Agriculture (Manure Management)

Globally, agricultural sources of methane emissions include enteric fermentation, rice planting, and livestock manure. Methane to Markets' agricultural activities focus on emissions from livestock manure, although the Partnership is exploring opportunities to expand to other methane sources. Methane produced and emitted during the anaerobic decomposition of livestock manure can be reduced, captured, and used as clean energy with anaerobic digestion technology. In 2005, the total amount of global methane from livestock manure that could potentially be utilized in this manner was estimated to be slightly more than 230 $MMTCO_2E$. Through Methane to Markets, the United States spent more than $1.9 million in 2008 advancing the recovery and use of methane at agricultural operations. Highlights of these activities are presented below.

Support for Livestock and Agro-Industrial Wastes

To stimulate the market for methane capture and use, EPA is conducting anaerobic digester feasibility assessments and technology demonstration projects in 11 countries in Southeast Asia, Latin America, and Eastern Europe. As a first step, EPA and in-country partners are identifying the resource potential for livestock manure and agro-industrial wastes by evaluating the methane reduction potential for specific sub-sectors (e.g., wineries, slaughterhouses, rice processing, dairy, fruit processing). The team is focusing on the sub-sectors with the greatest opportunities for cost-effective implementation of anaerobic digesters with methane recovery. As part of this effort, Methane to Markets developed a methodology for determining the feasibility of anaerobic digester systems at individual facilities, taking into account the size of the operation, waste management systems currently in place, potential for co-digestion of manure with agro-industrial wastes, and climate.

To date, resource assessments have been completed in Argentina and the Philippines and are underway for India, Mexico, Thailand, and Vietnam. During the project's next phase,

Reducing Methane Emissions in Vietnam

In Vietnam, swine farmers are recovering methane through household, farm, multiple-family, and communal demonstration systems. Many of these projects use recovered gas for cooking fuel, reducing the harmful health impacts of cooking with wood fuels by improving air quality in enclosed kitchen spaces. For example, in northern Vietnam's Tu Duong village, communal project participants collect pig wastes from 100 family-owned backyard piggeries. The waste is transferred through a gravity-based village canal system to a series of anaerobic digesters. The gas is piped back to the families and used as cooking and lighting fuel. The fee charged for the gas pays for system maintenance and a full-time operator.

An anaerobic digester in northern Vietnam's Tu Duong village helps provide fuel for the kitchen.

feasibility studies will be conducted at five facilities that will provide models for replication at other locations. As part of this effort, a feasibility study is being prepared for a covered lagoon for slaughterhouse wastes in Colombia, which (once completed) could provide the basis for replicating the covered lagoon design for other slaughterhouses in the country. In the final phase, the project will support construction, startup, operator training, and performance monitoring for systems at eight locations.

Improving Livestock Waste Management in Southeast Asia

Since 2004, EPA and the World Bank have supported improved livestock waste management projects in Southeast Asia. The World Bank has provided $21 million to China, Thailand, and Vietnam to develop affordable methods to help control pollution at livestock waste management facilities. As part of this program, EPA has provided financial support for demonstration projects, reviewed all technical aspects of livestock waste management programs, and begun developing sustainable policies to foster the replicating of and support for pollution control technologies, such as anaerobic digesters, over the long term. Individual countries are sharing their approaches to technical demonstrations, measuring impacts, and developing regional support infrastructure. Through the deployment of anaerobic digestion technologies and land application of waste to crops, these initiatives are mitigating water pollution from confined swine production while achieving other environmental and human health benefits. To date, six projects are in operation in China, three in Vietnam, and one in Thailand. A number of other projects are currently in the planning or construction phases.

Livestock Waste Management and Emissions Reductions in China

Dengdaming Pig Farm is a project demonstration site located in Changning Township in Guangdong Province, a major livestock production region in China approximately 90 kilometers from the provincial capital of Guangzhou. This farrow-to-finish swine farm has a standing pig population of 3,000, a typical number for swine farms in this region. An up-flow anaerobic digester with a separate floating type gas storage recovers gas to power a 60-kilowatt engine generator and produces electricity for 12 hours a day. The Chinese are also starting to demonstrate digesters that combine gas production with gas storage in factory fabricated steel tanks. These technical elements reduce costs and are critical in China's replication strategy.

