GOING ABROAD WITH LANDFILL GAS ENERGY: TAKING THE SUCCESS OF DIRECT USE IN THE UNITED STATES TO THE INTERNATIONAL COMMUNITY

Victoria Ludwig
Landfill Methane Outreach Program (LMOP)
U.S. EPA
Washington, District of Columbia

Brent L. Dieleman
SCS Engineers
Reston, Virginia

INTRODUCTION

In the U.S., stakeholders promoting landfill gas (LFG) energy projects are continually identifying new opportunities to utilize this valuable resource. Today, more than 550 beneficial LFG energy projects are in operation across the country. However, LFG utilization has not yet reached its potential domestically – and this is especially true internationally. In both the U.S. and other countries, the majority of LFG beneficial use projects utilize the gas for electricity generation. The U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP) believes the direct use of LFG is also important for reducing global methane emissions and shifting energy resources away from fossil fuels. The term "direct-use" is used to describe projects that involve the use of LFG as an energy source for boilers, furnaces, heaters, kilns, and other types of process operations. Typically, the landfill gas offsets the use of fossil fuels such as natural gas, oil, and coal, resulting in fuel cost savings and greenhouse gas emission reductions. To encourage the development of projects outside the U.S. that directly utilize LFG and educate corporations on how LFG can be a reliable and low-cost fuel source for their operations, LMOP has launched a number of activities and developed a number of resources as part of the Global Methane Initiative (GMI).

GMI OVERVIEW

GMI is a voluntary, multilateral partnership that aims to reduce methane emissions and advance the abatement, recovery and use of methane as a valuable clean energy source on a global scale. GMI achieves this by creating an international network of partner federal governments working together with private businesses, development banks, universities and non-governmental organizations. The network focuses on building capacity, developing strategies and markets, and removing barriers to project development in partner counties. Established in 2004, GMI currently consists of 41 partner countries and targets five main methane emission sources: landfills, agriculture, coal mines, municipal wastewater plants, and oil and gas systems.

The U.S. is a charter member of GMI, and EPA is the lead agency within the federal government that coordinates and implements the U.S. government's involvement in the Initiative. In the landfill sector, EPA's LMOP program carries out a variety of assistance activities in support of the Agency's commitment to collaborate with other GMI countries to reduce methane emissions from landfills. In its work with GMI countries, LMOP seeks to reduce barriers to LFG energy project development through the facilitation of technology transfer and demonstration, policy support, capacity building, and market development.

Key barriers that LMOP has identified to the utilization of LFG include a shortage of in-country expertise, inadequate identification or evaluation of suitable candidate landfills, a lack of demonstrated technical and economic feasibility of proven technologies and practices in local contexts, and other financial and institutional obstacles. In an effort to remove these barriers, LMOP focuses its work on developing country-specific profiles and strategies to overcome the barrier of limited information on landfills and LFG management practices. In addition, LMOP focuses on conducting preliminary feasibility studies and establishing demonstration projects at landfills. Facilitating training sessions on landfill operation and LFG energy projects, and modeling the LFG generation and potential recovery of LFG at specific landfills sites to identify sites that may

support an LFG energy project, are also important activities carried out by LMOP.

WHY FOCUS ON DIRECT USE OF LFG?

Recent efforts by LMOP are aimed at promoting and encouraging specifically the development of direct use LFG energy projects. The direct use of LFG as a source of medium-Btu fuel in industrial applications offers many benefits to landfill owners and also to the end users of the LFG, especially in terms of reduced fuel costs. However, the development of direct-use projects outside the U.S. has been slow at best. In many parts of the world, with the exception of Europe, LFG energy technology and project development is still in its infancy and very few (if any) projects exist. Furthermore, the majority of the projects that do exist utilize LFG for electricity generation. As a result, landfill owners and potential end users of LFG are reluctant to pursue direct-use projects because of their perceived risk and the uncertainty as to whether they will be successful in their country or region.

Direct-use projects have many economic and environmental benefits that make them desirable projects to implement. For example, utilizing LFG to offset the use of natural gas, coal, or fuel oil can help lower or stabilize fuel costs. This is especially important in the manufacturing sector where energy costs can represent a significant portion of operating costs. Fossil fuel prices often change quickly and drastically as the result of supply and demand fluctuations, but LFG prices are not as adversely impacted by such events, which gives industries the surety that their energy prices will remain relatively stable.

The direct-use of LFG benefits the environment by preventing the release of methane emissions into the atmosphere and also offsetting the need to burn fossil fuels such as coal, oil and natural gas. In addition, direct use of LFG for heating or steam production is more efficient in comparison to the generation of electricity from LFG. A typical LFG boiler project uses between 80 and 90 percent of the energy content of the gas, whereas only about 30 percent of the energy value of the gas is converted into electricity in a typical electricity generation project.

