Agriculture

Methane is produced and emitted from the decomposition of livestock and food processing wastes (LFPW) that are stored or treated in systems that promote anaerobic conditions (e.g., liquids or slurries in open lagoons, ponds, tanks, or pits). Reducing methane emissions from LFPW management, however, can yield substantial economic, environmental, and energy benefits. In the agriculture sector, implementing anaerobic digestion (AD) technology can lead to improved air and water quality, odor control, improved nutrient management, reduced GHGs, and the capture and use of biogas—a source of clean, renewable energy.

237 MMTCO$_2$E

estimated LFPW emissions in 2010

In 2010, global methane emissions from LFPW management were estimated to be nearly 237 MMTCO$_2$E, which is almost 4 percent of the total global anthropogenic methane emissions.[11] Over the next decade, methane emissions from LFPW are projected to increase by more than 11 percent, thereby providing significant potential for methane recovery from the LFPW sector.[12]

Through GMI, the United States invested more than $725,000 in 2010 to help advance the recovery and use of methane at agricultural operations internationally. Many of the supported activities will continue to lead to methane emission reductions in future years. Some of these activities are presented in this section.

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[11] U.S. EPA, 2011.

[12] Idem.

Identifying Project Opportunities Through Resource Assessments

The United States has continued to support a strategic approach to reducing methane from the LFPW sector. As a first step, the United States assists in developing country-specific resource assessments (RAs), which help to identify and rank the LFPW sectors and sub-sectors where emission reductions can be achieved. In 2010, EPA finalized RAs for four GMI Partner Countries: Brazil, Ecuador, Mexico, and Vietnam. Based on the RAs performed to date, more than 50 $MMTC0_2E$ could be reduced by implementing AD systems in the LFPW sector (see Table 2).

Table 2: Emission Reduction Potential from AD Implementation

Country	Total Carbon Emission Reductions ($MTCO_2E$/yr)
Argentina	2,274,700
Brazil	20,313,300
Colombia	1,241,700
Ecuador	386,500
India	5,716,100
Mexico	14,785,600
Philippines	2,553,800
Thailand	4,956,000
Vietnam	1,420,300
Total	**53,648,000**

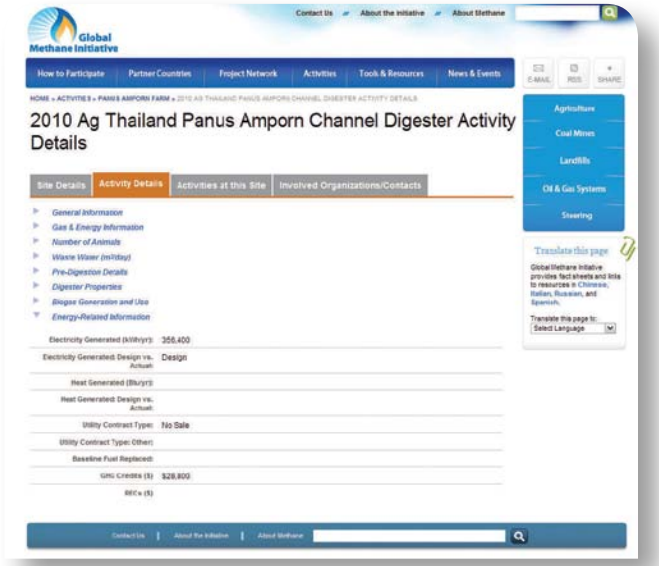
Additionally, EPA supported the development of a report titled *"Barriers and Constraints to Implementation of Anaerobic Digestion Systems in Swine Farms in the Philippines,"* which analyzes methane-reducing project development barriers faced by household- and commercial-scale pork production in the Philippines. The report is based on stakeholder interviews with lending institutions and project developers, data review, and communications with key experts and farm owners. This report is an important step in the development of a sustainable program to increase AD utilization in the Philippine swine sector.

Developing an International AD Database

EPA has begun developing an international database that will provide general information on the types and scale of operating AD systems in GMI Partner Countries. The database will track and report important project-specific information about each digester, such as:

- Agricultural Subsector
- Project Scale
- Digester Type
- Energy Production
- Methane Reduction

In 2010, EPA worked with Partner Countries to create a standardized data collection template that will streamline this process and ensure that the database presents quality information to its users.



Beta version of International AD Database.

