Best Practices to Cut Landfill Methane Pollution

An Imperative for Michigan's Climate and Communities

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1. Continuous Wellhead Monitoring and Automated Tuning
2. Enhanced Landfill Cover
3. Efficient Destruction, Recovery, and Treatment of Captured Gas
4. Comprehensive Methane Monitoring

Introduction

Michigan landfills are a major source of methane, a highly potent greenhouse gas that is driving near-term warming. Landfills also release hazardous air pollutants and pungent odors that threaten neighboring communities. Thankfully, there are proven practices and technologies that can better detect and control landfill pollution.

Michigan's Clean Energy Standard, signed into law by Governor Gretchen Whitmer in 2023, requires qualifying landfill projects to employ best practices for landfill gas collection, control, and monitoring, as determined by the Michigan Department of Environment, Great Lakes, and Energy (EGLE).[1] In this memo, we provide details on landfill methane pollution in Michigan, the opportunity presented by the clean energy standard, and the specific best practices that EGLE should require of eligible facilities. Without these vital safeguards, landfill energy risks undermining state goals to cut climate pollution and build healthy, thriving communities.

Landfill Methane Pollution in Michigan Threatens the Climate and Communities

Home to over 60 municipal solid waste landfills, Michigan has the most waste in its landfills per capita in the United States.[2] Methane is generated in landfills as organic waste — such as food scraps, yard trimmings, and paper — decomposes without oxygen. Pound for pound, methane traps 80 times more heat than carbon dioxide in the first 20 years after its release — making it a powerful warming accelerant. While some landfills are required to install a gas collection and control system (GCCS), the amount of methane actually captured varies widely by site.

In 2022, Michigan landfills released an estimated 213,000 metric tons of methane, equivalent to 17 million metric tons of carbon dioxide, or the climate-warming impact of driving nearly 4 million gas-powered cars for a year.[3] Further, recent remote sensing surveys conducted by aircraft and satellite suggest that actual emissions are higher than previously estimated.[4] Carbon Mapper, for example, has detected super-emitting methane plumes at landfills across the country, including in Michigan.[5]

Beyond the warming impacts, landfill gas contains hazardous air pollutants, precursors to ozone, and strong odors that negatively impact air quality, health, property values, and quality of life for neighboring communities. Among other pollutants, municipal solid waste (MSW) landfills release health-harming per- and polyfluoroalkyl substances (PFAS) and toxic benzene and formaldehyde. In Southeast Michigan, one study found that the combined influence of several landfills upwind of key monitoring sites may contribute significantly to observed exceedances of the US ozone standard.[6] Across the country, landfills are disproportionately located in low-income communities and communities of color.[7] More than 3 million Michiganders live within five miles of a landfill, facing increased risk of health and quality of life harms.[8]

A methane plume detected at a Michigan landfill with an energy project. *Methane Imagery © Carbon Mapper https://data.carbonmapper.org.*

This is also an opportunity: cutting methane pollution is the most immediate, cost-effective way to slow warming over the near term. In the waste sector, keeping organic waste out of landfills — through waste prevention, food donation, and composting — can avoid new methane generation, while delivering powerful community benefits. However, the waste already sitting in landfills today will continue to generate methane for decades. Strengthening air pollution controls at landfills — by requiring the latest best practices and technologies — can slash methane quickly while improving air quality and protecting public health.

Landfills with Energy Projects Can Have Significant Fugitive Emissions

Many US landfills route captured gas to an energy project to produce electricity, heat, pipeline-quality gas, or vehicle fuel. The overall climate benefits of landfill energy projects are highly dependent on how effectively they control fugitive methane emissions.[9] Collection efficiency at landfills can vary widely based on design and operational practices, such as the timing of GCCS installation in an active cell, the cover materials used to minimize surface emissions, and wellfield tuning practices.[10] Direct measurement surveys have shown some facilities collect less than 30% of the methane they generate, while others collect more than 90%.[11]

While an energy project should naturally incentivize landfill operators to maximize collection efficiency to boost project revenue, the reality is more complex. Recent research shows that landfills with energy projects often have higher observed fugitive methane emissions than those without energy projects.[12] At electricity projects, some collected gas escapes combustion in turbines or engines, resulting in "methane slip," and at renewable natural gas facilities, collected gas can leak or vent from treatment system components.[13] Landfills with energy projects may also have more

