

NOTE

Regulating Bioreactor Landfills to Decrease Greenhouse Gas Emissions and Provide an Alternative Energy Source

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ABSTRACT

Most household garbage in the United States is disposed of in landfills. The decomposition of our nation's trash in landfills creates methane, a powerful greenhouse gas that contributes to climate change. This gas could be captured and used as a source of energy, reducing greenhouse gas emissions and the use of dirty energy sources like coal-fired power plants. Bioreactor landfills make landfill gas-to-energy facilities more profitable by using liquid to speed the decomposition of waste and creation of methane. Current Environmental Protection Agency ("EPA") regulations, however, restrict the use of liquids in landfills, limiting the application of this technology to reduce greenhouse gas emissions and slow climate change.

This Note argues that EPA should amend its landfill regulations to provide an exception to the liquids restriction, allowing for the use of bioreactor technology to create landfill gas energy. This would encourage landfill owners and operators to build more gas-to-energy facilities, reducing greenhouse gas emissions and providing an alternative source of energy. Bioreactor technology provides additional community, environmental, and economic benefits that could be realized through the proposed regulatory change.

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INTRODUCTION

We are now faced with the fact that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history there is such a thing as being too late. . . . We may cry out desperately for time to pause in her passage, but time is deaf to every plea and rushes on. Over the bleached bones and jumbled residues of numerous civilizations are written the pathetic words: “Too late.”¹

The United Nations Development Programme began its 2007/2008 Human Development Report with this quote from Martin Luther King Jr.² The Report identified climate change as the “fierce urgency” facing humanity today and described it as “the defining human

¹ MARTIN LUTHER KING JR., WHERE DO WE GO FROM HERE 191 (1968).

² U.N. DEV. PROGRAMME, HUMAN DEVELOPMENT REPORT 2007/2008, at 1 (2007), http://hdr.undp.org/en/media/HDR_20072008_EN_Complete.pdf.

development issue of our generation.”³ Climate change threatens to flood our cities, devastate our crops, drive plants and animals to extinction, and cause more severe weather events.⁴ Much of the discussion about climate change focuses on carbon dioxide emissions,⁵ but another manmade greenhouse gas threatens “human progress” as well: methane has a global warming potential twenty-one times that of carbon dioxide, making it a much more potent greenhouse gas.⁶

Landfills are the third-largest source of manmade methane emissions in the United States, accounting for approximately seventeen percent of total U.S. manmade methane emissions in 2009.⁷ The United States sends more waste to landfills than any other country, accounting for twenty-three percent of global landfilled municipal solid waste.⁸ In 2009, methane emissions from U.S. landfills were equivalent to 117 million metric tons of carbon dioxide.⁹ That is the equivalent of annual carbon dioxide emissions from over 22 million cars or 10 million homes.¹⁰

Methane emissions from landfills are the result of the bacterial decomposition of organic material in municipal solid waste.¹¹ The gas created by this decomposition is called landfill gas and is approximately fifty percent methane and fifty percent carbon dioxide.¹² Under the right circumstances, landfill gas can be captured and

³ *Id.*

⁴ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 48 (Core Writing Team, Rajendra K. Pachauri, & Andy Reisinger eds., 2007), available at http://www.ipcc.ch/publications_and_data/ar4/syr/en/mains3-3-1.html.

⁵ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, RENEWABLE ENERGY SOURCES & CLIMATE CHANGE MITIGATION 175 (Ottmar Edenhofer et al. eds., 2012), http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf.

⁶ U.S. EPA, AVAILABLE & EMERGING TECHNOLOGIES FOR REDUCING GREENHOUSE GAS EMISSIONS FROM MUNICIPAL SOLID WASTE LANDFILLS 7 (2011), <http://www.epa.gov/nsr/ghgdocs/landfills.pdf>.

