Coal Mine Methane Project Opportunities: Globally and in Viet Nam

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1. Global Overview

1.1 Global Methane Emissions

Methane accounts for 14 percent of global greenhouse gas (GHG) emissions, second only to carbon dioxide (CO_2) as a GHG resulting from human activities. Methane is 25 times as effective at trapping heat in the atmosphere as CO_2 (Methane to Markets, 2010a). Global anthropogenic methane emissions for 2005 were estimated at 6,407 million metric tons of CO_2 equivalent ($MMTCO_2E$) (USEPA, 2006a). Global methane emissions have risen since 1990 and this increase is expected to continue.

Figure 1: Estimated Global Anthropogenic Methane Emissions by Source, 2005 shows the contribution of different sources of methane emissions to total anthropogenic methane emissions in 2005; coal mine methane (CMM) emissions accounted for 6 percent of total emissions (USEPA, 2006a).

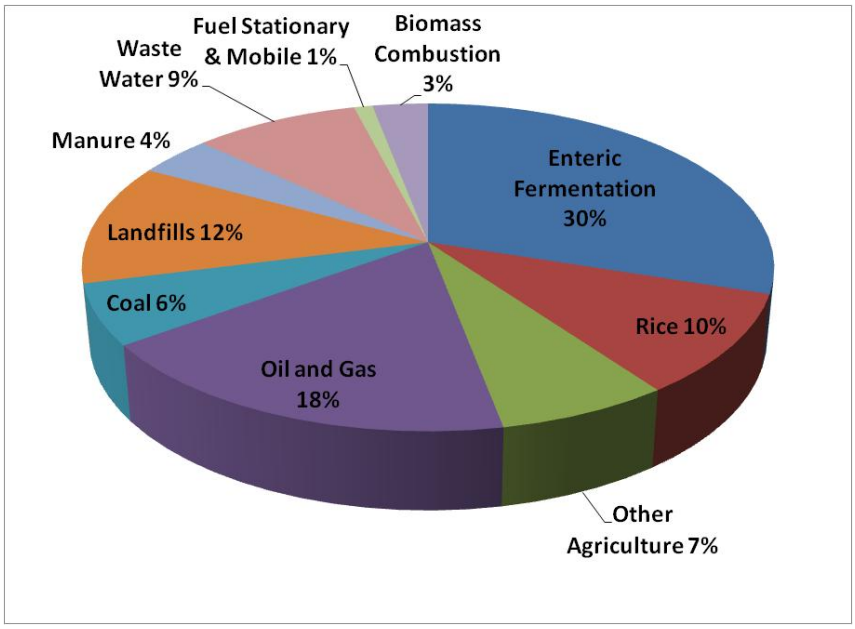

Figure 1: Estimated Global Anthropogenic Methane Emissions by Source, 2005
Source: USEPA (2006a)

China, India, the United States, Brazil, the Russian Federation, and Mexico were the top emitters of methane in 2005.

Figure 2: Methane Emissions by Country, projected 2010 shows the top emitters' contributions to the total estimated CMM emissions projected for 2010.