Landfills observed during 2023 airborne campaigns

Sites	Observed landfills	Emitting landfills	Percent of observed landfills with detected emissions	Mean of average landfill emissions (kg/h)
All landfills (open and closed)	217	115	53%	818
All open landfills	188	114	61%	826
Open landfills with LFGTE	86	70	81%	931
Landfills with RNG	24	22	92%	1,774

Emission rates only include landfills with quantified emissions. For 18 landfills, emissions were detected but not quantified. RNG landfills are a subset of landfills with LFGTE, so landfills with RNG are also included in the row above for LFGTE landfills (along with other kinds of energy projects, like gas-to-electricity). All observed landfills with RNG are open.

Source: Tia Scarpelli et al., "Investigating Major Sources of Methane Emissions at US Landfills," Environmental Science & Technology 58, no. 49 (November 2024).

fugitive emissions from the landfill surface than those without them,[14] as some operators seek to optimize the quality rather than quantity of collected gas. For example, to meet certain specifications and reduce upgrading costs, operators may reduce the gas collection system vacuum, which may allow more methane and pollutants to escape from the landfill surface.[15]

In Michigan, inspections by the US Environmental Protection Agency (EPA) and EGLE have identified significant fugitive emissions at several landfills with energy projects. For example, at the Brent Run Landfill, where collected gas primarily goes to a gas-to-energy plant owned and operated by a third party, an inspector found 38 methane concentration exceedances over the 500 ppm regulatory limit. EPA observed recurring areas of distressed vegetation and erosion gullies as well as cracks, tears, and holes in GCCS equipment.[16] In 2023, the EPA served the landfill with a Finding of Violation, noting:

> *"The violations [at Brent Run Landfill] have caused or can cause excess emissions of hydrogen sulfide, volatile hazardous air pollutants (VHAP), volatile organic compounds (VOC), and methane. Hydrogen sulfide can lead to irritation, headaches, nausea, and respiratory stress. Hydrogen sulfide also significantly contributes to local odor nuisances reducing surrounding quality of life. VOCs and methane contribute to ground-level ozone formation. Breathing ozone contributes to a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ground-level ozone can also reduce lung function and inflame lung tissue. Repeated exposure may permanently scar lung tissue. VHAP emissions can lead to a variety of adverse health effects including cancer, respiratory irritation, and damage to the nervous system."*[17]

At the Pine Tree Acres Landfill, where landfill gas is also collected and directed to a gas-to-energy plant, the EPA inspection discovered a disparity between the number of exceedances they had found compared with historic rates — underscoring the need for more comprehensive monitoring. EGLE and EPA inspectors conducted surface emissions monitoring and found 55 and 19 exceedances, respectively, compared to the roughly 10 exceedances typically identified by the operator. One exceedance that EPA identified was over 200 times the regulatory limit.[18]

In sum, there is a clear need to pair landfill energy projects with best management practices and comprehensive methane monitoring programs to maximize and verify landfill gas collection efficiency. Without these guardrails, fugitive methane emissions could cancel out the climate benefits of energy projects and expose fenceline communities to health-harming pollution.

By Establishing Best Practices, Michigan Can Slash Landfill Pollution and Protect the Integrity of Its Clean Energy Standard

The good news is that, per statute, EGLE holds the pen to develop common-sense and cost-effective solutions to address landfill pollution. Public Act 235, signed into law by Governor Whitmer in 2023, establishes a clean energy standard for Michigan of 80% by 2035 and 100% by 2040.[19] By transitioning the state to renewable energy sources, this standard will combat climate change, while lowering household utility costs, supporting good-paying jobs, and creating healthier communities.

The statute's definition of renewable energy includes the gas produced by landfills, among other sources like wind, solar, and geothermal energy. However, since landfills themselves can be a major source of climate- and health-harming pollution, Public Act 235 includes vital language that the landfill operator of a qualifying facility under the standard "employs best practices for methane gas collection and control and emissions monitoring, as determined by the Department of Environment, Great Lakes, and Energy."[20]

Promulgating these best practices is critical to minimize fugitive methane emissions, protect communities nearby, and uphold the integrity of Michigan's historic clean energy standard.