⁷ *Methane: Sources & Emissions*, U.S. EPA, <http://www.epa.gov/methane/sources.html> (last updated Apr. 18, 2011). The two largest sources of manmade methane emissions in the United States are natural gas systems and livestock enteric fermentation. *Id.*

⁸ Nickolas Themelis, Reducing Landfill Methane Emissions and Expansion of the Hierarchy of Waste Management 1 (2008), http://www.seas.columbia.edu/earth/wtert/sofos/GWMS_paper_Themelis_Oct2008.pdf.

⁹ U.S. EPA, *supra* note 7.

¹⁰ *Greenhouse Gas Equivalencies Calculator*, U.S. EPA, <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results> (results achieved when 117,000,000 is entered as metric tons of carbon dioxide equivalents). It is also equivalent to the amount of carbon dioxide generated annually from over 27 coal fired power plants. *Id.*

¹¹ *Landfill Gas*, U.S. EPA, <http://epa.gov/lmop/faq/landfill-gas.html> (last updated Apr. 6, 2011).

¹² *Id.*

burned for energy, eliminating the landfill's methane emissions to the atmosphere and contributing to reductions in the use of fossil fuels.¹³ There are approximately 2400 currently operating or recently closed municipal solid waste landfills in the United States.¹⁴ And although more than 550 of these landfills capture and collect landfill gas to burn as energy,¹⁵ the U.S. Environmental Protection Agency ("EPA") has estimated that over 540 additional landfills could use their gas to create energy, providing electricity to almost 716,000 homes.¹⁶

Although this gas could be used as a source of energy, it is often flared off (burned into the atmosphere) due to the high costs of gas-to-energy systems in traditional landfills.¹⁷ Landfill gas-to-energy systems can be more economically attractive if bioreactors are utilized. A bioreactor is a landfill that accelerates the decomposition of waste by introducing liquids, which enhance the growth of microbes responsible for decomposition.¹⁸ The enhanced decomposition of waste creates more gas with higher methane concentrations at faster and more predictable rates than in traditional landfills, where liquids are not added.¹⁹ The enhanced, predictable methane generation in a bioreactor makes landfill gas-to-energy projects more cost-effective than they would be in a traditional landfill.²⁰ Bioreactors also offer additional environmental and solid waste management benefits.²¹

¹³ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 5, at 46. For more on how landfill gas is collected, see *infra* note 59.

¹⁴ *Landfill Methane Outreach Program: Basic Information*, U.S. EPA, <http://epa.gov/lmop/basic-info/index.html> (last updated Sept. 28, 2012).

¹⁵ *Id.*

¹⁶ *Id.* This is more than twice the number of housing units in Washington, D.C., as of the 2010 census. *State & County Quick Facts: District of Columbia*, U.S. CENSUS BUREAU, <http://quickfacts.census.gov/qfd/states/11000.html> (last updated Sept. 18, 2012). An additional study on landfill gas-to-energy potential found that the state of Florida could triple the production of landfill gas energy by 2035 by installing landfill gas-to-energy projects at all of the state's landfills. Hamid R. Amini & Debra R. Reinhart, *Regional Prediction of Long-term Landfill Gas to Energy Potential*, 31 WASTE MGMT. 2020, 2025 (2011). The study estimated the electricity potential of such a switch to be "equivalent to removing some 70 million vehicles from Florida highways or eliminating the need to import over 800 million barrels of foreign oil" during the 2010–2035 timeframe. *Id.* at 2026.

¹⁷ Landfill gas from a traditional landfill has an energy cost equivalent of \$200 per barrel of oil. RAMIN YAZDANI ET AL., YOLO CNTY. PUB. WORKS, FULL SCALE BIOREACTOR LANDFILL FOR CARBON SEQUESTRATION AND GREENHOUSE EMISSION CONTROL 4 (2006), available at <http://www.yolocounty.org/Index.aspx?page=438>. See *infra* Part I.B for more on flaring.

¹⁸ U.S. EPA, SOLID WASTE MANAGEMENT AND GREENHOUSE GASES 120 (2002), <http://www.epa.gov/climatechange/wywd/waste/downloads/greengas.pdf>.