Anaerobic digester at Dengdaming Farm in Changning Township, China.

International Protocol for Anaerobic Digestion

EPA is developing an international protocol to evaluate the environmental performance of anaerobic digestion systems. Currently, comparison of various anaerobic digestion technologies is difficult because system data have not been collected following a standardized methodology. The ability to compare different system design approaches with respect to biogas production, waste stabilization, and cost effectiveness on a uniform basis has been lacking. The purpose of this protocol is to provide a standardized method to evaluate different anaerobic digestion technologies and allow for comparison of the technologies. EPA assembled a panel of international experts on anaerobic digestion to review the protocol in order to assure its applicability to systems used in different regions around the world. The final protocol was completed in September 2009.

Coal Mines

Methane gas released from coal mining activities can be captured and used as a clean energy source, resulting in reduced GHG emissions, improved air quality, and enhanced mine safety. In 2005, global methane emissions from coal mines were estimated to be nearly 400 $MMTCO_2E$. The United States is a leader in CMM recovery and continues to work with international partners through Methane to Markets to share information, expertise, and technology to promote CMM project development. In this reporting year, the U.S. government has supported these initiatives with more than $2.2 million in funding. Major activities from this sector are summarized below.

Supporting Technology Demonstration Projects in China and Poland

EPA is supporting demonstration projects to showcase cutting-edge technologies to recover and use CMM. In Poland, EPA is sponsoring a project to study and demonstrate a technology that converts CMM to liquefied natural gas (LNG). In China, EPA is supporting a project to evaluate and demonstrate the use of diluted methane emissions from underground mine ventilation systems (also known as ventilation air methane or VAM) using a new technology, a monolithic catalytic combustor, at a Chinese coal mine.

A small-scale LNG plant converts CMM into LNG at the Zory Coal Mine in Poland.

Building Capacity and Overcoming Informational Barriers in India and China

One significant barrier to developing effective CMM recovery and use projects is the lack of information about specific coal mine project opportunities and available technologies and practices. To help project developers overcome these barriers, the United States is supporting several initiatives to increase the flow of information and foster in-country technical expertise.

In India, which is currently the world's third-largest coal producer, EPA, USTDA, and the government of India established a CMM/Coalbed Methane (CBM) Clearinghouse. India's Ministry of Coal and the Ministry of Petroleum and Natural Gas manage the clearinghouse. In 2008, EPA and USTDA organized a kickoff event to inaugurate this work in Ranchi, India, and EPA has continued to provide technical training and funding. India's coal production is predicted to increase dramatically in the near future, and CMM emissions are expected to increase as well unless methane recovery and utilization projects are implemented.

In China, EPA continued to support the work of the CBM Clearinghouse in Beijing. The clearinghouse provides services to a variety of international organizations, including the International Energy Agency (IEA), the Asian Development Bank, and the United Nations Development Program. It also provides project developers and investors with easily accessible, in-country technical and regulatory expertise on CMM project development.

In 2008, the United States also supported a number of capacity building initiatives in China. For instance, USTDA and EPA sponsored an in-depth training program for the China National Development and Reform Commission in Dalian, China. With technical assistance from EPA, the training focused on technical aspects of CMM projects, including degasification, recovery, and end-use technologies.

EPA also supported several initiatives to increase awareness and expertise at the provincial level in China. For example, EPA funded the CMM Recovery and Utilization Initiative in Guizhou Province, a relatively poor province with more than 2,000 coal mines producing a total of 100 million tons of coal annually. This province has great potential for CMM recovery and utilization as a clean energy source, but for most mines it is not realized due to lack of information, communication, and market barriers. The initiative provided international project developers with focused and current information regarding project development opportunities at 45 coal mines in Guizhou and included a successful workshop to connect stakeholders with the international project development community.

