This article examines renewable natural gas revenue sources and provides guidelines for how to evaluate the prospects for this type of renewable energy project at a landfill.
The technology to convert landfill gas (LFG) into renewable natural gas (RNG) has been available for decades, but interest has intensified in recent years due to a variety of factors that increase the economic value of RNG projects. Although RNG may offer many benefits, these projects are not for every landfill. RNG projects carry significant investment risks due to high development costs, market volatility, and potentially burdensome project logistics.

What Is RNG?
RNG—renewable natural gas—is a renewable, non-fossil fuel of nearly pure methane gas that, following treatment, is compatible with pipeline-quality natural gas. The focus of this article is RNG produced by treating LFG, the gas produced by the decomposition of organic waste in landfills, to create a gas that can be injected into the natural gas pipeline network. RNG is not a new concept; it has existed as a commercially viable, though relatively uncommon, use of LFG since the 1980s and is sometimes known as high-Btu and pipeline injection. While not new, this beneficial use of LFG is enjoying increased popularity primarily due to the promise of greater revenue. RNG project feasibility is now within reach of many landfills. However, significant limitations and risks remain.

While this article deals with LFG-produced gas for injection into the pipeline or local distribution system, it should be noted that RNG can, and is, produced from other sources such as anaerobic digestion from agricultural waste, dairy farms, and wastewater treatment. RNG can also be used in place of natural gas as transportation fuel for compressed gas-powered vehicles; an approach applied to some solid waste collection vehicles and municipal bus fleets.

Commercially Valuable Energy Source and Potent Greenhouse Gas
Due to LFG's high energy content, its beneficial use has helped both landfill owners and the environment. LFG consists of approximately 50% methane, which means it is both a potential energy source at about 500 Btu/scf and a greenhouse gas roughly 25 times more potent than carbon dioxide. By recovering the energy value of LFG, energy projects can offset natural gas or fossil-fuel-generated electricity with a non-fossil fuel as well as a reduction in methane emissions. The treatment technologies briefly described below convert LFG into a product essentially indistinguishable from natural gas.

Turning LFG into pipeline-quality natural gas requires two main steps:

1. The removal of moisture and trace components by refrigeration, dehydration, filtration, adsorption or other processes.
2. The removal of carbon dioxide through several process options: Pressure Swing Adsorption (PSA), Selexol (or other solvent-based systems), membrane separation, or a combination.

Energy Value
Energy value, while critical to the price, is not the key reason for the intensified interest. LFG's energy content is always of value to an energy purchaser. The value for energy is captured in the LFG sales price, usually in the form of US$/MMBtu, and is tied to energy prices, which means this...
portion of revenue is subject to commodity price fluctuations. Historically, mitigating this risk for landfill owners (or project developers) has involved medium to long-term contracts at a mutually agreed sale price or base price with a floor and ceiling to moderate commodity prices swings.

For RNG projects, fixed-price contracts, often involving a gas utility tariff, are part of the project structure. Being tied to the natural gas commodity price, the energy value of LFG has generally fallen in recent years (see Figure 1), mainly as a result of increased supply of natural gas. In 2019, the Natural Gas Henry Hub price ranged from US$3.11/MMBtu in winter to a summer low of US$2.22/MMBtu. The lower cost, larger supply, and emissions advantages of natural gas relative to most other fossil-sources of fuel encourage the use of natural gas and can indirectly increase the attractiveness of RNG projects.

**Federal Renewable Fuel Standard**

A federal policy implementation, the Renewable Fuel Standard (RFS), has enhanced the attractiveness and encouraged the development of RNG projects, including those at landfills. Projects that qualify for RFS can generate renewable identification numbers (RINs), which are a credit commodity that trades in units of US$/gal. The value of RINs, which are offset credits for displacing fossil-based transportation fuel, are a key driver in fueling the RNG market. This is the same program that drives the ethanol market. RINs are creating value for RNG providers because they allow fuel producers to offset the fossil production with a non-fossil source.

Figure 2 provides a flowchart example of RIN generation and retirement, and Figure 3 illustrates the recent interest in RINs. RINs are tradeable commodities, and therefore, brokers are a key intermediary for a successful project. Qualified brokers provide RIN verification and tracking, access to customers for transportation fuel, and can function as the landfill’s buyer of the environmental attribute. Recent RIN values have ranged from US$2.16/gal (US$19.30/MMBtu) in January 2019 to an August 2019 trading value of US$0.64/gal (US$5.75/MMBtu). While the trading value of RINs has declined over this period, the value remains significantly higher than the energy value.

A significant risk associated with RFS is due to its nature as a regulatory measure: as political support for such environmental subsidies or rule-driven mechanisms change over time, RFS could vanish or change in ways that can be detrimental to project revenue. The RFS allocations are set to expire in 2022 and possibly no new allocations will be allotted. This uncertainty will negatively impact the willingness to engage in long term contracts.