In addition to the economic and environmental benefits of direct use, a key reason for LMOP's focus on implementation of these types of projects in GMI partner countries is due to the significant barriers that exist in some countries related to the generation of electricity from LFG. In countries such as Mexico, for example, the monopolization of the electric utility market is a barrier to the development of LFG electricity projects. In countries where electric utilities are run by the federal government, the cost for electricity is kept artificially low through subsidies based on the lowest cost fuel source for electricity generation. This rate structure gives renewable energy fuel sources such as LFG a competitive disadvantage. Also, the monopolization of the utility sector often leads to the creation of laws that prohibit the sale of self-generated electricity to the national grid. Under these kinds of conditions, direct-use projects may be the preferred project type, as they are more cost-effective and legally viable.

BARRIERS TO DIRECT USE

One of the major barriers to the implementation of direct-use projects is the lack of experience and expertise in the development of these types of projects. As discussed above, direct use of LFG outside the U.S. is not common and as such landfill owners and potential end users of the LFG are skeptical as to how these projects work. The implementation of an LFG energy project requires a significant investment, takes many resources to be successful and requires some degree of risk. The lack of direct-use project experience together with the popularity of LFG electricity projects typically leads landfill owners interested in an LFG energy project to pursue electricity generation as the first and only project choice. The presence of electricity generation projects gives landfill owners considering a project confidence that electricity projects work and provides actual project examples to confirm project viability. That confidence is lacking in the implementation of direct-use projects outside of the U.S.

In addition, there are some misconceptions about the implementation of direct-use projects. One such misconception is that the LFG requires costly cleaning in order to be piped to an end user. Based on the experience of the more than 200 direct-use projects in the U.S., LFG transported via a dedicated pipeline to an end user only needs to be cleaned up to the specifications of the device combusting the LFG. There are no requirements for LFG clean up for the pipeline itself. Concern by food product manufacturers – a large industrial end user of LFG in the U.S. – that the use of LFG at their facilities is unsanitary and compromises the safety and security of the food products produced is also a common misconception. LFG can be used just like natural gas, propane or any other fuel source typically used at these facilities. The LFG does not come into contact with the actual products being produced and does not adversely impact their quality or compromise their safety.

As discussed above, utilization of LFG for the production of electricity has seen significant growth in all parts of the world – more so than the direct utilization of LFG. As such, a perception has developed that LFG electricity generation projects are easier and more lucrative to develop. Many countries have in place incentives and other programs, such as "green tariff" programs and renewable energy production laws, that encourage electricity generation from eligible renewable energy resources, of which LFG usually qualifies. This has spurred the development of LFG electricity generation projects while having no impact on direct-use projects, as programs and incentives that encourage their development are lacking in many countries.

Compounding the lack of experience and misconceptions about direct utilization of LFG is that pipeline regulations in many countries have not been developed. In the cases where such regulations do exist, the regulations are vague and are left open for interpretation. This provides little confidence or certainty in how LFG injected into a pipeline will be regulated now or in the future. Even in the U.S., a major barrier to these projects is the installation of the pipeline and the right-of-way issues that result. Oftentimes the end user that is the best fit for a particular project is not located adjacent to the landfill. To get the gas to the end user, it is sometimes necessary to install a pipeline that intersects several neighboring properties and possibly even roads or railroad crossings. The task of securing approval from effected property owners is very time consuming and can be very expensive.

Many of the barriers and challenges to the implementation of direct-use projects summarized above exist in the U.S. as well. However, significant innovation, effective contract agreements, and favorable economic conditions have helped landfill owners and end users implement direct-use projects. The significant success of these types of projects coupled with the creativity and expertise that has been fostered in the U.S. provides a great opportunity for LMOP to provide technical assistance to encourage direct-use project expansion in GMI partner countries.

LMOP TOOLS AND RESOURCES

LMOP carries out a number of activities to support greater understanding and the development of direct-use projects. This section will discuss some of the key activities and resources that LMOP utilizes to promote direct-use projects in GMI partner countries.

Study Tours

LMOP regularly works with potential end users of LFG who are interested in the possibility of utilizing LFG in their facilities. One successful activity that LMOP has annually carried out the last couple of years is the planning and execution of study tours. This allows potential end users based in GMI partner countries to travel to the U.S. and tour operational direct-use projects. LMOP has established relationships with a number of companies and organizations that have expressed an interest in using LFG as an energy source. Many of these companies have sent representatives to the U.S. to explore the requirements for implementing a direct-use project. LMOP hosts these study tours with the goal of educating companies and showcasing the success of direct utilization of LFG.

