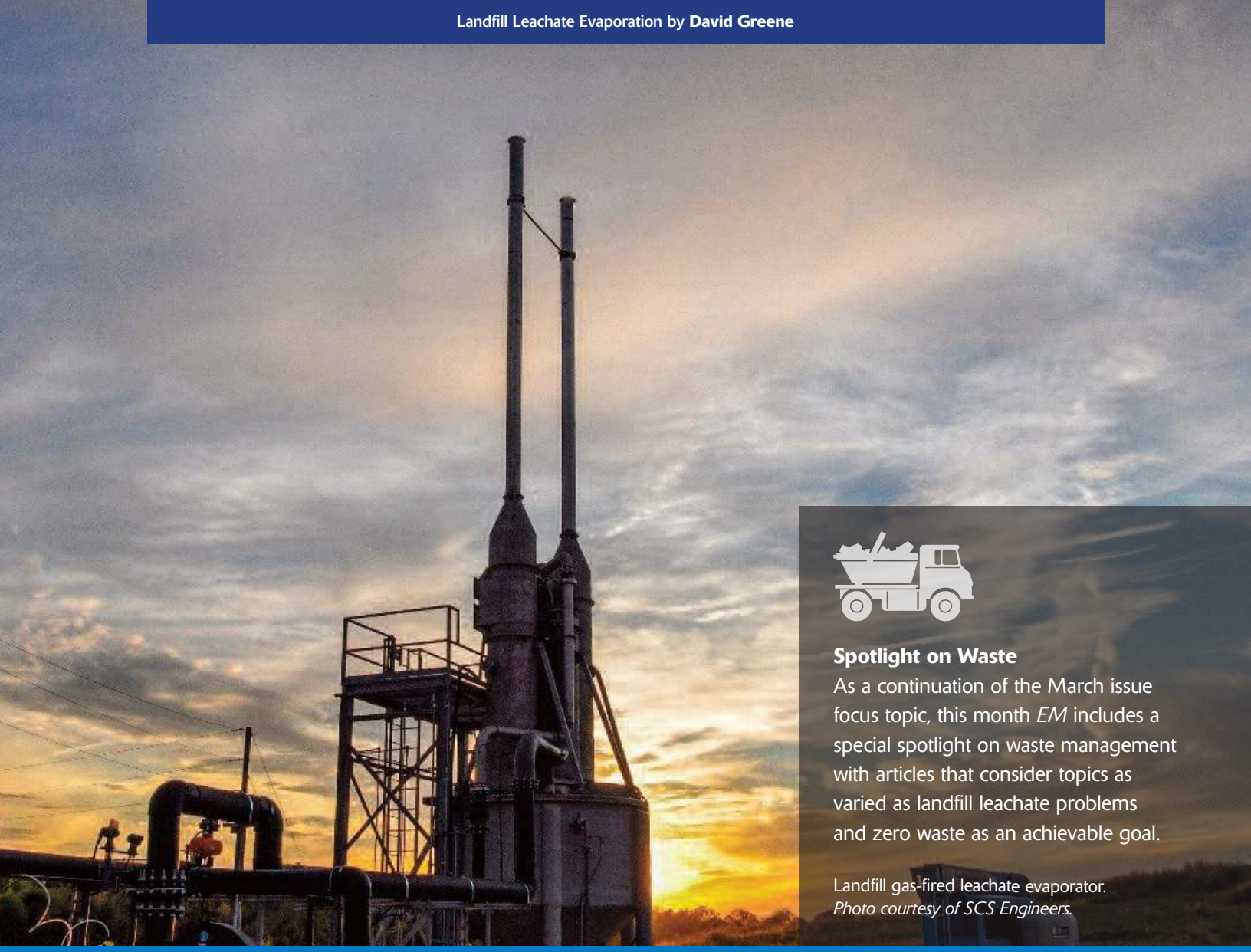

Spotlight on Waste
As a continuation of the March issue focus topic, this month *EM* includes a special spotlight on waste management with articles that consider topics as varied as landfill leachate problems and zero waste as an achievable goal.

Landfill gas-fired leachate evaporator.
Photo courtesy of SCS Engineers.

Landfill Leachate
Just 'Evaporate' the Problem

…or Permitting Issues for Using Landfill Gas to Reduce Leachate Volume

This article presents a novel technology that uses heat, generated by combusting methane-heavy landfill gas, to eliminate landfill leachate.

