Coal Mines

Methane is emitted from active and abandoned underground and surface mines, and as a result of post-mining activities, such as coal processing, storage, and transportation. Reducing methane emissions from coal mines can yield substantial environmental and economic benefits. Implementing available cost-effective methane emission reduction opportunities in the coal industry can lead to improved mine safety, greater mine productivity, and increased revenues.

In 2010, global methane emissions from coal mines were estimated at nearly 584 $MMTCO_2E$, which is approximately 8 percent of total anthropogenic methane emissions.[16] Over the next decade, CMM emissions are projected to increase by more than 15 percent, thereby providing significant potential for methane recovery from coal mines.[17]

The United States is a leader in CMM recovery and continues to work with international partners through GMI to share information, expertise, and technology to promote CMM project development. In 2010, the U.S. government supported these initiatives with $1.8 million. Major activities from this sector are summarized in this section.

15 percent

estimated increase in CMM emissions over the next decade

[16] U.S. EPA, 2011.

[17] Idem.

New CMM Feasibility Studies Highlight Opportunities in China

In China, EPA continues to support CMM recovery and utilization project opportunities with two new feasibility studies conducted at the Liuzhuang Coal Mine in Huainan Coal Field and the Linhua Mine located in Guizhou Province.

The Liuzhuang Mine, operated by state-owned SDIC Xinji Energy Co. Ltd., currently drains about 24.7 cubic meters per minute (m^3/min) of CMM to enhance safety and productivity. At present, none of this low-quality CMM (7 to 10 percent CH_4) is being utilized. The EPA-sponsored feasibility study proposes improving borehole drilling as a way to increase methane concentration to as high as 40 percent, which could then be utilized for onsite power generation with larger, more efficient internal combustion engines. SDIC has expressed interest in adopting this strategy. Over the 25-year life of the project, total net emission reductions are estimated to be approximately 8.26 $MMTCO_2E$.

The CMM drainage system at the Liuzhuang Mine may be transferable to a number of other Huainan mines with similar geologic and mining conditions. Widespread application of these technologies could cut methane emissions from the Huainan Coal Field in half, potentially avoiding nearly 1 billion m^3 (25 $MMTCO_2E$) of incremental annual methane emissions. In addition to the economic benefits and emission reductions, the system will improve mine safety, increase employment, and reduce local air pollution.

In Guizhou Province, EPA conducted a feasibility study to evaluate a CMM project opportunity at the Linhua Mine, which has a history of methane and CO_2 gas outbursts. The mine is estimated to have annual emissions of more than 40 million m^3 of methane per year. The feasibility study recommends implementing a directional drilling program consisting of a series of long directionally drilled boreholes ("trunks") and directionally drilled branching extensions ("side tracks") to pre-drain the coal seams in advance of mining. The study identified two viable end-use options for sale of the gas: 1) conversion of CMM to liquefied natural gas (LNG) and transporting the product to markets, which are experiencing an under-supply of natural gas; or 2) injecting produced CMM into a pipeline that connects with the Burma-China Pipeline.

The Linhua Mine was identified as an ideal site for a CMM recovery and use project because it is nearing the production stage of development, and similar projects could be replicated at other mines with similar conditions.

Assessing Coal Mine Emissions in Poland

CMM emissions account for more than 20 percent of Poland's overall methane emissions. As of 1997, about 300 million m^3 of methane were collected from active Polish coal mines annually, with 65 to 70 percent used on site at mines for heat, power, and coal drying.

Two EPA grants that evaluated potential CMM projects at active and abandoned mines in Poland were completed in 2010. The Institute for Ecology of Industrial Areas (IETU) in Katowice, Poland, was awarded a grant in 2008 to perform a feasibility study and assessment of converting abandoned mine methane (AMM) to LNG. Revaporated LNG can be used as an alternative to heating oil for technological processes in energy-intensive industry sectors. The project's overall goal was to identify and promote cost-effective, near-term methane recovery and end-use opportunities in Poland. It focused specifically on assessing the methane resources,

identifying the most promising application of available LNG at the Zory abandoned mine, and performing a market analysis of LNG applications as a clean-burning fuel.

Based on the final report submitted in 2010, an estimated 1.5 $MMTCO_2E$ per year can be recovered from the abandoned Zory mine area. These results indicate significant opportunities for CMM extraction and conversion to LNG. The Polish LNG market is promising because it is competitively priced and there is potential for further extension of the Polish gas distribution network, which is not fully developed. The greatest potential for LNG applications include heat and energy production, followed by vehicle fuel.