Expanding the Agricultural Sector in Thailand

Through the Division of Livestock Development in Thailand, EPA project support has expanded to explore methane reduction opportunities in the wet market waste sector.[13] The purpose of this sector expansion is to identify upstream methane-reducing options for these wastes before they are deposited in landfills. Based on the results of the Thailand RA, wet market waste is one of the sectors with large methane emission reduction potential. The analysis, which consists of characterizing waste handling and management across all wet markets in Bangkok, identifies and ranks various opportunities according to economic and operational merits. Examples of these opportunities include active and passive composting systems, vermiculture, AD, and other methane-reduction processes. The overall project objectives are to identify potential demonstration projects and to apply the analytical approach to rural areas in Thailand as well as other GMI countries. Some key findings to date include:

- In 2007, Thailand generated approximately 15 million metric tons of municipal solid waste (MSW). Wet market waste was estimated to represent about 9 percent of MSW. Therefore, potential reductions could be realized from the organic fraction of more than 1 million tons of waste.
- Methane emissions from Bangkok's wet market waste management (primary solids collection and landfill disposal) were estimated at 49,250 metric tons of methane per year, or approximately 1 $MMTCO_2E$ per year.[14]

EPA has also been assisting Thailand in reducing methane emissions from swine farms. Swine farming is a major subsector of Thailand's livestock industry. As of December 2008, Thailand had approximately 8.5 million pigs and hogs managed through a combination of "standard" commercial farms (about 3,400 operations representing 60 percent of the industry) and nonregistered commercial and backyard farms (totaling more than 200,000).

Sludge drying bed at Thailand's Kanchana Farm.

Thailand began working with GMI to reduce methane from swine farms in three provinces near Bangkok in 2010. Continued support from GMI, the World Bank's Global Environmental Facility (GEF), and Thailand's Department of Livestock Development and Energy Policy and Planning Office, resulted in nearly 60,000 $MTCO_2E$ of methane emission reductions in 2010 from more than a dozen swine farms—raising approximately 200,000 pigs total—that converted from open lagoons to biogas systems (e.g., Kanchana Hybrid Farm in Ratchaburi Province).

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[13] Wet market wastes are found in open markets in developing countries and consist of spoiled vegetable, meat, fish, and other perishable organics sold through these types of markets, which are typically disposed of in landfills.

[14] Based on IPCC's default method for solid waste disposal.

Continuing Methane Reducing Efforts With the World Bank

GMI's agricultural sector continues to work with the World Bank in other countries to provide technical support to reduce methane emissions from agricultural sources, improve living conditions, and increase the rate of economic development in rural areas. The main emphasis of this partnership is to develop a country-specific programmatic framework that enables project development. In 2010, EPA continued to support activities in Vietnam, China, the Philippines, Mexico, and Thailand—often through a *Program of Activities (PoA)*—to reduce carbon emissions from the LFPW sector.

The Philippines, for example, has used the *PoA* approach as the primary basis for developing an advanced program in the household- and commercial-scale pork sectors.[15] This approach has been responsible for the development of a number of household- and large-scale methane recovery projects using various types of AD systems.

An assessment of national capacity demonstrated a need for affordable delivery and maintenance of methane-reducing technologies in the Philippines. Therefore, in consultation with Philippine partners, EPA planned a series of hands-on trainings to transfer methane recovery and gas use technologies that had been used effectively in similar GMI projects around the world. In 2010, Philippine partners identified a select group of approximately 30 individuals in the government and private sectors to receive training on AD and the PoA as the first phase of a multi-year project. EPA conducted the first of a series of trainings for this group on AD technologies for small and large farms, gas utilization technology, techniques for conducting farm feasibility assessments, and estimating energy production and emission reduction potential, followed by a hands-on training for the group on construction of household-scale ferrocement fixed dome digesters. The partnership between GMI and the World Bank allowed the organizations to leverage resources at a ratio of about $1:$8 and provides an excellent model that could be replicated in other developing countries that are members of the Initiative.

Stacked fixed dome digester construction at Nueva Vizcaya, Philippines.

[15] Mexico has also used this approach to expand the use of AD in the pork sector.

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.

Landfills

Landfills produce methane when organic matter in the landfill decays under anaerobic conditions. Landfill gas (LFG) is composed of about 50 percent methane and, when captured, can be a source of clean energy. It can also be used as a substitute for fossil fuel in industrial boilers or to generate electricity, or it can be refined and injected into the natural gas pipeline or used as vehicle fuel. Capturing and using LFG in these ways can yield substantial energy, economic, environmental, air quality, and public health benefits.

