Why better landfill gas collection is the foundation of lower emissions and stronger RNG projects

Why landfill methane matters more than ever

Municipal solid waste landfills are the third-largest source of human-related methane emissions in the United States. Landfill gas is typically composed of roughly 50% methane and 50% carbon dioxide, with smaller amounts of nitrogen, oxygen, non-methane organic compounds, sulfur compounds, moisture, and other trace constituents. Methane is also a powerful greenhouse gas with an outsized near-term climate impact, which is why landfill emissions have received increasing regulatory attention.

In September 2024, the U.S. EPA issued enforcement alerts highlighting recurring compliance issues at municipal solid waste landfills, including excess surface emissions, deficiencies in GCCS design and maintenance, and inadequate cover integrity.

For landfill owners and operators, methane capture is no longer just an operational goal. It is central to environmental compliance, odor control, community relations, and the long-term value of landfill gas-to-energy and renewable natural gas projects.

What determines how much methane a landfill emits? The answer depends on more than gas generation alone. It also depends on how effectively that gas is collected, controlled, and used. The following five factors are among the most important drivers of landfill methane emissions and of capture performance.

1. Waste tonnage and waste composition

The amount of waste placed in a landfill is one of the strongest drivers of methane generation. More waste generally means more gas potential, but composition matters just as much as volume.

Organic materials break down under anaerobic conditions and produce methane. Landfills receiving higher percentages of food waste, paper, cardboard, sludge, and other biodegradable materials typically generate more landfill gas than sites dominated by construction and demolition debris, ash, industrial residuals, or other lower-organic waste streams. This is why two landfills with similar disposal tonnage can have very different methane generation profiles.

This distinction is especially important for RNG development. A project depends not only on total waste-in-place but also on the biodegradable fraction of the waste, the age of disposal, moisture conditions, and the expected gas-generation curve over time. Models such as EPA LandGEM are commonly used in the United States to estimate landfill gas generation.

For RNG projects, waste characterization affects facility sizing, long-term flow forecasts, expected methane concentration, project economics, and the ability of future landfill gas production to support expansion. A site with continued MSW disposal may support a very different RNG profile than a landfill with similar tonnage but a large historical share of inert or low-organic material.

2. Engineering design

Even a high-gas landfill cannot perform well without a properly designed gas collection and control system, or GCCS. Engineering design determines whether generated methane has a practical pathway for collection or is more likely to migrate through the waste mass and escape to the surface.

Vertical wells need appropriate spacing, depth, screen interval, and seal construction to influence the waste mass without creating excessive air intrusion. In active filling areas, however, permanent vertical wells are not always practical because waste grades are still changing and heavy equipment is operating nearby. This is where horizontal collectors can play an important role. Installed beneath or within active cells, horizontal wells can help capture landfill gas earlier in the filling sequence, including gas migrating toward the working face or recently placed waste that has not yet received permanent cover. While open working faces will always be harder to control than closed or intermediate-covered areas, thoughtful use of horizontal collectors and coordinated filling practices can reduce fugitive emissions before the final vertical wellfield is installed.

Header pipes and laterals must be sized for current and future flows, and condensate management features such as sumps, knockouts, drip legs, and low-point drains must be located where liquids can be removed before they restrict gas movement.

Design also directly affects RNG project performance. RNG facilities require a reliable supply of landfill gas, but landfill gas quantity and composition are constantly changing. Waste age, filling sequence, cover conditions, atmospheric pressure, liquids, temperature, and applied vacuum can all affect gas quality and flow.

Poor well coverage, undersized piping, flooded laterals, inadequate condensate control, or limited blower capacity can restrict recoverable flow long before the gas reaches the RNG facility.

3. Operations and maintenance

Operations and maintenance (O&M) may be less visible than design, but in practice, they are often the difference between a system that performs on paper and one that performs in the field.

