Database of Landfill Gas to Energy Projects in the United States

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16. ABSTRACT The paper discusses factors influencing the increase of landfill gas to energy (LFG-E) projects in the U. S. and presents recent statistics from a database. There has been a dramatic increase in the number of LFG-E projects in the U. S., due to such factors as implementation of the Clean Air Act regulations for municipal solid waste landfills, availability of economic incentives, and programs to help encourage greehouse gas reductions and renewable energy. The U. S. LFG-E industry has experienced about 10% per year growth since 1990. As of January 1999, there were about 300 operational facilities, 90 facilities under construction, and 144 planned projects. The data presented in the paper are the result of a partnership between the U. S. EPA, the Solid Waste Association of North America, and the U. S. LFG-E industry.

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Summary: There has been a dramatic increase in the number of landfill gas to energy (LFG-E) projects in the U.S. This is due to a number of factors including implementation of the Clean Air Act (CAA) regulations for municipal solid waste (MSW) landfills, availability of economic incentives, and programs to help encourage greenhouse gas reductions and renewable energy. The U.S. LFG-E industry has experienced about 10 percent per year growth since 1990. As of January 1999 there were about 300 operational facilities, 90 facilities under construction, and 144 planned projects. The data presented in this paper are the result of a partnership between the U.S. Environmental Protection Agency (EPA), the Solid Waste Association of North America (SWANA), and the U.S. LFG-E industry. This paper discusses factors influencing the increase of LFG-E projects in the U.S. and presents recent statistics from the database. This paper has undergone review by the EPA including peer, quality assurance, and administrative reviews.

1. INTRODUCTION

The environmental benefits of LFG-E are considered significant. Landfills are estimated to be the largest anthropogenic source of methane emissions in the United States. Methane is a potent greenhouse gas that has 21 times the warming effect of carbon dioxide. Landfill gas is considered to be a threat to human health and the environment. Utilization of landfill gas displaces fossil fuel, creates jobs, and reduces emissions that impact human health and the environment associated with the use of nonrenewable energy sources such as coal (Thorneloe, 1992).

Landfill gas has a composition of about 50% methane and 50% carbon dioxide with trace constituents of compounds that include volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Landfill gas has about half the heating value of natural gas. The EPA promulgated CAA regulations for municipal solid waste (MSW) landfills which were published March 12, 1996 (FR Vol. 61, No. 49). Although this regulation uses non-methane organic compounds (NMOCs) as its trigger, it recognizes the potential cobenefits of greenhouse gas (GHG) reductions, HAPs, and VOCs. The regulation

requires that sites containing more than 2.5 million megagrams (Mg) and 2.5 million cubic meters (m^3) or more of waste must collect and control landfill gas if their estimated emissions of NMOCs are 50 Mg per year or more. This will result in a reduction of ~6 million metric tons per year of carbon by the year 2000 (EPA, 1991). The associated GHG reduction is equivalent to ~8 billion liters of gasoline per year or taking 4 million cars off the road (FR Vol. 61, No. 49). Data have also shown that leachate is typically less contaminated as a result of landfill gas control.

2. FACTORS INFLUENCING THE INCREASE IN LANDFILL GAS UTILIZATION

A number of factors influence landfill gas utilization. The CAA regulations promulgated in 1996 will result in more landfills being required to collect and control landfill gas. While most of the landfills will flare the gas to be in compliance with this regulation, it is expected that there will be an increase in the number of landfills that utilize landfill gas to help offset regulatory compliance costs. The preamble of the promulgated regulation estimated that ~45 new landfills that are estimated to be constructed over the next 5 years and ~300 existing sites will be required to install gas extraction and control systems. Additional rulemaking activities are underway that may require additional sites to collect and control landfill gas to respond to residual risk and urban air toxic concerns. Also, many states have rules requiring landfill gas collection and control.

In addition to an increase in new projects as a result of CAA regulations, economic incentives have helped to encourage landfill gas utilization. The most significant of these has been a program providing Federal tax credits (i.e., Section 29). Qualification for this program was discontinued in June of 1998. Projects that qualified for tax credits have to complete implementation of the energy project in order to receive the tax credits. There has been a marked increase in new projects corresponding with the discontinuation of this incentive. The U.S. LFG-E industry and others have attempted to get this program continued, but its future remains unclear. Many in the industry claim that LFG-E projects are marginally economical and that the tax incentives have been essential in helping to encourage new projects as well as keep existing projects operating.