Although LMOP's work with potential end users is targeted to particular types of companies, LMOP will work with any company interested in exploring LFG energy. In selecting and identifying companies to participate in study tours, LMOP looked at companies that are currently using LFG in one or more of their facilities in the U.S. and also have manufacturing or production facilities in GMI partner countries. In addition, LMOP identified industries in the U.S. that are currently using LFG (e.g., food manufacturing/processing, auto manufacturing, cement and brick production, chemical manufacturing) and researched companies in GMI partner countries that are in the same industry. LMOP found that these study tours are most effective when industries represented on the tours view successful LFG energy projects with similar industries as their own. This gives the tour participants and actual LFG end users the opportunity to discuss LFG energy as it relates to their common core business operations.

In 2010 LMOP implemented its first study tour for potential end users of LFG. This tour included representatives from major manufacturing companies in Mexico. Mexico was one of the 14 original countries that joined the Global Methane Initiative at its inception, and the U.S. and Mexico have successfully collaborated for many years on key environmental challenges. In addition, some Mexico- based companies have established corporate renewable energy goals and supported the development of wind and other alternative energy sources in Mexico. The goal of the 2010 study tour was to educate the tour participants on the requirements, equipment, technical aspects and economics of direct-use projects by showcasing examples of real projects involving end users with similar needs and requirements as the study tour participants. Also, LMOP hopes that these study tours will aid in the transfer of technology from the U.S. to parts of the world where direct use LFG energy projects currently do not exist.

The study tour visited eight LFG energy projects and end users throughout Texas and Louisiana. Although there are many states and regions with LFG energy projects currently in operation, Texas and Louisiana sites were selected because of the variety and number of successful projects available, the responsiveness from the landfill owners and industrial end users to allow tours of their facilities and projects, the geographical proximity of these projects, and the diversity of projects that exist in the region. The tour was designed so that participants would see first-hand a number of aspects and requirements that go into making a direct-use project a success. This included visiting the landfill to observe the operational practices employed that facilitate LFG generation and recovery, the actual LFG energy project and the end user facility.

Each study tour typically began at the landfill working face to show tour participants the need for careful handling and placement of the solid waste. Landfill representatives reviewed the process and protocol for screening, accepting and placing of solid waste. The importance of waste compaction, maintaining a small working face, use of daily and intermediate cover materials, effective stormwater and leachate management, and other critical environmental considerations were discussed in detail.

Site visits also consisted of a thorough review of the gas collection and control system at each landfill. Landfill owners and LFG energy system operators explained the components of the system, how the equipment was selected, how the system was constructed, and details on how the system is maintained. Components discussed included the LFG extraction wells, wellhead components, lateral and header piping, condensate management, and the blower and flare skid. Seeing these aspects of the upstream collection and treatment of LFG before it arrives at the end user's facility helped to alleviate two concerns commonly held by potential end users of LFG, namely the level of moisture and quantity of impurities found in the LFG as it leaves the landfill.

To complete the picture of a direct-use project, study tour participants also toured the facilities where the LFG from each of the landfills visited was utilized. This was perhaps the most valuable portion of the tour as it allowed study tour participants to meet directly with representatives of companies who are using LFG as a fuel source to meet their energy needs. Company representatives were able to review the specifics of their projects and provide an account of how the technology works and the fuel cost savings that result. One of the major barriers to the implementation of direct-use projects outside of the U.S. is the unproven nature and reliability of the technology. Study tours give potential end users outside of the U.S. the confidence to know that the technology works, is reliable and is cost competitive with other alternative fuel sources.

Each landfill and end user visited during the 2010 study tour offered some unique insight into the implementation of a direct-use project. For example, at the Rosenburg Landfill's (TX) direct-use project with Frito Lay, tour participants were able to see the specialized gas cleaning skid that had been installed to clean up the LFG to meet Frito Lay's specifications. The Jefferson Parish Landfill's (LA) project with Cytec Industries provided an example of how flexible landfill owners and end users must be as they implement an LFG energy project. Representatives from the landfill and Cytec recounted how during the construction of the project they were forced to contend with hurricanes Katrina and Rita. Not only did these hurricanes delay the implementation and start-up of these projects, but it forced the landfill to dispose of a significant amount of construction and demolition debris in a very short period of time.

The study tour also included a direct-use project under construction. Champion Technologies, LFG end user for Republic Services' Blue Ridge Landfill, is in the process of installing their own dedicated pipeline from the landfill to their facility. This allowed study tour participants the opportunity to see the actual construction of the pipeline and discuss with Champion Technologies the challenges and barriers to pipeline installation. Tour participants also witnessed the media's role in promoting LFG energy projects while touring the East Baton Rouge North Landfill's (LA) LFG energy project with Novolyte Technologies. Novolyte Technologies issued a press release to local media outlets prior to the study tour participants arriving. While the study tour was being conducted, a local media crew arrived at the landfill to run a story on the study tour and the environmental and economic benefits of LFG energy projects. The media's interest in the technology provided a positive example of the public's acceptance of LFG energy as a clean, renewable and reliable energy source.

