundary i.e. methane fuel being supplied to adjacent areas through pipeline. The more the movement of energy generating matter to and from the enclosed space, the more complicated the problem will become.

To begin with, it is assumed that matter comes into the enclosed space from outside for <u>all</u> energy generation purposes. These include fossil oils, coal, lignite, LPG, natural gas and electricity through a grid but generated outside the enclosed space. Second assumption is that methane generated through a CBM project will replace 50% of any energy source.