

Getting the Gas Out

Before you can use it, you have to make it ready.



Photo Credit: Clean Energy

By Carol Brzozowski

There are 621 operational landfill gas (LFG) energy projects in the United States and approximately 450 landfills that are good candidates for projects, according to the US Environmental Protection Agency's Landfill Methane Outreach Program (LMOP).

The conversion of LFG to energy destroys methane and other organic compounds and offsets use of such nonrenewable resources as coal, oil, and gas and reduces emissions of SO², NO_x, PM, and CO².

LFG is generated 24/7, with projects having online reliability of more than 90%. It can serve as a long-term price and volatility hedge against fossil fuels, the EPA points out.

The primary beneficial use of LFG is electricity generation, including internal combustion (IC) engines ranging from 100 kW to 3 MW, gas turbines ranging from 800 kW to 10.5 MW, and microturbines ranging from 30 kW to 250 kW.

The number of direct-use projects is increasing and includes boiler applications that replace natural gas, coal, and fuel oil; direct thermal, including dryers and kilns; natural gas pipeline injection, including medium- and high-Btu; as well as ethanol production, greenhouse, infrared heaters, leachate evaporation, vehicle fuel such as compressed natural gas (CNG) and liquefied natural gas (LNG), glassblowing and pottery, blacksmithing, hydroponics, and aquaculture. LFG also is being used for vehicle fuel in a growing number of applications.

LFG qualifies for Renewable Energy Certificates (RECs) equivalent to 1 MWh of renewable energy generation. Among the financial incentives are Clean Renewable Energy Bonds (CREBs) where in lieu of interest, bond holders receive federal tax credits; Federal Renewable Energy Production Incentive (REPI) for systems online by October 1, 2016, with payment for the first 10 years of operation; and various other state grants, tax exemptions, and funding mechanisms.

One of the most important factors is that of permitting, says Patrick Sullivan. He is senior vice president for SCS Engineers and heads up engineering consultant for operations in the western US, including solid waste and landfill gas.

"Each type of these landfill-gas-to-energy plants will need some type of air quality permit from a state or local jurisdiction and, occasionally, directly from the USEPA for their proposed facility," says Sullivan, adding that the permit level and complexity depends on what is being proposed and the level of emissions being created.

"Traditionally, landfill-gas-fired engines have the greatest emissions," Sullivan says. "Permitting those has gotten more difficult. With pipeline quality or any case where you treat the gas and maybe directly sell it, you

have minimal emissions, because now you're not combusting it at that facility but treating it and sending it to another facility and they would deal with the permitting as part of their own facility."

If achieved, the pipeline quality is greater "because now the actual emissions from the combustion of the gas are shifted to people who are using the natural gas out of the pipeline," Sullivan points out. "That doesn't have to be permitted as a facility. You may still need a permit for the treatment facility, but at that point you have a lot less emissions because the emissions really come from the combustion. That's where the bulk of the emissions come from that are regulated for these landfill-to-gas-energy plants.

"Engines, turbines, and boilers—anything that's going to directly combust that landfill gas is going to have emissions, and those need to be permitted. More than likely, they are going to trigger more onerous requirements."

A second requirement that commonly arises is that of offsetting emissions with emission reduction credits, which also have associated costs, says Sullivan.

A third requirement is air dispersion modeling to ensure the new emissions being created by a system are not going to cause or contribute to exceeding any standards.

In the world of air quality, nothing ever gets less stringent, Sullivan points out.

Relatively speaking, other technologies—such as microturbines—are easier to permit because of their lower emissions, Sullivan says. And so is shifting the emissions away from the source at the facility, turning the landfill gas into LNG and CNG for use in vehicles, which is done by Waste Management and a few other operations.

"Those vehicle emissions are regulated in a totally different way—they've already been accounted for in terms of their emissions," says Sullivan.

While air-permitting agencies may not see the value in LFG, "we tend to get support from other permitting agencies because they do see the value, be it a conditional use permit from a planning agency, or a general environmental review," he adds. "Even landfill opponents have to admit that these are generally pretty good projects and would like to see them happen."

Having good feedstock is an important factor in landfill gas utilization, says Jason MacKenzie, project manager for ENERGYneering Solutions, a renewable-energy consulting firm that also provides design/build services for landfill gas energy projects

"There are multiple avenues of landfill gas utilization we're involved in, starting at the well field, a system of landfill gas collection wells, a header system, and the landfill gas blower system," says MacKenzie.

One of the biggest challenges in a landfill gas system is water—the condensation in the gas and managing that condensation both in the gas collection system and the utilization facility, says MacKenzie, whose company installs various systems to remove the moisture and allow it to purge through when it does accumulate.