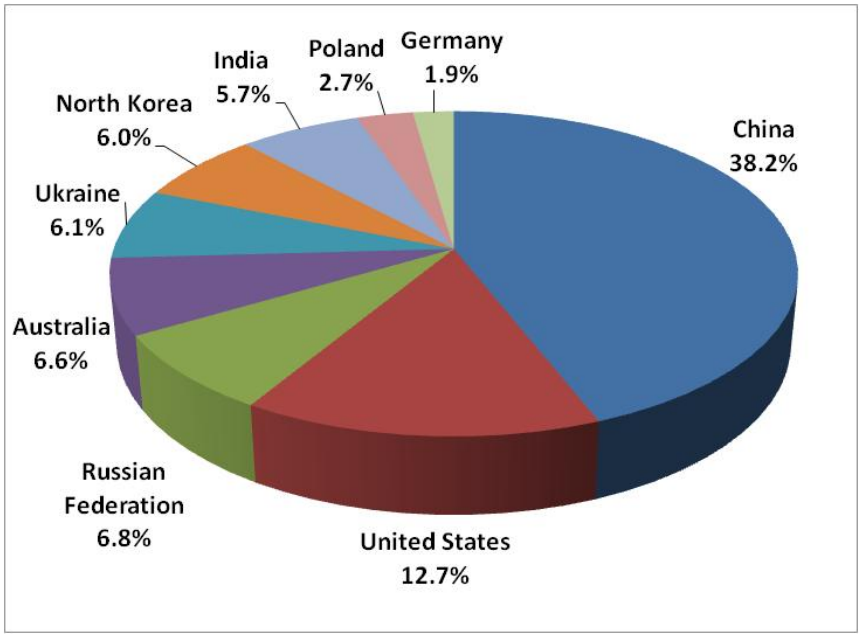

Figure 2: Methane Emissions by Country, projected 2010
Source: USEPA (2006a)

1.2 Global Coal Mine Methane Emissions

Coal mine methane (CMM) refers to methane released from the coal and surrounding rock strata as a result of mining activities. In underground mines, methane released can create an explosive hazard to coal miners, so it is removed through ventilation systems. In some instances, it is necessary to supplement the ventilation with a degasification system consisting of a network of boreholes and gas gathering lines. In abandoned mines and surface mines, methane might also escape to the atmosphere through natural fissures or other diffuse sources.

Coal mine methane is emitted from five sources:

- Degasification systems at underground coal mines (also commonly referred to as drainage systems). These systems may employ vertical and/or horizontal wells to recover methane in advance of mining (known as "pre-mine drainage") or after mining (called "gob" or "goaf" wells)
- Ventilation air from underground mines, which contains dilute concentrations of methane
- Abandoned or closed mines, from which methane may seep out through vent holes or through fissures or cracks in the ground
- Surface mines, from which methane in the coal seams is directly exposed to the atmosphere
- Fugitive emissions from post-mining operations, in which coal continues to emit methane as it is stored in piles and transported

Globally, CMM constituted 6 percent of anthropogenic methane emissions in 2005 with 388.14 $MMtCO_2E$. CMM emissions have dropped since 1990 but are expected to rise somewhat by 2020 (Figure 3: Global Annual CMM Emissions (Million metric tons CO2E)).

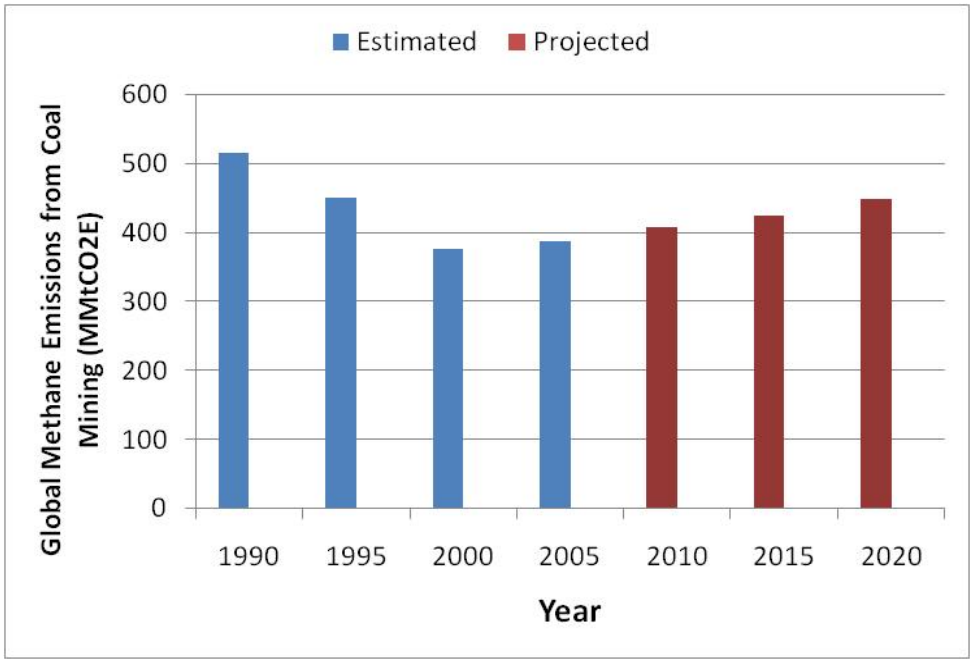

Figure 3: Global Annual CMM Emissions (Million metric tons CO2E)
Source: USEPA (2006a)

