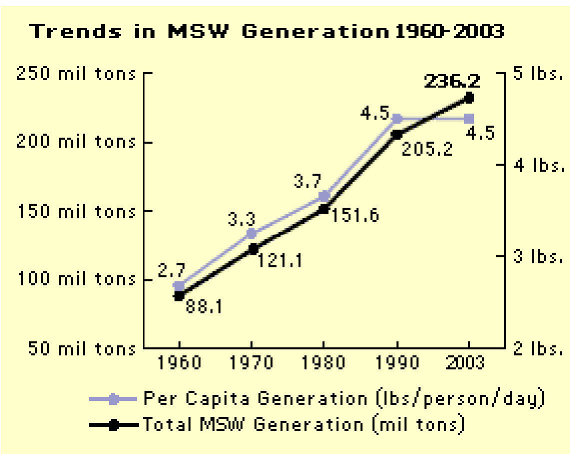
Methane to Markets Partnership Landfill Subcommittee

United States Profile of Solid Waste Disposal Practices and Landfill Gas Management

June 2005

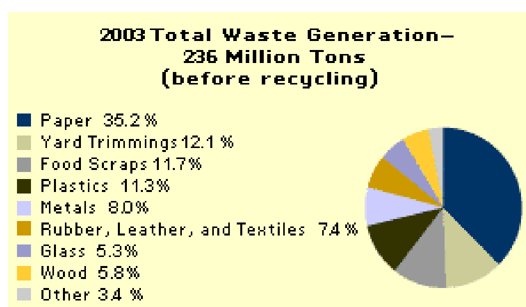
<u>Summary of Solid Waste Management Sector</u>

In 2003, U.S. residents, businesses, and institutions produced more than 236 million tons of municipal solid waste (MSW), which is approximately 4.5 pounds of waste per person per day.



In the United States, federal, state, Indian tribal, and local governments have adopted an integrated approach to waste management. This approach involves a hierarchy of waste management methods: decreasing the amount and/or toxicity of waste that must be disposed of by producing less waste to begin with (source reduction/reuse); increasing recycling of materials such as paper, glass, steel, plastics, and aluminum, thus recovering these materials rather than discarding them; and providing safer disposal capacity by improving the design and management of incinerators and landfills.

Currently, in the United States, 30 percent of municipal solid waste is recovered and recycled or composted, 14 percent is burned at combustion facilities, and the remaining 56 percent is disposed of in landfills.



Although source reduction, reuse, recycling, and composting can divert large portions of MSW from disposal, some waste still must be placed in landfills. Modern landfills are well-engineered facilities that are located, designed, operated, monitored, closed, cared for after closure, cleaned up when necessary, and financed to insure compliance with federal regulations. The federal regulations were established to protect human health and the environment. In addition, these new landfills can collect potentially harmful landfill gas emissions and convert the gas into energy.

Principal Federal Landfill Regulations

Under the Resource Conservation and Recovery Act (RCRA), enacted by Congress in 1976 and amended in 1984, landfills that accept MSW are primarily regulated by state, tribal, and local governments. The Environmental Protection Agency (EPA), however, established Criteria for Municipal Solid Waste Landfills (40 CFR Part 258) under RCRA on October 9, 1991 that municipal solid waste landfills must meet in order to stay open. The criteria contain location restrictions, design and operating standards, groundwater monitoring requirements, corrective actions, financial assurance requirements, LFG migration control, closure requirements, and post closure requirements. Under the design standards new landfills and lateral expansions that occur on or after October 9, 1993, are required to line the bottom and sides of the landfill prior to waste deposition. In addition, all landfills operating after October 9, 1991, must place a final cap over the landfill surface. The placement of liners and caps reduces the potential for subsurface and surface LFG migration and groundwater contamination.

While additional federal, state, and local landfill rules and regulations are in place, RCRA represents the primary laws covering land disposal of municipal solid waste.

Principal Federal Landfill Air Emissions Regulations

Because of the benefits of collecting and controlling LFG, the 1996 EPA Standards of Performance for New Stationary Sources (NSPS) and Guidelines for Control of Existing Sources, and the recently published National Emission Standards for Hazardous Air Pollutants (NESHAP) require "large" MSW landfills to collect LFG and combust it to reduce NMOC by 98% (or to an outlet concentration of 20 ppmv).

