LANDFILL METHANE OUTREACH PROGRAM

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# Adapting Boilers to Utilize Landfill Gas: An Environmentally and Economically Beneficial Opportunity

Utilization of landfill gas (LFG) in place of a conventional fuel such as natural gas, fuel oil, or coal in boilers is an established practice with a track record of more than 25 years of success. In the United States, more than 60 organizations have switched to the use of LFG in their industrial, commercial, or institutional boilers, with more than 70 boilers operating with LFG, either alone or co-fired with other fuels. Boilers firing LFG range in size from 2 to more than 150 million British Thermal Units per hour (MMBtu/hr). Companies using LFG are saving money while protecting the environment. General Motors fires LFG in boilers at four of their manufacturing and assembly plants and reports that they have realized energy cost savings of about $500,000 per year at each of the four plants.


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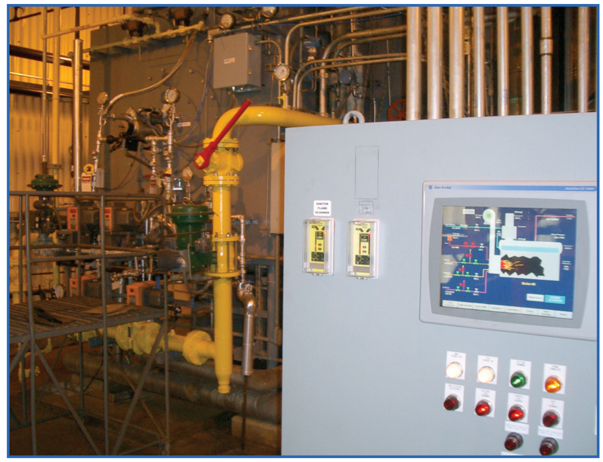
This fact sheet discusses the technical and engineering issues associated with using LFG in boilers designed to burn other fuels. The equipment and operational changes are relatively simple and use proven technologies, and dozens of firms can engineer and implement a conversion project.

## Comparison of Landfill Gas and Natural Gas

Like natural gas, LFG's heating value is derived largely from methane, but unlike natural gas, LFG is comprised about 50 percent by volume of non-combustible gas, mostly carbon dioxide ($CO_2$). LFG is classified as a "medium Btu gas" with a heating value of about 500 Btu per cubic foot, about half that of natural gas. Therefore, the volume of LFG that must be handled by the fuel train and burner is twice that of natural gas. This means that modifications to the fuel train and burner are usually required to accommodate the higher overall gas flowrate for an equivalent natural gas heating value. The increased gas flow, however, does not have an appreciable effect on the design and operation of boiler components downstream of the burner. The added volume of non-combustible (inert) gas in LFG is equivalent to the inert gas entering a boiler when about six percent of the flue gas is recirculated to the boiler. Flue Gas Recirculation (FGR) is a widely applied technique for reducing nitrogen oxide ($NO_x$) emissions from natural gas-fired industrial and commercial boilers, and boilers can typically operate at recirculation rates of 20-25 percent without adversely affecting boiler heat transfer and efficiency. This comparison illustrates that the increased flow of LFG as compared to natural gas will not adversely affect boiler operation, although the burner, controls, and fuel train will require some modifications.

## Burner, Control, and Fuel Train Modifications



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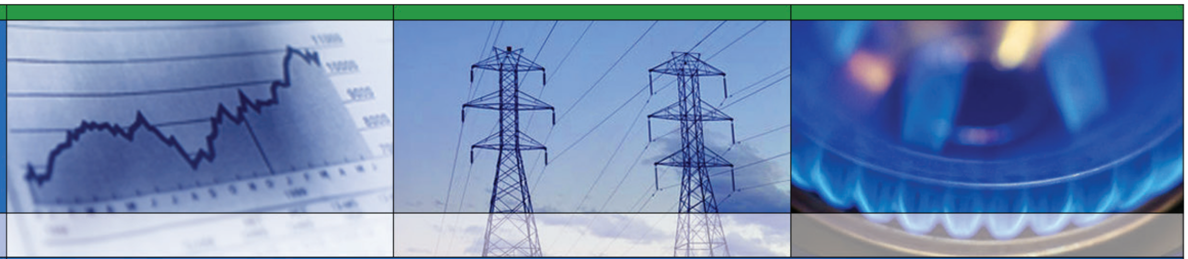
The equipment for retrofitting a boiler to burn LFG is commercially available, proven, and not overly complex. The decisions that must be made during engineering and design are, however, site-specific and may be somewhat involved. For example, some installations have retained the original burner but modified it for LFG (e.g., by installing separate LFG fuel train and gas spuds) while maintaining the existing natural gas fuel train and gas ring to permit LFG/natural gas co-firing. Other installations have replaced the entire burner, controls, and fuel train with a dual-fuel burner and dual-fuel trains specifically designed to handle medium Btu gas. In general, the decision to furnish all new equipment is made based on the owner's preference or because the existing burner and controls are nearing the end of their useful lives. Additional analysis may be required to determine the amount of LFG compression that is provided versus the modifications needed for the burner and gas train.

Because LFG is typically a wet gas often containing trace corrosive compounds, the fuel train and possibly some burner "internals" should be replaced with corrosion-resistant materials. Stainless steel has typically been the material selected.

The controls associated with fuel flow and combustion air flow need to be engineered to cope with the variable heat content of LFG. The complexity of the burner management system will depend upon whether the boiler is to be co-fired with natural gas or oil and whether the boiler is to be co-fired at all times or if there will be times when it will be fired with LFG only. Today's modern controls, fast-responding oxygen analyzers, and responsive flame sensors make it possible to fire LFG with the same level of safety that is characteristic of current natural gas systems.

