Waste Not, Want Not: Landfill Gas to Energy Projects, Climate Change, and the Clean Air Act

KATHERINE A. TRISOLINI*

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* Associate Professor of Law, Loyola Law School, Los Angeles; J.D., Stanford Law School; M.A. Political Science, University of California at Berkeley. The author would like to thank Lesley McAllister, the symposium organizers, and the editors of the San Diego Journal of Climate & Energy Law for advancing discussion of these important and pressing issues. Much thanks also goes to Margaret Clark, Douglas NeJaime, and Jonathan Zasloff for their very helpful comments, to Managing Editor Kristin Johnson for her skillful editorial work, and to Loyola students Henri Engle and Cara Crownover for valuable research assistance.

I. INTRODUCTION

Most landfill gas emissions in the United States are allowed to escape into the ambient air. Landfill gas is composed predominantly of methane, a very potent greenhouse gas. Because methane is also the primary component of natural gas, it can be burned for fuel; combustion dramatically reduces its climate impact. Landfill gas to energy projects (LGTE) offer a double benefit by reducing direct emissions that contribute to climate change and displacing more polluting fuels such as coal. Combustion also significantly reduces other harmful pollutants in landfill gas.

At the federal level, landfill gas emissions are directly controlled pursuant to Clean Air Act New Source Performance Standards adopted in 1996. This "Landfill Gas Rule" only covers the largest landfills and encourages but does not require LGTE. Despite increasing adoption of this technology, significant untapped potential remains. The benefits of LGTE have inspired federal, state, and local governments to create diverse incentives to expand its adoption.

Capturing landfill methane and converting it into usable fuel is one of those rare opportunities with multiple benefits and seemingly no downside. This technology drastically reduces both greenhouse gases and other hazardous landfill gas emissions while providing power that can displace more polluting fuels. What's not to like?

Like most stories, nothing is quite as simple as it seems. Not everyone endorses widespread adoption of LGTE and at least one environmental group has taken a firm position opposing it. Critics fear that classifying landfill gas as a "renewable" fuel and incentivizing project development will indirectly exacerbate methane emissions and discourage transition away from landfills toward environmentally preferable forms of waste management.

Against the current regulatory backdrop, these fears are not unfounded. The EPA's Landfill Gas Rule, which has remained largely unchanged since 1996, only indirectly reduces methane and exempts the vast majority of landfills from its purview. Without a national regulatory standard that directly limits methane emissions, financial incentives for LGTE run the risk of inducing landfill operators to manage landfills to increase methane production. Expanding mandatory federal controls by revising the Landfill Gas Rule, as described below, could significantly reduce this risk. Thus, the degree to which LGTE projects are "renewable" depends upon their regulatory context.

The legal framework for controlling methane forms an important aspect of climate change law because the gas strongly influences near term global warming. Nonetheless, the Landfill Gas Rule received little attention from legal scholars. This Article aims to address this gap, proposing how the Rule could be amended to reduce methane generally and enhance LGTE specifically.

The following sections discuss legal mechanisms to reduce landfill methane emissions and promote LGTE where appropriate, focusing on the federal Clean Air Act's potential role in regulating landfill gas emissions. Section II explains the adverse effects of methane emissions generally and the potential benefits of reducing landfill emissions specifically. Section III describes federal emissions standards under the Clean Air Act and incentive programs for expanded use of LGTE. The discussion highlights potential conflicts between divergent means of regulating landfill gas and discusses criticisms of LGTE incentives. Section IV proposes amendments to Landfill Gas Rule that would more effectively control landfill methane emissions and improve the benefits of LGTE projects by reducing their risks. Section V briefly concludes.

II. WHY LANDFILL GAS MATTERS

A. The Problem

Anaerobic decomposition of organic matter in landfills generates methane.[1] In the U.S., landfills emit substantial quantities of this potent greenhouse gas along with numerous other pollutants such as carbon dioxide, vinyl chloride, toluene, benzene, and over 100 other compounds. Landfill gas contains roughly 50% methane, 50% carbon dioxide,[2] and

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1. *See* U.S. ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2010 1–4 to –5 (2012) [hereinafter EPA INVENTORY], *available at* http://www.epa.gov/climatechacli/Downloads/ghgemissions/US-GHG-Inventory-2012-Main-Text.pdf.

> After being placed in a landfill, waste (such as paper, food scraps, and yard trimmings) is initially decomposed by aerobic bacteria. After the oxygen has been depleted, the remaining waste is available for consumption by anaerobic bacteria, which break down organic matter into substances such as cellulose, amino acids, and sugars. These substances are further broken down through fermentation into gases and short-chain organic compounds that form the substrates for the growth of methanogenic bacteria. These CH4-producing anaerobic bacteria convert the fermentation products into stabilized organic materials and biogas consisting of approximately 50 percent biogenic carbon dioxide (CO2) and 50 percent CH4, by volume.

Id. at 8-3.

2. *Id*. at 8-3.

proportionately small amounts of these non-methane organic compounds—although enough to be harmful if unabated.[3]

Because all landfills differ in terms of their contents, age, management status, size, and the weather in their location, the rate of landfill gas emission varies.[4] Two of the most important factors, however, are the volume of organic materials and the moisture content of the landfill.[5] Under the right conditions—the presence of organic waste and sufficient moisture—landfills begin emitting landfill gas within a couple of years of opening and emissions can continue for decades.[6] These emissions contribute to global warming and create health and safety hazards.

Methane is a potent greenhouse gas that has been accumulating in the earth's atmosphere. Atmospheric methane levels have increased more than 150% since 1750; roughly half of this increase stems from human activities.[7] The EPA estimates that in 2010, landfills emitted 5,135 gigagrams (Gg) of methane, making them the third largest source of methane emissions in the United States, behind only natural gas systems and enteric fermentation in the digestive systems of ruminant animals, such as cows and sheep.[8] The vast majority of landfill methane emissions stem from municipal solid waste,[9] which includes significant amounts of the organic matter on which methanogenic bacteria feed in oxygen depleted landfill conditions.

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3. KELSI BRACMORT ET AL., CONG. RESEARCH SERV., R40813, METHANE CAPTURE: OPTIONS FOR GREENHOUSE GAS EMISSION REDUCTION 10 (2011).

4. *See* CLIFF CHEN & NATHANIEL GREENE, NATURAL RES. DEF. COUNCIL, IS LANDFILL GAS CLEAN ENERGY? 3 (2003) [hereinafter NRDC]; *see also* EPA INVENTORY, *supra* note 1, at 8-3.

> Methane emissions from landfills are a function of several factors, including: (1) the total amount of waste in MSW landfills, which is related to total waste landfilled annually; (2) the characteristics of landfills receiving waste (i.e., composition of waste-in-place, size, climate); (3) the amount of CH_4 that is recovered and either flared or used for energy purposes; and (4) the amount of CH_4 oxidized in landfills instead of being released into the atmosphere.

EPA INVENTORY, *supra* note 1, at 8-3.

5. BRACMORT, ET AL., *supra* note 3, at 17.

6. EPA INVENTORY, *supra* note 1, at 8-3 ("Significant CH_4 production typically begins one or two years after waste disposal in a landfill and continues for 10 to 60 years or longer.").

