Chapter 17
Landfill Gas

Introduction

The natural decomposition of materials deposited in landfills creates more man-made methane than any other source in the U.S.[1] About half of the gas emitted by landfills is methane; these gases have about half the energy potential of natural gas. Landfills must monitor their methane production or collect and burn it to prevent air pollution. Therefore, using landfill methane to generate electricity, fire boilers or substitute for other energy sources can turn a potential liability into a benefit.[2]

Preparing a 1 million-ton landfill for energy production can entail initial capital costs of $600,000 to $750,000 or more and operating costs of $40,000 to $50,000 a year. Other costs include legal fees, permitting, environmental impact studies and other costs associated with maintaining the landfill.[3] Their long-term economic and environmental impacts, however, are difficult to calculate because landfills can pollute the air, ground and water if they are not managed well.

History

From colonial times, residents of American cities tossed trash and garbage onto their streets. As cities grew, so did the volumes of garbage. Modern solid waste management started in 1895, when New York City Street Cleaning Commissioner Colonel George E. Waring Jr. arranged to send the city's wastes to dumps and incinerators, or to be deposited in waterways. The New York Board of Health quickly noticed that this new policy lowered the city's death rate from disease, one indication of the problems caused by waste. Yet most cities at that time still had no organized system of disposal, continuing to pile rubbish in open pits that could accidentally catch on fire or be set on fire intentionally.[4]

In the 1920s, the British began the practice of "sanitary" landfilling — covering the trash each day with earth. This practice was adopted in the U.S. in New York City and Fresno, California in the 1930s. The U.S. Army Corps of Engineers also experimented with the practice during World War II. The practice spread rapidly in the postwar era, as civilian waste volume increased dramatically and open dumps spewed forth odors, smoke, rats, flies and paper trash.[5]

But engineers underestimated the amount of methane generated by landfills, and its ability to cause fires or explosions in nearby structures as the gas migrated. When landfills sited in quarries or pits are covered with earth each day, conditions are ideal for the formation of methane, which is produced by the anaerobic (meaning "without oxygen") decomposition of trash. More importantly, this methane can travel through porous ground or layers of trash, appearing up to one kilometer away.[6]

Methane is explosive even at low concentrations in air.[7] In previous decades, the U.S. Environmental Protection Agency (EPA) documented at least 40 explosions or fires caused by migrating landfill gas, including 10 accidents causing injuries or deaths.[8] More recent accidents are less common. On December 20, 2007, the Operations Manager of the Mountainview Landfill near Cumberland, Maryland received second- and third- degree burns from a methane gas explosion. A spark from an electrical device being used by the manager ignited the flash fire.[9]

The U.S. Solid Waste Disposal Act of 1965 established a federal solid waste research and development program and directed funds to states and cities for new disposal programs. In 1976, with the passage of the Resource Conservation and Recovery Act, the federal government assumed more responsibility for solid waste management. EPA guidelines issued in 1979 ended legal open dumping in the U.S. Clean Air Act amendments in 1990 required stricter regulations on landfills and the EPA issued these in 1991.[10]

Federally funded research and other changes in policy also spurred the development of a market

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for landfill gas. The Energy Research and Development Administration (ERDA), created by the federal Energy Reorganization Act of 1974, concentrated on developing technologies to enhance domestic energy resources. Also in 1974, the Non-Nuclear Energy Research and Development Act required federal research on the use of solid waste. A key ERDA study on municipal solid waste found that methane recovery from wastewater treatment could supply 10 to 15 times the amount of energy cities use in providing municipal services. The study spurred ERDA to study solid wastes. As a direct result of these studies, the first commercial landfill gas-to-energy project at Rolling Hills Estates in California opened in 1975.

Several more national energy policy changes were needed to make landfill methane economically feasible. The 1978 Public Utility Regulatory Policies Act required the Federal Energy Regulatory Commission (FERC) to guarantee a market for electricity produced by small power plants. FERC required electric utilities to buy electricity produced by facilities producing less than 80 megawatts (MW) of electricity, which generally includes landfill gas production sites.