¹⁹ Michael Fickes, *Bioreactors and Beyond*, WASTE360 (May 1, 2004), <http://waste360.com/bioreactors/bioreactors-and-beyond>.

²⁰ *Id.*

²¹ See *infra* Part I.C.

Current EPA regulations prevent the use of bioreactors by restricting the introduction of liquids into landfills and only allowing for the utilization of bioreactors pursuant to special permits,²² which can be costly and take months or years to obtain.²³ This prevents landfill operators from using bioreactors and is a lost opportunity to reduce methane emissions and provide an alternative source of energy.

This Note argues that EPA should amend its regulations to exempt all gas-to-energy landfills from the liquids restriction and eliminate the need for special permits to utilize bioreactor technology. Furthermore, EPA should promulgate regulations to require new landfills to use bioreactor technology and collect their gas emissions for energy use. EPA has the authority to promulgate these regulations under the Resource Conservation and Recovery Act (“RCRA”),²⁴ passed pursuant to Congress’s power under the Commerce Clause.²⁵ These regulatory changes would result in decreased methane emissions from landfills and produce an alternative energy source, decreasing the use of fossil fuels and slowing climate change.

Part I of this Note discusses traditional landfills and landfill gas-to-energy facilities, and it then introduces bioreactors and their benefits. It also discusses the current regulatory scheme and how it limits the use of bioreactors. Part II sets out a proposal to allow for the use of bioreactors in landfill gas facilities and require bioreactor technology in new landfills. Part III addresses potential objections to bioreactor landfills.

I. BACKGROUND

In order to understand the difference between bioreactors and traditional landfills, and the progression of waste disposal from open dumps to high-tech waste management systems, this Part lays out a brief history of solid waste management and then explains the traditional “dry tomb” landfills widely used today. It then discusses bioreactors and the benefits they offer over traditional landfills. Finally, it explains how the current regulations prevent more widespread use

²² See 40 C.F.R. § 258.28(a) (2012) (“Bulk or noncontainerized liquid waste may not be placed in [municipal solid waste landfill] units . . .”); *id.* § 258.4 (describing permitting requirements for research, development, and demonstration projects which may be exempt from the liquids restrictions).

²³ Jeremy K. O’Brien, *The Solid Waste Manager’s Guide to the Bioreactor Landfill—A 2009 Update*, MSW MGMT. (Apr. 30, 2010), <http://www.mswmanagement.com/MSW/Articles/10153.aspx>.

²⁴ 42 U.S.C. §§ 6901–7000 (2006).

²⁵ See *infra* Part II.B.

of bioreactor technology to create better landfill gas-to-energy facilities.

A. *Brief History of Waste Management*

To understand how our current system of waste management came to be, it is useful to look at its historical progression. Waste was not really “managed” until about 100 years ago. At the end of the nineteenth century, waste disposal consisted of throwing trash in the street to be scavenged by animals and the poor.²⁶ But by the beginning of the twentieth century, cities began to recognize the connection between this method of solid waste disposal and public health problems and began to collect garbage and “dispose of it in open dumps, incinerators, or at sea.”²⁷

Early landfill design did not devote much attention to environmental concerns. Landfills were created by filling a hole in the ground with trash and covering it with soil.²⁸ In the 1920s, it was common to fill in wetlands with garbage and incinerator ash.²⁹ Waste was placed directly on soil without any barriers.³⁰ As a result, rainwater would percolate through the landfill and pick up contaminants.³¹ The resulting contaminated water is called leachate and would escape into the environment and groundwater.³² Garbage deposited in landfills was typically burned or covered with a thin layer of soil.³³ Both of these methods allowed air pollutants and landfill gas to escape from the landfill into the atmosphere.³⁴

Gradually the environmental concerns associated with this kind of waste management were recognized and the federal and state governments began to regulate landfills to prevent environmental harms. It was not until 1929 that the federal government recommended that dumps be sited away from river banks.³⁵ In the 1930s and 40s, state

²⁶ NAT'L SOLID WASTES MGMT. ASS'N, *MODERN LANDFILLS: A FAR CRY FROM THE PAST* 2 (2008), <http://www.environmentalistseveryday.org/docs/research-bulletin/Research-Bulletin-Modern-Landfill.pdf>.