Major Opportunities to Improve Landfill Gas Collection, Control, and Monitoring

Michigan is building from a solid foundation. The state already has rules in place (Natural Resources and Environmental Protection Act, Part 115 Solid Waste Management), recently revised in 2023, that exceed minimum federal requirements under the federal Clean Air Act standards in several important ways, including earlier gas collection and control system (GCCS) installation, more robust design plan requirements, and liquid level monitoring. Specifically, Michigan law requires landfills to install the GCCS in new cells prior to waste placement, utilize horizontal collectors, and swiftly commence operation upon detection of landfill gas pressure.[21] Early GCCS installation and expansion mean significantly more methane is controlled and is a major improvement from federal requirements, which allow up to five years to pass before a GCCS is expanded in new areas of waste.[22]

However, there are several additional best practices beyond what Michigan law currently requires that are already being adopted by other states and landfill operators and are critical to effectively control fugitive methane. For example, the Colorado Department of Public Health and Environment (CDPHE) recently released draft landfill rules that include a remote methane monitoring program and would require landfill operators to improve their cover practices, boost methane destruction efficiency, and conduct more frequent wellhead monitoring.[23] Further, similar to Michigan's clean energy standard, the California Public Utilities Commission requires, under its biomethane utility procurement target, that landfill gas procurement is "limited to landfill facilities that stop accepting new organic waste and implement advanced landfill gas capture automation and monitoring technology to decrease fugitive methane emissions."[24]

It is clear that additional best practice requirements are necessary for landfill gas to be considered a "clean" energy source under Michigan's standard. Therefore, in addition to compliance with all Part 115 requirements, EGLE should require landfills with energy projects to adopt the following best practices and technologies, which are readily available and cost-effective.

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Best Practice #1: Continuous Wellhead Monitoring and Automated Tuning to Boost Gas Collection

Once the GCCS is in place, wellfield monitoring and tuning are critical to ensure that the system is functioning properly. Like California's PUC, EGLE should require landfills under its clean energy standard to install automated wellhead tuning systems, which continuously monitor system pressure, temperature, gas composition, and liquid levels and make real-time adjustments to maximize gas capture and reduce fugitive emissions.

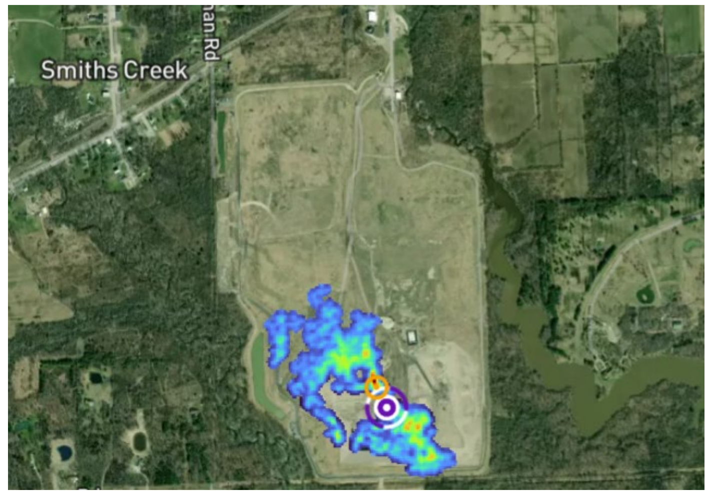
Compared to monthly monitoring and tuning, **real-time control systems can improve overall gas collection efficiency by at least 10–20%**, while alerting operators to other potential issues to inform faster mitigation.[25] These systems are **more cost-effective than manual tuning over time**, [26] and have already been deployed at more than one hundred North American landfills.[27] For landfills with RNG plants, an automated gas collection system can pay for itself with just a 3-5% increase in methane recovery.[28]

Automated wellhead tuning system at a landfill.

Other states are already embracing more frequent or continuous wellhead monitoring requirements for landfills with GCCS. Colorado recently proposed at least weekly wellhead monitoring rather than monthly,[29] and California is considering continuous monitoring for pressure at the system header, with corrective action requirements if pressure deviates from the setpoint.[30] Continuous monitoring is a reasonable requirement for landfills with energy projects, especially under a clean energy standard. **EGLE should require landfills to use real-time monitoring and automated tuning systems** in order to improve collection efficiency and minimize GCCS downtime. EGLE should also require facilities to mitigate emissions during periods of unavoidable downtime.[31]