The Department of Energy Act of 1977 created the U.S. Department of Energy, which was authorized to fund and regulate waste-to-energy research projects and energy research. Federal tax credits enacted in 1980 encouraged the development of private enterprises to participate in the landfill gas market. Finally, federal air pollution regulations enacted in 1991 and 1996 required some landfills to meet higher standards for controlling their gas emissions, another factor encouraging the adoption of landfill gas technology.[11]

Uses

Landfill gas can be burned directly to generate electricity or it can be processed into a higher-energy gas for power generation. It can also be burned as a heat source for various industrial processes.

Texas has 24 landfill gas energy projects and at least 57 more sites suitable for such projects.

The McCommas Bluff Landfill, Operated by the City of Dallas

Source: Texas Comptroller of Public Accounts.

Landfill Gas in Texas

According to an EPA landfill database, Texas has 24 landfill gas energy projects and at least 57 more sites suitable for such projects. All but two of these projects are generating electricity, with a total collective capacity of at least 79 MW. No economic data on these projects are available.

Texas' first landfill gas project, Harris County's McCarty Road Landfill, opened in 1986. Most projects in Texas, however, began after 2000. Compared to other states, Texas is a relative newcomer to the use of landfill gas as an energy source.

Waste Management, Inc. owns ten operating landfill gas energy sites; Allied Waste Services owns five operating sites. Texas cities and counties own the remaining sites.[12]

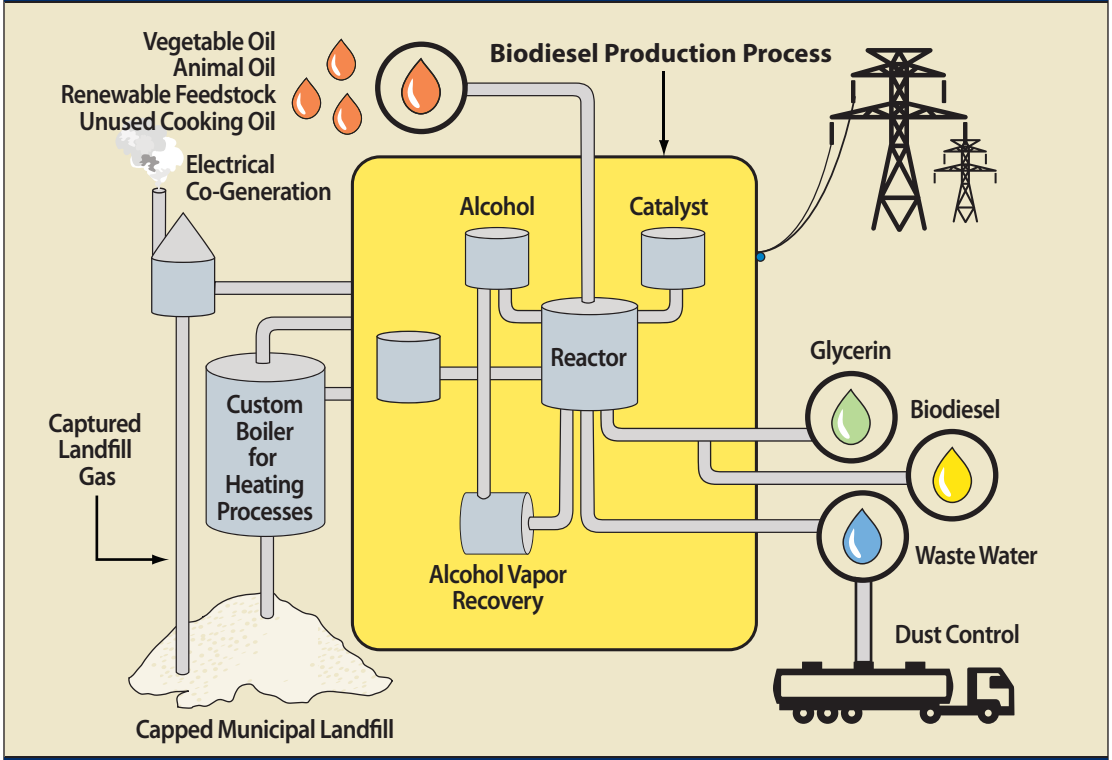
Two projects, Dallas' McCommas Bluff landfill and Houston's McCarty Road landfill, process landfill gas into a fuel with the same energy value as natural gas. The city of Dallas has contracted with a private company to develop the methane in its landfill; the company will own the rights to the gas produced for 30 years. The company sells the fuel directly to Atmos Energy Company, a natural gas supplier.[13]