Geosyntec Consultants helps facilities design and oversee LFG operations and collection systems, assisting with permitting, feasibility studies and RFP processes.

With respect to feasibility studies, "the important task is to determine how much landfill gas is going to be generated over the life of the landfill," says David Heitz, senior engineer for Geosyntec.

“It’s not an exact science, but there are models out there,” Heitz says. “A common one is the EPA LandGEM, which projects the amount of landfill gas that’s going to be generated over the life of the landfill.”

Heitz says while electrical generation projects have been the most common use of LFG systems, his company is noting a trend toward more high-Btu projects.

“There are several drivers for that,” he says. “The cost of technology has gone down significantly, such that in the past you had to have significantly higher volumes of gas to make a project viable economically, whereas now it’s gotten down to 500 to 1,000 cfm, which in today’s landfill is not a lot of gas.”

Renewable identification number (RIN) credits as a value for alternative CNG or LNG produced from natural gas are another driving factor and present a relatively new revenue stream, Heitz says.

“Then there is a tax credit for alternative fuel. And as you’re generating CNG and converting your fleet to CNG because typically the solid waste vehicles are going to be predominantly diesel, you’re actually generating your own fuel for your fleet, which can have a significant fuel savings.”

Mark Hadlock, P.E., senior engineer in the solid waste department of Jones Edmunds, points out that because landfills are regulated under the Clean Air Act and NSPS for municipal solid waste landfills, most landfills are required to collect gas and flare it off for greenhouse gas reduction, making it easier to build a power plant because the infrastructure is already in place.

With older landfills, most of the waste is already in place and subject to the NSPS regulations. The owner was required to install the gas collection system that delivers the gas to a flare. Most of that work has already been done as a result of the regulations that went on line in 1998, says Hadlock.

“Now the best opportunity to collect gas is as a new disposal is built and to install piping for early gas collection,” he says. “Old landfills have lost a lot of gas over the years as it decayed before a gas collection system was put in place. Now when you build your new cell, you start installing horizontal collectors on the very bottom, so as soon as there is 30 or 40 feet of waste in place, gas can be collected as early as possible.”

Early gas collection alone may not be enough for a power project unless it was a very large cell—which probably isn’t the case—but when added to the gas from the older part of the landfill can make a power project possible or allow expansion of an existing plant, Hadlock points out.

“For the most part, the portion of the landfill gas collection system constructed on the external side slopes can be considered permanent, and you won’t have to keep replacing it over and over again,” he adds. “But gas collectors—especially horizontals—don’t last forever. If you put in 10, maybe only eight are going to function particularly well. Maybe one is too close to a side slope and it will start pulling in too much atmosphere, and it won’t be a good producer for you.”

There are standardized design considerations for gas collection systems, such as piping size and installing the pipe at a “good slope” because of how landfills settle over the years, causing liquids to accumulate in the gas piping, notes Hadlock, adding that almost every problem with the systems is related to liquids blocking gas flow, which can be mitigated by devices designed to help maintain that flow.

In terms of conditioning, part of the drying takes place as the gas comes out of the landfill, Hadlock says.

“There are liquids in the gas in a couple of different forms,” he says. “One is as the gas flows through the pipe and the gas in the landfill is probably warm—it could be 100 degrees or more, depending on how hot your landfill is and how much biological activity is going on.”

As the gas flows through the pipe, it starts to cool off as it nears the surface of the landfill or ground, which may be about 70 degrees, Hadlock says, adding that it can get considerably colder in more northern climates.

“The gas starts cooling and dropping off the liquid just like air would in an air-conditioning system,” he says. “Now you’ve got gas flowing and a little river of liquid water flowing along with it. There are some very simple devices that make the gas flow through a condensate knockout or a liquid separator where the flowing water will drop and be removed from the flowing gas. There are other devices called demisters that function like an air filter that stop water particles suspended in the flowing gas.”

The remaining liquid in the gas is removed through a refrigerator dryer that cools the gas to near the freezing temperature of the water. Then the gas is allowed to reheat to 100 degrees or whatever is needed to ensure it will not turn into an aerosol or free liquid again before entering the power plant.

“Pure methane is about 1,000 Btus per cubic foot. When it comes from a landfill, it’s only about half of that. Most of the CO² has to be removed from the gas, which is about half of it,” he says. “When the landfill gas collection system runs, the well in the landfill pulls a little bit of the atmosphere into the system and a little bit of oxygen is in it. For every one percent of oxygen collected, you’re going to collect 4% nitrogen. For the operation of a flare or for NSPS, you can have upwards of 5% oxygen, which would also mean you have four times that in nitrogen, and there’s no high-Btu plant that can accept that low quality of gas.”