EPA also supported IEA's efforts to evaluate the potential for CMM projects in the Guizhou and Sichuan provinces, two relatively overlooked provinces in terms of CMM development. Based on extensive field visits and interviews, IEA developed a white paper that outlines recommendations for reducing technology, policy, and financial barriers. In addition, EPA funded a project organized by the Jackson Hole Center for Global Affairs that focused on the challenges and opportunities in the southern part of Shanxi Province, China's largest coal-producing province. This effort brought together key stakeholders at a workshop in Jincheng to address the barriers to CMM project development in this important coal region.

Chinese Mines to Use Advanced Technology to Deliver CMM-based Power

A recent EPA-sponsored feasibility study is helping operators at six mines in the Chongquing Municipality of China to purify and liquefy medium-concentration CMM into LNG. Implementing the latest technology for CMM, officials from the Songzao Coal Mine plan to integrate CMM-based power beyond the immediate vicinity of the mines and into the country's larger energy economy—a technological milestone for China.

The project sponsor, Chongquing Energy Investment Group, is pursuing funding while waiting for final government approvals. Construction is expected to begin in 2010 allowing operations to start in 2012. When completed, the Songzao Coal Mines are expected to generate 170 million cubic meters of LNG to be sold into China's booming natural gas market. Additionally, new on-site mine-mouth power generation facilities, with a capacity of 26.9 MW, will use a portion of the CMM pumped from the most remote stations as fuel. Total emission reductions are expected to reach 44.1 MMTCO_2E over the 15-year life of the project.

Supporting Pre-Feasibility and Feasibility Studies in Partner Countries

Pre-feasibility and feasibility studies are key steps in project development. Pre-feasibility studies help developers determine whether a project has the potential to succeed financially and technically. This information is necessary to raise needed capital and generate interest to move the project forward to the next stage of development: the feasibility study. The feasibility study provides developers with more detailed analysis on costs, challenges, and expected results based on project parameters. Undertaking either type of study can be challenging and expensive.

The United States has funded several pre-feasibility and feasibility studies for projects in the coal sector to help advance project development in China, India, Poland, and Mongolia. These studies provide important information that accelerates project implementation. For example, in 2008:

- EPA conducted three comprehensive feasibility studies at Chinese coal mines to assess the technical and economic viability of implementing CMM recovery and utilization projects:
  - Liuzhuang Mine in Anhui Province.
  - A group of six mines in the Songzao Coal Basin in Chongqing.
  - A group of six mines at Hebi in Henan Province.
- The study for the Songzao mines evaluated CMM use for a combined power generation/LNG project and estimated the potential to reduce emissions by 4.4 $MMTCO_2E$ annually.
- In India, EPA funded a study quantifying VAM from two mines in the Jharia Coal Basin. EPA is also funding a feasibility study of CMM recovery from underground coal mines in three coal basins: Bokaro, Jharia, and the Ranigani Coal Fields.
- In Poland, EPA funded an assessment of VAM at 10 mines to determine their feasibility for methane mitigation or energy recovery projects.
- In Mongolia, EPA funded a pre-feasibility study to evaluate the potential for CMM recovery and utilization at the Nalaikh Coal Mine.

Dr. M. Badarch, General Director of the Mongolia Nature and Environment Consortium and member of the Methane to Markets Coal Subcommitee, visits the Nalaikh Coal Mine near Ulaanbaatar, Mongolia.

Overcoming Financial and Policy Barriers in Russia and Eastern Europe

The United States has supported a multi-year effort by the United Nations Economic Commission for Europe (UNECE) to reduce financial barriers to CMM projects in Russia and Eastern Europe. In 2008, this project concluded as technical and financial experts helped develop bankable documents for the Krasnogorskaya Mine in Russia. This mine was then showcased before six interested investors in London. The final report has been posted on the UNECE Web site to share lessons learned.

Landfills

Methane is produced from landfills when organic matter decays under natural anaerobic conditions. Landfill gas (LFG) can be a source of clean energy, typically composed of about 50 percent methane. LFG can be used as a direct substitute for fossil fuel consumption to generate electricity, or refined and injected into the natural gas pipeline. Capturing and using LFG in these ways can yield substantial energy, economic, environmental, air quality, and public health benefits.