**State-Level Programs**

Some states have programs that can also create value for RNG projects. California’s program is known as the Low Carbon Fuel Standard (LCFS) and requires a physical pipeline pathway to theoretically route gas into its market. LCFS credits are priced in units of US$/metric ton and in some cases can exceed the value of federal RINs.

**Is Your Landfill a Candidate for LFG-to-RNG?**

RNG presents considerable advantages to landfill owners: economics that are currently attractive for a beneficial-use energy project and minimal on-site air emissions (since the product gas is combusted elsewhere). RNG can be considered an aspect of environmentally sustainable waste practices.

As an RNG producer, a landfill is a promising resource: a resource with steady gas production, long-lived potential, economies of scale, and often coupled with a potential user (i.e., vehicle fleets involved with waste collection and transport). However, not all landfills are suitable candidates. To
determine if your landfill is a promising RNG candidate, carefully consider the following.

The Customer
The first consideration should be the customer. Questions to consider include: Is there a utility willing to take the gas at mutually agreeable terms? How much will an interconnection with the utility’s pipeline cost? What is the distance from the landfill to such an injection point? What is the cost to build a connecting pipeline? Are there difficulties posed by geography or land ownership? If seeking to fuel a collection fleet: Is infrastructure for vehicle fleet fuel sufficiently available? Are the natural gas fueling stations advantageously located for an RNG project?

Landfill Gas Production
Another consideration is LFG production. Is the amount of LFG currently recovered, and the amount projected to be recovered over coming years, sufficient to generate revenues to offset costs associated with an RNG project? Is the LFG-producing landfill facility now closed, or is it presently operating and projected to continue receiving waste for an extended period?

Prediction always poses an uncertainty risk. One key to reducing this risk is the accurate prediction of how much LFG will be recovered. The landfill owner should ask, “How are future LFG flows projected?” The use of EPA’s LandGEM model, designed for regulatory purposes, could over-predict the amount of gas available for a project, leading to an overly optimistic basis for capital spending. A better approach is a knowledge- able assessment of the landfill’s LFG production through historic flow data and LFG recovery modeling, which includes gas collection and control system buildout, waste fill patterns,
Pipeline-Quality Landfill Gas by David Greene and Eric Peterson

and LFG well-field coverage.

A solid understanding of gas extraction system performance is required to quantify the revenue potential for the project. Are methane levels in the desired, 45–60% range? Are the current LFG wells located in gas-productive areas? Are there issues with high oxygen or nitrogen levels in the LFG? Are there leachate pockets inhibiting a stable consistent supply of LFG? Are hydrogen sulfide and siloxanes concentrations high in the LFG?

Project Rights and Development

An important question to consider is whether you own the rights to the LFG produced. Unless an RNG project will be self-owned and operated, is a qualified developer available on mutually agreeable terms? If the landfill is a municipal-owned site, are there administrative hurdles to such a project? To a large extent, successful RNG projects require different skills from those needed for successful landfill operation. Engage a qualified engineering firm to assist with technology infrastructure choices and economic evaluation. Are there experienced project developers and RIN brokers identified?

Conclusion

RNG projects can be a promising revenue source and an attractive beneficial-use option for landfill owners; however, some substantial risks exist in bringing a project to fruition and sustaining its operation. These are large, high-tech engineering projects built on future projections of revenue. In assessing the economic viability of an RNG project, be keenly aware of future uncertainty in the RIN market. RIN values trended down in 2019 combined with uncertainty for a renewal of the RFS. Such trends can discourage developers from assuming financial risks for a project. To better ensure a successful RNG project at your landfill, be sure to do your homework, engage industry professionals, and move deliberately.

David Greene, P.E., is a Project Manager, and Eric Peterson, P.E., is a Vice President, both with SCS Engineers.
E-mail: dgreene@scsengineers.com; epeterson@scsengineers.com

Community Wildfire Recovery: Environmental and Public Health Perspectives
April 14-15, 2020 • Sacramento, CA

Learn the latest information on the community effects of wildfires and approaches to better prepare for the future.

In the last five years, wildfires have devastated cities and caused loss of life, lasting health effects, and major property damage for many areas in Western North America. While we may not be able to prevent the disaster, we can build on the recent experience of others directly affected.

This conference will bring together public and environmental health providers, emergency responders, experts in community recovery, and disaster cleanup professionals to present the latest tools, concepts, and approaches to help us understand the community effects of wildfire and better prepare for the future.

Presenters will provide current research and field-tested solutions to help communities recover from wildfire disaster.

Topics and discussions will cover:
• Post-fire Conditions
• Initial Response and Planning Recovery
• Safe and Effective Cleanup
• Community Health and Effects
• Case Studies from CA counties that have been affected

Registration is open.
Make your plans to attend!
Book your room at the Hyatt Regency Sacramento by March 23.

Sponsorship and tabletop exhibit opportunities are available. Find details at www.awma.org/wildfires.