7. *Id*. at 1–5. "[Methane] is primarily produced through anaerobic decomposition of organic matter in biological systems." *Id*. at 1–4. Aside from municipal solid waste landfills, methane is also generated by: "agricultural processes such as wetland rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes . . . CH_4 is also emitted during the production and distribution of natural gas and petroleum, and is released as a by-product of coal." *Id*.

8. *Id*. at 8-3.

9. *Id*. ("Emissions from municipal solid waste (MSW) landfills, which received about 69 percent of the total solid waste generated in the United States, accounted for about 94 percent of total landfill emissions, while industrial landfills accounted for the remainder.").

Although methane is not as prevalent as carbon dioxide, it is a much more potent greenhouse gas. Its potency is often described as being 21-25 times greater than carbon dioxide.[10] This description uses the common metric that determines a greenhouse gas' "global warming potential" by comparing its effect over 100 years to the same quantity of carbon dioxide.[11] Although the resulting "carbon dioxide equivalence (CO_2e)" offers an important tool for describing greenhouse gas' combined effect and comparing gases over the long term, it understates methane's near-term impact. In the near term, methane is actually far more potent than carbon dioxide because methane has a much shorter atmospheric lifetime than carbon dioxide. Methane breaks down in the atmosphere in a matter of 8-12 years whereas carbon dioxide takes approximately 100 years to break down. Thus, comparing the gases over 100 years gives a diluted picture of methane's short-term impact because its heating is concentrated in the first decade.

Methane's potency and short atmospheric lifetime means that it is an important gas to address if we value near term reductions in radiative forcing. As is increasingly becoming clear, short-term reductions will likely prove critical to an effective climate change policy because of the need to avoid ecological tipping points. Although scientists have not pinpointed triggering thresholds, they have identified potential vicious climate cycles that continued emissions along current trajectories could set off.[12] For example, if warming reaches levels sufficient to melt large ice sheets, such as in the Arctic or Greenland, the ice cover that currently reflects solar radiation will be replaced by dark ocean water that will absorb and retain heat.[13] The heat will cause additional melting of other

10. *Id*. at ES-3 tbl. ES-1.

11. As EPA explains,

> The IPCC developed the Global Warming Potential (GWP) concept to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. The GWP of a greenhouse gas is defined as the ratio of the time-integrated radiative forcing from the instantaneous release of 1 kilogram (kg) of a trace substance relative to that of 1 kg of a reference gas. The reference gas used is CO_2, and therefore GWP weighted emissions are measured in teragrams (or million metric tons) of CO_2 equivalent (Tg CO_2 Eq).

Id. at ES-3.

12. *See* Timothy M. Lenton et al., *Tipping Elements in the Earth's Climate System*, 105 PROC. NAT'L ACAD. SCI. 1786, 1786 (2008), *available at* http://www.pnas.org/content/105/6/1786.full.pdf.

13. *See id*. at 1788–89.

ice sheets, contributing to a cycle of warming, melting, and further warming.[14]

Other ecological interactions make methane a critical focus for reductions. Although a greenhouse gas in itself, scientists now recognize that methane contributes significantly to background levels of another greenhouse gas: ground level ozone.[15] Researchers at the National Oceanic and Atmospheric Administration have recognized that reducing methane emissions could actually produce twice the climate benefit previously thought because of its contribution to ozone formation.[16] Or, to put it in a less positive way, unabated methane emissions doubly harm the climate because both the gas itself and the corresponding ozone contribute to global warming.

Unmitigated methane emissions create other harms unrelated to global warming. Recent research demonstrates that reducing methane emissions will benefit public health by concurrently reducing ground-level ozone.[17] Surface ozone contributes to premature death.[18] Authors of a National Academy of Sciences study estimated that reducing global human-induced methane emission by 20% starting in 2010 would prevent approximately 370,000 premature deaths between 2010 and 2030.[19] They argue that this benefit alone, if property valued, would exceed the marginal cost of the methane reductions even before considering the climate benefit.[20]

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14. *See id*. at 1789.

15. *See* Nat'l Oceanic & Atmospheric Admin., *Linking Climate and Air Pollution: Methane Emission Controls Yield a Double Dividend*, NOAA (Oct. 16, 2006), http://www.oar.noaa.gov/spotlite/2006/spot_methane.html.

> Until recently, methane was considered irrelevant for addressing surface ozone pollution because its long atmospheric lifetime (8–9 years) prevents it from contributing to the rapid photochemical production which leads to high ozone episodes. Rather, methane plays a role in contributing to background tropospheric ozone. Increases in methane will thus raise the baseline ozone level in air globally, including at the surface.

Id.

16. *Id*.

> GFDL scientists have been working to quantify the potential climate and air quality benefits resulting from controls on methane emissions. A 20% decrease in anthropogenic methane emissions would decrease surface ozone concentrations globally. The 20% decrease in anthropogenic methane emissions would also lower radiative forcing from both methane and ozone. In contrast, while reductions in traditional ozone precursors (nitrogen oxides and non-methane hydrocarbons) improve air quality, they have little effect on climate.

17. *See* J. Jason West et al., *Global Health Benefits of Mitigating Ozone Pollution with Methane Emission Controls*, 103 PROC. NAT'L ACAD. SCI. 3988, 3988 (2006), *available at* http://www.pnas.org/content/103/11/3988.full.pdf.

18. *Id*.

19. *Id*. at 3988–89.

20. *Id*. at 3988.

Methane also creates public health risks for the simple reason that, when it builds up, methane can explode.[21] Landfill methane can migrate underground and accumulate in nearby buildings; although regulations require monitoring and mitigation of excess levels, accidental explosions can occur. Because of the public health and safety impacts of methane, regulation designed to reduce its climate change impacts will have significant co-benefits for public health and safety.

B. The Opportunity

Because methane is the primary component of natural gas, landfill emissions can be captured and used for fuel. Landfills' significant contribution to U.S. methane emissions stem from a relatively small number of operations, making them a comparatively easy regulatory target. Finally, the technology is well-established and can provide financial benefits.

While landfills are not responsible for the highest percentage of methane among various sources, they come in a close second and are likely much easier to control than some other significant sources, such as livestock. Livestock operations produce two percent of U.S. greenhouse gases through the process of enteric fermentation. However, the vast number of cattle operations—roughly 967,440—makes this source difficult to control. Moreover, emissions capture is not a common aspect of animal husbandry. Landfills, on the other hand, are responsible for almost the same percentage of emissions, but these stem from a total of about 1900 operations.[22] The limited number of sources renders regulatory targets easier to identify and manage. Moreover, many landfills that are not currently required to capture gas emissions are nonetheless subject to other permitting requirements.

Capturing landfill emissions for energy provides multiple benefits. Landfill gas can be converted to electricity, either for use on-site or for

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21. Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills, 61 Fed. Reg. 9905, 9917 (Mar. 12, 1996) (codified at 60 C.F.R §§ 60.30c-60.36c, 60.750-60.759 (2012)) [hereinafter NSPS: MSW Landfills] ("The EPA has documented many cases of acute injury and death caused by explosions and fires related to municipal landfill gas emissions.").