Another important program is EPA's Landfill Methane Outreach Program (LMOP) that was initiated as part of the Administration's Climate Change Action Plan which targeted landfill methane as a priority. LMOP was formed to help promote and facilitate LFG-E. LMOP is working to minimize barriers impacting LFG-E and provide assistance to the U.S. LFG-E industry in developing new projects. The website for further information on the LMOP is http://earth1.epa.gov/lmop.

Utility deregulation and its impact are unclear. Some states require a certain amount of renewable energy. This could have a positive benefit on the growth of new LFG-E projects and other types of renewable energy. However, renewable-based energy is not as cost competitive as fossil-based energy due to current low costs of fossil fuels in the U.S. Efforts to create a carbon tax have not been popular in the U.S. Policy discussions are under way at the national and state levels to develop programs that will encourage the use of renewable energy and reduce GHG emissions.

Consolidation of the waste disposal industry and consulting and engineering services is also impacting the U.S. LFG-E industry. Two of the largest waste management companies in the U.S., Waste Management, Inc. and Browning-Ferris Industries, Inc. have undergone or are undergoing consolidation. Waste Management, Inc. has 28 operating projects, with 3 under construction and 7 planned. They have the largest number of projects of any developer and were an early pioneer in developing LFG-E projects. Since 1992, Browning-Ferris Industries, Inc. has been aggressively developing projects: currently they have 19 operating projects, 3 under construction, and 6 planned. With increased emphasis on profit margins and cost-cutting measures being adopted, these consolidations may impact the expansion or continuation of existing projects and the development of new projects.

As a result of many factors influencing landfill gas utilization, the need exists for up-to-date, credible statistics. A goal for the development and maintenance of the database described in this paper is to help track industry trends. The database will also help to better quantify the emission reductions occurring at U.S. landfills and document pollution prevention benefits. Efforts are also underway as a result of funding by EPA's LMOP to collect data from sites that are flaring landfill gas. It is hoped that this information will help to identify potential new sites for LFG-E projects. In addition, the type of data collected for LFG-E projects is being expanded to collect additional information on existing and state-of-the art technologies including leachate evaporators, fuel cells, and operation of landfills as a "biocell" or enhanced bioreactor that can help improve the economics of landfill gas utilization. (Thorneloe et al., 1998; Roe et al., 1998)