1.3 CMM Emissions of Key Countries

China, the United States, Ukraine, the Russian Federation, North Korea, and Australia emitted the most CMM in 2005. Figure 4: CMM Emissions by Country (Million metric tons CO2E) shows CMM emissions of these countries as estimated in 2005 and projected through 2020.

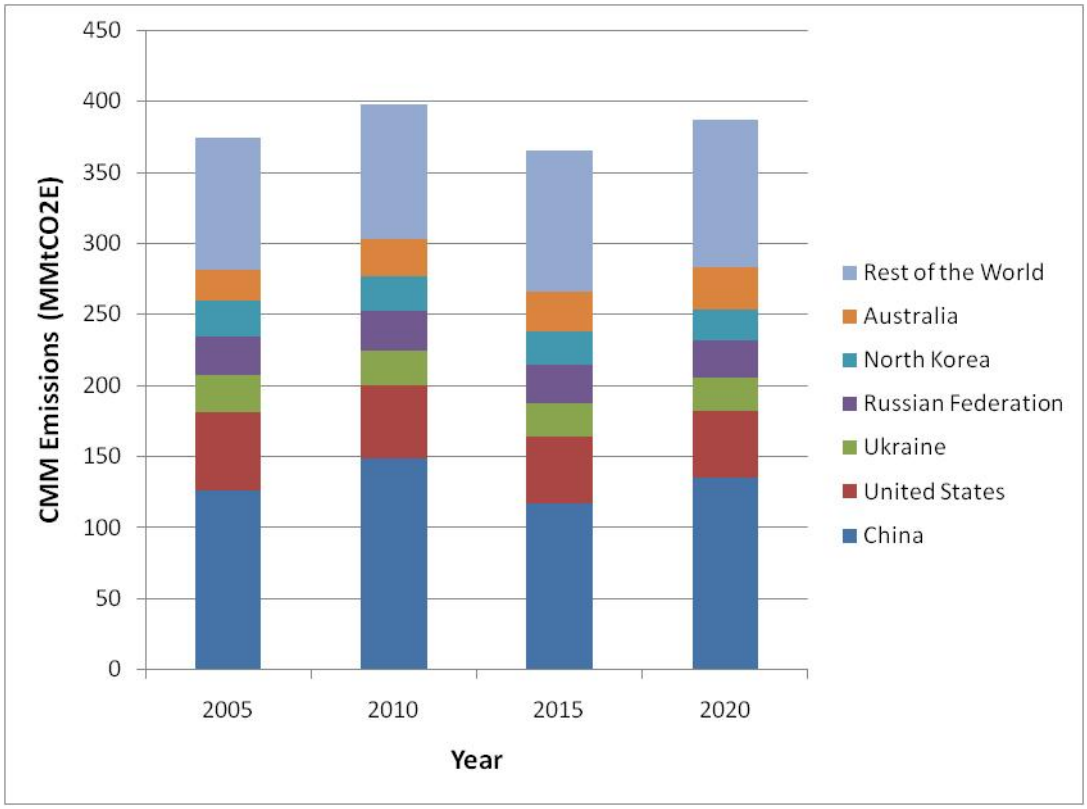

Figure 4: CMM Emissions by Country (Million metric tons CO2E)
Source: USEPA (2006a)

2. CMM Recovery and Utilization Options

In underground mines, methane can create an explosive hazard to coal miners, so it must be removed. This is done most commonly through ventilation systems. In very gassy coal mining conditions, it is necessary to supplement ventilation with a degasification system consisting of a network of boreholes and gas pipelines.