Six other Texas projects generate energy for direct use. For example, in Denton, landfill gas is used to produce biodiesel fuel. Gas wells from Denton's landfill supply gas for heating water, as part of a chemical process that converts vegetable oils and animal fats to biodiesel fuel (**Exhibit 17-1**). The biodiesel production facility, owned and operated by BioDiesel Industries of Greater Dallas Fort Worth, sells the fuel it produces to other companies for blending with diesel; the blended fuel is used in garbage trucks and other utility trucks.[14]

Some landfills use gas to power generators that provide electricity to a utility or industrial customer.

Exhibit 17-1

Denton Biodiesel Plant



Source: Biodiesel Industries of Greater Dallas Fort Worth, LLC.

Consumption

Federal statistics combine landfill gas with the burning of municipal solid waste (See Chapter 18) for energy production in calculating state comparisons. Texas landfill and municipal waste projects produced just 230 million kilowatt-hours (kWh) in 2006. California, Florida, Massachusetts, New York and Pennsylvania each produced in excess of 1 billion kWh of electric power from both sources, led by Florida, with 1.9 billion kWh in 2006.[15]

Production

Most new landfills, if they fall under federal regulations, are required to collect methane to prevent air pollution, but most existing Texas landfills simply burn it off, a process called "flaring," without producing any useful energy.[16]

Landfills with collection systems can drill small wells and install compressors and pipes to remove the gas. The gas collects in the pipes and is channeled to a central collection point, where it may be treated to remove contaminants and moisture. It then can be transported by pipeline or used on site to generate heat or electricity, or transformed into cleaner gas and sent to a natural gas pipeline.[17]

The State Energy Conservation Office estimates that if the 70 largest landfills in Texas were fully developed for energy production, about 40 billion cubic feet of methane could be put to use generating nearly 200 MW of electricity.

Methane is generated as soon as solid waste is put in a landfill. Peak production starts about a year after deposit, but gas can be generated for 20 or more years, depending on the individual landfill characteristics. Moisture, the composition of materials in the landfill, soil types, air temperatures and other factors make each landfill unique in how much gas it produces, what the gas's components are and when it begins producing the gas.[18]

Generation

There are many ways to generate energy from landfill gas. The gas from the landfill can generate electricity; heat water into steam; be converted to fuel for vehicles; or purified to be used in natural gas pipelines.

The simplest and cheapest way to use landfill gas is to pipe the gas directly to the customer, who uses the gas to fuel boilers or combustion equipment. It can be used commercially for industrial kilns, thermal dryers (used in waste management operations), and cement and asphalt plants.[19] A greenhouse in Burlington, N.J. uses landfill gas to fuel a boiler for heating and to power four microturbines to convert landfill gas into electricity.[20]

Some landfills use gas to power generators that provide electricity to a utility or industrial customer. There are several types of electric generators: combustion turbines; steam/boiler turbines; and internal combustion engines.

About two-thirds of the landfill sites collecting methane in the U.S. generate electricity for on-site use or for sale. Most of these projects use internal combustion (IC) engines because they are efficient, cost effective and are usually a good match with the gas output of the average size landfill. IC engines are generally used at landfills where gas flows are capable of producing one to three MW.[21]

Larger landfills, with gas flows of more than two million cubic feet per day (cfd), can more efficiently use a combustion turbine to generate electricity, generating at least three or four MW.[22] Boiler/steam turbines are used mainly at very large landfills that have gas flows of at least five million cfd, generating at least eight to nine MW. The boiler/steam turbine systems are expensive to operate and only the largest landfills can afford to use them.[23]