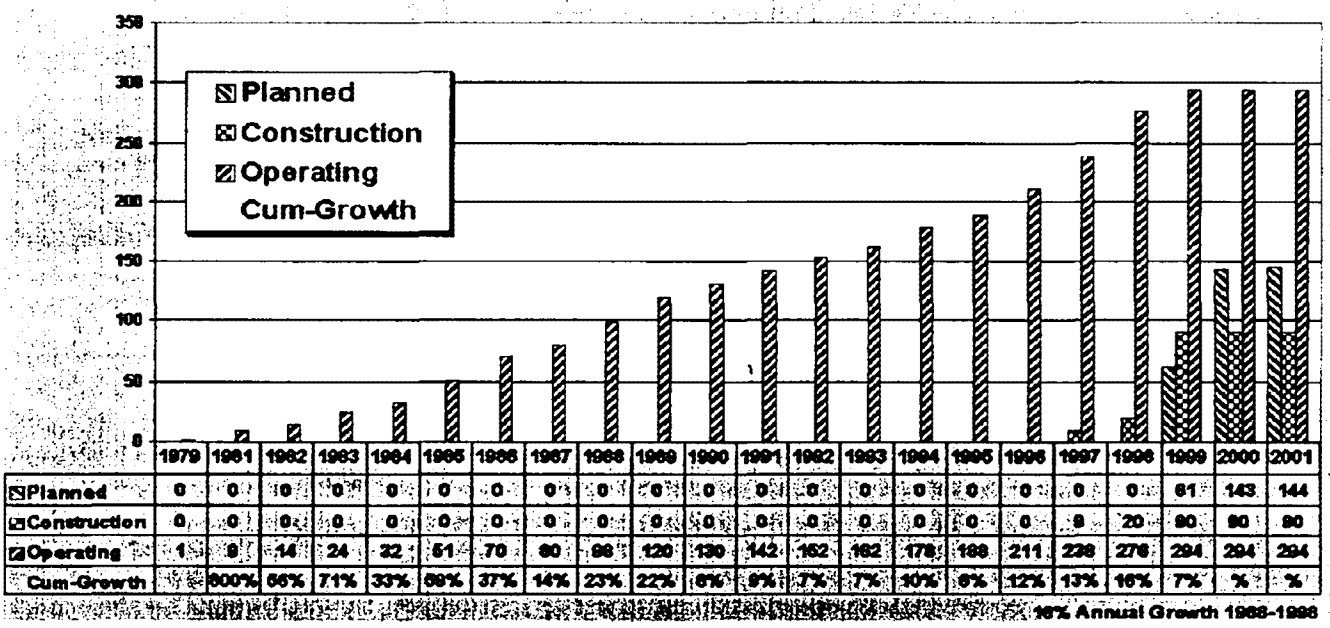
3. DATABASE OF U.S. LFG-E PROJECTS

For several years, through SWANA's landfill gas database committee, information has been collected to help track industry trends. EPA has provided support to this effort through its Office of Research and Development and LMOP. This has been a voluntary effort and there has been excellent cooperation by the U.S. LFG-E industry. Using data collected in 1998, the LFG-E database is being updated and verified through contacts with the industry and site visits. The updated version is to be released later this year.

Data have been collected on projects that are currently operating, under construction, or in advanced planning status. Tentative projects and projects without signed contracts are excluded. The term "project" is defined as the number of different technologies in use at a site. For example the largest LFG-E plant in the U.S., Puente Hills, has four separate projects including a boiler/steam turbine plant, a gas-fed turbine, a process for producing compressed landfill gas for providing vehicle fuel, and gas sales to a local college. As gas flow changes, many developers will use a modular approach and add equipment for increased power generation capacity or remove equipment for use at another site. Expansions are considered one project unless different technologies are in use. Also, developers occasionally will collect gas from nearby sites to improve economies of scale. There are several cases where two or more landfills fuel one project. This is counted as one project.

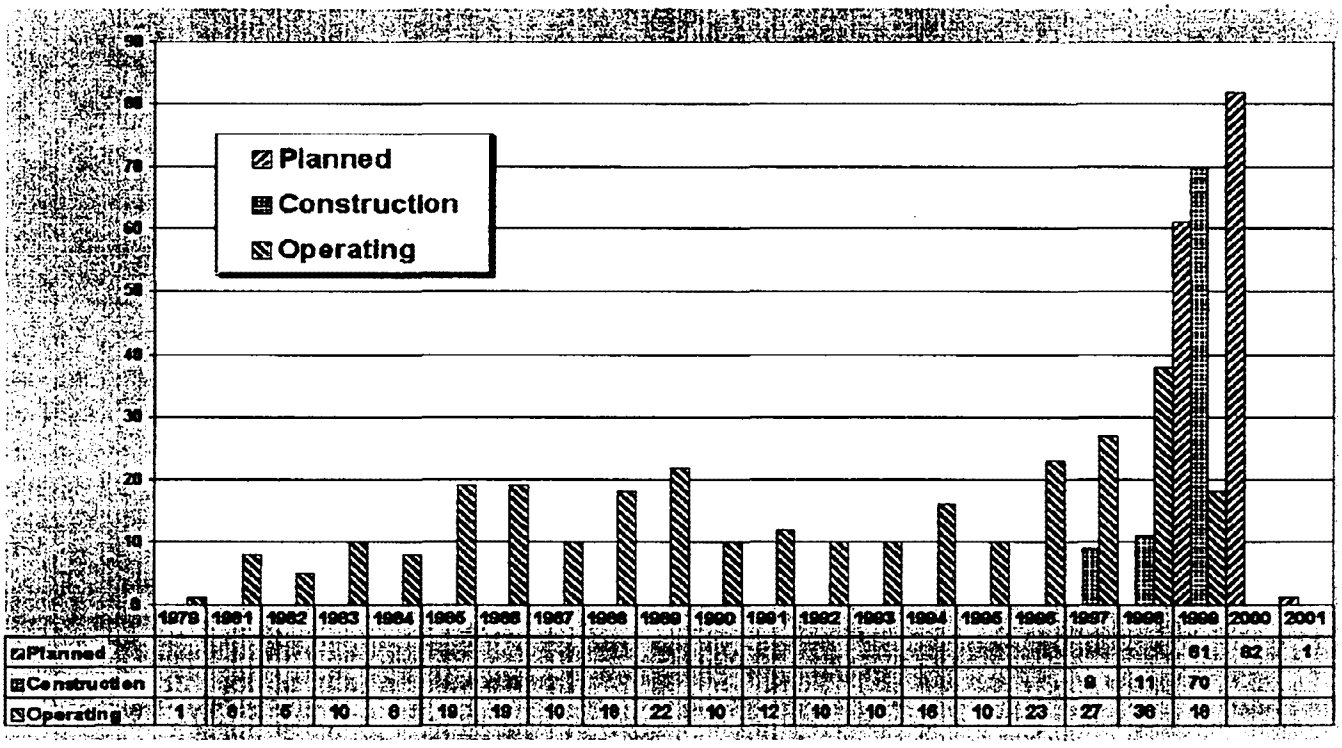
Using data collected in 1998 for the U.S. LFG-E industry, we have found about 10% per year average growth with a 16% per year average growth of new projects for this decade. Eighty-three new projects began operation since 1996 with 18 new facilities in the last