High-Btu plants will at most accept about 3% of the combined oxygen and nitrogen, says Hadlock.

“That means oxygen needs to be down around .5% and then multiply that times four and that takes you to about 2.5% combined oxygen and nitrogen,” he points out.

Hadlock points out that before the recession, raw energy prices were continuing to go up, making many alternative energy projects economically feasible.

James Chabot, P.E., and senior technical director for AEG, points out that one primary factor to keep in mind with respect to the production of landfill gas is that it is dependent on a complex system of components, including cover materials management and overall landfill management, with gas systems design largely regulated.

“Designs are generally somewhat prescriptive in concept and then the details are site specific, but overall the systems have to also be designed to manage the liquids in the gas,” he says, adding that the landfill is a “very dynamic environment”.

Most systems will require the removal of moisture to dry the gas in a conditioning process, Chabot says.

For beneficial use projects, “more often than not these days, siloxanes will need to be removed from the gas,” he says. “The gas may need to be enhanced or the methane concentrated. The concentration of methane needs to be increased to meet the specifications for pipeline-quality gas. Nitrogen and oxygen needs to be removed to concentrate the methane. Activated carbon may be required to remove other contaminants in the gas.”

With respect to design, “if you are just putting in a collection system because it’s required by regulations, then you would look at design criteria 40CFR 60 Part WWW, the New Source Performance Standards for municipal solid waste landfills,” says Keith Johnson, senior project manager for Tetra Tech BAS.

Developers look at landfills much more closely regarding their capabilities of reusing the landfill gas, he says.

“Most large landfills, if they are over 2.5 million megagrams or 2.5 million cubic meters of waste, are going to have to install a gas collection system, but that gas may not have economic value, so the gas will just be flared,” Johnson adds.

There are many factors in considering landfill gas reuse, including site conditions, whether the landfill has final cover or daily cover, the landfill location, and the amount of moisture inside the landfill. For instance, a landfill in Florida is going to generate more gas quicker than a landfill in Arizona,” Johnson notes.

The age of the waste is another factor. As with a very old landfill, most of the waste is already decomposed and you’re going to be on the tail end of the production curve, so less landfill gas will be available to collect,” Johnson says. Moreover, waste composition makes a difference.

“You have to look at what the landfill is accepting or has accepted in the past,” Johnson says. “If a landfill has accepted a lot of construction-and-demolition waste or inert waste, then that material is going to generate very little or no landfill gas. So even though there’s a large waste volume, you’re not going to get much gas, whereas if the landfill were strictly taking municipal solid waste from residences, you should be able to collect enough landfill gas for a reuse project.”

Discussing what it takes to bring gas to pipeline standards, Johnson says that in the typical landfill gas composition of about 55% methane, 45% carbon dioxide, “you don’t need to remove the carbon dioxide for an internal combustion (IC) engine application, because the engines are happy with 55% methane, but if you want to get it up to pipeline grade, then the Btu content needs to be increased quite a bit.

“To do that, you need to remove the carbon dioxide, an extra step beyond the siloxane removal,” he adds. “Typically, that’s done with CO² separation membranes or pressure swing adsorbers to take the carbon dioxide out.”

One of the biggest challenges in landfill-gas-to-energy projects is how to decrease the cost of treatment system operation and maintenance, says Johnson.

Johnson points out there is a growing trend toward turning LFG into vehicle fuel, driven by credits for renewable CNG.

“Renewable identification numbers are renewable fuel credits, and right now they are worth more than the RECs for electricity,” he says. “I believe the trend of turning landfill gas into compressed natural gas and using it as a vehicle fuel is probably going to continue, especially for large refuse collection fleets, because it will level out their fuel costs over time, whereas the price of diesel has a tendency to spike up from time to time. You can produce your own CNG from renewable landfill gas and your fuel cost is fixed for many years, so you don’t worry about spikes in diesel prices.”

In designing a landfill-gas-to-energy system, the key issue is the sizing of the new energy facility to make sure you have adequate gas of sufficient quality to run it, says Michael McGuigan, vice president of business development for CB&I. “Historically there have been projects oversized for the landfill, and they’ve not been financially successful.”

“In the last few years, we’ve seen a strong interest in leachate management using landfill gas,” McGuigan says. That sector, in fact, has been a growth area for his company. “We use the landfill gas to evaporate their landfill leachate so they don’t have to truck it to a wastewater treatment plant. They can do it cheaper and dispose of the leachate onsite using the landfill gas fuel, saving them a lot of money in their leachate management costs.”