In 2010, global methane emissions from landfills were estimated to be 799 $MMTCO_2E$, which is approximately 11 percent of total anthropogenic methane emissions.[18] Over the next decade, landfill methane emissions are estimated to reach more than 855 $MMTCO_2E$.[19]

The United States has been a leader in the recovery and use of LFG and spent more than $1.3 million in 2010 to expand the productive use of LFG through GMI. Specific workshops and projects to capture and reuse methane from LFG are described below.

855 $MMTCO_2E$

estimated landfill methane emissions by 2020

[18] U.S. EPA, 2011.

[19] Idem.

LFG workshop in Santiago, Chile.

Delivering Information and Training via Workshops

In the past year, nearly 1,000 individuals have attended workshops on LFG recovery and use in 10 Partner Countries, including Argentina, Brazil, China, Colombia, Mexico, the Philippines, Poland, Russia, Serbia, and Ukraine.

The landfill team at EPA consistently works with its partners to develop training materials to build capacity in the waste sector. EPA has developed three core curricula to advance LFG energy: landfill operations and management, LFG collection system operations, and LFG energy project procurement. These trainings are targeted directly at landfill operators or municipalities with prospective projects and have served to improve the overall conditions at landfills in addition to advancing LFG energy.

Philippines Training for Site Assessment and Potential Emission Reductions

In June 2010, EPA staff facilitated a training session in conjunction with Landbank in Manila, Philippines, to build capacity for local officials on identifying project opportunities, as well as assessing LFG energy systems. The workshop provided guidance on assessing site characteristics, infrastructure, and operational practices to determine the potential for emission reductions. Representatives from Landbank's carbon finance unit, as well as several local landfill owners, attended the training.

International Solid Waste Association (ISWA) Organizes Forums Around the Globe

In June 2010, the ISWA Beacon Conference in Buenos Aires, Argentina, invited landfill owners and managers, government officials, project developers, and project financiers to a workshop covering the basics of LFG projects. Titled "Creating Viable LFG-to-Energy Projects in Latin America," the workshop provided an overview of the landfill sector, explained LFG energy systems, and reviewed the basics of project planning. Speakers shared strategies on how to bring a landfill online, as well as insights into project design and financing. Representatives from Partner Countries presented specific opportunities and project models for LFG capture and use in Latin America and also discussed financing and incentive programs.

In December 2010, ISWA held a conference in Novi Sad, Serbia, with representatives from Bulgaria, Poland, Serbia, and Ukraine in attendance. The one-day conference included an overview of gas collection and control systems, business models for LFG energy projects in southeastern Europe, and opportunities and barriers to developing such projects in the region. Speakers presented case studies of regional projects, including LFG energy projects in Poland.

Advancing LFG Data Collection and Analysis

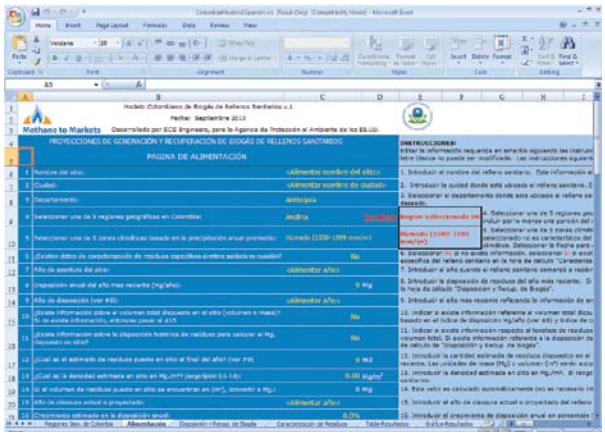
Nigerian Landfills Inventory

With support from EPA, Rutgers University received funding to develop an inventory of landfills in Nigeria. The 2009 grant built on a previous GMI grant that funded preliminary site visits

and assessments at landfills in two Nigerian cities: Lagos and Abuja. To complete a national landfill inventory, data collection targeted landfills in six other major population centers in Nigeria. The first phase of research entailed meeting with waste management authorities and landfill managers in Akure, Jos, Kano, Kaduna, Zaria, and Port Harcourt to explain the project and distribute a survey designed to collect information for GMI's International Landfill Database. After data collection, preliminary site assessments were conducted at 26 dumpsites, and results were shared with local officials. The next phase will require project leaders to explore partnerships with private companies to begin improving disposal sites and recovering LFG.