22. *Id*. ES-5 tbl.ES-2, 8-3 (The largest of these 1900 landfills receive most of the waste in the U.S. and generate the majority of landfill methane. The total number of U.S. landfills has decreased substantially, from a high of over 6,000 twenty years ago, while the average size of individual landfills has increased.).

transmission through the electricity grid.[23] While new technologies are being developed, LGTE projects can rely on existing technology—such as internal combustion engines, turbines, and microturbines.[24] The gas can also be used directly; for example, heating boilers, firing kilns, running dryers.[25] Combusting landfill gas for power has numerous benefits, including dramatically reducing its global warming effect and eliminating the vast majority of other non-methane pollutant emissions.

LGTE projects have several upsides as a power source. They can displace electricity generation from more polluting fuels, such as coal.[26] Landfill gas is often used on-site or locally and can thus provide renewable power without the complexity of other renewable sources such as grid-tying. Even when not used on site, it can be transferred without the grid-tying because the gas itself can be piped to another nearby site directly for use (unlike electricity generated by solar or wind that needs to go through transmission lines). When it is tied into the grid, it provides steady and predictable "baseload" power[27] that is necessary to balance intermittent renewables like solar and wind.

In addition to eliminating direct methane emissions and displacing more polluting forms of power, this technologically offers a proven and accessible source of power that can reduce operating costs for public or private entities and/or generate revenue directly. If landfill gas that would otherwise be emitted is instead used to power LGTE projects, it is essentially free once the equipment and operating costs are accounted for. Along these lines, in 1997, a St. Louis County high school used state and local funding and grants to retrofit boilers to burn landfill gas and to install a pipeline to a nearby landfill, which donated the methane.[28] At the time of installation, the school expected to save $40,000 annually in energy costs.[29] Similarly, Sioux Falls, South Dakota found a customer for the gas generated by its regional landfill, setting up an 11-mile pipeline

23. Landfill Methane Outreach Program, U.S. Envtl. Prot. Agency, *Landfill Methane Outreach Program: Basic Information*, EPA, http://www.epa.gov/lmop/basic-info/index.html (last updated Sept. 28, 2012).

24. *Id*.

25. *Id*. The gas can also be liquefied and transferred.

26. *Id*.

27. LANDFILL METHANE OUTREACH PROGRAM, U.S. ENVTL. PROT. AGENCY, GREEN POWER FROM LANDFILL GAS: HELPING BUILD A SUSTAINABLE ENERGY FUTURE WHILE IMPROVING THE ENVIRONMENT 1 (2010), *available at* http://www.epa.gov/lmop/documents/pdfs/LMOPGreenPower.pdf.

28. Connie Farrow, *Methane from Neighboring Landfill Heats Up High School*, FREE-LANCE STAR (Fredericksburg), Apr. 3, 1997, at C3.

29. *Id*.

from the landfill to a boiler at a local biofuel plant.[30] Once initial capital investments are repaid, the City anticipates that sale of the landfill gas and carbon credits will generate annual net revenues of $1.5 million.[31]

C. Untapped Potential

Despite the fact that the technology has been available for more than 20 years and the fuel is free after recovering initial investments,[32] landfill owners have only recently begun utilizing LGTE. As I have argued elsewhere,[33] LGTE is not as widely adopted as the seeming benefits would merit.

The EPA's Landfill Methane Outreach Program (LMOP), a voluntary program to assist landfill owners in converting landfill methane to power sources, identifies sources that are particularly good candidates for LGTE projects.[34] As of December 2009, the EPA had identified over 300 landfills owned by local governments that would be particularly good candidates for LGTE projects that had not yet adopted the technology.[35] The combined effect of implementing LGTE projects at these sites would be sufficient to displace roughly 5.7 coal-fired power plants.[36] Even greater climate savings could be realized if projects incorporated cogeneration through a system that uses the waste heat from power generation to provide onsite heat or perform other functions.[37] Untapped potential exists in the private sector as well. In 2009, the EPA identified an additional 200 privately owned landfills that would be good candidates for LGTE projects.[38]

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30. LANDFILL METHANE OUTREACH PROGRAM, U.S. ENVTL. PROT. AGENCY, LANDFILL METHANE OUTREACH PROGRAM AND LANDFILL GAS ENERGY: THE POWER OF PARTNERSHIP 3 (2010), *available at* http://www.epa.gov/lmop/documents/pdfs/lmopbro.pdf.

31. *Id*.

32. *See* Sarah Simon et al., *Landfill Gas as Fuel for Combined Heat and Power*, 22 COGENERATION & DISTRIBUTED GENERATION J. 33, 38 tbl.1 (2007) (estimating payback periods of eight to fifteen years depending on the specific technology utilized).

33. Katherine A. Trisolini, *All Hands on Deck: Local Governments and the Potential for Bidirectional Climate Change Regulation*, 62 STAN. L. REV. 669, 722 (2010).

34. EPA's Landfill Methane Outreach Program encourages and facilitates methane capture programs in partnership with states, local governments, and private companies. Landfill Methane Outreach Program, *supra* note 23.

35. Trisolini, *supra* note 33, at 722 (discussing these figures and describing calculations).

36. *Id*.

37. *See* Simon et al., *supra* note 32, at 34.

38. *See* Trisolini, *supra* note 33, at 721–22.

Several barriers likely slow adoption of LGTE. Small landfills may not produce sufficient methane to make LGTE profitable. The price offered by the electric power industry may not be competitive and pipeline capacity may not be available.[39] In addition, lack of knowledge, inertia, and fluctuating fuel prices may limit investment in LGTE projects. For local governments, which own and operate the majority of U.S. landfills,[40] certain institutional barriers likely impede adoption. Most lack institutional expertise in LGTE and are not repeat players, generally owning or operating only one or a few landfills. So, unlike large waste companies, the transaction costs for utilizing an unfamiliar technology will likely be higher than for large waste companies that can employ it at multiple sites. In addition, municipalities traditionally separate waste management and energy purchase or production departments—if they own their own utility.

As discussed further below, the benefits of LGTE projects and the gaps left by federal regulation have led to a spate of incentive programs at all levels of government. Although the 1996 Landfill Gas Rule promulgated by the EPA pursuant to the Clean Air Act encourages energy recovery, the Rule permits operators to flare the landfill gas.[41] But incentives that are not backed by stringent emissions standards have the potential to exacerbate methane production. Therefore, a broader federal rule will play an important role in the best use of LGTE.

III. EXISTING LEGAL LANDSCAPE FOR LGTE

Existing legal programs designed to reduce landfill gas emissions and to expand use of the LGTE projects fall into two broad categories: (1) mandatory capture under the Clean Air Act with an option to flare or implement energy recovery, and (2) various incentives at the local, state, and federal level. Federal Clean Air Act regulations fail to capture sufficient quantities of methane because they target pollution from non-methane organic compounds and exempt the vast majority of landfills. At the same time, incentive programs cannot be relied upon to gap fill for the federal rule because incentives can potentially exacerbate emissions

39. BRACMORT ET AL., *supra* note 3, at 20. To the extent lack of profitability impedes otherwise beneficial LGTE projects, measures that put a price on carbon dioxide emissions (such as a carbon tax or cap-and-trade program) would reduce this barrier by improving LGTE's competitiveness.