More wastewater treatment plants are putting restrictions on leachate quantities and quality to meet their standards, “so it’s getting more difficult and more expensive to transport the gas with the higher fuel prices for

trucking. We're finding you can only recirculate leachate for a certain amount of time before you start to get saturation and elevated leachate levels that you need to manage otherwise."

"There is a 30-year history of using landfill gas in the US and quite a few equipment vendors who have robust equipment that is performing well," he says. "The key is for landfill owners or developers to make sure they look at the track record of the industry and take advantage of the lessons learned and not make the same mistakes that others have made over the last 30 years. We still see that from time to time where new entries into the market are making mistakes made many years ago."

Granger Energy's Zylstra explains that his company has two distinct areas of business: a waste services division and an LFGTE division that it initiated with a pipeline project at its own landfill in 1984.

"It became clear that electrical generation, at least in Michigan, was going to have to be part of an ongoing development, because we didn't have industrial customers close to our second landfill," he says. "We built our first electrical project and standardized on our equipment, which we thought was important when we developed renewable projects."

Zylstra realized his company had created a model that could be replicated elsewhere.

"We started soliciting gas rights throughout Michigan. When we ran out of landfills in Michigan, we started looking in other states. That's how we evolved into the energy services division. It's been growing ever since."

When his company started out in this business sector, the medium-Btu fuel technology was available for conversion to boiler fuel.

"We started with something we knew could be a technical success," Zylstra says. "But then we were forced to get into electrical generation because there was no other industrial customer close by to some of these other sites."

"In Michigan, when we were first starting to develop these projects, there was legislation in place that mandated a certain electrical price for renewable landfill gas electricity," says Zylstra. "That cleared the way for projects that economically would make decent sense, and we've got something to plan on with these electrical rates."

"We've gone back and forth a bit, as with some of our larger projects we had the opportunity to do more pipeline, Btu-boiler-type projects, but then when the natural gas market bottom fell out, that's forced us to go convert some of those projects back to electrical, only because market prices for electric tend to be more stable."

Granger Energy typically builds its electrical generation projects on landfill property. At a site in Pennsylvania, seven large industrial customers are taking gas from a landfill that's pushed through 30 miles of underground gas transportation pipeline.

Most recently, Zylstra says, Granger has decided to do some electrical generation projects for customers in need of steam, which can be produced as a secondary commodity by the heat from the engines.

"We could sell them landfill gas for heat, sell them electricity that we generated on their site, and then we take the waste heat from our engines, convert it to steam, and sell them that," he adds. "We've got three commodities that are being sold to one of our industrial customers out in Pennsylvania. That model is intriguing because we're taking that resource of landfill gas, which would otherwise be wasted, and get three separate utilization pieces out of it to get as efficient as possible with those Btus."

“When you’re changing the chemistry of the base, it tends to get complex,” he points out. “Our design mantra is ‘Minimize gas processing, maximize the utilization of the gas.’ What we do is compress the filter dry. We’ve used a sliding vein-type compressor from General Electric rather than a blower in all of our projects that’s proven to be a very hardy machine. It’s much more expensive, but it’s a machine that is very reliable and lasts a long time.”

Caterpillar systems often are used in power generation from landfill gas and may include generators, generator sets, and equipment required to help the generator set operate correctly, such as radiators and cooling systems.

“There are a number of engines that we have running on landfill gas,” says Michael Devine, Caterpillar’s product marketing manager. “Landfill gas to us is more of a subset of the anaerobic digestion business. In theory, that same engine could run on ag or industrial biogas, methane from wastewater treatment plants, or from other sources.

“In the landfill business, the gas tends to be more challenging in that you have a lot more of the siloxanes in there, a contaminant in the gas that’s pretty nasty for these engines. It can accumulate in the cylinder, which can cause some problems in the engine and cause more regular service intervals so that you’re servicing more frequently than you would if it were just natural gas alone.”

“You need to understand about the amount of Btus you have coming in on a per-cubic-foot basis and make sure your engine is sized properly,” he says. “It’s not uncommon for landfills to be somewhere between 30% and 50% methane content.”

In order to know how to size the engine accordingly, “understanding your gas is the best thing that one can do,” says Devine.

“You must understand not only what it is on a given point in time but what it tends to want to do over time,” he says. “As the sun goes down in winter versus summer, I’m going to have different levels of gas production, so in knowing what you can expect of that landfill over time and sizing it accordingly, you’re going to make money while the engines are running. If the engines aren’t running and generating kilowatt-hours to be sold, you’re not making money on it.”

It’s a waste of time and money to not have enough gas to run them, Devine adds.