²⁷ *Id.*

²⁸ *Id.* at 4.

²⁹ *Id.* at 2.

³⁰ *Id.* at 4.

³¹ *Id.*

³² *Id.*

³³ *Id.*

³⁴ *Id.*

³⁵ Jon Roberts, *Garbage: The Black Sheep of the Family—A Brief History of Waste Regulation in the United States and Oklahoma*, OKLA. DEP'T OF ENVTL. QUALITY, <http://www.deq.state.ok.us/lpdnew/wastehistory/wastehistory.htm> (last visited Oct. 13, 2012).

statutes and court rulings began to place more restrictions on waste disposal.³⁶ The American Society of Civil Engineers first published guidelines for a “sanitary landfill” in 1959, suggesting compacting waste and covering it with soil at the end of each day to control odors and rodents.³⁷ In 1965, the federal government passed the Solid Waste Disposal Act³⁸ to assist state and local governments in developing solid waste disposal programs.³⁹ States began to develop their own solid waste management regulations in the 1960s and 70s, requiring design and operational standards, as well as permits.⁴⁰ In 1976, the federal government passed RCRA, which directed EPA to promulgate environmentally protective criteria for sanitary landfills and close or upgrade existing open dumps that did not meet the criteria.⁴¹ EPA developed regulations for sanitary landfills in 1979 and revised them in 1991.⁴²

B. *Traditional Dry Tomb Landfills*

Americans continue to be dependent on landfills for waste management needs today. The United States sends more waste to landfills than any other country, creating twenty-three percent of global landfilled municipal solid waste.⁴³ Over half of all municipal solid waste in the United States is landfilled, and there are approximately 1800 operational landfills in the United States, accepting approximately 132 million tons of municipal solid waste annually.⁴⁴

³⁶ *Id.* (“[I]n 1934, the United States Supreme Court upheld a lower court ruling requiring New York City to cease disposal of its municipal waste at sea. In the 1930s, California passed laws prohibiting disposal of garbage within 20 miles of shore.”).

³⁷ NAT'L SOLID WASTES MGMT. ASS'N, *supra* note 26, at 2.

³⁸ Solid Waste Disposal Act, Pub. L. No. 89-272, 79 Stat. 992 (1965).

³⁹ H. Lanier Hickman Jr., *A Brief History of Solid Waste Management in the US, 1950–2000*, MSW MGMT. (Apr. 30, 2000), <http://www.mswmanagement.com/MSW/Articles/4522.aspx>.

⁴⁰ NAT'L SOLID WASTES MGMT. ASS'N, *supra* note 26, at 3.

⁴¹ Resource Conservation and Recovery Act of 1976, Pub. L. No. 94-580, § 2, 90 Stat. 2795, 2813–15.

⁴² Criteria for Classification of Solid Waste Disposal Facilities and Practices, 44 Fed. Reg. 53,438 (Sept. 13, 1979) (codified at 40 C.F.R. pt. 257 (2012)); Solid Waste Disposal Facility Criteria, 56 Fed. Reg. 50,978 (Oct. 9, 1991) (codified at 40 C.F.R. pts. 257–58).

⁴³ Themelis, *supra* note 8, at 1.

⁴⁴ U.S. EPA, *supra* note 6, at 6–7. Fifty-four percent of municipal solid waste in the United States is landfilled, twelve percent is incinerated, and thirty-four percent is recycled or composted.