An environmental risk commonly associated with solid waste landfills is that posed by landfill leachate flowing off-site, potentially contaminating nearby ground or surface waters. Typically, landfill leachate—which is, ironically, a landfill's own waste—must be treated, often at high cost, either off-site at a wastewater treatment plant or on-site via expensive biological or other types of treatment processes. What if landfill owners could use a freely available, high-potency greenhouse gas to eliminate the cost of managing this environmental liability?

A novel technology entails the use of heat, generated by combusting methane-heavy landfill gas (LFG), to eliminate most of the liquid portion of landfill leachate. Although using heat from LFG combustion to evaporate leachate is not completely cost-free and leachate management costs are not entirely eliminated, this technology proposes to accomplish something close. What is more, by combusting LFG to evaporate leachate, methane is converted to lower-potency carbon dioxide. With technologies for on-site evaporation of leachate now becoming available, landfill owners are actively considering this novel technology and the opportunity it offers for reducing operating expenses.

However, the planning process for obtaining the air permit required for LFG-fired leachate evaporation cannot be overlooked and can present a challenge. To successfully permit, the owner, operator, and regulator need to understand the technology and recognize how it can affect air permitting.

What Is Leachate?

Landfill leachate is produced when precipitation falling on the landfill, or moisture present within the waste, percolates through the waste mass, extracting and entraining dissolved and suspended contaminant matter. Leachate properties are influenced by factors such as the type of waste accepted, the age of waste, variations in precipitation, and operational practices. In addition to posing an environmental risk, leachate can impact operations and interfere with LFG extraction. Therefore, modern landfill design includes measures to prevent leachate from migrating beyond the lined portion of the landfill, as well as measures to collect and remove the leachate from the waste mass. Leachate collection and removal systems consist of collection piping, transport piping, cleanout access, and although typically gravity-driven, pumps and force mains are employed. Effective stormwater management practices are critical in reducing the volume of leachate generated.

After removal via the collection and removal system, and routing to storage tanks, ponds, or a lagoon, leachate is then treated through either on-site biological treatment systems, deep-well injection, discharge to natural wetlands, or more commonly trucked or piped to an off-site public wastewater treatment facility. A typical leachate storage lagoon is shown in Figure 1.

Important advances in leachate treatment have emerged, with industry, regulators, and environmental professionals having collaborated to produce such innovative approaches as LFG-fired evaporation, mechanically-induced evaporation, reverse osmosis, vegetative methods, among others. However, traditional treatment via hauling off-site to a publicly operated treatment plant (POTW) currently remains a common method.

Discharge of leachate to a POTW presents the landfill owner with considerable challenges: truck-hauling costs that can vary with the price of fuel; discharge fees at the POTW,

Figure 1. Landfill leachate lagoon. *Photo courtesy of SCS Engineers.*

over which the landfill owner exercises little control; limits on permissible levels of leachate contaminants; and POTWs that may be overstressed on capacity due to population growth. These service and cost uncertainties encourage landfill owners to seek alternatives. The combination of lower landfill gas prices and improved evaporation technologies makes LFG heat-assisted leachate evaporation more attractive to landfills challenged with high leachate disposal costs.

What Is LFG-Fired Leachate Evaporation?

This approach employs heat generated by onsite combustion of untreated LFG to evaporate the liquid portion of leachate, eliminating, or substantially reducing, the quantity of leachate that will need to be transported off-site, or otherwise treated. The process can be viewed as performing the same evaporative process that occurs naturally when a leachate pond or lagoon is used, only in a greatly accelerated manner regardless of weather conditions. Following evaporation, some residuals remain, typically containing only minimal water content, depending on the design of the evaporation system, and these can be disposed in the landfill. An example of an LFG-fired evaporator is shown in Figure 2.

Typically, this process uses an enclosed flare whose stack is mounted so as to discharge downward, somewhat similar to the childhood-fun practice of blowing through a straw downward into a drink to make bubbles. An example process diagram is shown in Figure 3. As commercial-scale technologies for leachate evaporation arrive on the market, many landfill owners are now exploring this option, especially given related economic drivers: prices for selling LFG as an energy fuel are dropping, while costs for conventional treatment of leachate are rising.

Permitting Challenges

Although operating an enclosed flare to control LFG is a long-established, conventional technology that is well-understood by air regulators, an enclosed flare combusting LFG to evaporate leachate is uncommon, presenting uncertainties for regulators. Accordingly, landfill owners pursuing LFG-fired evaporation should strive to understand regulator concerns, in addition to understanding applicable environmental regulations.