40. *See* EPA INVENTORY, *supra* note 1, at 8-3; NSPS: MSW Landfills, *supra* note 21, at 9914 ("Of the landfills required to install controls, about 30 percent of the existing landfills and 20 percent of the new landfills are privately owned. The remainder are publicly owned.").

41. Flaring burns the methane off and greatly reduces other non-methane organic pollutants without any attempt at energy recovery.

if not backed up by stringent controls on fugitive emissions. Moreover, the existing combination of laws has been insufficient to keep pace with growth in methane emissions.

A. The Clean Air Act

The EPA adopted landfill gas emissions regulations in 1996 pursuant to its Clean Air Act authority to set New Source Performance Standards (NSPS)[42] for new or modified industrial sources and enforceable emission guidelines (EG)[43] for existing ones.[44] This "Landfill Gas Rule," which has not been significantly amended since then, only mandates NSPS for very large landfills constructed or modified after May 30, 1991.[45] Landfills that received waste after November 8, 1987 have similar collection and control requirements pursuant to EG but the latter are implemented through state plans.[46] The Landfill Gas Rule does not cover landfills closed before 1987.

Landfills that fall under the Rule are required to install collection systems to capture landfill gas. The captured gas can either be flared or combusted in an enclosed manner that meets emissions reduction requirements for non-methane organic compounds. Enclosed combustion options include boilers, internal combustion engines, and gas turbines. Alternatively, the operator can treat the landfill gas prior to using it to produce energy.[47] Flaring simply burns off the gas and does not create

42. 42 U.S.C. § 7441(a)–(c), (f) (2006).

43. *Id*.

44. 42 U.S.C. § 7441(d). A different portion of the CAA limits emission of hazardous air pollutants from landfills. *See* Clean Air Act § 112, 42 U.S.C. § 7412 (2006). Landfills are also subject to regulation under RCRA and the Clean Water Act. *See* 42 U.S.C. § 6901 (2006); 33 U.S.C. § 1251 (2006).

45. 40 C.F.R. § 60.750 (2012). For purposes of this section, "new" includes landfills that commenced construction, reconstruction, or modification on or after May 30, 1991.

46. *See* 40 C.F.R. § 60.33b (2012); U.S. ENVTL. PROT. AGENCY, LFG ENERGY PROJECT DEVELOPMENT HANDBOOK 5–11 (2010) [hereinafter EPA HANDBOOK].

> For older landfills that received waste after November 8, 1987 (existing landfills), the EG (40 C.F.R. pt. 60(C)(c)) apply. The collection and control requirements in each of these standards are the same; only the start of the compliance clock differs. However, the federal NSPS directly applies to new landfills, whereas the EG for existing landfills are implemented through either a federal plan or EPA-approved state plans. Individual state plans must be similar to, but might not be identical to, the EG. Therefore, landfills and developers should review the applicable state rules for existing landfills.

Id.

47. EPA HANDBOOK, *supra* note 46, at 5–11.

energy. However, both flaring and LGTE drastically reduce the presence of non-methane organic compounds and transform the methane into carbon dioxide; although the carbon dioxide is also a greenhouse gas, the remaining climate forcing is much lower after combustion.

Although the 1996 Landfill Gas Rule indirectly reduces methane emissions, it does not target methane but rather aims to reduce non-methane organic compounds emitted from landfills. The trigger for falling under this regulatory provision is based on the total amount of waste in place and the quantity of non-methane organic compound emissions rather than the quantity of methane emissions. Two threshold tests must be met to render a municipal solid waste (MSW) landfill subject to the Landfill Gas Rule's requirement to collect and reduce emissions. First, the landfill must have a design capacity of at least 2.5 million cubic meters of waste in place. Second, the landfill must emit non-methane organic compounds at a rate of 50 megagrams or more per year.[48]

For sources listed as subject to NSPS, the EPA determines the "best demonstrated technology" for controlling emissions. For MSW landfills, the EPA concluded that this standard requires two things: (1) a well-designed and well-operated gas collection system; and (2) a control device capable of reducing non-methane organic compound (NMOC) emissions by 98 weight-percent.[49] Critically, this focus on NMOC means that the rule only reduces methane indirectly.

Closure provisions ignore the long-term methane emissions that landfills produce. The 1996 Landfill Gas Rule permits operators to remove collection and control systems if the landfill is permanently closed and the NMOC rate stays below specific thresholds.[50] Significantly, the rate of methane emissions is not relevant to the closure conditions because

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> The collected LFG can either be (1) combusted in an open flare that meets design and operating specifications in the rule or (2) combusted in an enclosed combustor (e.g., enclosed flare, boiler, internal combustion engine, or gas turbine) that achieves 98 percent NMOC destruction or 20 parts per million by volume NMOC concentration at the combustion device outlet. A third alternative is to treat the LFG prior to combustion for energy recovery. If the gas is treated, then the energy recovery device does not need to meet the NMOC emission limits or emissions testing requirements

Id.

48. 40 C.F.R. § 60.33b (2012).

49. NSPS: MSW Landfills, *supra* note 21, at 9907.

50. *Id*. The rule allows for system removal if the following conditions are met: "(1) The landfill must be permanently closed; . . . ; [and] (2) the collection and control system must have been in continuous operation a minimum of 15 years; and (3) the annual NMOC emission rate routed to the control device must be less than the emission rate cutoff on three successive dates, between 90 and 180 days apart, based upon the site-specific landfill gas flow rate and average NMOC concentration."

NMOC is the target. The fact that methane emissions could continue for another 60 to 100 years—long after the 15-year period—is not considered.

Because of the limitations of the federal rules, other programs have developed in a patchwork manner, with overlapping and sometimes conflicting mandates. However, as this paper will argue in Section IV, the recent recognition that greenhouse gases fall within the Clean Air Act's definition of "pollutant" and subsequent regulatory initiatives by the EPA create an opportunity to address landfill methane in a more systematic way through expanded national regulation. This could create a uniform national baseline for emissions capture and reduction, eliminate incentives to overproduce methane, and advance a longer term plan for separation of organic materials from the waste stream.

EPA statistics show that emissions reductions from methane capture have not kept pace with increases in landfill gas production. While an initial drop in methane emissions occurred in the 1990s, more recent levels are increasing. Between 1990 and 2010, U.S. landfill methane emissions fell by roughly 27 percent despite a 23 percent increase in the total quantity of waste-in-place.[51] The EPA primarily attributes this reduction to two trends: (1) increased collection and combustion of landfill gas; and (2) changed waste composition due to increased recycling and composting.[52] Recycling and composting divert away from landfills the organic degradable materials, such as paper, food, and yard waste, that are necessary for methane formation.[53]

Nonetheless, the EPA has observed a reverse trend over the last nine years. Although the amount of landfill gas collected and combusted increases every year, it no longer exceeds the rate of additional methane generation from the organic waste landfilled by a growing U.S. population.[54]

Given that the Landfill Gas Rule was adopted in 1996, it should not be surprising that total emissions dropped between 1990 and 2010. But the trajectory towards increasing emissions shows that the Rule and other laws have been insufficient to keep pace with methane emissions, let alone to reduce them.