2.1 CMM Recovery Options

2.1.1 Ventilation Air Methane

Ventilation air methane (VAM) refers to the very dilute methane that is released from underground mine ventilation shafts. VAM is recovered from the mine's ventilation fan for abatement using either a thermal or catalytic oxidation technique, both of which started as volatile organic compound (VOC) abatement technologies. These technologies produce no flame, yet in addition to abating VAM emissions, they can produce thermal energy or electricity using a steam turbine. Mines are ventilated by using fans to either exert positive pressure to push air through the mine or by creating negative pressure to draw air through the mine. In both cases, large fans are used to move the air.

Methane concentration in ventilation air is generally less than 2 percent. Under this scenario, VAM oxidation results only in the destruction of CMM. At VAM concentrations greater than 0.6 percent it is possible to produce electricity by circulating water through the oxidizer and capturing superheated steam which may be used to power a steam turbine. However, the economic feasibility of generating electricity from VAM destruction is determined by local electricity sales prices. This technology is relatively new, with only two commercial VAM projects operating worldwide. Both the United States and Australia introduced the technology with demonstration projects, and now both countries have commercial projects operating at active underground mines. Commercial projects are also in development in the United States and China.

2.1.2 Degasification Systems

Degasification or methane drainage systems may also be installed to recover methane for use. Methane can be recovered from coal seams by drilling vertical wells up to 10 years in advance of a mining operation or drilling horizontal boreholes several years before mining (USEPA, 2006b). Methane also can be obtained from gob wells. Gob wells extract methane from the gob areas of a mine after mining of the coal results in caving of the overlying strata. The gob refers to the collapsed area of strata produced by the removal of coal and artificial supports behind a working coalface. Gob gas methane concentrations can range from 50 percent to over 90 percent (USEPA, 1999). Depending on the gas quality, methane recovered from degasification systems may be utilized in a number of ways.

2.2 CMM Utilization Options

Worldwide, CMM is most often used for power generation, district heating, or boiler fuel; but it can also be used as town gas or sold to natural gas pipelines. Other end-use options include use as a chemical feedstock or onsite uses such as coal drying. In the United States, most CMM that is recovered is subsequently injected into the natural gas pipeline system. Methane can also be destroyed by use of a flare. The following are descriptions of the most common CMM end uses.

2.2.1 Power Generation

CMM can be used to generate power using a number of technologies, including internal combustion (IC) engines, gas turbines, and boiler or steam turbines. There are currently 67 power generation projects utilizing CMM worldwide. Most of these projects are in Germany (30), China (17), the United Kingdom (11) and Australia (6).

2.2.2 Gas sales

CMM can be injected into natural gas pipelines if the infrastructure is available. Enrichment of the gas may be required before CMM is considered pipeline quality. There are 36 CMM to pipeline projects globally. The United States has 32 projects, 24 of which are at abandoned mines. There are also 10 town gas projects in China, with several of these projects serving over 100,000 households

each. Other projects may sell gas directly to large manufacturers, such as an abandoned mine methane project in the Midwest United States, which sells gas to a nearby Toyota truck plant.

2.2.3 Compressed Natural Gas and Liquefied Natural Gas

A number of technologies exist for liquefying and compressing natural gas. CMM projects operate at a much smaller scale than conventional natural gas projects, thus, technologies that can be economically applied at a smaller scale must be used. There is one vehicle fuel project at the Furong Mine in Sichuan, China using CMM to fuel buses, with other LNG projects planned or in development in China and Poland.

2.2.4 Boiler Fuel

CMM is used in boilers for space and water heating. For example, bath houses, dormitories or residences which require hot water may be located onsite or nearby to a gassy mine. Also, in some regions, it may be desirable to heat ventilation air in the winter before it is pumped into the mine. There are 23 boiler fuel projects operating on CMM, with five in Poland, four in both Russia and China, and several in Ukraine and the United Kingdom. Conversely, heat exchangers may be used to cool the air in deep mines or at mines located where high ambient air temperatures are prevalent.

