Environmental and Energy Study Institute
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Issue Brief

Biogas Capture and Utilization: An Effective, Affordable Way to Reduce Greenhouse Gas Emissions and Meet Local Energy Needs

June 2009

According to the U.S. Environmental Protection Agency (EPA), methane is over 20 times more effective at trapping heat in the atmosphere than carbon dioxide over a 100 year period.[1] Methane's role as a potent greenhouse gas, coupled with the fact that its average lifespan in the atmosphere is 12 years, means that activities to reduce methane emissions efforts have great potential for reducing human impact on climate change in the near term.[2]

Methane is commonly produced through anaerobic digestion of organic material. In this process, bacteria in an oxygen-deprived environment break down organic material into a mixture of gases, water, and a solid effluent. The gaseous mixture, called biogas, can contain 50 to 95 percent methane depending on the source. According to the most recent data from the Energy Information Administration (EIA), the United States emitted 699.9 million metric tons carbon dioxide equivalent ($MMTCO_2E$) of methane in 2007, which accounted for 9.9% of the country's total GHG emissions.[3] Of this total, landfills accounted for 169.0 $MMTCO_2E$, solid waste from animals for 65.0 $MMTCO_2E$, and wastewater management for 26.7 $MMTCO_2E$.[4]

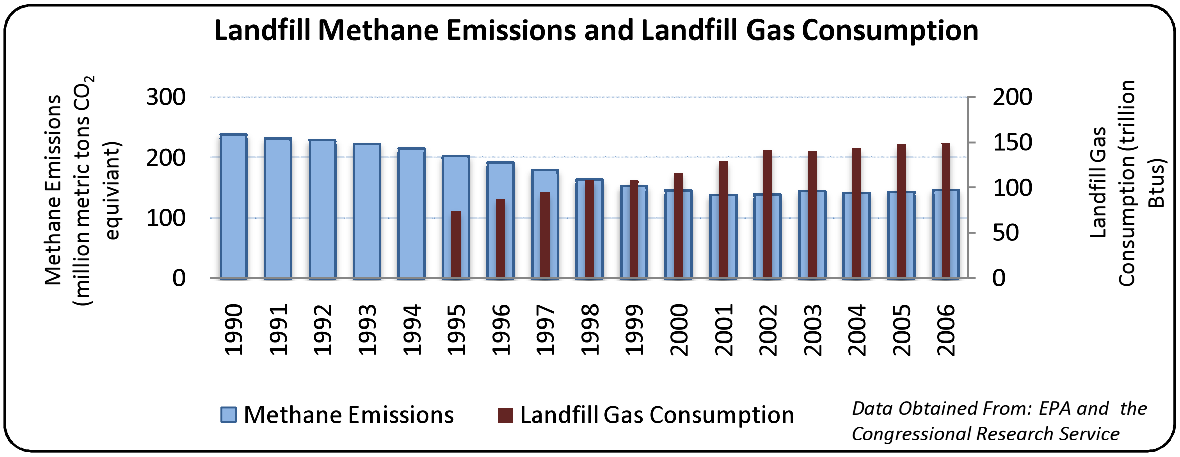
At many of these sources, biogas can be captured and burned on site (a process called "flaring"), thereby reducing climate change impacts substantially as the methane in the gas is converted to carbon dioxide. Even greater effects can be realized by using the energy-rich biogas as a substitute for carbon-intensive fossil fuels. A number of technologies exist that allow biogas to be collected and used on site or transported to a central location, where it can be refined to pipeline-quality gas (comparable to natural gas, which is 97% methane) or combusted for electrical generation or heating.[5,6] Biogas capture at many facilities can be an effective, affordable way to reduce greenhouse gas emissions by reducing methane emissions and displacing fossil fuels for energy production.

BIOGAS FROM LANDFILLS

Anaerobic digestion occurs naturally inside landfills due to the presence of large amounts of organic waste and the scarcity of oxygen. This emits a biogas normally composed of about 50% methane, 50% CO_2, and trace amounts of other gases. To harvest this gas, landfill operators drill a series of wells into the landfill, collecting between 60% and 90% of the biogas. The gas is then pumped to a central processing facility where it can be flared, refined, or used for heat or electricity generation.[7] Although a number of high-value products, such as compost and other soil amendments, are currently made from waste organic material, significant amounts of organic material still end up in landfills. Capturing the resulting biogas is a clean, low-cost way to reduce methane emissions while generating a reliable source of energy. Additionally, biogas can be captured during the composting process, adding additional value to the product.