The success of the 2010 study tour led LMOP to implement a similar study tour that took place in September 2011. LFG energy professionals from Mexico and Serbia participated in this tour where they traveled to several LFG energy projects located in Georgia, North Carolina and South Carolina. The following landfills and end use facilities participated in this study tour:

- Live Oak Landfill – High-Btu Pipeline Injection (Conley, GA)
- Seminole Road Landfill – Electricity Generation (Ellenville, GA)

- FujiFilm – Direct-Use Project with the Greenwood County Subtitle D Landfill and Greenwood Landfill (Greenwood, SC)
- BMW Manufacturing – Direct Use and Electricity Project (combined heat and power) with the Palmetto Landfill (Wellford, SC)
- Spartanburg County/Wellford Landfill – Direct-Use Project with Milliken and Company and Electricity Generation with Lockhart Power Company (Wellford, SC)
- EnergyXchange Renewable Energy Center – Direct-Use Project with the Yancey/Mitchell County Landfill (Burnsville, NC)
- Jackson County Green Energy Park – Direct-Use Project with the Jackson County Landfill (Sylva, NC)

Study tours have proved to be an important opportunity to showcase successful LFG energy projects while giving participants the ability to interact directly with landfill and end user representatives that have on the ground knowledge implementing these projects. LMOP finds having participants from multiple countries participate in a study tour allows for extensive networking and information sharing that helps participants better understand LFG energy projects worldwide – not just in the U.S. In addition to the study tours, LMOP has a number of tools and resources available to assist landfill owners and potential end users in evaluating the possibility of a direct use LFG energy project, and these are discussed in the following sections.

Landfill Searches

The contacts and connections developed during the study tours do not end when the tour is over. LMOP continues to work with companies that participate in study tours; oftentimes, assisting them with identifying landfill resources closest to their facilities. LMOP also assists landfill owners in identifying potential end users near their landfill site. Once LMOP makes contact with an end user that is interested in identifying landfill resources near their facility, LMOP collects as much data as possible from the potential end user. One key piece of information collected is the physical location of the facility or facilities that may be a candidate for using LFG as an energy resource, as this is crucial to determining the length of the pipeline that would need to be constructed to move the LFG to the end use facility. In order for a project to be successful, LFG resources should be relatively close to the end use facility. The actual distance whereby LFG can be economically piped from a landfill to an end user will depend on a number of site specific parameters; however, in most instances a pipeline length of five miles or less is considered ideal.

Once the physical location of the end user has been established, LMOP then uses different means and resources to determine the number of landfill sites within close proximity to the potential end user. These resources include GMI's International Landfill Database, Google Earth, landfill inventories, reports, and other sources. When conducting this initial evaluation, LMOP generally looks for landfills within 10 miles of the potential end user's facility. Once the closest landfill(s) has been identified, LMOP maps out any physical barriers, such as roads, railroad crossings, and rivers, which may prohibit or significantly challenge the installation of a pipeline. It is also important to obtain as much technical and operational data on the potential landfill site as possible. Information such as the landfill open and closure years, amount of waste-in-place, design capacity of the site, and operational data – to the extent known and available – is identified and summarized for each landfill identified. All of this information is summarized in a report that is provided to end user facility representatives for further review and analysis to determine if a good match has been found.

If the results of the initial study hold promise and the potential end use facility expresses further interest in LFG, LMOP takes a more detailed approach to the analysis. This entails reaching out to the landfill owners and/or operators of the identified site(s) to gauge their interest in pursuing an LFG energy project. If there is interest, LMOP representatives work to verify existing information that has been collected and obtain additional data that can be used to further analyze the feasibility of an energy project. Oftentimes a site visit is part of this data gathering and verification process. This is particularly important for understanding the operational practices carried out at the landfill and gives a better picture of the possible pipeline routes and the obstacles and barriers that may be in the way.

Once all the site specific information is collected and verified, LMOP uses the appropriate country specific LFG emissions model to estimate gas generation and potential gas recovery at the landfill. The results of the LFG modeling are then compared to the amount of gas required by the end user to make an estimation of how LFG might meet the facility's energy needs. The results and estimates are presented in a more comprehensive report that summarizes the assumptions made in evaluating the compatibility of the landfill and the potential end user. LMOP tailors their specific assistance to the needs and desires of the particular end use facility.