“Understanding the constituents and the corrosives of the gas to make sure you have the right pieces in place to be able to optimize the performance certainly is helpful,” he adds.’

“It’s one of those ‘pay me now or pay me later’ things,” he says. “To condition for the gas, you look for siloxanes and hydrogen sulfite. That number can go up or down easily with the methane content in the field, so depending on the anaerobic digester and how the bugs are working, they may give off a little more hydrogen sulfite than at other times.”

Halides are another concern.

“What happens is the sulfur in the hydrogen sulfide loves to mix with water, and in a landfill you’ve got a lot of leachate; it’s a very wet fuel,” says Devine. “It has a very high humidity level, and so the hydrogen sulfide has an affinity for the water, and it creates a sulfuric acid. The sulfuric acid then raises havoc with metal pieces in the engine.”

That in turn affects the oil’s total base number, an ash content that absorbs the acids up to a point where it gets full of the acid. Once the oil starts going acidic, it starts to contaminate the engine, he adds.

As a result, “you have to change your oil more regularly in highly acidic areas,” Devine points out. “You may have to do additional work on the cylinder heads, which you normally wouldn’t do on a natural-gas engine or something that didn’t have those contaminants in there.”

Halides also have an affinity for water and can make hydrochloric or hydrofluoric acid, neither of which is good for an engine’s metal parts, Devine says.

“It may increase my cost per service from a penny a kilowatt-hour to a penny and a quarter or a penny and a half or a little more, depending on how extreme it is,” he says. “I can compare that to what it would cost to put a cleanup system on, plus something to maintain it over time.”

Therein lies the “pay me now or pay me later” proposition.

“I can buy this cleanup system and pay for the maintenance of it upfront, or I can have an engine that has been hardened to some of those chemistries and use that engine ... but at the same time recognizing there’s still going to have more maintenance on the engine than what I would have on a basic natural gas engine.”

QED Environmental Systems manufactures environmental monitoring and remediation equipment. For the landfill market, the company makes automatic air-powered pumps for leachate and condensate control, as well as wellheads, well caps, control valves, and flow meters.

The pumps’ internal float mechanism senses the presence of liquid, ejects it, and then shuts itself off, eliminating the need for external controls.

Iron Horse Extended-Duty Piston Pumps are designed for such specialty pumping needs as handling extremely thick, viscous fluids and greater depths.

Without a pump in the well, high levels of hot, aggressive liquids choke off landfill gas recovery. AutoPump AP4 is designed to pump the liquids down, exposing more screen and increasing landfill gas extraction rates.

The pumps are used to mitigate problems caused by landfill gas collection being significantly impaired by excessive liquid levels in the collection wells and piping.

While high moisture levels increase the generation rate of biologically produced landfill gas, excessive liquid accumulation at critical points can block or restrict the flow of the gas produced.

In the collection well, high liquid levels can impede the flow of gas through the fill itself as well as block off the openings in the collection well screen. In the gas collection piping, liquids can condense from the humid gas, accumulate at low points, and block the flow of gas.

“We found the entire control system for the flow of gas from each well was limited to a plastic valve that has traditionally been used for turning water on and off. It really wasn’t designed specifically for gas control,” says David Kaminsky, QED’s senior vice president. “You’ve got this engineered system designed very specifically to maximize gas collection efficiency that goes for energy purposes or to maintain regulatory compliances, and yet they had almost no control over flow at each well.”

Controls enable technicians to put the maximum amount of vacuum on the well to capture all of the available methane while at the same time not pull too hard on the well, Kaminsky says.

“If they apply too much vacuum, they start pulling air into the system, and they’ve got several problems,” he adds.

Regulatory compliance is the first. If the site falls under the NSPS, the oxygen in the well cannot exceed 5%, and overpulling on the well can lead to this, Kaminsky says.

“The other problem in pulling air into the system is that air leans out or dilutes the gas mixture,” says Kaminsky.

“If they’re running engines to produce electricity, and if they get too lean, they not only let their power output go down, but they can actually damage the engines. They can burn valves and cause other problems with the system.”

Although it’s taken a quarter of a century to get the US to 621 operating energy projects, Kaminsky believes the future holds considerable promise for additional opportunities.

“We’re quite a number of years away from building out,” he says. “We’re going to find ways that we can improve the efficiency so some of the more marginal sites also will have opportunity. There could be as many as 1,000 sites or more that could still produce energy in the US from landfill gas.”

Sullivan says every time he passes a landfill and sees a significant amount of gas beings flared, he cringes.

“It seems like such a wasted resource,” he says. “I wonder how we can make that one happen. There’s so much energy value there.”