Federal and state air regulations govern LFG combustion, as well as volatile organic compounds (VOCs), products of combustion, and particulate matter (PM). For LFG-fired evaporation, air permitting can be more complex. For example, are regulated air pollutants emitted differently than in standard LFG combustion, as a consequence of evaporating the liquid fraction of the leachate? Do leachate constituents change due to the heat of combustion, inducing variation in air pollutant emissions? Will the products of LFG combustion in the leachate evaporation process be emitted at a high enough rate to push the landfill into the most complex level of air permitting (e.g., PSD permitting)?

Emissions and Air Permitting

LFG-fired leachate evaporators produce emissions in two general categories: emissions from the combustion of landfill gas and emissions related to leachate volatilization. Although most emissions in the evaporation category can be assumed to be water, there will normally be some emissions of regulatory concern in the form of VOCs and PM.

Based on decades of experience, LFG combustion emissions are well understood and have a widely accepted basis for quantification. As the design of the enclosed combustor used

Figure 2. Landfill gas-fired leachate evaporator. *Photo courtesy of SCS Engineers.*

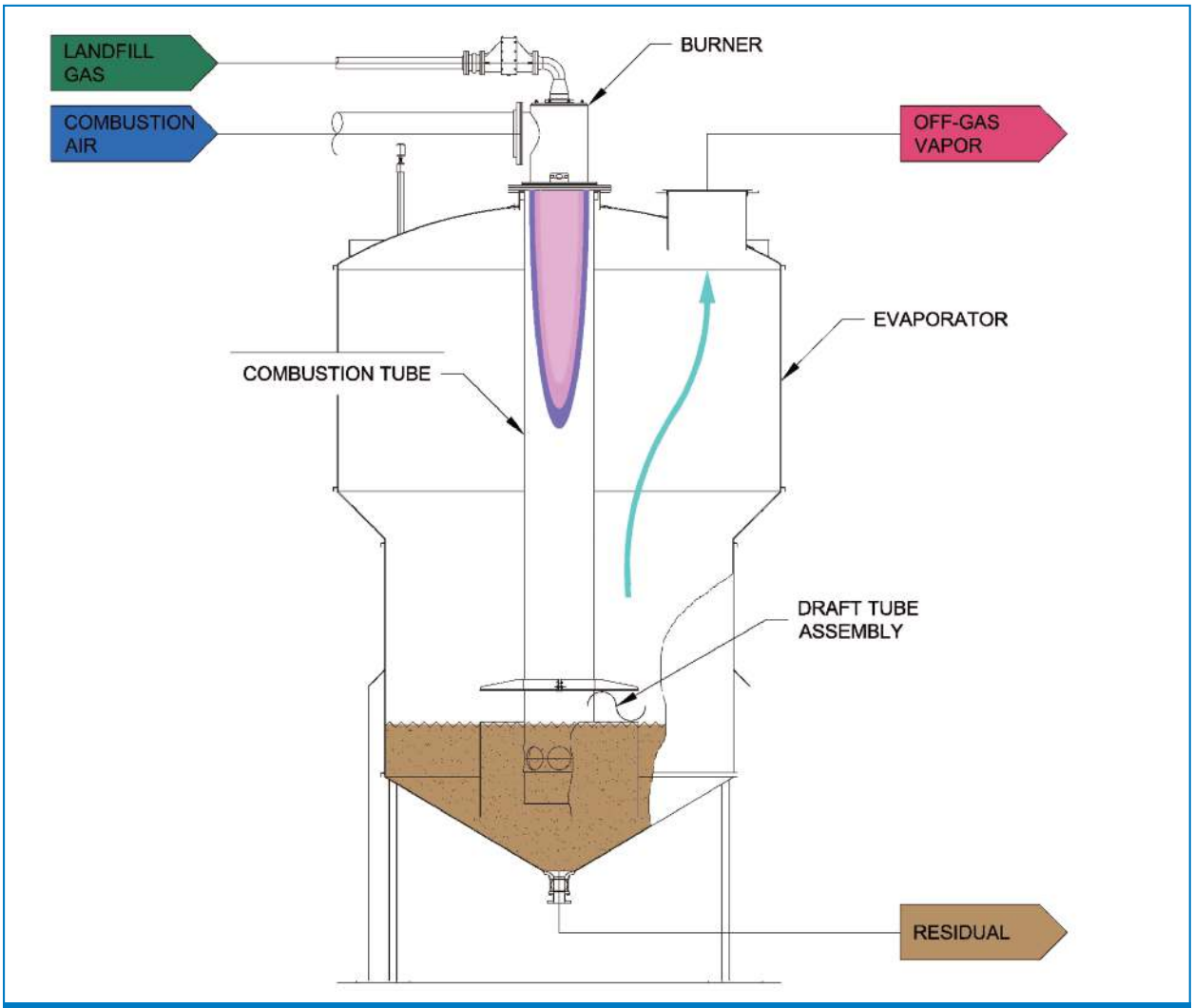

Figure 3. Evaporator process diagram. *Diagram courtesy of Aptim.*

in LFG-fired evaporation can differ from a conventional enclosed flare, the landfill owner should rely upon manufacturer emission guarantees when permitting. In calculating combustion emissions of sulfur dioxide, the assumed hydrogen sulfide concentration in the LFG should be representative of the particular landfill involved.