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51. EPA INVENTORY, *supra* note 1, at 8-3.
52. *Id.*
53. *Id.*
54. *Id.*

B. Incentives

Many governmental entities, scholars, and private corporations have touted landfill gas as "green" or "renewable" power. As described below, all states that have adopted renewable portfolio standards, categorize LGTE projects as a renewable source. This view has led to a broad array of incentives at different levels of government and in private networks.

One set of incentives stem from greenhouse gas emissions reduction credits. Landfill gas collection and destruction has been recognized as an exchangeable commodity in several new voluntary markets, including the Chicago Climate Exchange, as well as emerging greenhouse gas compliance markets such as the Regional Greenhouse Gas Initiate and the Western Climate Initiative.[55]

Federal tax incentives aim to increase methane capture generally and have included LGTE projects specifically. These incentives have taken one of two distinct approaches: compensating for the amount of methane captured versus reimbursing for initial capital costs. The production tax credit has applied to energy produced at solid waste facilities,[56] allowing a credit of $.01 per Kwh.[57] Another tax credit focuses on one-time investments in the facilities, rather than production rates, providing a 30% credit for facilities that opened after December 31, 2008.[58] Finally, the federal stimulus package created grants for LGTE projects that began operating in 2009 and 2010.[59]

The environmental benefits of LGTE projects also have value in states with renewable portfolio standards.[60] As of September 2012, all 37 states that have adopted renewable portfolio standards (RPS) (as well as the District of Columbia, the Northern Mariana Islands, and Puerto Rico and the Virgin Islands) included LGTE projects as eligible renewable sources.[61] Although the details of RPS programs differ significantly, generally speaking states mandate by statute that some or all electric service providers supply a specific percentage of their electricity from renewable sources. The environmental benefits of LGTE projects can be

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55. EPA HANDBOOK, *supra* note 46, at 5–7, 5–9.

56. BRACMORT ET AL., *supra* note 3, at 21–22.

57. *Id*. at 22. Municipal solid waste facilities may claim the credit for the first 10 years if they were or will be placed in service between August 8, 2005 and December 31, 2012; the credit is based upon the amount of electricity generated at a rate of $.01 per KWh. *Id*.

58. *Id*.

59. *Id*.

60. EPA HANDBOOK, *supra* note 46, at 5–9.

61. *See* U.S. Envtl. Prot. Agency, *State Funding Resources and Renewable Portfolio Standards (RPS)*, EPA, http://www.epa.gov/lmop/publications-tools/funding-guide/state-resources/index.html (last updated Oct. 2, 2012).

marketed in the form of tradable renewable energy certificates used by service providers to meet RPS requirements.[62]

Direct subsidies provided by some states have successfully promoted LGTE development. For example, Illinois offers grants for renewable energy projects that include landfill gas to energy production. Due in part to this generous funding, Illinois has four times as many landfill gas to energy projects as the national average.[63] While greenhouse gas emissions credits, federal tax incentives, renewable portfolio standards and state subsidies have been effective at increasing LGTE projects to some degree, absent sufficient mandatory controls, this piecemeal approach can be problematic.

C. Why Regulatory Form Matters

Despite all of its benefits and the widespread enthusiasm for LGTE—demonstrated by the number of governmental entities supporting its adoption—some environmentalists have raised concerns and objected to classifying landfill gas as a "renewable" fuel.[64] Sierra Club has taken the position that LGTE projects should be opposed as doing more harm than good.[65] The Natural Resources Defense Council (NRDC) has taken a cautious stance, supporting LGTE in certain circumstances.

Critics charge that LGTE inadvertently exacerbates methane emissions by encouraging landfill management practices that generate excess methane

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62. EPA HANDBOOK, *supra* note 46, at 5–9.

> Renewable energy certificates (RECs) are the tradable units that allow electric services providers to meet RPS requirements; a typical REC represents the environmental attributes of 1 megawatt-hour of electrical generation delivered to the grid. Pricing for RECs varies greatly by state, depending on the RPS regulations and supply and demand for a given renewable generation technology.

Id.

63. NRDC, *supra* note 4, at 26 (41% of the state's landfills use LGTE).

64. *Id*. at iv, 17 ("Because LFG is a by-product of landfills and landfills are such a poor way to manage our waste, LFG cannot be considered renewable."); *see also* RECYCLING WORKS! CAMPAIGN ET AL., THE DANGER OF CORPORATE LANDFILL GAS TO ENERGY SCHEMES AND HOW TO FIX IT: WHY ORGANICS RECYCLING IS AN ALTERNATIVE THAT PREVENTS GREENHOUSE GASES AND CREATES JOBS 6 (2010), *available at* http://www.teamster.org/sites/teamster.org/files/6310GreenhouseGasReportrevisedlowres.pdf [hereinafter RECYCLING WORKS].

65. SIERRA CLUB LGTE TASK FORCE, SIERRA CLUB, SIERRA CLUB REPORT ON LANDFILL-GAS-TO-ENERGY 3 (2010) [hereinafter SIERRA CLUB] (recommending that, "Sierra Club should resist legislative and policy initiatives that encourage LFGTE projects or that allow LFGTE facilities to receive credit in GHG emission reduction programs.").

and make them occur sooner than they would otherwise.[66] As discussed earlier, methane is only produced in the presence of organic materials and wet conditions. If landfill operators aim to maximize profit from methane production, they may seek out organic material and increase the landfill's moisture content by recirculating leachate or adding water. This would not matter if 100% of the site's methane emissions were captured; however, some amount escapes as "fugitive emissions."[67] Critics also charge that the EPA's estimate that landfills capture 78% of landfill gas is unproven and that some landfills may have much higher fugitive emissions levels.[68] Further, they contend that the EPA fails to account for the long-term emissions that continue after capture systems close down, resulting in a "second wave" of unaccounted for methane emissions.[69]

Additionally, some fear that touting the benefits of landfill gas undermines efforts to move away from current patterns of excess consumption, disposal, and landfilling generally.[70] To the extent that landfilling continues to be utilized in the future, separating out organic matter for composting would eliminate gas generation in the first instance, a preferable route.[71] Incentives for LGTE encourage landfilling of organic materials, or at least slow transition to a preferable system that separates organic materials for composting.

Others point to non-climate harms that render landfills unsustainable. Landfills can contaminate groundwater and incomplete combustion allows NMOCs to escape while combustion itself generates dioxins. Based on these effects combined with potential contributions to global warming, the NRDC contends that landfill gas cannot be considered a "renewable" resource.[72] Moreover, NRDC cites the potential for LGTE subsidies to undermine recycling: "since the cost-effectiveness of recycling programs is directly linked to the cost of alternative waste-management options, landfill-gas energy subsidies could possibly reduce the competitiveness

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66. *Id*. at 2.

67. *Id*. app. A at 1 ("Because gas escapes from the tops, sides, and bottoms of landfills, and because landfills often cover several hundred acres and are piled with wastes as much as several hundred feet deep, capturing all the gas is extremely challenging, even for the period when there is any gas collection.").