2.2.5 Industrial Use

CMM may be used as a chemical feedstock, such as in methanol or carbon black production. Other projects use CMM for coking coal development in Ukraine and France, as fuel for aluminum hydroxide roasting furnace systems at an aluminum plant in China, and as a fuel at a glassworks factory in the United Kingdom. CMM has also been used to produce di-methyl ether by Japanese technology providers (Methane to Markets, 2009).

2.2.6 Others

CMM is sometimes used in coal preparation plants to fuel thermal dryers that heat the air used to remove surface moisture from the coal. CMM is also used in combined heat and power systems at 22 projects worldwide.

2.2.7 Flaring

Flaring is used solely for the purpose of methane destruction for GHG emission reduction, with three projects currently utilizing flares in the United Kingdom. Flaring also occurs in Ukraine and Australia (Methane to Markets, 2010b).

3. Emission Reductions

There are over 200 CMM recovery and utilization projects worldwide resulting in annual emissions avoided of over 3.8 billion cubic meters of methane or 54 $MMTCO_2E$. The United States is the second highest emitter of CMM, and leads in emission reductions with approximately 1.1 billion cubic meters of methane (16 $MMTCO_2E$) emissions avoided annually as of 2005 (Franklin, 2007). Other countries recovering significant quantities of CMM include China, Germany, and Australia (Figure 5: CMM Emissions and Emissions Avoided by Country in 2005 (MMTCO2E)).

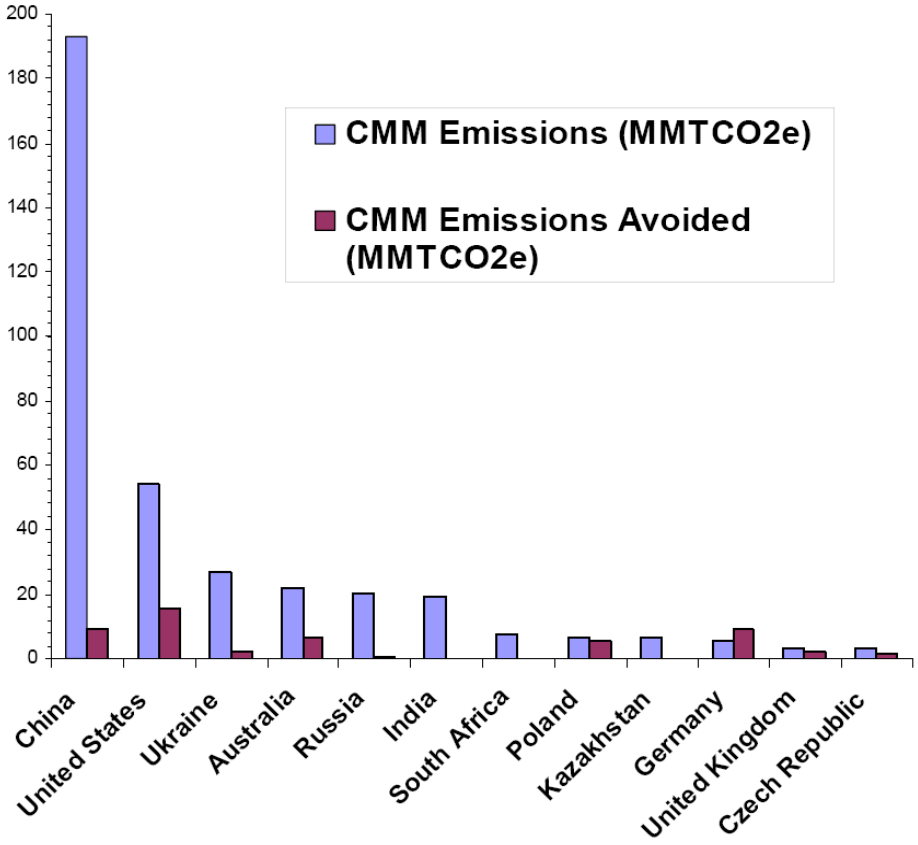

Figure 5: CMM Emissions and Emissions Avoided by Country in 2005 (MMTCO2E)
Source: Franklin (2007)