A "large" landfill is defined as having a design capacity of at least 2.5 million metric tons and 2.5 million cubic meters and a calculated or measured uncontrolled NMOC emission rate of at least 50 metric tons (megagrams) per year. Landfills are meeting these gas destruction standards using flares or energy recovery devices including reciprocating engines, gas turbines, and boilers. In addition to gas destruction requirements, the NSPS and NESHAP require that gas collection systems be well designed and well operated. They require gas collection from all areas of the landfill, monthly monitoring at each collection well, and monitoring of surface methane emissions to ensure that the collection system is operating properly and to reduce fugitive emissions. Smaller MSW landfills are not required to control emissions by the NSPS or NESHAP, but can still greatly reduce emissions of NMOC by collecting and combusting LFG for energy recovery or in a flare.

Recent Landfill Innovations

Over the past few years there has been increasing interest in demonstrating and potentially put into practice the wet landfill or bioreactor landfill. A bioreactor landfill operates to rapidly transform and degrade organic waste. The increase in waste degradation and stabilization is accomplished through the addition of liquid and air to enhance microbial processes. This bioreactor concept differs from the traditional “dry tomb” municipal landfill approach.

The bioreactor accelerates the decomposition and stabilization of waste. At a minimum, leachate is injected into the bioreactor to stimulate the natural biodegradation process. Bioreactors often need other liquids such as stormwater, wastewater, and wastewater treatment plant sludges to supplement leachate to enhance the microbiological process by purposeful control of the moisture content and differs from a landfill that simple recirculates leachate for liquids management. Landfills that simply recirculate leachate may not necessarily operate as optimized bioreactors.

Potential advantages of bioreactors include:

- Decomposition and biological stabilization in years vs. decades in "dry tombs"
- Lower waste toxicity and mobility due to both aerobic and anaerobic conditions
- Reduced leachate disposal costs
- A 15 to 30 percent gain in landfill space due to an increase in density of waste mass
- Significant increased LFG generation that, when captured, can be used for energy use onsite or sold
- Reduced post-closure care

Currently, there are no full scale commercial bioreactor landfills in operation in the U.S. However, bioreactor landfills are in operation in a number of states for research and demonstration purposes.

Key Stakeholders in the Solid Waste Disposal Sector and LFG Industry

Federal Government

EPA's Office of Solid Waste and Emergency Response, Office of Air Quality Planning & Standards, Office of Research and Development, Office of Enforcement and Compliance, and Office of Air and Radiation are primarily charged with solid waste and air emissions programs. These offices and programs address promulgation of rules and regulations, research, and enforcement and compliance aspects related to the municipal solid waste management sector.