The Central Mining Institute of Katowice, Poland, also completed work under an EPA-funded grant in 2010. This project focused on assessing the ventilation air methane (VAM) emissions at 10 gassy mines in the Upper Silesian Coal Basin. The study characterized the VAM emissions (e.g., individual shaft flows, fluctuations, methane concentration variations) and explored the potential to mitigate or recover energy from these mines. During the project, the Central Mining Institute created a database for this information that can be used to promote better understanding of VAM, estimated the amount of recoverable methane, and identified technologies capable of converting low-concentration methane into electricity or heat. The study also provided information about electricity and heat demands at the coal mines themselves and nearby neighborhoods.

Capacity-Building and Project Evaluation in Mongolia

Through an EPA grant, in 2010 the Mongolian Nature and Environment Consortium (MNEC) completed a project designed to promote CMM recovery in Mongolia. The work included a detailed prefeasibility study on methane recovery and utilization, as well as data collection. In addition, MNEC identified barriers to CMM recovery and use, developed in-country capacity and awareness, disseminated information on investment opportunities, and submitted a proposal to the GEF to continue its efforts to remove barriers and promote investment in CMM recovery in Mongolia.

Based on the prefeasibility study results, the Mongolian government entered into a partnership with the Korean government to undertake a formal CMM reserves assessment at the now-closed Nailakh underground coal mine, including core drilling and resource assessment. MNEC is seeking funding for a combined 3.6 megawatt (MW) heat and power plant to be run on the CMM reserves. Estimated annual GHG reductions are 0.87 $MMTCO_2E$.

Drilling rig and coal core samples at Mongolia's Nailakh Mine.

In August 2010, EPA sponsored a two-day workshop in Ulaanbaatar to provide training on CMM project development in Mongolia. The workshop covered topics such as the legal and regulatory frameworks to promote CMM and coalbed methane (CBM) development, sampling and analytical

techniques, methane drainage and recovery technologies, and appropriate end use technologies for Mongolia. Representatives from seven different Mongolian coal companies participated, as well as officials from the Mongolian government, non-governmental organizations, the U.S. embassy, the World Bank, and international experts. The workshop concluded with a site visit to the Nailakh Mine site.

Disseminating Best Practices in China

In 2010, the report *Best Practice Guidance for Effective Methane Drainage and Use in Coal Mines* was published by the United Nations Economic Commission for Europe (UNECE) and GMI. This new document was developed by an international group of technical experts and peer-reviewed under the auspices of the UNECE's Ad Hoc Group of Experts on Coal Mine Methane. The *Best Practice Guidance* provides a genuine contribution to improving mine safety practices at active underground coal mines and encourages the use of CMM to reduce GHG emissions and utilize otherwise-wasted energy resources.

In October 2010, EPA funded a workshop in Beijing, China, focusing on application of best practices for methane drainage and recovery at Chinese coal mines. At the workshop, which was coordinated by the UNECE, ten Chinese experts representing major coalfield areas in China's northern, central, and western provinces actively participated in focused roundtable discussions. The workshop provided an excellent opportunity for Chinese coal mine engineers, mining institution representatives, and researchers to learn, debate, and exchange best practices on drilling, outburst prevention, and gas drainage and utilization issues with the international panel.

This event, held in conjunction with the GMI Coal Subcommittee and the 10th International Symposium on CBM/CMM, was the first of three planned best practices workshops. The second workshop was held in Karaganda, Kazakhstan, in May 2011, and the final workshop was held in Donetsk, Ukraine, in September 2011.

Promoting CMM Project Investment in Ukraine

To support activities raising awareness on the benefits of methane capture and utilization from coal mines in Ukraine, EPA sponsored an *International Investment Forum: Funding of Coal Mine Methane Projects in Ukraine* in June 2010. Held in Donetsk, an important coal mining and economic region in eastern Ukraine, the seminar attracted more than 100 stakeholders and drew strong support from the Committee of Verkhovna Rada of Ukraine on Fuel and Energy Complex, Nuclear Policy and Nuclear Safety; the Ministry of Coal Industry of Ukraine; and the Donetsk Regional State Administration. The forum's objective was to promote CMM recovery and utilization investment in Ukraine by providing information on project opportunities and highlighting the success of current and developing projects. The forum provided an opportunity for project developers, technology vendors, and financial institutions to exchange dialogue. A follow-up event was held in Donetsk in September 2011, focusing on degasification in advance of mining and VAM utilization.