Technical Documents

In addition to the activities and initiatives summarized above, LMOP develops a number of technical documents that educate and provide detailed information on direct-use projects to potential end users of LFG. For example,

LMOP anticipates releasing a technical document titled "Direct Use of Landfill Biogas for Energy: A Potential Alternative to Electricity Generation" in the summer of 2012. This document is designed for landfill owners as well as potential end users and summarizes the types of projects and applications for the direct use of LFG. Particular emphasis is placed on the unique benefits associated with the direct utilization of LFG. Additional information on considerations that should be evaluated – such as pipeline installation, LFG quantities over time, and LFG treatment options – give a helpful overview of the important components of a direct-use project.

LMOP has also developed a technical document titled "Adapting Boilers to Use Landfill Gas: An Environmentally and Economically Beneficial Opportunity." This document focuses specifically on one of the most common types of direct-use projects - using LFG in a boiler to offset the use of some other fossil-based fuel source such as natural gas or propane. Issues discussed include modifying an existing boiler to run on LFG in lieu of natural gas, cleaning and maintenance requirements, and determining if an installed boiler is a candidate to be retrofitted to run on LFG.

In addition to producing documents and publications, LMOP conducts training workshops and seminars on LFG utilization technologies in a number of their partner countries. The direct utilization of LFG is discussed at many of these events and the presentations are posted on GMI's website at www.globalmethane.org.

Recognizing that many of LMOP's target audience do not speak English, there is an increased effort to translate LMOP's technical resources and fact sheets into Spanish, Chinese, Russian and other languages. LMOP hopes that as the Initiative expands these resources will be translated into additional languages.

CASE STUDIES

LMOP has assisted a number of companies in identifying available landfill resources that may match the energy needs of their facilities. This section will discuss specific case studies of companies that LMOP has worked with recently and what types of assistance was provided.

ALFA

ALFA is a Mexican company comprising four business groups: Alpek (petrochemicals), Nemak (high-tech aluminum auto components), Sigma (refrigerated food), and Alestra (telecommunications). The company has manufacturing facilities in many countries.

ALFA initially provided LMOP with a list of 51 manufacturing facilities located in 13 countries for analysis and identification of LFG resources. The company selected these facilities based on their large energy needs and their location in countries with high natural gas prices. In an effort to provide the best level of service, LMOP targeted those facilities located in four countries – Brazil, Mexico, Poland and U.S. – based on LMOP's presence and the extensive network of partners established in each of these countries. Because the majority of ALFA's facilities are located in Mexico, LMOP focused extra attention on 17 ALFA facilities located in large metropolitan areas in Mexico where the likelihood of finding adequate landfills would be higher.

LMOP used the International Landfill Database, Google Earth, the United Nations Framework Convention on Climate Change's Clean Development Mechanism website, and past experiences working with landfill sites in targeted countries to identify landfill resources for ALFA. LMOP conducted additional research on each of the landfill sites identified to research key pieces of information that are critical for conducting an initial assessment of whether a landfill might be a potential partner for ALFA to approach about implementing an energy project. Information on the type of landfill (sanitary, controlled/managed, open dump, etc.), operational status, distance between the landfill and ALFA facility, presence of a gas control and collection system, and additional details on the landfill were noted. Information identified was summarized into simple tables and presented to ALFA representatives for further review and analysis. Exhibit 1 provides a snapshot of the data that was collected for the initial ALFA analysis.