If dispersion modeling is required for permitting, note the maximum, permissible LFG flow to the evaporator may be limited in the resulting air permit to the value used for modeling; therefore, a desire to increase LFG flow after permitting may require an additional dispersion modeling demonstration. For true potential-to-emit calculations of maximum emissions, the owner should assume the design maximum LFG flow rate. Alternatively, the owner can chose to accept a lower LFG flow rate limit and an associated monitoring condition to demonstrate compliance.

Considering emissions from leachate evaporation, quantifying the maximum VOC emissions associated with evaporation requires taking into account the VOC content of liquid leachate, and multiplying the associated emission rate by a reasonable safety factor. For conservative emissions estimates, calculations can assume complete volatilization during evaporation of the VOC compounds present in the leachate.

PM emissions are expected due to salts left after evaporation, and depending on the leachate constituents, one can assume that a portion of the particulate emissions is calculated as the PM_{10} and $PM_{2.5}$ fractions. For anticipated relative quantities of each, owners should rely on manufacturer guarantees or guidance. Simply stated, a margin of safety can be a good practice in setting the stage for "livable" permit conditions, and for showing a good faith effort in working with a regulatory authority on a technology that may be unfamiliar in its jurisdiction.

Key Air Regulations

Besides the air permitting requirements discussed above, federal air regulations typically apply to devices combusting LFG. As combustors of untreated LFG, LFG-fired evaporators are considered a control device for LFG, and, if applicable to the landfill, are regulated as such. Per the related rule, combustors will need to be "designed and operated to reduce [emissions of Non-Methane Organic Compounds (NMOC) by]….98 weight

percent or…to less than 20 [ppm_v]," as stated in CFR 60.752 (Subpart WWW) and 60.762 (Subpart XXX).

Presuming the evaporator uses an enclosed combustion device, the rule also requires maintaining a minimum combustion temperature to ensure adequate control of NMOC emissions. To demonstrate required destruction efficiency, the evaporator combustor will be subject to an initial compliance test [per 60.752 (b)(2)(iii)(B) or 60.762(b)(2)(iii)(B), as applicable]. This test will also establish the minimum combustion temperature to be maintained [per (60.758(c)(1)(i) or 60.768(c)(1)(i)]. Because the test is required for control of NMOC emissions from landfill gas combustion and not from leachate evaporation, a landfill owner can work with the state regulator to test LFG combustion only, not leachate evaporation.

For most sites, the evaporator's enclosed flare heat source is part of the overall landfill gas collection and control system (GCCS) that also includes one or more primary control devices, such as candle stick flares or traditional enclosed LFG flares. The evaporator, when operated as part of the GCCS, can help reduce overall downtime that occurs when a primary control device goes offline for maintenance or due to a malfunction.

Additional air regulations may apply to LFG-fired leachate evaporators, including state-only or local jurisdictional rules.

Conclusion

LFG-fired leachate evaporation is a novel technology attracting the attention of landfill owners because it offers an operational win-win. The technology uses a readily available resource at landfills, LFG, to remove liquid from landfill leachate via evaporation, thus abating this environmental liability onsite, often at a lower cost than conventional leachate treatment options. In addition, combusting LFG to evaporate leachate converts methane, a highly potent greenhouse gas, to carbon dioxide, which reduces overall greenhouse gas emissions.

Landfill owners seeking to implement LFG-fired leachate evaporation must undergo the necessary air permitting and follow applicable emissions regulations. In this regard, air permitting and regulatory requirements for the combustion-related component of LFG-fired evaporation are similar to those applicable to conventional LFG flares. However, in addition, there are evaporation-related emissions that must be considered in permitting. As this is uncharted territory for regulators, it is important to work closely with the agency to ensure these technology-specific requirements are properly addressed.

With LFG prices generally low and leachate disposal costs rising, be on the lookout for LFG-fired leachate evaporation making an appearance at a landfill near you! **em**

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