In 2005, global methane emissions from landfills were estimated to be nearly 750 $MMTCO_2E$. This year, the United States has been a leader in the recovery of LFG and has spent more than $3.2 million to expand the productive use of LFG through Methane to Markets. Highlights of these efforts are summarized below.

Building Capacity Through Workshops and Training in Colombia, Ecuador, and Nigeria

At the International Renewable Energy Conference Africa, held annually in the Nigerian capital city, Abuja, EPA shared international developments in the LFG-to-energy sector and brought organizations together to stimulate project development at Nigeria's landfills. More than 100 people from Nigerian state and federal government agencies, the private sector, and academia attended as well as several participants from other African and European countries. The Nigerian landfill sector is now seeing a burst of activity. Developers are preparing a preliminary inventory of landfills, planning to evaluate the feasibility of LFG energy at landfills, and working with other stakeholders in Nigeria's waste management sector, including the Waste Management Society of Nigeria, to identify opportunities.

In Colombia, as part of a national conference organized by the Colombian Association of Environmental and Sanitation Engineering, EPA held a workshop and training session on the basics of LFG capture, estimating gas recovery potential, and energy utilization technologies. Approximately 100 participants attended, including landfill and solid waste officials representing several Colombian municipalities.

In July 2008, EPA helped train approximately 150 representatives of Ecuadoran municipalities, including several mayors, in LFG energy project development. The workshop was interactive, allowing participants to share lessons learned and best practices.

Pre-Feasibility and Assessment Studies Conducted in Argentina, India, Mexico, and Ukraine

Thorough study and analysis are essential for launching successful LFG projects. Using a range of energy recovery technologies, engineers conduct pre-feasibility and assessment studies to generate important data, such as the availability of LFG, and determine the economic feasibility of a specific project. These data are vital in helping developers and investors decide if they want to take the project to full development.

- In Bahia Blanca, Argentina, a seaport city in the southeast portion of Buenos Aires Province with a population of approximately 300,000, EPA conducted a pump test for an LFG pre-feasibility study. EPA estimated that projected gas recovery potential in 2008, after installation of a gas collection system, was approximately 625 cubic meters per hour. EPA completed and presented the report to municipal officials in June 2008. A potential end-user has been identified and EPA continues to work with the municipality to advance this project.
- In Ahmedabad, India, EPA conducted a direct user assessment of five local industries around the Pirana Landfill. The local industries included a compost factory, cement factory, denim factory, dyeing facility, and a chemical facility. EPA collected information on the energy needs of these facilities as well as their distance from the landfill. EPA also conducted a feasibility study to determine whether LFG could be used as a source of LNG for vehicles in India. The final report will be released in late 2009.
- In Mexico City, EPA conducted a preliminary assessment of the potential for LFG recovery and utilization at the Bordo Poniente Landfill. With a capacity to hold 56 million tons of solid waste, the landfill is Mexico's largest and serves the 20 million residents of Mexico City. The Mexico City municipal government asked EPA to conduct this assessment to enable it to have an objective third-party evaluation with which to compare LFG studies that it and other organizations have completed. The assessment found that Bordo Poniente is a good candidate for an LFG recovery and utilization project. It would have the potential to reduce approximately 5.15 $MMTCO_2E$ through 2012 and produce 14 MW of electricity at full capacity.
- In Mariupol, Ukraine, near the Sea of Azoz, EPA conducted pump tests at a local landfill. Three vertical extraction wells, seven monitoring probes, collection piping, and an electric blower provided by an adjoining brick manufacturing facility were installed, and local Ukrainian engineers conducted the drilling. Based on the initial results, EPA estimated LFG recovery to be 290 to 408 standard cubic feet per minute, a robust estimate considering most landfills in the country are controlled but uncapped and uncovered. After finalizing the pump test, EPA examined various end users for the gas, including a flaring only option as well as direct use by the brick manufacturing facility. EPA will use data from this pump test, as well as a 2007 pump test conducted in Chernvtsi, to develop a Ukraine-specific LFG recovery model in 2009.

Constructing a test well for a pump test at the Bahia Blanca landfill in Argentina.