The O&M team is the last line of defense against methane emissions. A landfill can have strong engineering, proper well spacing, adequate blower capacity, and well-designed piping, but if the GCCS is not actively operated and maintained, performance will decline. Landfills change every day. Pumps fail. Condensate traps flood. Header lines settle or become pinched. Wellheads get damaged by equipment. Wells in active areas need to be raised. Sumps lose their function. Liquids accumulate in wells and laterals, reducing available vacuum and limiting gas movement through the waste mass.

When these issues are not quickly identified and corrected, methane capture suffers. A flooded lateral or watered-in condensate trap can reduce vacuum to an entire section of the wellfield. A damaged wellhead can pull oxygen into the system or reduce effective extraction. A pinched or settled header can restrict flow even when the wells themselves are capable of producing more gas.

Strong methane control requires coordination between the landfill owner, the GCCS O&M team, the landfill operations team, and, where applicable, the RNG facility operator. Filling plans, cover placement, grading, stormwater management, leachate management, and GCCS maintenance all affect gas collection. If those teams are not aligned, gas capture can be compromised even when each group is doing its own job correctly.

RNG projects can also create a positive feedback loop. When landfill gas has long-term economic value, there is a stronger incentive to invest in wellfield expansion, condensate management, monitoring, preventive maintenance, and system optimization. Better GCCS performance can mean more methane captured, fewer fugitive emissions, improved odor control, and more feedstock available for RNG production.

4. Landfill gas tuning

Landfill gas tuning is where engineering, field conditions, data, and operator judgment come together.

At a minimum, landfill gas wells are typically evaluated for methane, carbon dioxide, oxygen, balance gas, temperature, flow, and applied vacuum. The technician must then decide whether each well should be opened further, held steady, or backed off. That decision directly affects whether methane is captured and conveyed to a control device or allowed to migrate and potentially escape through the landfill surface.

There is no universal formula for tuning a landfill gas well. Each landfill behaves differently, and often each well does as well. One well may respond well to additional vacuum and produce more methane-rich gas. Another may begin pulling oxygen at a very small increase in vacuum, suggesting poor cover, a compromised seal, a shallow screened interval, or another air intrusion pathway. A third may show strong methane concentration but low flow, indicating that gas is present but restricted by liquids or settlement.

Good tuning is not simply “pull harder.” It is controlled optimization. The goal is to maximize methane recovery while avoiding conditions that can create compliance or operational problems. This balance becomes even more important for RNG projects. Some upgrading technologies are sensitive to nitrogen and oxygen, which can pressure operators to reduce the vacuum to improve inlet gas quality. But reducing vacuum too aggressively can leave methane in the landfill, increase fugitive emissions, reduce total energy recovery, and create odor or compliance issues.

The best RNG project is not necessarily the one with the cleanest inlet gas on paper. It is the one that captures the most usable methane while maintaining environmental compliance and stable long-term operations.

5. Cover integrity

Cover integrity is one of the most overlooked drivers of landfill methane emissions. Even when a gas collection system is well designed and properly operated, methane can still escape if the daily, intermediate, or final cover is cracked, thin, poorly compacted, or otherwise compromised. Surface defects can create preferential pathways that allow gas to bypass collection wells and vent directly to the atmosphere. In active disposal areas, maintaining cover quality can be especially challenging because traffic, settlement, weather, and ongoing filling activities constantly disturb the surface. Strong cover practices are therefore not just about odor or housekeeping—they are a critical part of methane control.

The bottom line

Reducing landfill methane emissions is not about one single fix. It requires accurate waste assumptions, sound GCCS design, disciplined maintenance, skilled field tuning, strong cover practices, and a well-coordinated beneficial-use strategy.

For RNG projects, methane capture is the foundation of project performance. A landfill gas upgrading facility does not create methane; it creates value from methane the landfill is already generating. The opportunity comes from collecting more of that methane, controlling it effectively, and upgrading it into pipeline-quality renewable natural gas that can replace fossil natural gas in existing infrastructure.

As regulatory scrutiny increases and methane monitoring becomes more transparent, the best-performing landfills will be those that treat methane capture as both a technical discipline and an operational priority.