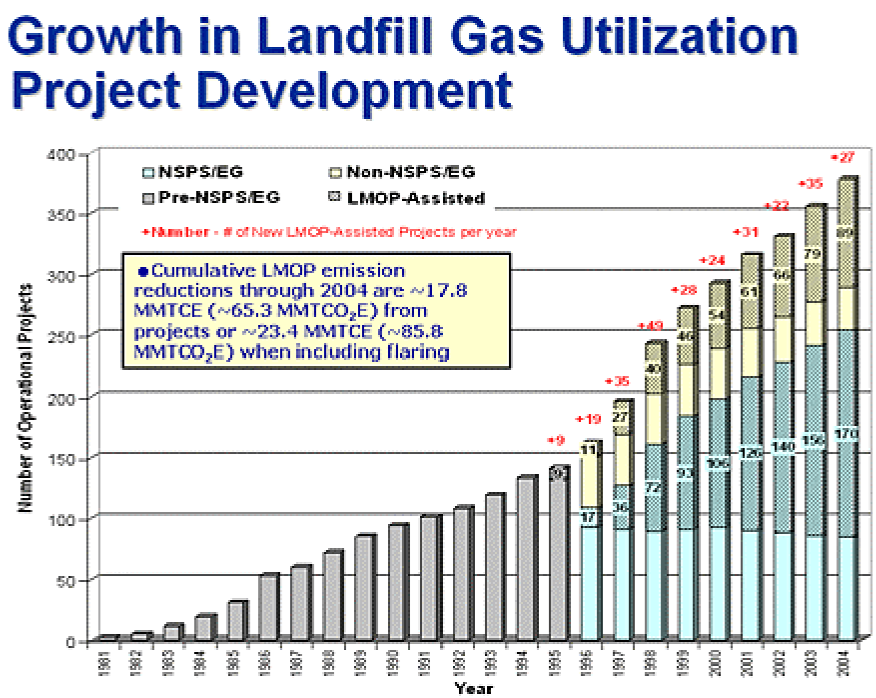
One of EPA's successful voluntary programs aimed at addressing methane emissions from landfills is the Landfill Methane Outreach Program (LMOP). Established be EPA in 1994, LMOP promotes the use of landfill gas (LFG) as a renewable energy source. By preventing emissions of methane - a powerful greenhouse gas - through the development of LFG energy (LFGE) projects, LMOP helps businesses, states, and communities protect the environment and build a sustainable future. LMOP works with landfill owners/operators, industry organizations, energy providers and marketers, state agencies, communities, end-users, and other stakeholders to help them overcome barriers to LFG energy development.

- Over the past ten years, LMOP has assisted in the development of over 285 LFG energy projects. As of December 31, 2004, LFG projects with LMOP involvement have cumulatively prevented more than 3.1 million tons of methane from entering the

atmosphere and about 18 million metric tons of carbon equivalent from direct and avoided emissions reductions (MMTCE - the basic unit of measure of greenhouse gases) into the atmosphere over the past 10 years.
  - This reduction is the carbon equivalent of removing the emissions from 14.5 million cars on the road or planting 19.6 million acres of forest for one year.
  - These reductions also have the same environmental benefit as preventing the use of 154 million barrels of oil or offsetting the use of 325,000 railcars of coal.
- LMOP has more than 425 Partners that have signed voluntary agreements to work with EPA to develop cost-effective LFG energy projects.

The collective results of EPA's voluntary methane partnership programs have been substantial. Total U.S. methane emissions in 2001 were more than 10% lower than emissions in 1990, in spite of significant economic growth over that time period. EPA expects that these programs will maintain emissions below 1990 levels in the future due to expanded industry participation and the continuing commitment of the participating companies to identify and implement cost-effective technologies and practices.

The chart below illustrates that growth of landfill gas utilization projects has more than tripled since LMOP's inception. The chart also demonstrates the number of landfill gas utilization projects effected by the NSPS/EG rules.



State and Local Governments

Rules and regulations, permits, incentive programs, and policies for LFG projects vary greatly from state to state and jurisdiction to jurisdiction. State regulations must usually be as stringent as applicable Federal regulations.

Non-Governmental Organizations (NGOs)

The primary NGOs representing the solid waste industry are the Solid Waste Association of North America (SWANA) and the National Solid Waste Management Association (NSWMA). Both of these organizations represent public and private sector solid waste professionals and whose goals is to provide their members with educational and training opportunities, research, dissemination of information about solid waste management, and advocacy capability.

Overview of Landfill Gas Emissions

Landfills are the largest anthropogenic source of methane emissions in the United States, accounting for 24 percent of total U.S. methane emissions. In 2001, landfill methane emissions were approximately 131 teragrams (Tg) CO_2 Eq. Emissions from municipal solid waste landfills, which received over 55 percent of the total solid waste generated in the United States, accounted for about 94 percent of total landfill emissions, while industrial landfills accounted for the remainder. Approximately 2,000 operational landfills exist in the United States, with the largest landfills receiving most of the waste and generating the majority of methane.

From 1990 to 2003, net CH4 emissions from landfills decreased by approximately 24 percent, with small increases occurring in some interim years (see Table 1). This downward trend in overall emissions is the result of increases in the amount of landfill gas collected and combusted by landfill operators, which has more than offset the additional methane emissions resulting from increases in the amount of municipal solid waste landfilled.