Best Practice #2: Enhanced Landfill Cover to Minimize Surface Emissions

Landfill cover plays a critical role in methane mitigation, and EGLE should develop comprehensive requirements related to acceptable materials, installation timing, and cover integrity for landfills under the clean energy standard. Recent remote sensing surveys have identified significant emissions coming from the landfill's working face, which can dominate total site emissions.[32] Fugitive emissions generally decrease with the order of daily, intermediate, and final covers; high to low permeability covers; and thin to thick covers.[33]

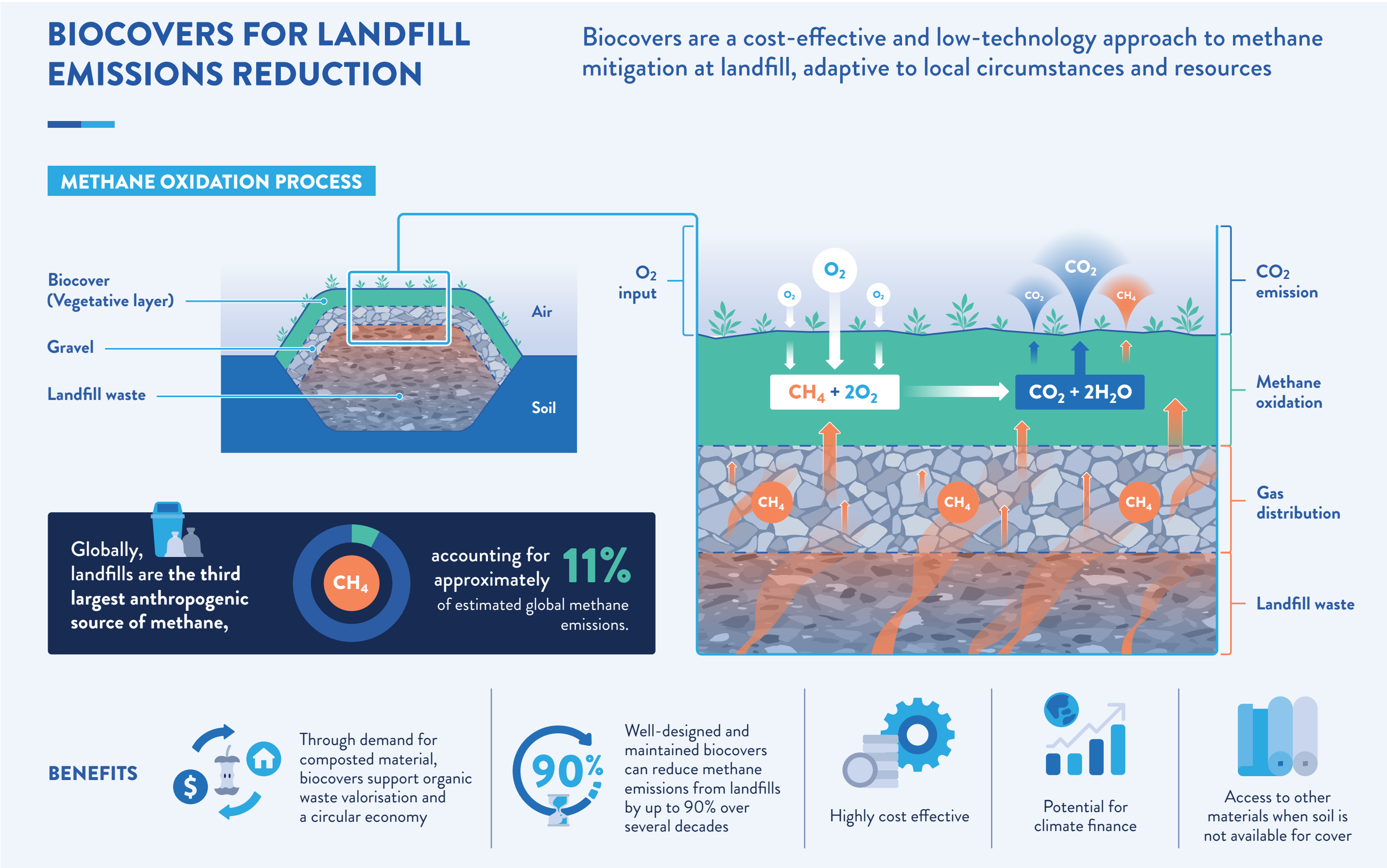


A methane plume detected at a Michigan landfill's work face.
Methane Imagery © Carbon Mapper https://data.carbonmapper.org.