EPA's LFG Models Assist Project Development

EPA developed a new LFG model for Colombia, that can be used to estimate LFG generation rates from landfills and potential LFG recovery rates for landfills that have—or plan to have—gas collection and control systems. In September 2010, EPA held a workshop in Medellin, Colombia, to train people to use the new model. Approximately 60 individuals participated in the event, including representatives from federal, state, and local governments; employees from waste management companies; consultants; developers; and students.


Colombia's LFG Model.

LFG models were also developed for the Philippines, Ukraine, and Thailand; these models were completed and circulated in 2010 to help stakeholders estimate LFG generation and recovery potential in each country. The models provide recommended values for input variables based on climate data, waste characteristics, and disposal practices, and the estimated effect of these conditions on the amounts and rates of LFG generation. Each model has a companion user's manual for reference.

Collecting LFG for On- and Off-Site Uses

The Closed Mariupol Landfill is located in the city of Mariupol, Ukraine, and is owned by the Mariupol City State Administration. The landfill is located in a mixed-use area with residential, agricultural, commercial, and industrial uses. Until its closure in 2008, the landfill accepted domestic and commercial waste from the city of Mariupol. During its active phase, certain landfill management practices led to significant leachate production, stormwater runoff, and unintended fires.

In August and September 2008, EPA conducted pump tests at this landfill, which yielded a LFG recovery rate capable of supporting a flare and/or electricity project. In February 2009, the Mariupol City Council awarded the LFG capture and utilization project at two of the city's landfills to TIS Eco Company. GMI Project Network members TIS Eco Company, in partnership with Scientific Engineering Center (SEC) Biomass, began construction activities at the first landfill in June 2009. The system was commissioned in February 2010. In August 2010, the National Environmental Investment Agency issued a Letter of Approval to the "Collection and

recycling of methane from solid waste landfills, Mariupol, Ukraine" for a Joint Implementation project.

The collected LFG is being directed to a cogeneration plant, where up to 1.25 MW of electricity is expected to be generated and supplied to a distribution network. Some of the electricity produced will also offset the needs of the LFG collection and distribution system. Heat energy generated at the plant will provide an alternative energy source for a nearby greenhouse and brick manufacturing facility using an infrared heater or a kiln. Surplus LFG will be flared. The LFG collection system and cogeneration plant are expected to function for up to 15 years.

Generating Electricity at Gaoantun Landfill

Gaoantun Landfill is a sanitary landfill owned and operated by the Beijing Chaoyang District Garbage Innocent Disposal Center. In 2007, EPA conducted a pump test and produced a prefeasibility study on the potential to expand LFG utilization at this site. In 2010, EPA provided follow-up technical assistance and monitoring of the gas collection system to identify how the site could improve gas collection efficiency. As of August 2010, the gas collection system consisted of 150 gas extraction wells that were converted from passive vents. The owners then installed a 500-kilowatt (kW) reciprocating engine to generate electricity for the onsite leachate treatment plant in 2007; a second 500-kW engine was installed in 2008. Two new engines came online in January 2011, bringing the total electric-generating capacity to 2.5 MW.

The site plans to increase the power-generating capacity to 4 MW, and although current gas collection efficiencies are low, if the system can improve design and operation of the wells and gas header systems, a higher collection efficiency can be achieved, enabling the site to achieve its planned expansion to a 4-MW power plant.

When fully implemented, the project is expected to reduce GHG emissions by 306,000 TCO_2E from electricity generation and 213,000 TCO_2E through direct use. Additional environmental benefits include mitigated odors and reduced LFG migration in surrounding neighborhoods, as well as offsets from avoided fossil fuel. Social benefits from the project include revenues from the sale of unused electricity to the local power grid or the sale of certified emission reductions, as well as thermal energy for industrial or agricultural use. Two boilers have been installed to burn LFG to supply heat to the landfill staff canteen and the washing room.

China's Gaoantun Landfill

Oil and Gas Systems

Methane is emitted during normal operation and routine maintenance within the oil and natural gas industry, as well as during system disruptions. Emissions vary greatly from facility to facility and are largely a function of operation and maintenance procedures and equipment conditions. Reducing methane emissions from the oil and gas industry, however, can yield substantial economic and environmental benefits. Implementing available, cost-effective methane emission reduction opportunities can lead to reduced product losses, lower methane emissions, and increased revenues.