3.1 Clean Development Mechanism Projects

Operational since the beginning of 2006, the Clean Development Mechanism (CDM) has registered more than 1,000 projects and is anticipated to produce certified emission reductions (CERs) amounting to more than 2.7 billion metric tons of CO_2 equivalent in the first commitment period of the Kyoto Protocol, 2008–2012. The first CMM project to be registered as a CDM project was registered in 2007. Since then, a total of 26 projects have been registered. All CDM CMM projects presently registered are hosted by China.

The methodology applied for CMM projects as CDM projects is Approved Consolidated Methodology ACM0008: *Consolidated methodology for coal bed methane, coal mine methane and ventilation air methane capture and use for power (electrical or motive) and heat and/or destruction through flaring or flameless oxidation --- Version 6*. ACM0008 applies to project activities at active underground mines. A revision to the methodology has been submitted and if accepted, would expand the scope of ACM0008 to include pre-mine drainage at active surface mines as well (UNFCCC, 2010).

3.2 Methane to Markets

Recognizing the important role of methane in global warming and its potential use as a clean energy source, 14 countries came together in 2004 to launch the Methane to Markets Partnership. By engaging partner governments and private sector entities, Methane to Markets brings together the technical and market expertise, financing, and technology necessary for methane capture and use project development in four sectors: agriculture, coal mines, landfills, and oil and gas systems. There are currently 32 partner countries, including Viet Nam. Methane to Markets has created a number of important and useful tools and resources available to each sector. Specific to the coal mine sector are a project database system that is searchable by a number of criteria and includes projects in all countries worldwide, as well as the document "Coal Mine Methane Global Overview", which includes:

- information on coal and its role in each country,
- existing CMM and coalbed methane activity worldwide, as well as

- market and regulatory issues for all Methane to Markets partner countries, as well as other key coal-producing countries.

4. Project Opportunities in Viet Nam

4.1 Overview of Viet Nam Coal Sector and Viet Nam's CMM Emissions

Viet Nam has total recoverable hard coal reserves of 150 million metric tons, the majority of which is anthracite (EIA, 2009; EIA, 2007). Viet Nam's most significant coal reserves are found in the northern part of the country in the Quang Yen anthracite region near the Red River Delta. Reserves in this area are estimated to be 190 to 272 billion metric tons (Methane to Markets, 2009). Viet Nam's coal mining industry is owned and operated by the state mining company, Vinacoal. Vinacoal operates 100% of all coal mines in the country.