Landfill Data Collection Efforts in Argentina, Russia, Thailand, and the Philippines

EPA collaborated with Partner Countries in the collection of landfill data to explore the capture and use of LFG.

- In Argentina, working with the Asociación para el Estudio de los Residuos Solidos (ARS) and Universidad Nacional del Centro de la Provincia de Buenos Aires, Olivarria (UNCPBA), EPA has launched efforts to collect landfill profile data on mid-size municipal landfills and controlled dumps (serving populations greater than 100,000) and to evaluate potential direct-use opportunities, respectively. To date, ARS has identified 40 landfills and is continuing efforts to collect additional profile data. Additionally, UNCPBA has evaluated 10 sites that are currently collecting gas but not using it for energy. Of those sites, two appear to have the potential for a direct-use project. EPA will be exploring direct-use opportunities at these sites in the future.
- In Novokuznetsk, in southern Siberia, EPA assessed candidate sites and assisted a local nonprofit organization, the Ecological Research Centre (ERC), with the first comprehensive landfill inventory in Russia. With funding from an EPA grant, ERC has collected data from more than 800 landfills representing 72 out of Russia's 83 regions. The data include critical information on landfill location, size, capacity, waste depth, and open and closure years. ERC completed the database and presented the results at Russia's biannual Waste-Tech Conference in Moscow in 2009.
- With EPA participation, the governments of Thailand and the Philippines took part in a scoping mission to gather data and information on their landfills. As part of this effort, EPA met with LFG energy stakeholders and visited landfills to obtain additional site-specific landfill data.

EPA Assessment Advances Recovery Options at Colombian Landfill

The Doña Juana Landfill, located in and owned by the city of Bogotá, Colombia, will soon be a source of clean, domestic energy. Thanks in part to a 2007 EPA grant, engineers were able to assess the landfill and find significant potential for methane capture and use. This led to the site being featured at the 2007 Partnership Expo in Beijing, China. Since then, landfill operators have installed a flaring system that began operating in early 2009, and they continue to research full methane generation potential and consider future options. While site conditions and leachate collection system limitations prevent recovery of all biogas at the site, EPA estimates the landfill could realize annual emissions reductions of more than 1.2 $MMTCO_2E$ by 2016 when the landfill is anticipated to close with more than 48 million tons of waste in place.

Doña Juana Landfill in Bogotá, Colombia.

Model Developed for Chinese LFG

EPA completed the first draft of the Landfill Gas Emissions Model (LandGEM) simulating waste and climate conditions in China. This model will allow users to produce typical LFG generation and recovery estimates for landfills located in various regions of China. EPA is anticipating a full launch of the model to take place in late 2009.

Oil and Gas Systems

Methane emissions from oil and gas systems can be the result of normal operations, routine maintenance, and system disruptions. Reducing fugitive emissions can minimize product losses, enhance energy security, lower methane emissions, and increase revenues. In 2005, global methane emissions from oil and gas systems that could be utilized were estimated at nearly 1,170 $MMTCO_2E$.

The United States has collaborated with the Methane to Markets Partnership to encourage Partner Countries to implement proven, cost-effective technologies and practices that improve operational efficiency and reduce emissions. In this reporting year, the U.S. government has spent more than $2.3 million to support the deployment of these measures. Some of the U.S. government's notable 2008 accomplishments and ongoing activities are discussed below.

USAID and EPA Continue to Assist in PEMEX Efforts to Reduce Methane Emissions

USAID and EPA are continuing their support of several project activities with Mexico's state-owned oil company, Petróleos Mexicanos (PEMEX). The overall aim is to achieve significant cost-effective reductions in methane emissions at PEMEX and implement a sustainable GHG management program. The key benefits will include increased projects, improved energy efficiency, conservation of a valuable non-renewable resource, and reduced emissions. Ongoing activities focus on identifying and developing methane emission reduction projects and building organizational resources to sustain this work. To date, PEMEX has conducted campaigns at six facilities to quantify methane emissions, identify emissions reduction opportunities, and provide on-the-job training.