Facility Name	Facility Location	Country	Landfill Name	Approximate Distance (miles)	Estimated Current Energy Potential (MMBtu/hr)	Landfill Years of Operation (or Status, if known)	Gas Collection System in Place?	Comments
Nemak Brasil	Betim, MG	Brazil	Betim Sanitary LF	8.0	Max 9.8 (2014)	1996 - 2013	No	Venting LFG.
		Brazil	Essencis MG LF	5.6		?	?	Private LF for industrial waste. Landfiill data: www.essencis.com.br/unidades/essencis-mg
		Brazil	Contagem Sanitary LF	5.6	Max 30.7 (2020)	1997 - 2019	No	Venting LFG.
		Brazil	Belo Horizonte Controlled LF	8.1		1975 - 2007	Yes	CDM LFGE project. May require follow up to determine status of CDM project.
Nemak Poland	Bielsko-Biala	Poland	Bielsko-Biala Landfill	2.4		2003 - 2010	No	LFG Electricity project. May require follow-up if more LF information is necessary.
Nemak Dilligen	Dilligen	Germany	Merzig-Fitten Landfill	7.6		?	Yes	Landfill data limited; may require follow-up.
Nemak Wernigerode	Wernigerode	Germany	Wernigerode :Am Turm Landfill	2.5		?	Yes	Landfill data limited; may require follow-up.
Nemak Saltillo	Ramos Arizpe, Coahuila	Mexico	Ramos Arizpe Landfill	?		?	?	Unable to find in Google Earth, but there is reference to one landfill in the area in several
Nemak Monterrey	Monterrey, Nuevo Leon	Mexico	Garcia Landfill	2.5		1996 - 2020	Yes	LFGE project planned. To start in 2011.
Akra Polyester	Monterrey, Nuevo Leon	Mexico	Simeprodeso Monterrey Landfill II	10.0		1999 - 2023	Yes	CDM LFGE project.Unsure if there may be gas available for additional projects.
Polioles Lerma	Lerma, Mexico	Mexico	Socavon San Jorge LF	6.7		?	No	Landfill data limited; may require follow-up.
Polioles Altamira	Altamira, Tamaulipas	Mexico	Altamira Landfill	2.1		?	No	Landfill data limited; may require follow-up.
PTAL	Altamira, Tamaulipas	Mexico	Altamira Landfill	4.5		?	No	Landfill data limited; may require follow-up.
Indelpro	Altamira, Tamaulipas	Mexico	Altamira Landfill	4.8		?	No	Landfill data limited; may require follow-up.
Petrocel	Altamira, Tamaulipas	Mexico	Altamira Landfill	5.0		?	No	Landfill data limited; may require follow-up.
Sigma Saltillo	Saltillo, Coahuila	Mexico	Saltillo Controlled Landfill	5.3	Max 25.1(2017)	2002 - 2030	No	
Sigma Chihuahua	Chihuahua, Chihuahua	Mexico	Chihuahua Controlled LF	3.3		1993- 2013	No	CDM LFGE project. May require follow up to determine status of CDM project.
Sigma Noreste	Monterrey, Nuevo Leon	Mexico	Simeprodeso Monterrey LF II	13.8		1999 - 2023	Yes	CDM LFGE project.Unsure if there may be gas available for additional projects.
		Mexico	Cadereyta Landfill	19.4		1999 - 2036	No	PASA landfill. PASA is planning an LFGE project, but no planned date yet
Sigma Occidente	Guadalajara, Jalisco	Mexico	Coyula Landfill	10.8		1989 - 2005	No	CDM LFGE project. May require follow up to determine status of CDM project.
Sigma El Salto	Guadalajara, Jalisco	Mexico	Coyula Landfill	9.8		1989 - 2005	No	CDM LFGE project.May require follow up to determine status of CDM project.
Sigma Lagos	Lagos de Moreno	Mexico	El Verde Sanitary Landfill	13.5		2000 - 2022	Yes	CDM LFG Flaring project.
Sigma El Molino	Mexico City, DF	Mexico	Rincon Verde Landfill	4.5		1975 - 2006	?	CDM LFGE project. May require follow up to determine status of CDM project.
		Mexico	Puertos Chivos Landfil	9.2		1994 - 2021	No	CDM LFGE project.May require follow up to determine status of CDM project.
		Mexico	Tlalnepantla Landfill	9.0		1998 - 2018	No	CDM LFGE project.May require follow up to determine status of CDM project.
Sigma Bernina	Mexico City, DF	Mexico	Tlalnepantla Landfill	9.0		1998 - 2018	No	CDM LFGE project.May require follow up to determine status of CDM project.
		Mexico	Tultitlan Landfill	11.2		1987 - 2007	?	CDM LFGE project.May require follow up to determine status of CDM project.
		Mexico	Puertos Chivos Landfil	9.2		1994 - 2021	No	CDM LFGE project.May require follow up to determine status of CDM project.
Sigma Xalostoc	Mexico City, DF	Mexico	Tultitlan Landfill	6.8		1987 - 2007	?	CDM LFGE project.May require follow up to determine status of CDM project.
		Mexico	Santa Maria Chiconaulta LF	11.5		1990 - 2005	Yes	CDM LFGE project, but as of 2007 just flaring.
		Mexico	Tecamac Landfill	11		2004 - 2014	Yes	CDM LFGE project.May require follow up to determine status of CDM project. Unsure if there may be gas available for additional projects.
Sigma Republica Dominicana	Santiago	Dominican Republic	Rafey Landfill	2.5		2008	No	Open dump being converted to controlled landfill in 2008. Landfill data limited; may require follow-up.

