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Project Summary

Landfill Gas Energy Utilization: Technology Options and Case Studies

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Landfill gas, from refuse decomposing in sanitary landfills, can be a fuel for a variety of energy applications. This report discusses technical, environmental, and other issues associated with using landfill gas as a fuel, and presents case studies of projects in the U.S. illustrating some common energy uses. The full report, summarized below, begins by covering basic issues such as gas origin, composition, and means of collection; environmental and regulatory background is presented. Landfill gas' properties as a fuel are reviewed; equipment that can utilize landfill gas is discussed. The report then describes experience with six projects in the U.S. where landfill gas has been used for energy. It also references literature on other landfill gas energy projects of interest. Conclusions regarding uses of landfill gas for energy are presented.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Gas derived from decomposing refuse in landfills, or "landfill gas," can be fuel for a variety of energy applications. Its uses are currently significant, and increasing. Because of interest from many parties concerning landfill gas energy, information and documentation of experience in several areas of landfill gas energy uses are needed. The report reviews the various landfill gas energy uses, their associated issues and constraints, and case studies of six landfill gas energy projects in the U.S. The report provides useful background to those interested in, and particularly those implementing, landfill gas energy uses.

Landfill Gas

Most residential and municipal solid waste in the U.S. is currently disposed of in sanitary landfills. In landfills, a portion of the waste organic fraction decomposes (typically over decades) into landfill gas containing about half methane, with the rest carbon dioxide and smaller quantities of other components. Because of its methane content (the same methane in pipeline or "natural" gas) and the quantity available, landfill gas is a significant fuel resource. It is currently extracted and used for energy at an increasing number of sites, currently over 100 in the U.S. Its properties, and the circumstances of its use, pose some fairly unique issues and constraints.

Energy Applications

With appropriate allowance for its features, landfill gas is usable in much commercially available equipment that normally uses more conventional fuels such as pipeline natural gas. The applications (both current and potential) that can use it are shown in Table 1. Also shown are estimated extents to which the applications are carried out in the U.S.

Table 1. Landfill Gas Energy Applications

Application [a]	Current degree of use [b]
Current applications	
Space heating (and cooling)	*Limited*
Industrial process heat	*Limited*
Boiler fuel	*Moderate*
Electric generation: IC engines	*Most common*
Electric generation: gas turbines	*Common*
Electric generation: steam turbines	*Limited*
Purification for pipeline use	*Moderate*
Potential future applications	
• *Electric generation using fuel cells*	*N/A*
• *Compressed methane vehicle fuel*	*N/A*
• *Synfuel or chemical feedstock*	*N/A*

[a] Most significant actual or potential uses.
[b] Statistics on use are far from complete. Defining degree of use in terms of the fraction of the total landfill gas recovered and used for energy in the U.S., "limited" is of the order of 5%, "moderate" 5 to 20%, "common" 20% or more, and "most common" about 50%.

Technical Considerations with Gas Energy Uses

Specific factors and likely consequences need to be considered when landfill gas (rather than more "conventional" fuels) is used in any application. Two important considerations common to most applications are, equipment derating, which occurs because of landfill gas' lower energy content, and the possible effects of contaminants. Equipment deratings compared to operation on pipeline gas or other fuels are most often between 5 and 20%. This is because of both the gas' inert components and also sometimes parasitic energy uses (compression). Contaminants are present to varying levels in gas from all landfills and can corrode equipment and cause other problems. Because of contaminants, gas cleanup is important; current gas cleanup approaches have limits in that some of the halogenated compounds that are threats because they can cause equipment corrosion are not easily removed. For this and other reasons, contaminant- related problems remain frequent in landfill gas energy projects. Because of the contaminants, lower energy content, and other factors, several design and operational modifications have been developed to adapt conventional equipment to landfill gas energy use.

Other factors are important in gas energy applications. These include whether gas use is intermittent or continuous. Applications that can use the gas continuously, such as electric generation, are the most attractive because the gas is continuously available and there is no established way of storing it. Several issues of normal concern for landfill gas (such as forecasting its recoverable quantity over time, and collecting it efficiently) are also key factors in using it for energy.

Environmental Issues

Energy use of landfill gas has environmental consequences that can be considered predominantly beneficial. Extracting methane mitigates migration hazards, and emission of the landfill gas constituents. These constituents include both nonmethane organic compounds (NMOCs) of concern as local air pollutants, and the methane, which is a potential contributor to climate change ("greenhouse effect"). The energy use of methane also most typically offsets fossil fuel use elsewhere, reducing the emissions that would otherwise be associated with the use of that fossil fuel. The energy conversion equipment emissions can, however, be a concern; equipment must meet emission constraints.