year. Currently there are about 300 operational projects, 90 projects under construction, and 144 planned projects. Figure 1 illustrates the growth for the U.S. LFG-E industry. New LFG-E projects begun each year are provided in Figure 2.



	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Planned	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61	143	144
Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	20	90	90	90
Operating	1	9	14	24	32	51	70	80	98	120	130	142	152	162	178	188	211	238	276	294	294	294
Cum-Growth		800%	56%	71%	33%	59%	37%	14%	23%	22%	8%	9%	7%	7%	10%	6%	12%	13%	16%	7%	%	%

Figure 1– Annual and Cumulative Growth for U.S. LFG-E Projects



	1979	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Planned																				61	82	1
Construction																		9	11	70		
Operating	1	9	5	10	8	19	19	10	18	22	10	12	10	10	16	10	23	27	36	18		

Figure 2 – Cumulative Growth of New LFG-E Projects in the U.S.

3.1 Operational Facilities

There is a dramatic increase in the number of LFG-E projects in the U.S. with ~130 in 1990 and with ~300 projects in 1999. This is due to a number of factors as previously discussed. California was the early leader in LFG-E because of a favorable utility Standard Offer #4 contract that offered high electrical prices. Due to heavy response, this contract was offered only in 1984 and 1985. California was also one of the first states to require landfill gas collection and control. Similarly, in 1989 Michigan passed legislation providing incentives for renewable power that has resulted in the construction of many LFG-E facilities in that state. However, Michigan is fully subscribed, which has slowed additional development. Other states have also used incentives to encourage LFG-E including Pennsylvania, New York, and New Jersey. Due to programs to help encourage renewable energy and GHG reductions and the implementation of the CAA regulations, the number of projects is expected to increase. However, it is not expected to grow at the rate experienced in this decade because many of the large projects that provide favorable economics have been developed. However, new landfills being planned are typically larger sites and will likely be required to collect and control landfill gas. Hopefully programs will exist that will encourage utilization of the landfill gas so that increased benefits to human health and the environment can be realized.

3.2 Future Growth - Facilities in Construction and Advanced Planning

About 61 projects are in an advanced planning status and 90 projects are under construction. The majority of these projects are commercial projects that are taking advantage of the tax credits that can potentially offset regulatory compliance costs. However, for these projects to go forward there must be favorable economics. It is unclear what the impact may be on these planned projects as a result of the recent consolidations occurring in the waste industry.

A developer must secure an energy contract that exceeds the developmental costs. The existence of favorable energy contracts in the early 1980's, over $0.08/kWhr, caused many more LFG-E facilities to be developed in California than in any other state. Then California development slowed significantly in the early 1990's because the utilities were typically offering about $0.03/kWhr and the Standard Offer #4 contracts began to phase out. Tax credits have helped to offset the lower value of the energy contracts.

Other states have bills to favor renewable energy. Illinois passed a bill that has resulted in at least 11 projects currently in construction or in advanced planning. Other states in the East are gaining momentum. Medium heating value projects – half that of natural gas – are increasing in frequency, and the U.S. has over a decade of experience using boilers. There are 28 planned medium heating value projects and 10 in advanced planning status. Also, utilities have more interest in landfill gas utilization to help them meet GHG reduction goals. Currently, several utilities are using, or planning to use, landfill gas in large fossil-fueled plants and are helping to develop new projects including the use of fuel cell technology.