Landfill Gas Capture is a Proven, Reliable Technology

As of December 2008, 485 projects to collect landfill gas (LFG) existed in 43 states. These projects supply 12 billion kWh of electricity per year and 255 billion cubic feet per day of LFG for commercial and residential space and water heating[8]–enough to power 870,000 homes and heat an additional 534,000.[9] LFG capture and use reduces greenhouse gas emissions by an amount equivalent to taking 22 million cars off the road.[10]



According to the EPA Landfill Methane Outreach Program (LMOP), approximately 520 landfills are strong candidates for new LFG projects (out of a national total of 2300). To be considered, a landfill must contain a minimum of one million tons of waste, be currently accepting waste or have been closed for five years or less, and not contain a currently operating LFG project. If all candidate landfills are used for LFG production, the EPA estimates they could generate enough electricity to power 700,000 additional homes.[11] Because landfill waste continues to emit methane for roughly 100 years, this could provide a reliable, long-term energy solution for local communities while cutting off an important source of greenhouse gases.[12]

LFG Capture is a Cost-Effective Way to Reduce Methane Emissions

While initial capital costs to install a LFG project are high, the EPA estimates that the benefits of LFG capture for direct use can outweigh the costs by as much as a factor of 10.[13] This makes LFG capture appealing not just from an emissions standpoint, but also from an economic one. LFG can generate electricity at a cost as low as $0.055 per kWh.[14] The attractiveness of LFG from these two standpoints has led to successful growth in the industry and a major drop in methane emissions from landfills over 1990 levels.

Landfill Gas to Renewable Natural Gas in Winder, Georgia

Renewable Solutions Group and Republic Services, Inc. have teamed up to provide pipeline-quality natural gas derived from landfill gas. The project, located in Winder, Georgia, is designed to use a clean, renewable energy source to meet the heating needs of up to 10,500 homes in the region. According to Renewable Solutions president David Wentworth, the project did not benefit from any public financial incentives, believing instead that the right market conditions were in place to support a strong bottom line.[15, 16, 17]

University of New Hampshire a Pioneer in Landfill Gas

The University of New Hampshire has established itself as a leader in carbon reduction with the opening of a new $49 million combined heat and power (CHP) facility on campus. In partnership with Waste Management, Inc., the university is capturing biogas in a nearby landfill and combusting it to meet 85% of its electricity needs. The project, with an expected payback period of 10 years, marks UNH as the first campus in the country to meet the majority of its power needs from landfill gas.[18,19,20]

BIOGAS FROM WASTEWATER

According to the U.S. EPA, the wastewater treatment industry uses the equivalent of 56 billion kWh of electricity per year, or about 3% of total U.S. consumption. In addition, the industry is responsible for emitting 26.7 $MMTCO_2E$ of methane every year.[21]

Wastewater to Power at Point Loma

The Point Loma Wastewater Treatment Plant in San Diego, CA, is a success story. The plant treats up to 240 million gallons of sewage a day, producing enough biogas to run a 4.5 MW generator. In 2000, the plant saved $3 million in energy costs and sold $1.4 million of power to the electrical grid.[22]

Most large wastewater treatment facilities (processing more than five million gallons per day) already use anaerobic digestion as a step in the cleaning process. The biogas released from this process (which contains between 60% and 95% methane) can be captured and used for electricity and heat generation.[23] However, most facilities today simply flare the gas. Out of the roughly 1000 large facilities currently in operation, only 106 are currently using biogas for heat or power generation. Of these, 76 plants use the biogas for both heat and power, generating 220.1 MW of electricity, while the remaining 30 produce only heat or power.[24]

Methane Capture from Wastewater Makes Economic Sense

While the cost of biogas capture from wastewater can vary widely depending on the technology used, the quantity of wastewater treated, and the current methane capture equipment in place, many plants have shown an ability to offset capital costs completely through income and savings from the generation of heat and electricity. According to the EPA, it is possible to produce electricity for as little as $0.038 per kWh[25] assuming a 20-year capital repayment horizon. This compares favorably to national electricity rates that range from $0.057 to $0.228 per kWh.[26]

BIOGAS FROM AGRICULTURE

Most large farms today manage manure in liquid-based systems, in which anaerobic digestion occurs naturally. But at present, very few farms capture and use the methane that is emitted. Three types of digester systems currently exist for capturing biogas.

- **Covered Lagoon**—A covered earthen lagoon passively collects biogas as it is produced from the liquid manure. Most appropriate for waste with a solids content of 0.5-3.0 percent.
- **Complete Mix Digester**—A heated tank made of reinforced concrete or steel with a gas-tight cover. The contents are mixed periodically with a motor-driven impeller or a pump. Appropriate for slurry manure with a solids content of 3-10 percent.
- **Plug Flow Digester**—A long, narrow heated tank, generally built below ground level and provided with a gas-tight cover. Only used for dairy manure with a solids content of 11-13 percent.[29]

"Cow Power" Gaining Traction in California

Bioenergy Solutions, a California-based renewable energy company, sees promise in the agricultural waste-to-biogas market. The company already has a contract with major utility PG&E to provide up to 3 million MMBtu/year of renewable natural gas, derived from biogas emitted by cow manure. The company currently operates a demonstration project at Vintage Dairy in California that can process manure from up to 5000 cows, and has plans to build a network of digesters in clusters across the state.[27, 28]

In addition to manure, anaerobic digesters can be utilized to process other varieties of separated biomass. While composting is also an option for much of this material, anaerobic digestion can serve as a low-cost alternative that reduces harmful emissions while capturing energy. Once biogas is captured from digesters, it is pumped into a central processing facility and refined, used for heat or electricity, or flared. Meanwhile, the solid effluent can be used as a soil amendment.