EXHIBIT 1: SEARCH RESULTS FOR ALFA PLANTS OUTSIDE OF THE UNITED STATES

Once ALFA representatives reviewed the data they were able to further refine the list of facilities and landfills. LMOP then conducted further research to obtain as much detailed information about the landfills as possible. LMOP developed a short summary report for each landfill site that contained information on the landfill's

size, details of the gas control and collection system (if one exists), waste acceptance quantities, and waste composition data. In addition, LMOP used Google Earth to map the ALFA facility to the landfill identified as having the most promise for an energy project. This allowed LMOP to determine the approximate length of a pipeline that would be needed to transport the gas from the landfill to ALFA. Using Google Earth also provides ALFA with the general terrain that would need to be crossed in order to install a pipeline. This is helpful to determine how feasible the development of a pipeline would be, such as whether the pipeline would run through an urban area or rural countryside and if any right-of-way issues might exist. Exhibit 2 provides an example of a Google Earth image that establishes the proximity between an ALFA facility (Nemak Poland) and landfill (Bielsko-Biala) in Poland.

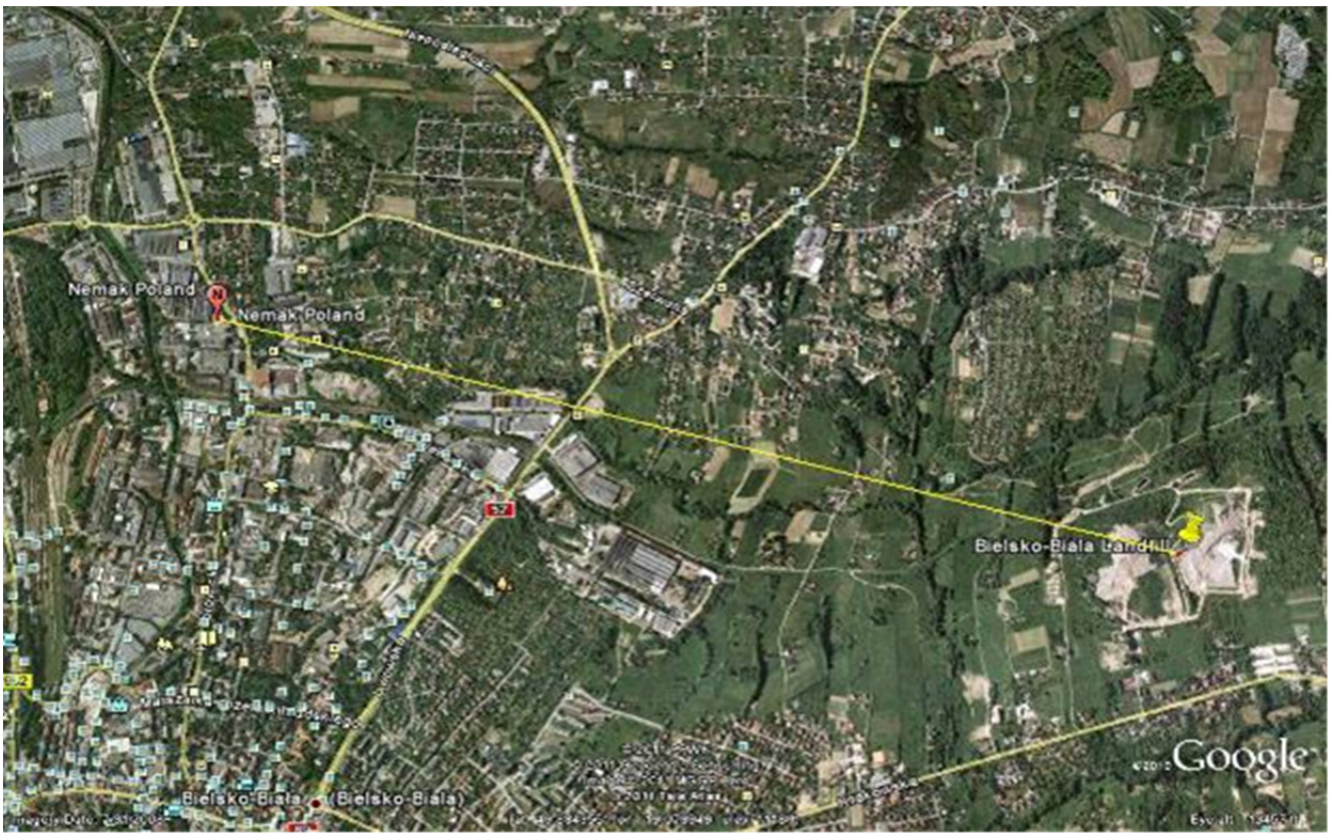

EXHIBIT 2: GOOGLE EARTH IMAGE DOCUMENTING THE DISTANCE FROM AN ALFA FACILITY AND NEARBY LANDFILL IN POLAND

Summaries of each landfill and potential corresponding end use facility were organized into a comprehensive report and submitted to ALFA for review to further pare down the list. Additional analysis of the landfill sites led ALFA officials to prioritize the evaluation of the Contagem Landfill as a potential LFG energy source for its Nemak Brazil facility. Both the landfill and facility are located in the City of Betim, State of Minas Gerais. LMOP approached the landfill owner to gauge their interest in exploring the possibility of a direct-use project with ALFA. Because of their interest LMOP representatives and contractors traveled to the Contagem Landfill to meet with the owners and tour the site. The purpose of the visit was to obtain as much information on the landfill as possible and get a better idea of the interest and commitment level of the owners as far as an LFG energy project. As part of its 2012 activities to further support and work with ALFA and the Contagem Landfill, LMOP is in the process of conducting a comprehensive LFG energy feasibility analysis for the site. This study will evaluate the possibility of different types of LFG energy projects, including direct use and electricity generation.

Kimberly-Clark

LMOP also recently worked with another global

company, Kimberly-Clark, which also expressed an interest in using LFG as a fuel source in their manufacturing facilities in Latin America. The company has a successful direct-use project at their Beech Island facility in South Carolina and would like to replicate this success at other plants. Similar to the process undertaken in the case of ALFA, Kimberly-Clark first identified 10 plants throughout seven countries where the company was interested in exploring possible LFG resource availability. LMOP targeted the Kimberly-Clark plants located in GMI partner countries of Argentina, Brazil, Colombia and Peru, and researched potential landfills located within about 10 miles of each facility. Using a variety of different tools and resources LMOP identified a number of landfills near the designated Kimberly-Clark facilities and researched the basic information about each site. LMOP also used Google Earth to map out the distance that would be required to pipe the LFG to the end user facility. The results of each landfill search and the known characteristics of the landfill sites were summarized in a report presented via conference call to Kimberly-Clark representatives. At this time Kimberly-Clark is still evaluating which of their facilities might hold the most promise for using LFG as an energy source.