In 2010, global methane emissions from oil and gas systems were estimated at more than 1,595 $MMTCO_2E$, which is approximately 22 percent of total anthropogenic methane emissions.[20] Over the next decade, methane emissions from oil and gas systems are estimated to increase by 12 percent.[21] However, significant potential exists for methane recovery from oil and gas systems.

The United States has participated in GMI to encourage Partner Countries to implement proven, cost-effective technologies and practices that can minimize methane losses. In 2010, the U.S. government spent more than $3.7 million to support the deployment of these measures. Some of the U.S. government's notable 2010 accomplishments and ongoing activities in this sector are discussed in this section.

12 percent

estimated increase in oil and gas emissions by 2020

[20] U.S. EPA, 2011.

[21] Idem.

Conducting Workshops in Russia, China, and Mexico

An important element of all work conducted through EPA's Natural Gas STAR International Program and GMI is highlighting the effectiveness and specific advantages of identifying cost-effective methane emission reduction opportunities and institutionalizing a corporate emissions management program. With that goal in mind, EPA co-hosted several technical workshops in the following GMI Partner Countries.

Russia

In early 2010, the Environmental Defense Fund; EPA's Natural Gas STAR International Program; and Gazprom, the world's largest producer of natural gas, co-hosted a production facility site tour and a technical workshop in Novy Urengoy, located above the Arctic Circle. The workshop included a two-day tour of Gazprom's Yamburg gas production and processing sites and a technical workshop to exchange information on methane emission reduction strategies and climate policy.

Gas valves at Russia's Yamburg gas production and processing site.

In late 2010, WWF Russia, Pacific Northwest National Laboratory, and EPA's Natural Gas STAR International Program held a seminar with oil and natural gas producers in Russia to discuss best practices for methane emission reduction. The seminar drew participants from companies such as Lukoil, TNK-BP, and Gazprom VNIIGAZ. The one-day workshop in Moscow addressed methane emissions from both the production and processing sectors—well completions/workovers, liquids unloading, storage tanks, pneumatic devices, dehydrators, reciprocating/centrifugal compressors—and covered programs such as directed inspection and maintenance to help detect, prioritize, and repair leaks. Several companies also gave presentations on their related experience in both methane mitigation technologies and emissions accounting and reporting.

Mexico

In February 2010, GMI joined with representatives from the World Bank's Global Gas Flaring Reduction (GGFR) Partnership, PEMEX, the government of Mexico, and other oil and natural gas companies for the "Gas Flaring Reduction Best Practice Workshop." The workshop was well attended by more than 300 participants from PEMEX (e.g., key high-level officials from Corporate Operations; Safety, Health and Environment; Exploration and Production [E&P]; Planning; Asset Managers) and staff from SENER (i.e., officials from International Affairs, E&P Hydrocarbons Office, National Hydrocarbons Commission), in addition to GMI, GGFR, and other international participants. The workshop focused on sharing gas flaring and venting reduction best practices that apply to Mexico as well discussing and formulating concrete actions and tasks to be incorporated into Mexico's 2010–2012 venting and flaring reduction policies. GMI presented on the long history of collaboration with PEMEX and highlighted the many methane emission reduction opportunities that have been identified by numerous GMI-PEMEX methane emission measurement studies.

Capacity-Building and Technology Transfer in India

India's Oil and Natural Gas Corporation (ONGC), a state-owned oil and gas company, is one of Asia's largest exploration and production companies, operating more than 11,000 kilometers of pipeline and contributing 77 percent of India's crude oil production and 81 percent of India's natural gas production. Since joining Natural Gas STAR International (see text box) and GMI in 2007, ONGC has made significant efforts to build a strong program, focusing on engaging management, raising awareness of Natural Gas STAR within the company, providing specialized training to personnel on Natural Gas STAR-recommended technologies and practices, and building internal capacity to identify and implement methane emission reduction opportunities within ONGC operations.

Natural Gas STAR International Overview

In support of GMI, in 2006 the EPA's Natural Gas STAR Program expanded to include oil and natural gas companies with international operations. The launch of Natural Gas STAR International significantly increases opportunities to reduce methane emissions from oil and natural gas operations worldwide and creates a framework for global application of the Program's principles, including cost-effective methane emission reduction technology and practice implementation.

In 2010, Natural Gas STAR International reported actual annual emission reductions of more than 2.7 $MMTCO_2E$.