To reduce emissions from the active working face and areas under daily cover, EGLE should limit the size of the landfill working face relative to the incoming annual tonnage of waste.[34] As discussed further below, EGLE should require that the active working face be included in emissions monitoring — with drone surveys or fixed sensors — to ensure mitigation strategies (e.g., early gas capture, small active face, daily cover application) are working as intended. At sites with persistent issues at the working face, EGLE should require further corrective action, such as application of an enhanced daily cover material to boost oxidation.[35] EGLE should ensure that any materials approved for use as alternative daily cover (ADC) meet minimum standards for methane and nonmethane organic compounds (NMOC) mitigation to ensure equivalency to six inches of soil or a stricter standard.[36]

EGLE should also bolster requirements for intermediate cover, requiring installation of a 12- inch cover in all areas left temporarily unused for at least one month. Once installed, the intermediate cover can be in place for long periods of time, decades in some cases. Therefore, EGLE should require landfill operators applying longer-term intermediate cover (e.g., in place for six months or longer) to increase the intermediate cover's thickness and install a methane-oxidizing layer or biocover, which EPA notes "not only enhances gas collection efficiency but also facilitates the oxidation of methane."[37] Biocovers rely on the presence of methanotrophic bacteria to naturally convert methane into less-potent carbon dioxide and are considered "highly cost-effective" climate solutions.[38] Methane oxidation efficiencies can exceed 90% in well-functioning biocover systems,[39] and research has also shown that biocovers can support the biodegradation of NMOC, including a reduction in VOCs.[40] Colorado is considering biocover requirements for intermediate cover in its proposed rule.

Finally, EGLE should require that final cover be installed on an ongoing basis once a landfill cell reaches its final grade or after a predetermined number of years in order to avoid long-term use of intermediate covers.[41]



Biocover diagram from the Climate and Clean Air Coalition (CCAC)[42]

Best Practice #3: **Efficient Destruction, Recovery, and Treatment of Captured Gas**

Once landfill gas is captured, it must be destroyed, recovered, or treated in a manner that minimizes venting and leaking to the atmosphere. To address this, several states have proposed or finalized requirements to phase out open flares and replace them with enclosed combustion devices that achieve a minimum 99% destruction rate and can be more easily monitored and tested.[43] The cost-effectiveness of this measure is well documented.[44]

Following these states, EGLE should require that all destruction devices and energy recovery devices at landfills under its clean energy standard achieve a methane destruction efficiency of at least 99% by weight and that any flares used at the landfill are enclosed. For landfills that route collected gas to a treatment system, EGLE should require continuous monitoring to ensure venting or leaking does not occur. Further, all flares, recovery devices, and treatment systems should be equipped with a gas flow rate measuring device that is installed, calibrated, and operated according to the manufacturer's specifications, and records at least every 15 minutes. Finally, EGLE should require annual performance tests for all energy recovery, destruction, and treatment systems.[45] Maintaining high destruction efficiency is critical to actually controlling methane and other hazardous air pollutants from landfills – minimizing harm to the climate and communities.

Best Practice #4: **Comprehensive Methane Monitoring**

Comprehensive monitoring is essential to effectively identify and mitigate methane leaks and ensure the gas collection system, cover, and destruction devices are working effectively. There are significant gaps in conventional landfill monitoring protocols. The walking survey methods currently required by EGLE miss emissions that could be mitigated due to its incomplete spatial coverage, infrequency, and susceptibility to human error and manipulation. In fact, many high-emitting areas of the landfill are excluded entirely from walking surveys, such as the active working face, which is a significant source of methane emissions. Surveys in the United States and Canada show active face emissions can represent 60-79% of total site emissions, meaning surface emissions monitoring (SEM) effectiveness would top out at only 21-40% of emissions.[46]

In September 2024, the US EPA Enforcement Division issued a nationwide alert noting "wide spread" compliance issues it had found during more than 100 inspections of landfills. The alert stated in part, "EPA inspections revealed chronic compliance issues with landfill emissions monitoring, including technicians moving too quickly, improper exclusion of areas from monitoring…expired calibration gases, failure to fully inspect penetrations, and deviations from required monitoring procedures have led to inaccurate emissions data and missed pollution sources."[47]