Transmission

Most landfill gas energy projects collect, process and either use or distribute methane near the landfill site. However, landfill gas can be moved across longer distances via pipeline. In Hopewell, Virginia, Honeywell has a 23-mile long, 18-inch polyethylene pipeline carrying gas from a landfill in Sussex County, Virginia, and a 15-year contract with the landfill owner, Atlantic Waste Disposal. This is believed to be the longest landfill gas pipeline currently in use in the United States.[24]

In 2001, EPA reported that projects of this type were economically feasible only with pipeline lengths of less than five miles, however the Honeywell pipeline, which came on line in 2004, demonstrates the changing market potential for landfill gas and the fact that a longer pipeline can be successful.[25]

Storage and Disposal

The methane gas produced by landfills is not stored. It is used to produce energy either for sale or use on site or to generate energy as heat or steam for other purposes.

Landfill Gas Wells and Collection Systems

Source: Texas Comptroller of Public Accounts.

Availability

Every year, U.S. residents and companies discard mountains of waste — an estimated 251 million tons of it in 2006.[26]

Texans threw away 30.5 million tons of garbage in 2006. Even after removing construction waste and water treatment plant sludge from the total, this means that an average of 5.8 pounds of solid waste for every man, woman and child in the state was thrown away each day. This waste was deposited in one of 187 landfills actively accepting waste.[27]

According to the Texas Commission on Environmental Quality (TCEQ), landfills suitable for transformation into power-generating sites are those that have more than 1 million tons of refuse, are at least 40 feet deep and are in areas receiving more than 25 inches of rainfall annually. TCEQ estimated that 59 Texas landfills meet these criteria.[28] This is similar to EPA's landfill gas energy database estimate that Texas has 57 landfills that are candidates to generate power.[29]

By any estimate, Texas has potential for using this untapped energy source. The State Energy Conservation Office estimates that if the 70 largest landfills in Texas were fully developed for energy production, about 40 billion cubic feet of methane could be put to use generating nearly 200 MW of electricity, powering more than 100,000 homes in Texas.[30]

Costs and Benefits

According to EPA, preparing a 1 million-ton landfill for energy production can entail initial capital costs of $600,000 to $750,000 and operating costs of $40,000 to $50,000 a year. Administrative costs associated with legal issues and permitting, environmental impact studies and other costs also may be incurred.[31] Capital costs vary according to the type of plant used to process the methane. California's capital costs varied from $606 per kW to $6,811 per kW in 2001.[32]

Production costs and gas prices vary according to the size of the project, the technology used and the uses to which landfill gas is put. Prices of most renewables are not collected, according to the Energy Information Administration. Most newer renewable projects are developed and operated by independent power producers, and sold to utilities on a contractual basis (known as a power purchase agreement, or PPA). The price in the PPA represents wholesale cost and is typically held confidential by the parties involved.[33]

Landfill gas is less expensive than natural gas. For March 2008, the average natural gas price on the New York Mercantile Exchange was $9.590 per million Btus (MMBtu).[34]

Environmental Impact

Using landfill gas as another source of energy reduces the release of methane into the atmosphere and thus the accumulation of greenhouse gases. Landfills operators are required to meet air quality standards, so recovering energy from methane can help them offset the cost of meeting federal requirements.[35]

According to EPA, a three MW landfill gas project producing electricity generates the environmental equivalent of removing 25,000 cars from the road; planting 35,000 acres of trees; or preventing the use of 304,000 barrels of oil.[36]

Sometimes, pipelines carrying landfill gas traverse sensitive environmental areas. Methane gas is

Using landfill gas as another source of energy reduces the release of methane into the atmosphere.

transported from the Arlington, Texas, landfill via a four-mile pipeline to the Fort Worth Village Creek Wastewater Treatment Plant. This pipeline passes under River Legacy Park, a 1,300-acre Trinity River greenbelt, forest and floodplain area.[37]

Other Risks

Methane forms naturally as organic materials decompose. If not properly vented or collected and flared, it can potentially cause fires or explosions. The gas can migrate into nearby structures or buildings built on top of old landfills. EPA regulations requiring landfills to have non-porous liners and to vent, collect or flare gas have greatly enhanced safety.