Economic Factors

Cost/benefit ratios of landfill gas applications at different sites vary greatly because of high variability in costs, revenues, and revenue-equivalent benefits. This is partly due to site-specific factors that influence costs, and partly due to energy market conditions, which influence revenue. In particular available revenue from electric energy sales varies greatly from location to location around the U.S. Energy conversion practicality is limited by economics at many U.S. landfill sites, including at many of the smaller sites.

Case Studies

The case studies review landfill gas energy uses at six sites within the U.S. The case studies are "snapshots" representing a few of the total of U.S. landfill gas energy projects. They do, however, illustrate experience and some benefits. The sites, with their applications, are

1. The Brown Station Road Landfill, Prince George's County, Maryland. At this facility, the landfill gas is used to fuel electric power, space heating, and hot water provided to a very large county building complex. Surplus electric power generated is vended to the local utility grid.
2. The Otay Landfill, San Diego, California. At this site a Cooper-Superior* internal combustion (IC) engine powered generator provides electrical power for export sale to the local utility grid.
3. The Marina Landfill, Marina, California. At this site two Waukesha IC engine powered generators produce electrical power for export sale to the utility grid. The facility was one of the first to be implemented and is one of the longest running in the U.S.
4. The Sycamore Canyon site, San Diego, California. This site illustrates the use of Solar combustion gas turbines to power generation of electricity for sale to the local utility grid.
5. A site in Raleigh, North Carolina, where landfill gas is pipelined 3/4-mile (1.2 km) to a local pharmaceutical plant. It fuels a Cleaver-Brooks boiler at the plant that provides most of the plant process steam needs.
6. A site in Yolo County, California, where landfill gas fuels three Caterpillar engines that power electric generation for sale to the local utility.

The case study applications reflect that IC engine and gas turbine powered electric generators are the most common applications of landfill gas energy. A space-heat and steam-generation project are also included in the case studies. These case study applications are considered to be among the more attractive candidate approaches for future sites.

Though case studies cover only six projects, the spectrum of experience is indicative of the variety and site specificity of U.S. landfill gas energy projects. Two projects (1 and 6 above) experienced serious and unforeseen problems at one or

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

more times. Two projects (2 and 5 above) appear to have done well since inception. The other two do well technically but economic performance has not been as good as technical performance because of low electric revenue.

The details and complexities of implementing several projects (sites 1, 3, 5, and 6) may be of particular interest to others contemplating energy uses.

Conclusions

Based on this study, important conclusions include:

- Landfill gas can be a satisfactory fuel for a wide variety of applications, and its use in these applications provides environmental and conservation benefits. Many types of energy equipment that operate on more "conventional" fuels can also operate on landfill gas.
- Some reduction in the energy output of conventional equipment, about 5 to 20 percent compared to output on conventional fuels, is normally associated with landfill gas use.
- When landfill gas is used as a fuel, its properties and unique nature, and particularly its contaminants, must be considered. Many pitfalls are possible in landfill gas energy applications. Especially important are equipment damage caused by the gas contaminants, and gas supply problems such as shortages resulting from incorrectly forecasting the availability of the gas.
- Cleanup stringency and methods vary widely. The necessary degree of landfill gas cleanup has not been well established. Cleanup is often expensive, both economically and in energy requirements.
- The optimum tradeoffs between cleanup stringency and the frequency of maintenance, such as oil changes, are not well established.
- Collection technologies are developed but probably could be further improved.
- Methods of forecasting gas availability for new sites are available but could be improved.
- Economics vary greatly; at some sites, economics may be excellent but at others, economics are a major limitation. Economics now tend to preclude smaller scale and remote site uses where electric power sale prices are low and there are no other convenient energy applications.
- Emission limits in some U.S. locations may also inhibit landfill gas energy uses despite an environmental balance sheet that would generally appear to be strongly positive.

Further Needs

Based on this project's work and cited literature, further needs regarding landfill gas energy use appear to include:

- Examining ways to improve and standardize gas cleanup for specific applications.
- Examining further the tradeoffs between approaches such as more stringent gas cleanup and maintenance measures such as more frequent oil changes.
- Examining further optimum operating parameters, such as the best oil, coolant, and exhaust gas temperature.
- Examining further and documenting appropriate engine and other equipment design modifications to reduce current contaminant-related problems experienced with landfill gas use.
- Improving technology in ancillary areas that relate to energy uses such as forecasting gas recoverability and improving gas collection efficiency and reliability.
- Developing and improving economic small-scale uses for the landfill gas.
- Developing further detailed documentation of experienced problems, and attempted and successful solutions to them, to benefit the community of present and future landfill gas users.
- Examining ways to reduce economic (and institutional) barriers to landfill gas energy applications.

Technical improvements, in the areas referred to above, should help advance landfill gas energy use. In addition, incentives and other approaches are possible that may help to reduce the nontechnical barriers to landfill gas energy use.

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The complete report, entitled "Landfill Gas Energy Utilization: Technology Options and Case Studies," (Order No. PB92-203116/AS; Cost: $27.00; subject to change) will be available only from:
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