Thankfully, advancements in methane monitoring technology — from satellites to aircraft to drones and fixed sensors — can fill these major gaps. Relative to manual methods, advanced technologies can cover more of the landfill surface area (e.g., capturing the active working face and other areas excluded from walking surveys) and provide more frequent and even continuous emissions data.[48] Furthermore, advanced methods are replicable, objective, and protect workers from hazardous, time-consuming, and physically demanding conditions. Advanced methane detection technologies can enhance operators' leak detection and repair programs, while also informing continuous improvements to landfill design and operations to prevent fugitive emissions from occurring in the first place. These technologies can also support state agencies with compliance and enforcement. Importantly, the data collected by advanced methane detection technologies can easily and swiftly be made available to the public, boosting emissions transparency and providing communities with vital information about potential exposure to health-harming pollution.[49]

These technologies are cost-effective, widely available, and being deployed by leading states and operators to identify and reduce emissions. Advanced technologies for detecting and quantifying methane are generally cheaper than walking SEM. Satellite, aircraft, drone, and mobile truck methods range $3,000 to $14,000 per survey, and fixed sensors that take continuous measurements cost between $7,000-$30,000 annually.[50] There are dozens of companies that provide equipment and/or services for methane detection at landfills.[51]

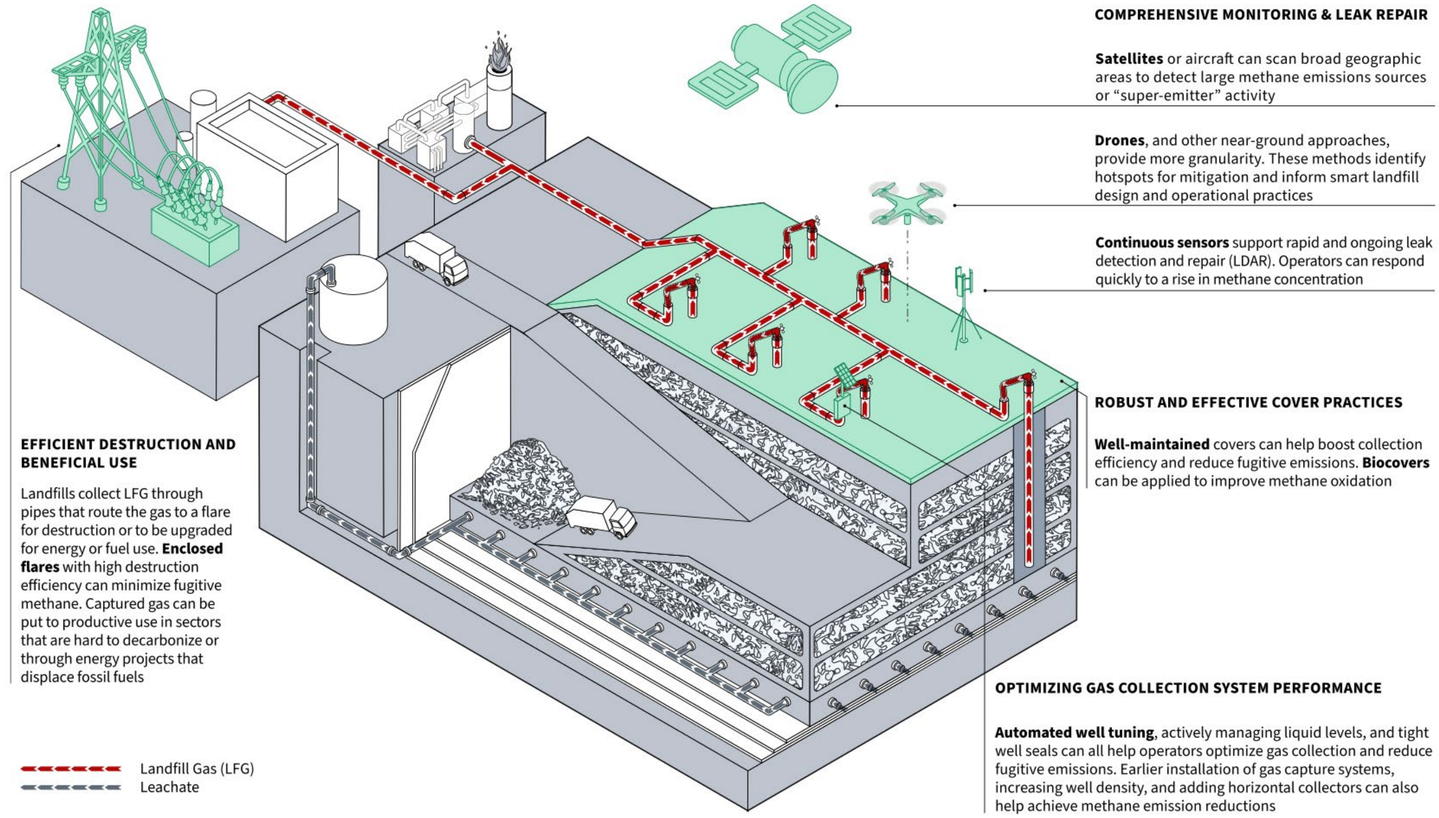
Many landfill operators — both large private companies and municipalities — are already integrating satellite, near-ground, and continuous emissions monitoring into their operations to monitor for areas of elevated methane concentration and inform leak repairs and operational decisions. Michigan-based Sniffer Robotics, for example, deploys its technology at more than 150 landfills, and the methodology has been approved by the EPA as an alternative test method for SEM.[52]