Table 1. Methane Emissions from Landfills (Tg CO_2 Eq.)

Activity	1990		1997	1998	1999	2000	2001	2002	2003
MSW Landfills	197.2		215.9	219.1	222.3	226.5	231.9	238.6	245.0
Industrial Landfills	13.8		15.1	15.3	15.6	15.9	16.2	16.7	17.2
Recovered									
Gas-to-Energy	(14.0)		(34.7)	(42.4)	(48.0)	(51.9)	(57.5)	(59.1)	(61.9)
Flared	(5.6)		(32.6)	(38.2)	(41.0)	(45.2)	(50.5)	(55.3)	(54.6)
Oxidized[a]	(19.1)		(16.4)	(15.4)	(14.9)	(14.5)	(14.0)	(14.1)	(14.6)
Total	**172.2**		**147.4**	**138.5**	**134.0**	**130.7**	**126.2**	**126.8**	**131.2**

Note: Totals may not sum due to independent rounding.
[a] Includes oxidation at both municipal and industrial landfills.

The estimated annual quantity of waste placed in landfills increased from about 209 Tg in 1990 to 279 Tg in 2003, an increase of 33 percent. During this period, the estimated CH_4 recovered and combusted from landfills increased as well. In 1990, for example, approximately 935 Gg of CH_4 were recovered and combusted (i.e., used for energy or flared) from landfills. In 2003, the estimated quantity of CH_4 recovered and combusted increased to 5,545 Gg.

Over the next several years, the total amount of municipal solid waste generated is expected to increase slightly. The percentage of waste landfilled, however, may decline due to increased recycling and composting practices. In addition, the quantity of methane that is recovered and either flared or used for energy purposes is expected to increase, as a result of a 1996 regulation that requires large municipal solid waste landfills to collect and combust landfill gas (see 40 CFR Part 60, Subparts Cc 2002), and the Landfill Methane Outreach Program.

The Landfill Methane Outreach Program estimates currently over 600 landfills with a potential MW capacity of over 1,500 MWs or 280 billion cubic feet/yr of LFG for direct use are candidates for LFG energy projects.

These 600 landfills represent approximately 17 MMTCE potential emissions reductions and total expected annual environmental benefits if all projects were developed/ producing power:

- Planting over 20 million acres of forest, or
- Removing the emissions from over 14.6 million cars on the road, or
- Powering over 1 million homes per year.

List of Existing or Planned Landfill Gas Capture and/or Use Projects

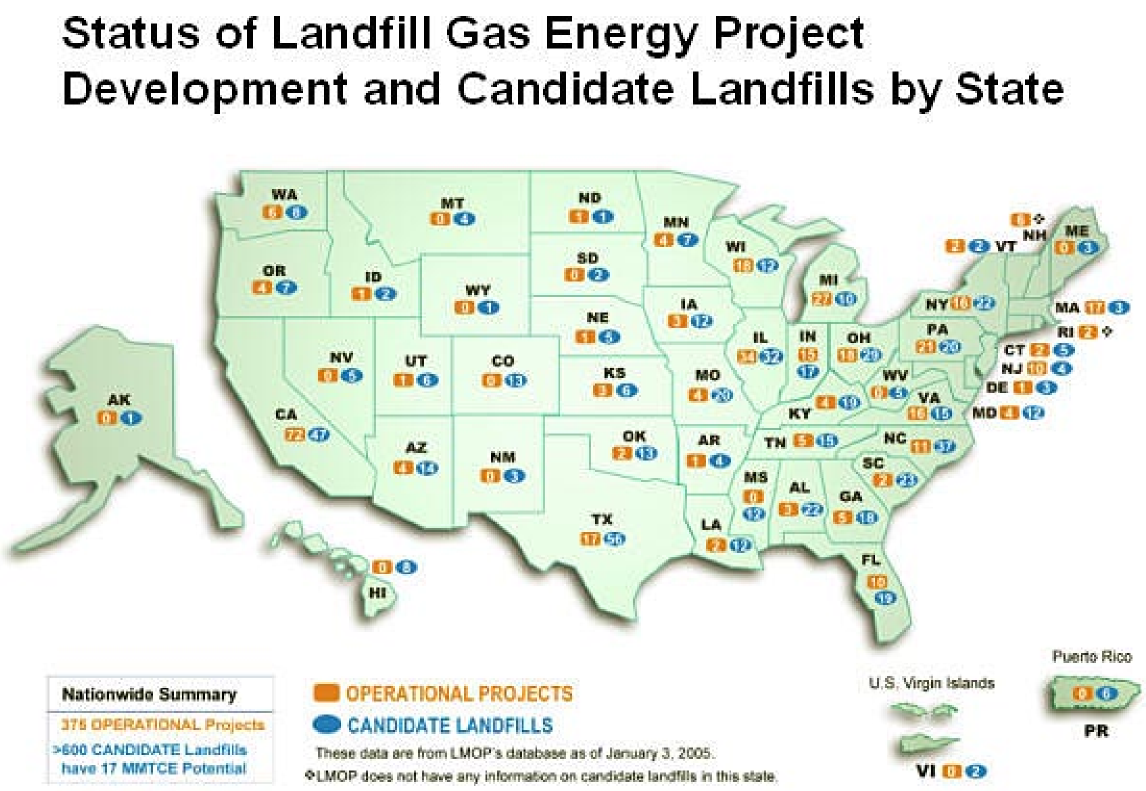
In 2004, more than 375 operational LFG energy projects in 38 states supplied:

- 9 billion kilowatt hours of electricity, and
- 74 billion cubic feet of LFG to end users.

An additional 120 projects are currently under construction or are exploring development options and opportunities. In addition, LFG is combusted by flaring at over 1,000 landfills.

The estimated annual environmental benefits and energy savings associated with these 375 operational projects are equivalent to:

- Planting 19,000,000 acres of forest, or
- Preventing the use of 150,000,000 barrels of oil, or
- Removing the CO_2 emissions equivalent to 14,000,000 cars, or
- Offsetting the use of 325,000 railcars of coal.



LFG energy projects also have a substantial impact on economic growth and cost savings. A typical 3 megawatt LFG electricity project is estimated to have the following national benefits (direct, indirect, and induced) during the construction year:

- Increase the output of the U.S. economy by more than $10 million.
- Increase U.S. employee earnings by more than $3 million (e.g., wages, salaries).
- Employ more than 70 people (expressed in fulltime equivalents per year).

These projects bring significant cost savings and long-term energy price stability to LFG end users:

- BMW Manufacturing expects a savings at their Greer, SC plant of more than $1 million per year.
- General Motors expects savings of more than $5 million per year from their 5 current direct use LFG projects.
- SC Johnson estimates $1 million in savings per year at its plant in Racine, WI.

<u>Challenges and/or Priorities to Greater LFG Recovery and Use</u>

While landfill gas recovery offers significant environmental, energy, and economic benefits, there are still barriers to project development, including:

- Project Economics: Finding cost effective ways to produce electricity in states with low electric prices and no financial incentives. Distance from landfill to potential end users effects
- Recovering gas from landfills located in arid climates that produce low quantities of gas.
- Siting and permitting processes are in most cases arduous and complex. For example, need for streamlining engine air permitting requirements so that engine efficiency is not compromised, and cost for control methods do not deem project infeasible.
- Lack of demonstrated commercial success can often make financing new technologies difficult.

Market Assessment and Reform Issues

There are many conventional and innovative opportunities for converting LFG to energy. Below are descriptions of some of the typical project types and emerging technologies.