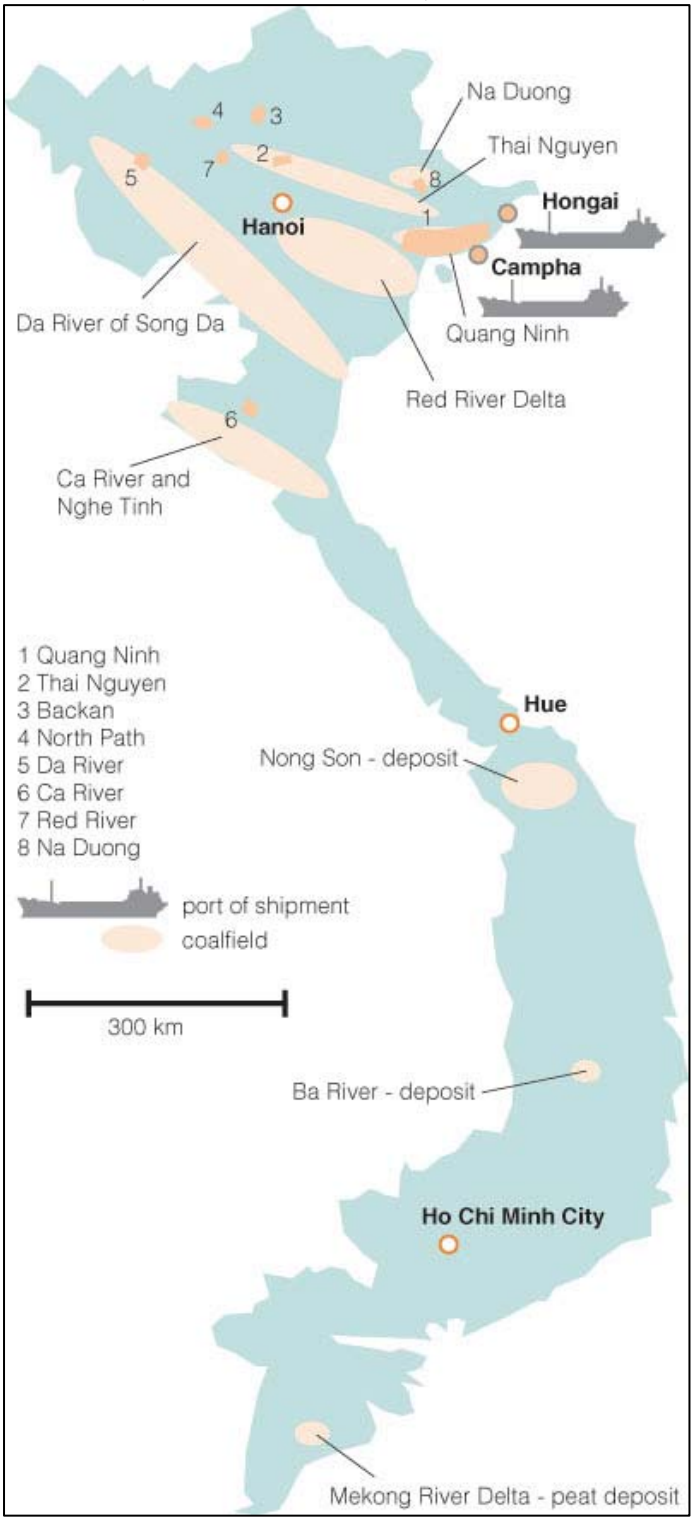

Figure 6: Viet Nam's Coalfields
Source: Baruya (2010)

Viet Nam produced almost 40 million metric tons of coal in 2008. Coal production has steadily risen since the early 1990s (EIA, 2009) and has reached up to 35% of capacity. Viet Nam is seeking to increase production of its deeper anthracite reserves for high-quality export grade coals, as well as for its expanding coal power sector. Viet Nam's coalfields are shown in Figure 6: Viet Nam's Coalfields.

With increasing coal production and the mining of deeper seams, CMM emissions in Viet Nam have also increased. No CMM recovery projects are currently operating or in development in Viet Nam. In 2005, Viet Nam ranked 23rd in worldwide CMM emissions. Table 1: Viet Nam's CMM Emissions summarizes Viet Nam's CMM emissions.

Table 1: Viet Nam's CMM Emissions

Emission Source	1990	1995	2000	2005	2010
Total million cubic meters	32	58	70	83	99†
Total thousand metric tons of CO2 equivalent (MtCO2E)	457	828	1,000	1,185	1,414†

Source: USEPA (2006a). †Projected.

4.2 Project Potential in Viet Nam

A recent study of Viet Nam's 25 gassy hard coal mines was commissioned to determine gas content of coals and to forecast methane release into the mines. Seven mines were classified as especially gassy. The results of the forecasts and a study of the capacities of these mines' ventilation systems are being used to estimate the amount of methane that may be captured by drainage systems. Additionally, the gassiest mine, Mao Khe, was equipped with an automatic methane content measurement control system. These efforts are a direct result of recent accidents in coal mines in Viet Nam resulting from increased methane emissions.

Viet Nam is a signatory to both the UNFCCC and the Kyoto Protocol. As a Non-Annex I Party to the Kyoto Protocol, it has no national emissions targets and is eligible to host mitigation projects under the Clean Development Mechanism. Viet Nam has a number of successfully registered CDM projects in other sectors, including hydro, waste water, and landfill gas.