To ensure landfill energy projects under the clean energy standard are not leaking significant fugitive methane and minimizing the output of toxic material, EGLE should consider the following monitoring provisions:

- **Continuous perimeter monitoring systems with action thresholds:** EGLE has already required one landfill, Arbor Hills, to install perimeter monitors for methane and hydrogen sulfide, and is considering requiring a second facility, Smiths Creek, to do the same.[53] These monitoring systems are an excellent way to alert community members and landfill operators to potential issues in real time, prompt fast corrective action, and ensure the equipment and practices described above are functioning as designed. EGLE should consider requiring all landfills under the clean energy standard to install perimeter monitors to identify and minimize the impacts of climate- and health-harming pollution.
- **Frequent surface emissions and component monitoring with advanced technologies:** In addition to fenceline monitoring, EGLE should ensure landfills are using the best available technologies for periodic screening of the landfill surface area, GCCS components, and energy project infrastructure. EGLE should require these surveys to be conducted with OTM-51 or other advanced monitoring methods approved by EGLE or EPA on at least a quarterly basis. In addition, EGLE should require a tighter surveying pattern (25 feet), a lower exceedance threshold (200 ppm), cover all areas of the landfill, and specify allowable conditions for wind speed and barometric pressure. All readings should be reported to EGLE. EGLE should also consider requiring fixed methane sensors around treatment systems and energy recovery devices.
- **Remote sensing program for swift investigation and mitigation of large leaks:** If an EGLE- or EPA-approved measurement provider detects a large methane plume at a Michigan landfill, EGLE should notify the landfill operator and require investigation,

corrective action, and reporting. California and Colorado are both pursuing this approach, and there have been success stories in Pennsylvania and other states where prompt notification has led to successful corrective action.[54]

Best practices to monitor and mitigate landfill methane



Implementation and Other Considerations

To implement these recommendations, EGLE should ensure the best practices and technologies above are included in qualifying landfills' design and operational plans. These plans should be reviewed and approved by the department on a site-by-site basis — and then included in the clean energy plans submitted by electric providers for compliance with the clean energy standard.

Further, EGLE should require ongoing reporting from landfills, including results from methane monitoring surveys and gas collection system performance data. All monitoring data should be promptly made available to the public, and if a facility has persistent issues, EGLE should reserve the right to disqualify a project from consideration under the clean energy standard.

EGLE could consider strategies to quantitatively assess landfill gas collection system performance.[55] There are emerging technologies and methods that can measure, quantify, and annualize total site emissions at landfills. When compared with gas collection system data on recovered methane, this could be used to calculate an annual-average site-wide collection efficiency, which EGLE could use to evaluate landfills' overall performance and compliance with the clean energy standard. While average landfill gas collection efficiency is estimated to be around 65% by EPA, collection efficiency observed in the field can vary widely, from the low 20% range to the high 90% range — and with regional differences. For example, a study using airborne remote sensing data and reported annual gas collection data to estimate annual average site-wide collection efficiencies found that collection efficiencies at landfills in California were around 69% while landfills in Alabama and Georgia were around 46%.[56] EGLE could require eligible facilities to maintain collection efficiency at the upper end of this range.

Finally, as EGLE works to better control methane pollution from waste-in-place, it is critical that the state implement parallel efforts to divert organic waste from the landfill to avoid future methane generation.

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