68. *Id.* ("[T]echnology to measure fugitive emissions over a wide area has not been available . . . EPA estimates, without supporting data, that the best collection systems capture about 78% of the gases during the relatively small fraction of landfill's emitting lifetime that they are installed and functional."); *see also* NRDC, *supra* note 4, at 3.

69. Sierra Club, *supra* note 65, app. A at 1, 4–5.

70. *See* RECYCLING WORKS, *supra* note 64, at 6.

71. *Id.* at 2, 13. Because composted material breaks down under aerobic conditions, it does not produce methane.

72. *See* NRDC, *supra* note 4, at vi–vii.

of recycling programs by enabling landfill operators to charge lower tipping fees."[73]

The divergent approaches of direct regulation and incentives can directly conflict. For a landfill's project to qualify for a greenhouse gas emission credit, the destruction of landfill gas must be "additional," meaning that the landfill gas must be collected and controlled voluntarily. Generally, a project does not qualify for greenhouse gas credits if the landfill is required to collect and control landfill gas under any local, state, or federal regulations for control of emissions, odors, and/or gas migration.[74] Of course it seems logical to avoid double counting by requiring this "additionality." If mandatory standards turn out to have advantages over such market mechanisms, however, the interests that develop to utilize the credits may create political resistance to expansion of mandatory standards.

The approaches can also indirectly conflict. Any means that compensate operators for the quantity of landfill gas emitted and captured—such as the federal production credit or state renewable portfolio standards—incentivizes landfill operators to manage landfills to increase methane emissions. Although any added emissions are theoretically being captured, some emissions escape, leaking out of the landfill at points outside the reach of the capture system. Unless extremely well-understood and strictly controlled, the "fugitive emissions" could more than offset any benefit of LGTE.

Although some incentive based approaches would be undermined by expanded federal control because of conflicts with the additionally requirement, broader and stricter federal standards are necessary to prevent the indirect conflict between methane emission reduction goals and inducements for operators to increase methane generation. Expanding the federal Rule is also necessary to capture the full lifetime of methane emissions and to regulate smaller and older landfills.

IV. REGULATORY OPTIONS

A. Goals of a Better Policy

What would a better Landfill Gas Rule do? First, it would target methane directly, something that would be quite timely given the EPA's

73. *Id*. at v–vi.
74. EPA HANDBOOK, *supra* note 46, at 5–7.

initiation of greenhouse gas regulation under other parts of the CAA. Second, it would incorporate solid waste reduction provisions and separation requirements for organic matter. At the same time, it would strongly encourage capture, combustion, and energy recovery for waste currently in place and for methane. It would include stringent fugitive emissions monitoring requirements based on solid research.

Like most things, the merits of LGTE depend on the alternative to which it is being compared. We need solid research showing that a high percentage of fugitive emissions could be captured with existing technology. Then, enforceable standards could be put in place to ensure it would in fact be captured. A good policy would be flexible enough to allow expanded use of LGTE if it ultimately proved environmentally superior to the alternatives.

Simply asking whether or not LGTE is "renewable" likely conflates several distinct issues, which are better considered individually. First, using LGTE to reduce methane emissions from closed landfills or waste that is already in place has different implications than planning to use LGTE for future waste streams. If the primary concern is the combining of organic and inorganic materials, to the extent this has already occurred in existing landfills, capturing and combusting the emissions to make power has little downside. Materials separation requirements could be added for new landfills and ongoing operations at existing landfills. Management practices that increase methane emissions over baseline could be proscribed absent comprehensive fugitive emission prevention. LGTE will be more beneficial in the presence of stringent standards that eliminate some of the perverse incentives identified by critics. Such standards could include more stringent monitoring for fugitive emissions, waste separation requirements, and better controls to reduce the potential for groundwater and air quality contamination.

We do not necessarily need to adopt an all-or-nothing approach, presuming that LGTE is either a fabulous renewable or a corporate scam to be avoided. In the U.K., LGTE projects have been aggressively developed but in the context of an overarching European Union policy that mandates segregation of organic materials from landfills going forward, a landfill tax, and a cap-and-trade program to address greenhouse gases.[75] This suggests how widely applicable regulatory standards can serve as a backstop to development of individual LGTE projects to capture its benefits while avoiding perverse incentives for augmenting methane.

75. *See* Carson Bennett, Note, *Landfill Gas-to-Energy in the US and UK: An Analysis of Differing Policy Objectives Regarding Landfill Gas and Accompanying Regulation and Incentives*, GEO. INT'L ENVTL. L. REV. 531, 535 (2011).

B. Greenhouse Gas Regulation under the Clean Air Act

One advantage of targeting landfill methane via the Clean Air Act is that it does not require additional legislation. The EPA already has the authority to regulate methane emissions from landfills and could amend the Landfill Gas Rule to adopt options rejected in the 1996 rulemaking process, including directly targeting methane emissions.

1. Prevention of Significant Deterioration

After the Supreme Court's 2007 holding in *Massachusetts v. EPA*, that the Clean Air Act's definition of "air pollutant" includes greenhouse gases,[76] the EPA began regulating emissions of these gases. The EPA first issued a Mandatory Greenhouse Gases Reporting Rule (Reporting Rule) in October 2009.[77] In December 2009, the Administrator found that greenhouse gas emissions from motor vehicles "cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare."[78] While this "Endangerment Finding" formally applied only to motor vehicles, by compelling regulation of mobile source emissions,[79] EPA rendered greenhouse gases a pollutant "subject to regulation."[80] Subjecting a pollutant to regulation under any part of the

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76. Massachusetts v. EPA, 549 U.S. 497, 527–33 (2007).

77. The Reporting Rule was designed "to gather greenhouse gases information to assist the EPA in assessing how to address greenhouse gas emissions and climate change under the Act." Mandatory Reporting of Greenhouse Gases, 74 Fed. Reg. 56,260, 56,265 (Oct. 30, 2009) (codified at 40 C.F.R. pts. 86, 87, 89, 90, 94, 98, 1033, 1039, 1042, 1045, 1048, 1051, 1065). This rule also required municipal solid waste landfills to report their emissions if the annual methane emissions were greater than 25,000 metric tons of carbon dioxide equivalent. *Id*. at 56,264.

78. 42 U.S.C. § 7521(a)(1) (2006); Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the Clean Air Act, 74 Fed. Reg. 66,496, 66,497 (Dec. 15, 2009) (codified at 40 C.F.R. pt. 1).

79. *See* Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 75 Fed. Reg. 25,324, 25,324 (May 7, 2010) (codified at 40 C.F.R. pts. 85, 86, 600, 49 C.F.R. pts. 531, 533, 536, 537, 538).

80. On March 29, 2010, EPA finalized a rule amending provisions of the PSD requirements to formalize the definition of pollutants "subject to regulation" under the CAA as:

> any air pollutant . . . subject to either a provision in the Clean Air Act, or a nationally-applicable regulation codified by the Administrator . . . that requires actual control of the quantity of emissions of that pollutant, and that such control requirement has taken effect and is operative to control, limit or restrict the quantity of emissions of that pollutant released from the regulated activity.