EPA and ONGC have collaborated on prefeasibility studies to identify and estimate major methane emission sources from several ONGC sites. Based on the study results, measurement studies were carried out at seven ONGC sites. The company is now implementing methane mitigation projects at several locations. In 2009, working with Natural Gas STAR and GMI, ONGC completed a detailed study to measure emissions from tank vents. The study objective was to accurately measure the tank vent emissions and identify possible emission reduction opportunities. The study results identified vapor recovery units (VRUs) as a cost-effective option for reducing emissions. As a direct result of this work, ONGC rehabilitated non-working VRUs on storage tanks at its Uran onshore oil and natural gas processing plant—an activity that will save a significant amount of methane emissions. Most recently, ONGC delegates participated in GMI's North American study tour, linking delegates with peer companies that have implemented emission reduction technologies of interest, as well as technology and service providers.

ONGC was also instrumental in organizing and sponsoring the 2010 Methane to Markets Partnership Expo in New Delhi, India, and featured two projects at the Expo. In November 2010, ONGC was named the Natural Gas STAR International Partner of the Year. This award is based on methane emission reductions achieved, implementation of a variety of technologies and practices, and support of overall Program activities, initiatives, and outreach. Each year, EPA recognizes the efforts and achievements of outstanding partners.

Since joining GMI and Natural Gas STAR International, ONGC has made considerable progress in advancing its GHG management program, and continues to build its internal expertise to enable ONGC to share technical information with all affiliates.

ONGC staff with EPA Natural Gas STAR Program representatives.

Municipal Wastewater

Methane is produced when the organic material in municipal and industrial wastewater decomposes anaerobically. Varying amounts of methane are emitted during the collection, handling, and treatment of wastewater depending on methods employed. Most developed countries rely on centralized aerobic wastewater treatment systems to manage their municipal wastewater; these systems generate large quantities of sludge that are often treated in anaerobic digesters, which produce biogas that can range from 60 to 70 percent methane and 30 to 45 percent CO_2 on a dry basis.[22] However, in developing countries with little or no wastewater collection and treatment, anaerobic systems such as latrines, open sewers, and lagoons are prevalent and yield considerable methane emissions.

Wastewater accounts for more than 6 percent (approximately 450 $MMTCO_2E$) of the estimated global anthropogenic methane emissions. China, Indonesia, Mexico, Nigeria, and the United States are the world's largest emitters in this sector.[23] Total estimated methane emissions from municipal wastewater sources are expected to increase by nearly 10 percent in the next 10 years.[24]

EPA is still exploring how best to engage in this sector and envisions that GMI might play a catalytic role in supporting the analysis and documentation of technical and economical options for methane emission reductions from the wastewater sector. EPA will begin supporting information-sharing and will add this sector to its annual GMI grant solicitation; however, EPA does not anticipate major investment of time or funding until the Steering Committee—with the support of additional developed countries—recommends a more directed strategy for this sector.

[22] *Evaluation of Combined Heat and Power Technologies for Wastewater Treatment Facilities* (EPA 832-R-10-006, December 2010), www.cwwga.org/documentlibrary/121_EvaluationCHPTechnologiespreliminary[1].pdf.

[23] U.S. EPA, 2011.

[24] Idem.

Wastewater Timeline Within GMI

Recognizing the interrelationships of the topic of wastewater within both the Landfill and Agriculture Subcommittees, the Steering Committee initially established a Wastewater Task Force under the Methane to Markets Partnership in 2009 to explore interest among Partner Countries and determine how wastewater could best be incorporated within the Partnership. In 2010, the Steering Committee formally added wastewater as a focus area within the TOR; however, it did not decide on a structure or process to incorporate wastewater within GMI. The Wastewater Task Force was charged with developing a set of options on the focus area's structure and preparing recommendations for the Steering Committee's review.

The task force held its first meeting in November 2010 in Venice, Italy, in conjunction with the Landfill and Agriculture Subcommittee meetings. The meeting included presentations from wastewater experts from Brazil and the Netherlands that focused on the current state of wastewater biogas capture and utilization projects in Latin America and Europe. These presentations helped to frame discussions about the most effective way to focus GMI's efforts in this area, overcome obstacles to implementing projects, encourage greater participation, and leverage existing financial sources or Clean Development Mechanism funding. During the Venice meeting, the task force decided to focus only on municipal wastewater as a potential GMI sector. The Wastewater Task Force also discussed possible technical and financial support opportunities, such as preparing studies, raising awareness, conducting demonstration and pilot projects, and developing a best practices manual.