4. TYPES OF TECHNOLOGIES BEING USED IN THE U.S.

Landfill gas can displace natural gas in essentially all applications and other fossil fuels in most applications (Augenstein and Pacey, 1992; Doorn et al., 1995). The distribution of technologies in use by the LFG-E industry is provided in Table 1. Over 70% of

operational LFG-E projects generate electricity. Electrical generation technologies include reciprocating engines, gas turbines, boiler/steam turbines, combined cycles (gas turbine and steam turbine), and fuel cells. Over 50% of the operating LFG-E projects use reciprocating engines. Innovations in their design have improved energy efficiency and reduced by-product emissions.

Table 1 – Distribution of Project Types in the U.S. LFG-E Industry

Reciprocating Engine	47	55	46	248
Medium Heat Value	70	13	29	112
Boiler/Steam Turbine	5	1	1	6
Gas Turbine	35	4	1	30
High Heat Value	7	9	8	24
Leachate Evaporation	9	2	2	13
Combined Cycle	3		1	4
Other Electricity	1	1	10	36
Unknown			41	46
Fuel Cell	2	1	1	3
Special-Greenhouse	1		2	3
Cogeneration	1		1	2
Special-Methanol synthesis			1	1
Total Projects	**294**	**90**	**144**	**528**

Emerging technologies such as fuel cells and leachate evaporators are being more widely considered for future use. EPA's Office of Research and Development conducted a review of emerging technologies for landfill gas. It provides a ranking of these technologies based on the degree of field demonstration (Roe et al., 1998). Fuel cells are considered to be a preferred technology for landfill gas utilization due to its higher energy efficiency compared to conventional technology and minimal environmental impact. There has been a recent demonstration of the application of the fuel cell technology on landfill gas that was conducted by EPA's Office of Research and Development (Spiegel et al., 1997; 1999).

Leachate evaporators are also being used more widely. These processes use heat to evaporate leachate and combust the exhaust gas which contains VOCs and HAPs. There are different variations of this system. The unit manufactured by Organic Waste Technologies has two different designs that are described in a recent EPA report (Roe et al., 1998). Another company, Power Strategies, has a unit that exhausts the evaporated

gas from the leachate evaporator to a reciprocating engine where it is combusted while producing electricity. The waste heat from the engines is also utilized to evaporate the leachate.

5. U.S. LFG-E DEVELOPERS

Currently there is much more competition and the potential profit is much less than a decade ago when often 10 to 20 % royalties were obtainable. Decreasing prices for electricity and natural gas have forced LFG-E developers to become more efficient, and many have eliminated royalties. U.S. developers typically offer to install and operate the gas collection system at cost. Depending on the size of the landfill, the landfill owner can save millions of dollars in avoiding the cost of installing, operating, and maintaining a landfill's gas collection system by contracting with a LFG-E developer. Small lease payments may be offered to large landfill owners by LFG-E developers.

Numerous independent developers are actively contacting landfill owners to contract landfill gas rights and to develop LFG-E projects. LFG-E developers are typically specialists who focus on the utilization of landfill gas and tax benefits as opposed to landfill owners who focus on refuse disposal and landfill operations.

Over 10 independent developers are looking for new projects to develop, which results in a competitive market. Owners of medium to large landfills issuing requests for proposals (RFPs) for the development of LFG-E facilities can generally expect several competitive proposals in response. An established community of competitive developers has grown with the LFG-E industry. LFG-E projects are quickly developed whenever economically feasible, given willing landfill owners.

6. ACKNOWLEDGEMENTS

The information provided for this database has been collected under a voluntary basis. This is being accomplished by a combined effort by SWANA, the EPA, and the U.S. LFG-E industry. The data presented in this paper are being updated and verified and will be released in an electronic version in 1999. Future updates and maintenance are also planned.

The database is also being expanded to provide data on Canadian projects to include a complete set of data for North America. Anyone interested in providing additional data or information is encouraged to contact SWANA. The goal is to provide up-to-date and credible data to help track trends that are occurring as a result of landfill gas utilization.

Discussions are underway to determine how best to release the database. One option under discussion is providing an electronic form of the database that is available through SWANA, who will be responsible for providing updates and maintenance of the data. There may be a cost for accessing the database that will help to offset the cost associated with future updates. A report providing a summary of the data is also being developed.

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