- **Electricity Generation:** The generation of electricity from LFG makes up about two-thirds of the currently operational projects in the U.S. Electricity for on-site use or sale to the grid can be generated using a variety of different technologies, including internal combustion engines, turbines, microturbines, Stirling engines (external combustion engine), Organic Rankine Cycle engines, and fuel cells. The vast majority of projects use internal combustion (reciprocating) engines or turbines, with microturbine technology being used at smaller landfills and in niche applications. Certain technologies such as the Stirling and Organic Rankine Cycle engines and fuel cells are still in the development and demonstration phase.
- **Direct-Use:** Directly using LFG to offset the use of another fuel (natural gas, coal, fuel oil) is occurring in about one-third of the currently operational projects. This direct use of LFG can be in a boiler, dryer, kiln, greenhouse, or other thermal applications. It can also be used directly to evaporate leachate. Innovative direct uses include firing pottery and glass blowing kilns; powering and heating greenhouses and an ice rink; and heating water for an aquaculture (fish farming) operation. Current industries using LFG include auto manufacturing, chemical production, food processing, pharmaceutical, cement and brick manufacturing, wastewater treatment, consumer electronics and products, paper and steel production, and prisons and hospitals, just to name a few.
- **Cogeneration:** Cogeneration (also known as combined heat and power or CHP) projects using LFG generate both electricity and thermal energy, usually in the form of steam or hot water. Several cogeneration projects have been installed at industrial operations, using both engines and turbines. The efficiency gains of capturing the thermal energy in addition to electricity generation can make these projects very attractive.
- **Alternate Fuels:** Production of alternate fuels from LFG is an emerging area. Landfill gas has been successfully delivered to the natural gas pipeline system as both a high-Btu and medium-Btu fuel. Landfill gas has also been converted to vehicle fuel in the form of compressed natural gas (CNG), with a number of liquefied natural gas (LNG) and methanol production projects in the planning stages.

Mechanisms used to promote markets for LFG projects include:

- The federal Public Utilities Regulatory Policy Act (PURPA) of 1978 is a landmark for the development of an independent power generation industry in the US, including the landfill gas industry. The Act authorized contracts between utilities and qualifying facilities for the purchase of electric power based on the concept of a utility's avoided cost of generating that power.

- Green Pricing and Green Power

    - Green-pricing programs have developed in many states to directly value renewable energy by allowing customer choice of the source of energy provided by utilities. Allowing customers direct access to green power suppliers provides a mechanism to pass through generation costs.

    - Renewable Portfolio Standard (RPS): a policy that states can use to remove market barriers to renewable power and ensure that green power continues to play a role in the competitive environment that follows restructuring of the electricity generating industry. In their simplest form, RPSs specify that a percentage of all electricity generated must come from identified renewable energy sources, such as wind, hydro, solar, landfill gas, geothermal, and biomass. Some states require that a minimum percentage must come from new renewable sources, with this percentage increasing gradually over time. Under a more market-based approach, a state or group of states allow the RPS to be met with tradable renewable energy credits (RECs). Under this system, utilities and other electricity retailers earn credits for all renewable-generated power they produce and sell each year, and submit those credits to demonstrate compliance with the standard. Utilities with excess credits can sell them to others that have not met the standard.

- Net metering: a low-cost, easily administered method to encourage customer investment in renewable energy technologies. It allows the electric meters of customers with generating facilities to turn backwards when the generators are producing energy in excess of the customers' demand. Customers are thus able to use their own generation to offset their consumption over a billing period. This offset means that customers receive retail prices for the excess electricity they generate. Without net metering, a second meter is usually installed to measure the electricity that flows back to the provider, with the provider purchasing the power at a rate much lower than the retail rate.

Financing Options

Federal:

- Signed into law on October 22, 2004, H.R. 4520, the "American Jobs Creation Act of 2004," is a corporate tax measure containing an expanded Section 45 tax credit for LFG electricity-generating facilities. This credit formerly applied to only wind and some biomass energy projects, but Section 710 of the law expands the credit to a wide range of renewables, including landfill gas. The expanded Section 45 tax credit is available for electricity produced from open loop biomass (including waste wood and agricultural livestock waste nutrients), landfill gas, trash combustion, geothermal, solar, and small irrigation power facilities that are placed in service prior to January 1, 2006. The credit is \$0.009/kW-hr paid out over a period of five years.

- The Renewable Energy Production Incentive (REPI) provided incentive payments for electricity sold by new qualifying renewable facilities, including landfill gas, biomass, anaerobic digestion, and fuel cells employing renewable fuels. The REPI expired for new projects in December 2003. QFs were eligible for annual incentive payments of \$0.015/kWh indexed for inflation for the first ten years of the project. MSW combustion projects were ineligible for the program.