40 C.F.R. § 51.166(b)(48) (2012); *see also* 40 C.F.R. § 52.21(b)(49) (2012); Reconsideration

Act also triggers control requirements for all new major stationary sources—including landfills—through the Prevention of Significant Deterioration (PSD) program[81] and also requires major sources to obtain operating permits under Title V.[82] PSD mandates pre-construction review to ensure that new sources employ the "best available control measures" as determined on a case-by-case basis with state permitting entities.

As sources emit greenhouse gases in much greater quantities than other pollutants covered by the CAA, the EPA adopted a "Tailoring Rule" that initially employs higher regulatory thresholds for greenhouse gases and phases in lower limits.[83] These limiting conditions prevented many small emitters from being newly classified as "major sources" in need of pre-construction and operating permits,[84] avoiding the costs and administrative burden of imposing permitting protocols on small entities.[85] The first phase applied only to sources already subject to permitting for non-GHG pollutants with subsequent phases reaching new and existing sources with high emission levels.[86]

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of Interpretation of Regulations That Determine Pollutants Covered by Clean Air Act Permitting Programs, 75 Fed. Reg. 17,004, 17,004 (Apr. 2, 2010) (codified at C.F.R. pts. 50, 51, 70, 71).

81. *See* 42 U.S.C. § 7475(a)(4) (2006).

82. *See* 42 U.S.C. § 7661a(a) (2006) (requiring operating permits for any source subject to PSD pre-construction permitting requirements).

83. *See* Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31,514, 31,516. (June 3, 2010) (codified at 40 C.F.R. pts. 51, 52, 70, 71) (Tailoring Rule). The first phase of the Tailoring Rule, which took effect January 2, 2011, required only those new and existing stationary sources already subject to the PSD and title V permitting requirements for non-greenhouse gas pollutants to acquire permits for the greenhouse gas emissions. *See* 40 C.F.R. § 51.166(b)(48)(iv) (2012). The second phase, taking effect July 1, 2011, expanded the scope of sources to new sources "that will emit or have the potential to emit 100,000 tpy CO_2e or existing stationary sources that emit or have the potential to emit 100,000 tpy CO_2e" and "undertakes a physical change or change in method of operation that will result in an emissions increase of 75,000 tpy CO_2e or more." *Id*. § 51.166(b)(48)(v).

84. *See* 42 U.S.C. § 7479(1) (proposed May 26, 2011); *see also* 40 C.F.R. §§ 51.166(b)(1)(i)(a), 52.21(b)(1)(i)(a) (2011) ("Major Stationary Sources" are defined as a discrete set of sources which emit or have the potential to emit 100 tons per year of a regulated pollutant); 40 C.F.R. §§ 51.166(b)(1)(b), 52.21(b)(1)(b) (2011) (all stationary sources which emit or have the potential to emit 250 tons per year of a regulated pollutant).

85. *See* Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 75 Fed. Reg. 31514, 31517 (June 3, 2010 (codified at 40 C.F.R. pts. 51, 52, 70, 71) [hereinafter Tailoring Rule].

86. 40 C.F.R. § 51.166(b)(48)(iv)-(v) (2011). The Tailoring Rule initially exempted all sources with emissions below 50,000 tons per year (tpy) of CO_2e, and all modified sources whose modifications resulted in net increases of less than 50,000 tpy CO_2e from PSD or Title V permitting requirements until at least April 30, 2016. *See* Tailoring Rule, 75 Fed. Reg. at 31,516. EPA justified the initial exemption for small sources on the grounds that:

> [T]he administrative burdens that would accompany permitting sources below this level will be so great that even the streamlining actions that EPA may be able

The EPA rejected comments proposing that the Tailoring Rule exempt landfill emissions from contributing to permitting thresholds. However, on July 20, 2011, the EPA issued a final rule deferring for three years inclusion of biogenic emissions of CO2 from the emissions calculation to establish the threshold.[87] This Rule explicitly rejected calls to exclude methane from contributing to the regulatory threshold.[88] Nonetheless, given that fugitive emissions are not counted towards the greenhouse gas thresholds and the largest landfills already combust their emissions, converting them to CO2, this may delay the greenhouse gas requirements under PSD and Title V for most landfills.

2. New Source Performance Standards: Revisiting the 1996 Landfill Gas Rule

The Landfill Gas Rule, adopted pursuant to New Source Performance Standards (NSPS) under CAA Section 111, differs from potential PSD requirements. NSPS establish a nationwide standard—as opposed to the case by case analysis for stationary sources subject to PSD—and generally create a regulatory floor for PSD. In addition, Section 111 prompts corresponding emissions guidelines for states to apply to existing sources.

The Landfill Gas Rule currently mandates collection and flaring of landfill gas from large landfills.[89] The Rule can become a much more useful tool for environmental protection if it is amended to directly target methane. Revising the Landfill Gas Rule to address methane is a logical next step given EPA's recognition that greenhouse gases endanger public health and welfare and its now recognized role in mitigating climate change through the Clean Air Act.

The options rejected in the original rulemaking in 1996 illustrate several critical ways in which the Landfill Gas Rule could be amended

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> to develop and implement in the next several years, and even with the increases in permitting resources that we can reasonably expect the permitting authorities to acquire, it will be impossible to administer the permit programs for these sources until at least 2016.

Id. The Tailoring Rule, however, established an "enforceable commitment" to study PSD and Title V permitting for smaller sources and to engage in further rulemaking by April 2016. *See id*. at 31,525.

87. *See* Deferral for CO_2 Emissions From Bioenergy and Other Biogenic Sources Under the Prevention of Significant Deterioration (PSD) and Title V Programs, 76 Fed. Reg. 43,490, 43,490 (July 20, 2011) (codified at 40 C.F.R. pts. 51, 52, 70, 71).

88. *Id*. at 43,492.

89. *See* 40 C.F.R. §§ 60.30c-36c (2012).

to address methane's adverse impacts: by directly targeting methane, rather than only NMOC; requiring materials separation; expanding coverage to smaller landfills; and mandating energy recovery unless the operator can demonstrate that it is not practical.

In its proposed rule, the EPA requested input on four issues, quite relevant to the production of landfill methane: "(1) the use of an alternative format for the regulatory cutoff; (2) the inclusion of materials separation requirements . . . ; (3) the establishment of a separate [control standard] for methane; and (4) the inclusion of specific energy recovery requirements . . . "[90]

In response to comments, the EPA significantly revised the proposed version of the Landfill Gas Rule, ultimately exempting the vast majority of U.S. landfills. The proposed rule had excluded small landfills with a design capacity of less than 100,000 cubic meters of waste in place. In response to comments, the EPA revised the exemption level upwards to 2.5 million, a change that the agency explained would exempt 90 percent of existing landfills.[91]

Because the Rule targets non-methane organic compounds, the EPA focused on how changes would affect emissions of these substances. The EPA reasoned that by focusing only on the largest landfills it could relieve the regulatory burden on small businesses and local governments while not appreciably affecting the regulation's ability to reduce non-methane organic compounds. However, these changes allowed substantially more methane to be emitted from the landfills. Lowering the threshold to capture more landfills would be a first step in reducing landfill methane.