State and Federal Oversight

House Bill 3415, enacted by the 2001 Texas Legislature, encouraged the use of landfill gas for state energy purposes. The bill required TCEQ and the Public Utility Commission to promote the economic development and use of landfill gas. Specifically, the agencies were to publicize agency information on landfills with a potential for landfill gas development; assist various industry sectors to form partnerships for developing landfill gas; and establish an information clearinghouse on landfill gas development and use.[38]

In November 2002, TCEQ released a status report on the development of Texas' landfill gas resources. The report concluded that there were few obstacles to the development of landfill gas projects, but that some actions could speed their development. TCEQ recommended outreach and informational efforts such as developing a primer and Web page on landfill gas development and sponsoring a workshop for interested parties.[39]

Also in 2002, the Texas Senate Interim Committee on Natural Resources made legislative recommendations on alternative fuel sources. The committee recommended surveying existing landfills and connecting potential gas recovery projects with the U.S. EPA's Landfill Methane Outreach program (LMOP).[40] LMOP provides information and resources to communities, companies and other parties interested in recovering and using landfill gas.

State laws and regulations require landfills to acquire appropriate air, wastewater and solid waste permits. These rules outline actions a landfill must take to protect the environment and public health and safety.[41]

As noted above, federal involvement with landfill regulation began with the Resource Conservation and Recovery Act of 1976 and was intensified by 1979 EPA guidelines and 1990 Clean Air Act amendments.[42] In the 1990s, federal air pollution regulations further tightened emissions standards at existing landfills.[43]

Subsidies and Taxes

A federal production tax credit of one cent per kWh is available for energy produced from landfill gas. Chapter 28 contains more information on biomass subsidies.

Other States and Countries

Pennsylvania serves as a model state in the development of landfill gas. The state has 24 landfill gas-to-energy projects, representing a relatively high percentage of all Pennsylvania landfills.[44] In 2006, EPA named Pennsylvania as the State Partner of the Year for its work in promoting the use of landfill gas as a renewable energy source. Pennsylvania developed a landfill methane database and wrote a landfill gas development primer.[45] Landfill gas is included as part of the state's alternative energy portfolio standards, and the state has provided an estimated $3.8 million from several different programs to benefit landfill gas projects.[46]

Massachusetts has 15 landfills producing about 51 MW of power across the state. In Massachusetts, one megawatt powers about 1,200 homes. Many of these projects began in the 1990s when the Massachusetts Department of Environmental Protection began promoting landfill gas as a renewable fuel source. The state was looking for ways to diversify and expand its energy portfolio so that it did not rely on a few sources for energy. Landfill gas to energy projects benefited the state in two ways: they decreased the methane emissions from landfills (which improved air quality), and provided the state with a renewable fuel for generating power. More landfill gas to energy projects are in development and are expected to generate an additional 9 MW of power for Massachusetts residents when completed.[47]

Outlook for Texas

Given the rising costs of oil and natural gas, landfill gas presents an attractive and relatively untapped energy source. Yet it has not been a major focus for research and development in the state.

Some new technologies in this area are being studied, however, such as "landfill bioreactors," in which water is added to the landfill to speed up the process of decomposition. Other companies are exploring ways to thoroughly clean the gas that landfills produce. Cleaning the gas separates the methane, which is the main component of natural gas, and CO2, which can be sold separately for commercial purposes.

Richard DiGia, vice president of operations and construction for DTE Biomass Energy, has said that landfill gas is very attractive for electric generation compared with other renewable sources of energy because of the capacity. "As long as we keep landfilling there'll be landfill gas," he stated.[48]

With 186 landfills actively accepting waste and an estimated 50-plus candidate sites that could develop landfill gas, Texas has an opportunity to turn much more of its waste into cash.

Developing landfill gas facilities makes sense only if private or public entities can use, buy or sell it. Gary Bartels, general manager of the city of Arlington's landfill for Republic Waste Services, pointed out the advantages of having private companies as partners: as private entities, they can qualify for federal landfill gas production tax credits, lowering the break-even threshold for the operation.[49]

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