CONDITIONS FOR SUCCESSFUL DIRECT-USE PROJECTS

LMOP believes that the significant growth in direct-use projects throughout the U.S. has the potential to be replicated in other GMI partner countries. Although there are no silver bullets to the successful implementation of a direct-use project, there are some general conditions that increase the likelihood of implementing a successful direct-use project.

The most costly component of a direct-use project is the installation of the gas transport pipeline. Pipeline costs vary significantly and depend on where the project is located, equipment used to construct the pipeline, materials, and the terrain. These costs may rise sharply if any right-of-way issues are encountered. Thus direct-use projects are typically the most cost-effective and therefore successful with the shortest pipeline distance. If multiple landfill resources are available and accessible to a particular end user, utilizing the LFG from the closest landfill is likely to result in the most financially viable project.

Direct-use projects are also typically the most successful when the energy output from LFG utilization closely matches the energy needs of the end user. This maximizes project efficiency and prevents the loss of LFG energy resources that cannot be put to use by the designated end user. LFG generation and recovery amounts will vary over the life of an LFG energy project, so it is nearly impossible to completely match the energy needs of the end user to the recoverable LFG at the landfill for the complete duration of the project. However, many projects have achieved success by paying careful attention to detail and ensuring synergy between the amount of energy produced and the amount of energy required.

Finally, a significant condition for the successful implementation of a direct-use project is buy-in and support from staff at the landfill and at the end use facility. In order for these projects to work and for financial benefits to be realized by all parties involved, there need to be project champions on both sides. These champions need to promote and encourage the development of the project even when the negotiations become challenging and barriers and disagreements regarding contract terms threaten the success of a project.

CONCLUSION

The growth of direct use LFG energy projects worldwide is important for promoting energy independence and reducing global greenhouse gas emissions. LMOP believes that direct utilization of LFG holds a significant amount of promise for GMI partner countries. This has led LMOP to initiate a number of activities and develop a number of resources that educate potential end users on the benefits of using LFG to meet their energy needs. This includes the implementation of annual study tours whereby representatives from industries interested in using LFG in their operations travel to the U.S. to view actual projects and meet with company representatives who are already using LFG. In addition, LMOP regularly assists potential end users in identifying nearby landfills with available LFG resources. LMOP produces a number of technical documents and tools, many of which have been translated to other languages, for companies to use to better understand the requirements and details of direct utilization of LFG. Together, these various resources and tools demonstrate how LMOP and the U.S. EPA are furthering the goal of GMI to reduce global emissions of methane while developing clean energy and stronger economies.

REFERENCES

U.S. EPA Landfill Methane Outreach Program, *Landfill Gas Energy Project Development Handbook*, September 2010.

U.S. EPA Landfill Methane Outreach Program, *Adapting Boilers to Utilize Landfill Gas: An Environmentally and Economically Beneficial Opportunity,* December 2009.