In addition, the proposed rule requested comments on the option of setting a separate standard for methane. Ultimately, however, the EPA rejected comments that had supported a separate methane standard based on its contribution to global warming and tropospheric ozone formation.[92] The EPA contended that the NMOC standard would indirectly reduce methane emissions by a projected 39% and concluded that NMOCs were of greater concern.[93] However, the absolute loss in methane emissions

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90. OFFICE OF AIR QUALITY PLANNING & STANDARDS, U.S. ENVTL. PROT. AGENCY, EPA-453/R-94-021, AIR EMISSIONS FROM MUNICIPAL SOLID WASTE LANDFILLS—BACKGROUND INFORMATION FOR FINAL STANDARDS AND GUIDELINES 1–24 (1995), *available at* http://www.epa.gov/ttn/atw/landfill/bidfl.pdf.

91. NSPS: MSW Landfills, *supra* note 21, at 9,910–11 (As the EPA explained, "the 2.5 million Mg exemption level would exempt 90 percent of the existing landfills while only losing 15 percent of the total NMOC emission reduction . . . The 2.5 million Mg level was chosen to relieve as many small businesses and municipalities as possible from the regulatory requirements while still maintaining significant emission reduction").

92. OFFICE OF AIR QUALITY PLANNING & STANDARDS, U.S. ENVTL. PROT. AGENCY, *supra* note 90, at 1–25, 1–26.

93. *Id*. at 1–26.

reduction between the proposed and final rules was substantial; based on its estimated total methane emissions from MSW landfills, the EPA presumed that a rule without a cutoff would reduce annual methane emissions by 8,270,000 whereas a 2,500,000 cutoff would result in only a 3,370,000 reduction.[94]

Although the final rule "strongly" recommended energy recovery, the EPA rejected comments proposing mandatory energy recovery, presuming that the decision should turn on individual profitability, a site-specific determination.[95] Thus, covered landfills were left to decide between flaring and energy recovery on their own. The EPA did establish the Landfill Methane Outreach Program to facilitate voluntary adoption by providing information on technologies and funding.

Finally, the EPA rejected comments proposing that the rule require waste separation for organic materials. Such a requirement, as has been adopted by the European Union, would reduce future methane generation and potentially remove the incentive to manage solid waste for increased methane production by adding organic material.

All of these rejected options signal how the Landfill Gas Rule could be changed to improve federal control of landfill gas generally and methane specifically. First, identifying methane as an independent target would be critical to formulating each part of the Rule to maximize climate benefits. Second, expanding to smaller and older landfills would further reduce greenhouse gas emissions along with other pollutants. Third, treating waste composition as an emissions issue would coordinate recycling and composting efforts with methane mitigation. Finally, the Rule should mandate LGTE where feasible. A rebuttable presumption in favor of LGTE could allow sites to demonstrate infeasibility; a default position favoring LGTE would ensure that its benefits would be expanded

94. NSPS: MSW Landfills, *supra* note 21, at 9,915.

95. OFFICE OF AIR QUALITY PLANNING & STANDARDS, U.S. ENVTL. PROT. AGENCY, *supra* note 90, at 1–27, 1–28.

> Such a decision should be made after the landfill owner or operator considers the potential for income from energy utilization given the uncertainty in the amount of gas produced. Many other variables come into play when considering energy recovery, such as gas market fluctuations, gas production rates, ability to market or distribute electricity produced, and the quality of the gas. Technical difficulties vary from site to site . . . On the other hand, some landfills may generate adequate volumes of clean burning gas that would make energy recovery profitable. For these reasons, the EPA is strongly encouraging, but not mandating, energy recovery within these standards.

Id.

where appropriate. Some flexibility could be maintained by allowing owners and operators to choose both from a range of technologies and end uses—from sale to powering local buildings.

Other revisions would include extending control mechanisms temporally to capture lifetime emissions. This would prevent many of the problems identified by critics, such as second wave emissions. Critically, this should be coupled with research on fugitive emissions and more stringent monitoring. Expanding the Landfill Gas Rule in these would ensure a more systematic approach because the NSPS under which the Rule is promulgated serve as a floor to state standards.

California's landfill gas rules demonstrate that it is possible to better address fugitive emissions and to capture smaller landfills. Pursuant to its authority under the Clean Air Act and the California Global Warming Solutions Act of 2006, the California Air Resources Board has adopted more stringent controls over municipal solid waste landfills than the floor set by the federal NSPS. Unlike the federal rule, California's rule applies to a much broader range of landfills and directly aims to reduce methane emissions. Significantly, the rule expressly states that its purpose is to "reduce methane emissions from municipal solid waste landfills."[96] Moreover, it applies to all facilities that received waste after January 1, 1977, much earlier than the federal rule.[97] In addition, it reaches smaller landfills, those with more than 450,000 tons of waste-in-place.[98] Finally, California's rule also has more stringent control over fugitive emissions. It requires service monitoring to be spaced more closely and conducted more frequently than federal rules require.[99] California's approach provides a model that can—and should—be adopted at the national level.

V. CONCLUSION

This is a particularly good time to revise the federal Landfill Gas Rule to require emissions capture from more landfills and to focus on reducing methane particularly. The EPA's recent regulatory initiatives have begun to directly target greenhouse gases; revising the 1996 Landfill Gas Rule is an obvious next step.

For solid waste that cannot be eliminated through recycling or that sits in pre-existing landfills, methane-to-energy systems can capture methane

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96. CAL CODE REGS. tit. 17, § 95460 (2012) ("The purpose of this subarticle is to reduce methane emissions from municipal solid waste (MSW) landfills pursuant to the California Global Warming Solutions Act of 2006.").

97. CAL CODE REGS. tit. 17, § 95461 (2012) ("This subarticle applies to all MSW landfills that received solid waste after January 1, 1977.").

98. *See id.*

99. *See* CAL CODE REGS. tit. 17, § 95469 (2012).

emissions and generate energy to replace demand for fossil fuel based power. While incentives have been a useful mechanism for advancing adoption of this technology, they fall short in multiple respects. They have failed to capture enough emitters to even keep pace with methane generation when reducing emissions are required to address climate change. Moreover, absent sufficient regulatory standards as a backstop, financial incentives can create perverse incentives to generate additional methane. They also may discourage transition to a preferable alternative of simply avoiding the generation of landfill gas in the first instance by separating out organic materials from the waste stream.

Methane's highly concentrated climate change impact in the short term has important implications for landfill management. Near term reductions will likely prove critical to avoid tipping points that could trigger irreversible global warming. While landfill methane composes a relatively small share of U.S. emissions when gases are compared on a 100-year timeframe, its short atmospheric lifetime means that big cuts in methane emissions will have a quicker impact than comparable efforts to cut other gases. Landfills are also discrete targets that can be manageably regulated. An optimal policy will take advantage of the multiple benefits of landfill gas to energy while avoiding the trap of incentivizing increased emissions. It will broadly recognize landfill methane as an important target for climate change regulation, aiming to drastically reduce its generation in the future and to capture methane from past landfilling practices.