## Boiler Deposits and Boiler Cleaning

In recent years, a family of organo-silicon compounds, known as siloxanes, commonly found in detergents, shampoos, deodorants, and cosmetics, have gradually found their way into the solid waste stream and into LFG. Their quantity in LFG is small and varies with the age of the landfilled material. When LFG is burned, the siloxanes are oxidized to silicon oxide—the primary chemical compound in sand. After firing boilers for an extended period with LFG, operators report a thin coating of white powder, described as similar to talcum powder, on some of the boiler tubes and substantial accumulations of the white powder on portions of the boiler floor. Where the material collects and how much of it accumulates is likely to be a function of the velocity patterns in the boiler and the siloxane concentrations in the LFG. One firetube boiler operator reported no deposits at all, probably due to the high flue gas velocity that is characteristic of the firetube boiler configuration.



Operators' experiences to date indicate that annual cleaning is sufficient to avoid operational problems related to silicon oxide accumulation. More frequent cleaning may be necessary as future installations encounter higher LFG siloxane concentrations or when low gas velocities exist in the boiler, either because of boiler design or continuous operation well below full capacity. In all cases, the silicon oxide powder is easily removed from surfaces by brushing or water washing.

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## Other Considerations

In designing and assessing the economic feasibility of projects utilizing LFG in boilers, several factors in addition to the boiler retrofit must be considered. For example, the quantity of LFG available must be considered and compared to the facility's steam needs and boiler capacities. Factors such as pipeline right-of-way issues and the distance between the landfill and the boiler will influence costs and the price at which LFG can be delivered and sold to the boiler owner. Because LFG is generally saturated with moisture, gas treatment is needed before the LFG is introduced into the pipeline and subsequently the boiler, to avoid condensation and corrosion. Additionally, condensate knock-outs along the pipeline are necessary as condensation in the main pipeline can cause blockages. Fortunately, the level of LFG clean-up required for boiler use is minimal, with only large particle and moisture removal needed. Other compounds in LFG, such as siloxanes, do not damage boilers or impair their function. Generally, LFG clean-up and compression systems are located at the landfill and are often installed by a developer rather than by the boiler owner. LFG compression provided at the landfill must be sufficient to compensate for pipeline pressure losses and provide sufficient pressure at the boiler to permit proper function of the fuel controls and burner. Proper attention to burner selection or burner modification for low-pressure operation can minimize the LFG compression costs.

## Is My Boiler a Candidate for Landfill Gas Retrofit?

Virtually any commercial or industrial boiler can be retrofitted to fire LFG, either alone or co-fired with natural gas or fuel oil. The firing profile is a primary consideration, regardless of the boiler type, since the fuel cost savings associated with LFG must offset the costs of the LFG recovery (if a LFG collection system is not yet in place), the gas clean-up equipment, and the pipeline. Operation at substantial load on a 24-hour/7 day-per-week basis or something approaching continual operation is generally important to the economic viability of a potential project.

Both the smaller, lower-pressure firetube package boilers and larger, higher-pressure watertube package boilers are already in operation with LFG. Older field-erected brick set boilers have also been retrofitted for LFG fuel. Many major boiler manufacturers, such as Cleaver Brooks, Babcock &

Wilcox, Nebraska, and ABCO, are represented in the population of boilers that have been converted for LFG service. Similarly, leading burner manufacturers (e.g., Todd, North American, and Coen) have provided specially designed LFG burners or have experience modifying standard natural gas burners for LFG service.

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## Examples of Successful Boiler LFG Energy Projects

**NASA Goddard Space Flight Center.** In early 2003, NASA's Goddard Space Flight Center in Greenbelt, Maryland, began firing LFG in two Nebraska watertube boilers, each capable of producing 40,000 pounds per hour of steam. The gas is piped approximately five miles from the Sandy Hill Landfill to the boiler house at Goddard. NASA modified the burners and controls to co-fire LFG, natural gas, and oil; however, LFG provides the total firing requirement for approximately nine months of the year. Later, a third boiler also began utilizing LFG. NASA estimates an annual savings of more than $350,000. Current NASA plans call for LFG use to continue for at least 10 years, with a possible extension to 20 years. LMOP Partners Toro Energy and CPL Systems developed and implemented the project.

**Cone Mills White Oak Plant.** The LFG retrofit project at textile manufacturer Cone Mills' plant in Greensboro, North Carolina involved a very old (circa 1927) field-erected brick set boiler. In this instance, the developers chose to install two new, multi-fuel burners supplied by Coen Company, Inc. Full operation began in early 1997, with a steaming capacity of 30,000 pounds per hour from the LFG fuel. Additional steam is provided as needed by co-firing with natural gas or fuel oil. The gas is supplied to the Cone Mills plant via a three-mile pipeline originating at Greensboro's White Street Landfill. The project is a partnership between the City of Greensboro, Duke Solutions (now part of Ameresco, Inc.), and Cone Mills.

Information about additional projects can be found at the project profiles section of the LMOP website at www.epa.gov/lmop/lmop-landfill-and-project-database. The photographs in this document depict a boiler retrofitted to burn LFG, courtesy of Mallinckrodt, Inc. in Raleigh, North Carolina.

## Where Can I Obtain Further Information?

LMOP is a voluntary program that helps landfill owners, project developers, and communities develop LFG energy projects. LMOP offers technical support that includes finding a landfill, estimating gas generation, analyzing project economics, and providing other tools to help landfill owners and operators realize their facility's LFG use potential. For more information, visit the LMOP website at www.epa.gov/lmop.