As coal mining is poised to continue escalating in Viet Nam to meet the demand of 200 million metric tons by 2020, CMM projects will become increasingly attractive (MONRE, 2010a). As surface mines have closed, Viet Nam is seeking to increase production of deeper anthracite reserves to meet demand. Coal fired power is increasing as Viet Nam suffered a shortage of electricity of 8–10 TWh in 2008-09. By 2020, the shortage could be 115-225 TWh (Baruya, 2010).

There have been recent discussions within the country surrounding the use of natural gas to fuel power plants as well as the use of natural gas in the form of compressed natural gas (CNG) to operate vehicles (MONRE, 2010b; MONRE, 2010c). Between 2008 and the first half of 2009, Viet Nam commissioned 5 GWe of new electric capacity, much of which was gas-fired (2.7 GWe) (Baruya, 2010). As demand for natural gas grows, coal mine and coalbed methane should be considered.

A number of potential areas for CMM and CBM development exist in Viet Nam. The Red River Basin is an economically important area of northern Viet Nam. The area has coal deposits lying at depths of 250 to 1,200 meters spread over a 3,500 square kilometer area. Gas content of the basin's sub-bituminous coal is estimated at 0.94 to 1.6 m^3/tonne (30 to 50 scf/ton), with conservative resource estimates ranging from 170 to 280 billion m^3 (6 to 10 Tcf). Another area of interest is the Quang Yen Basin, which extends over 200 km from east to west in northeast Viet Nam and covers approximately 5,000 square kilometers. Though yet undetermined, CBM and CMM potential of this area is a target for study (Thai, 2008)

No CMM projects have occurred in Viet Nam; however, the CBM industry is emerging in areas where mining is poised to take place. Most of Viet Nam's CBM activity to date has been confined to the Red River Basin. Keeper Resources has been working on the first CBM extraction projects. The negotiated CBM concession with PetroVietnam and PetroVietnam Exploration Production Corporation (PVEP) covers approximately 3,600 square kilometers of the Red River Basin to the southeast of Hanoi. Three years of negotiations were concluded with the signing of a CBM Production Sharing Contract (PSC) in early 2010. The project proceeded with the signing of drill site construction and preparation contracts after acquiring land access approvals (Dragon Capital, 2008; Dragon Capital, 2010). A scoping study of the CBM potential in the Red River Basin commissioned by Keeper estimated prospective gas resources to be 55 billion cubic meters in the study area, which represents 28 percent of Keeper's concession (Keeper, 2005).

In addition, Arrow Energy has signed a PSC with PVEP in a CBM concession of 2,743 square kilometers in the Red River Basin. The PSC requires Arrow to drill eight wells on the block. Exploration drilling began in January 2009 (Arrow, 2009).

5. Conclusions

Currently, over 200 CMM projects operating in 14 countries are capturing 3 billion cubic meters of methane annually (OECD/IEA, 2008). The US and China, both top emitters of CMM, lead the way in CMM recovery and utilization. Currently, most projects involve gas sales or power generation; however, a number of other end-uses are applicable to CMM and are operated throughout the world. With VAM and LNG technologies expanding, new project opportunities for CMM continue to grow.

There are a number of countries in Asia with high CMM project potential. China has many operating CMM projects; however, with thousands of coal mines, project potential is still high. Mongolia and India have large coal reserves and a relatively untapped CBM and CMM market. CBM development is beginning in Indonesia and CMM projects would be possible at a number of the many surface mines. As many Asian countries are signatories to both the UNFCCC and the Kyoto Protocol as well as Non-Annex I Parties, many countries are eligible hosts to CDM projects thus project potential is enhanced by the opportunity for carbon credit sales.

In Viet Nam, with projected power shortages and increased demand for both coal and natural gas, CMM projects present a way to reduce emissions from the burgeoning coal mining industry and earn revenue by way of CDM, as well as produce much needed natural gas for the electric power industry.

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