As of February 2009, there were 125 manure digester systems operating in 26 states.[30] The EPA AgSTAR Program, which promotes agricultural biogas recovery programs, estimates that these systems could be technically feasible at an additional 6000 swine and dairy operations nationwide. If all of these operations implement biogas capture, the EPA estimates they could generate up to 6.3 million MWh per year of electricity while reducing annual methane emissions by 27.3 $MMTCO_2E$ (66% of the total methane emissions from those operations).[31]

Agricultural Biogas Capture Can Be Profitable for Farmers

Depending on the type of system installed, conventional waste storage facilities cost from $60 to over $400 per animal unit (AU) (one AU is equivalent to 1000 pounds live animal weight, approximately the weight of one head of cattle). Digester costs can range from $200 to $550 per AU. However, digesters also generate revenue from methane and reduce costs for fertilizer. Annual revenue from electricity sales and cost offsets range from $32 to $78 per AU, while fertilizer purchases avoided by using digested solids can generate from $41 to $60 per AU. This means that the use of anaerobic digesters is often equal to or better than simple storage from an economic standpoint.[32] Although there is a size constraint (a facility generally needs at least 300 cows or 2000 swine to break even), investment in anaerobic digestion can often have a payback period of as little as 3 to 7 years.

BARRIERS TO BIOGAS AND POTENTIAL POLICY SOLUTIONS

Biogas still faces a number of barriers to accelerated use. Among the most important of these are high, up-front capital costs, lack of financing, barriers to interconnection with the electricity and gas grids from utilities and regulators, the lack of a guaranteed price for heat and power, and state and local regulatory barriers. Establishing an ambitious national renewable energy standard (which includes standards for both renewable heat and power) and/or a firm price on carbon from fossil fuels through a carbon tax or cap and trade program could be key to overcoming many of these barriers and accelerating biogas capture and utilization.

POET Uses LFG to Power Ethanol Refinery

POET, LLC., one of the nation's most successful ethanol production companies, has taken a novel approach to landfill gas. POET's largest corn ethanol refinery, located in Chancellor, SD, utilizes a mixture of biogas and wood chips as its primary input. Company leaders believe that once the generation process is perfected, the facility will be able to meet 90% of its energy needs through clean, low-cost renewable energy. [33,34,35]

If all of the LFG and agriculture projects currently deemed feasible by the EPA were put in place, the United States could reduce its methane emissions by up to 102.3 $MMTCO_2E$, or the equivalent of taking over 19.8 million cars off the road. Reducing methane production from wastewater by just 10% could reduce GHG emissions by the equivalent of another 500,000 cars. While biogas capture is already cost competitive in some regions with high electricity or heating prices, a much faster path to widespread deployment of the technology could be created with supportive federal policy that creates a stable business environment while recognizing the essential role biogas can play in creating a clean, reliable, low-carbon source of energy.

In addition, biogas can provide a number of indirect environmental and social benefits:

- Substituting clean-burning, renewable biogas for electricity for dirtier fossil fuels (particularly coal) will reduce SO_2, NO_x, particulate matter (PM), and CO_2 emissions associated with burning those fuels. While the EPA acknowledges that, depending on the power supply replaced and the technology used for LFG capture, net NO_x emissions may rise, the avoidance of methane and other pollutants more than offsets this increase.[36] Even when replacing natural gas, which has a comparable emissions profile, biogas has an advantage because it emits carbon that was already circulating in the atmosphere, while natural gas releases greenhouse gases that would have remained sequestered underground.[37]

- The relatively constant output of biogas from landfills allows for a stable, local supply of renewable energy. It can supply fuel at a relatively constant rate, providing a hedge against price and supply instability in the broader energy market.
- Anaerobic digestion virtually eliminates the release of harmful pollutants, including fecal coliform bacteria, into the water supply from feedlot operations.[38]
- Capturing biogas from landfills or manure can significantly improve air quality in the surrounding community by reducing odor.[39]

Methane reduction efforts have tremendous potential as part of a broader greenhouse gas reduction plan. Removing policy obstacles to the development of clean, sustainable biogas capture could help create new jobs while providing the right incentives for biogas-producing industries to make a significant contribution in the fight against climate change.

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