State: Financing options vary widely from state to state. Some states do not have financial incentives other than those available at the federal level; whereas, some states offer several incentives. Typical funding mechanisms available for landfill gas energy projects include:

- *Grants* provide direct financial support and are usually awarded by government and non-profit agencies. Grants are often, but not always, made for research activities in a particular subject area (e.g., to develop or demonstrate a landfill gas energy project or technology).

    - EXAMPLE: The Pennsylvania Departments of Environmental Protection (DEP) and Agriculture initiated a \$5 million Energy Harvest Grant Program in 2003 to improve air quality, preserve land and protect local watersheds while providing economic opportunities for the state's agricultural community. The initiative, Pennsylvania Energy Harvest, helps finance the implementation of clean and renewable-energy technologies that will have measurable benefits in terms of pollution reduction, environmental quality, and reduced energy usage rather than those that focus solely on public outreach and communication. In February 2004, Pennsylvania's governor announced plans to expand the Energy Harvest initiative by \$80 million over four years.

- *Loans* are arrangements in which a lender (e.g., a government agency or a non-profit organization) provides money to a borrower (e.g., a landfill gas energy project developer), and the borrower agrees to repay the money, along with interest, at some future date.

    - EXAMPLE: The Illinois Resource Development and Energy Security Act adopted a statewide renewable energy *goal* of at least 5% of total energy by 2010, and at least 15% by 2020. The legislation also authorizes up to \$500 million of new state revenue bonding to support the development of technologies for wind, biomass and solar power in Illinois.

- *Production incentives* are financial payments, usually on a cents-per-kWh basis, for electricity generated by qualifying landfill gas energy facilities.
    - EXAMPLE: California's Renewable Resources Trust Fund supports existing, new, and emerging renewable technologies through funds collected from the state's investor-owned utilities. The funds are divided among four different accounts, with landfill gas utilization projects being eligible for funding under the New Renewable Resources Account. Funds available under the New Renewable Resources Account are distributed via a financial incentives auction, through a production incentive based on a competitive solicitation process, with a cap of 1.5 cents per kilowatt-hour (kWh). The funds are paid over a five-year period after a project begins generating electricity.

- *Tax credits and exemptions* reduce the tax liability of eligible parties. A tax exemption for a landfill gas energy project might exclude equipment and facilities used in generating energy from landfill gas from property taxes. : Tax credits for landfill gas energy projects are generally offered on a specified cents-per-kWh basis.

Current Cooperation among Countries

LMOP's efforts to promote LFG recovery and use extend beyond U.S. borders. On the international level, LMOP works with organizations to promote LFG recovery and use by offering a broad spectrum of outreach, education, and technical assistance services to countries interested in LFG project development.

Over the past 7 years, LMOP has assessed the technical and economic feasibility of LFG project development at selected landfills in a number of countries around the world. Specific cities that have been evaluated as potential hosts for LFG project development include Sao Paulo (Brazil), Manila (Philippines), Bangkok (Thailand), Seoul (Korea), and Mexico City (Mexico). The objective of these feasibility assessments is to identify economical and technically feasible project development opportunities, both in the host country and for international project developers, and to promote the benefits of LFG use as a local source of renewable energy.

Another aspect of LMOP's international efforts is to assist and participate in workshops and training opportunities conducted overseas under sponsorship by EPA and other organizations (see presentation below). To date, EPA has held workshops in Seoul (Korea), Rio de Janeiro (Brazil), Warsaw (Poland), Bangkok (Thailand), Kiev (Ukraine), Mexico City (Mexico), and Nanjing (China).

"Wish List"

What are you looking for from the Methane to Markets Partnership (e.g., financing, technical assistance, feasibility assessments) and/or what expertise can you provide to the Partnership?

The US is hoping to provide technical assistance and feasibility assessments that will reduce global methane emissions to enhance economic growth, promote energy security, improve the environment, and reduce greenhouse gases. Other benefits include improving reducing waste, and improving local air quality. In addition, the US is hoping that this partnership will open channels for private industry to transfer expertise from US experience.

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