Through directed inspection, maintenance, and replacement of wet seals on compressors, PEMEX has reduced on-site emissions by approximately 30,000 metric tons of CO_2 equivalent ($MTCO_2E$). PEMEX has additional compressor seal replacement projects underway, which will reduce emissions by an additional 70,000 $MTCO_2E$. Projects that could yield additional reductions of approximately 400,000 $MTCO_2E$ in four other facilities have been identified.

EPA is helping PEMEX management establish internal leadership and organization to sustain further methane emissions reduction activities. As part of this effort, PEMEX is developing a comprehensive, corporate-wide emissions inventory. The inventory will serve as the basis for determining abatement potential. Specifically, in parallel, EPA has developed a marginal abatement cost (MAC) model tailored to the specific attributes of PEMEX. The MAC model is intended to provide information and guidance to PEMEX leadership as it advances its climate change strategy and sets methane emission reduction targets.

Work Continues on Reducing Emissions From Oil and Natural Gas Assets in India

In 2008, through Natural Gas STAR International, EPA continued its partnership with India's Oil and Natural Gas Company (ONGC) to work on reducing methane emissions. ONGC provided detailed operational data on seven of its sites, and EPA performed analysis to determine four priority sites. EPA analyzed and aggregated the emissions measurement results as well as the economic features for 12 methane recovery projects at these sites. If fully implemented, these projects could save approximately 154,000 $MTCO_2E$.

Methane to Markets–ONGC Collaboration Builds Capacity for Methane Reductions

The technical collaboration between EPA and the Oil and Natural Gas Corporation of India (ONGC), administered under the Methane to Markets Partnership, is building a strong base of knowledge and capacity within ONGC to cost-effectively reduce methane emissions now and into the future. Based on methane emissions identified and quantified during collaborative measurement studies in May 2008, and a resulting directive from the Board of Directors to actively implement mitigation projects, ONGC has reduced methane by approximately 115.47 thousand cubic feet, which is approximately 46,700 $MTCO_2E$. ONGC achieved these reductions through a variety of means, including repairing pipeline leaks, changing valves and replacing valve packings, replacing rod packing seals in reciprocating compressors, and at times simply tightening bolts. Thanks to these simple maintenance activities, ONGC is reaping the benefits of saving natural gas valued at $134,116 (at local natural gas values), increasing operational efficiency, and enhancing workplace safety by reducing fire hazard.

And this is just the start. ONGC has formed an internal measurement team and is currently procuring methane emission detection and measurement equipment in order to be able to replicate measurement studies in the future. EPA and ONGC have collaborated to train this team on the use of the measurement study equipment and conducted detailed technical studies to support implementation plans for more extensive capital investment projects to reduce methane emissions in the future. These plans—scheduled for completion in late 2010—include capturing low-pressure vented and flared gas at the Heera and Neelam Offshore Platforms in order to compress the gas for sale and internal use and capturing oil storage tank emissions from ONGC's Uran Plant near Mumbai.

Identifying Methane Emission Reduction Opportunities in Russia

Russia is a significant emitter of methane from oil and gas operations because of its large oil and gas operations. As Russian natural gas production continues to grow, identifying opportunities to reduce emissions is increasingly important. Several companies in Russia, including Gazprom, have begun to monitor or mitigate methane emissions from their systems. EPA and Battelle Memorial Institute, an international science and technology enterprise that explores emerging areas of science, have launched a project to work with Russia on methane mitigation in the Russian oil and gas sector. The project focuses on three main areas:

- Exchanging technical information on approaches to reducing methane emissions in the oil and gas sector.
- Developing a network of contacts in Russia to enhance awareness of methane identification and mitigation opportunities in the natural gas sector.
- Promoting technology transfer and investigating opportunities to develop methane mitigation projects in the Russian oil and natural gas sector.

In October 2008, Gazprom, VNIIGAZ (Gazprom's research institute) and EPA, with technical support from Battelle Memorial Institute, held a technology transfer workshop on methane mitigation in the natural gas and oil sectors in Moscow. The workshop focused on exchanging detailed technical information on proven, cost-effective technologies and practices to reduce methane emissions. Participants also visited a Russian compressor station to view several state-of-the-art technologies that detect and measure methane leaks.