EPA regulations under RCRA reflect the dry tomb landfill used today. The regulations require most municipal solid waste landfills⁴⁵ to meet certain design criteria; landfills not meeting these criteria will be deemed open dumps, which the Act prohibits.⁴⁶ In order to prevent the groundwater contamination that occurred in early landfills, current regulations prevent any moisture from entering the landfill, resulting in a so-called “dry tomb” for waste.⁴⁷

EPA regulations require several pollution prevention techniques in dry tomb landfills. First, owners or operators are required to cover municipal solid waste in the landfill with six inches of dirt at the end of each day.⁴⁸ Second, landfills must have liners and leachate collection systems.⁴⁹ “Liners prevent leachate and gas migration out of the landfill while directing liquids to the leachate collection system.”⁵⁰ Third, owners or operators must install a final cover when the landfill is closed to minimize moisture infiltration and erosion.⁵¹ Finally, municipal solid waste landfill owners and operators must perform post-closure care for thirty years.⁵² This includes: “[m]aintaining the integrity and effectiveness of any final cover”; “[m]aintaining and operating the leachate collection system” until it no longer poses a threat

⁴⁵ The regulations do not apply to landfills receiving less than twenty tons of municipal solid waste daily under certain conditions. 40 C.F.R. § 258.1(f)(1) (2012).

⁴⁶ 42 U.S.C. § 6944 (2006); 40 C.F.R. § 258.1(h). Section 258.24(b) of the regulations also prohibits the open burning of any waste in municipal solid waste landfills. 40 C.F.R. § 258.24(b).

⁴⁷ David L. Hanson & Frank R. Caponi, *US Landfill Disposal: The Big Picture*, MSW MGMT. (Dec. 31, 2008), <http://www.mswmanagement.com/MSW/Articles/1198.aspx>. Section 258.26 requires run-off/run-on control systems to prevent stormwater from entering the active portion of a landfill. 40 C.F.R. § 258.26. Section 258.27 prohibits the discharge of pollutants from a landfill into surface waters. *Id.* § 258.27. Section 258.28 prohibits the addition of any liquids, aside from leachate recirculation, into the landfill. *Id.* § 258.28. See *infra* Part I.C for more on leachate recirculation.

⁴⁸ 40 C.F.R. § 258.21(a) (“[O]wners or operators of all [municipal solid waste landfill] units must cover disposed solid waste with six inches of earthen material at the end of each operating day, or at more frequent intervals if necessary, to control disease vectors, fires, odors, blowing litter, and scavenging.”).

⁴⁹ Section 258.40(a)(2) requires a composite liner and leachate collection system. 40 C.F.R. § 258.40(a)(2). Sections 258.50–.58 additionally require groundwater monitoring and corrective action. *Id.* §§ 258.50–.58.

⁵⁰ NAT’L SOLID WASTES MGMT. ASS’N, *supra* note 26, at 4. Liners consist of layers of low permeability compacted clay or synthetic materials, such as high-density polyethylene. Leachate is collected from the landfill by placing a perforated leachate collection pipe in a layer of gravel. *Id.*

⁵¹ 40 C.F.R. § 258.60. The final cover is similarly constructed with compacted clay or synthetic material and covered with a drainage layer of gravel to divert water off of the landfill. Finally, “a protective cover is placed on top of a filter blanket and topsoil is placed as the final layer to support vegetation.” NAT’L SOLID WASTES MGMT. ASS’N, *supra* note 26, at 5.

⁵² 40 C.F.R. § 258.61(a).

to human health and the environment; monitoring groundwater; and maintaining and monitoring the gas monitoring system.⁵³ Leachate must be monitored after a landfill is closed to ensure it will not contaminate groundwater.⁵⁴ This means there is a long postclosure care period.⁵⁵

Traditional dry tomb landfills produce landfill gas, which may need to be collected under current regulations. The decomposition of waste in a landfill generates methane due to the lack of oxygen.⁵⁶ As a result of the dry tomb method, landfill gas production from decomposition increases slowly but steadily during the life of the landfill and a large percentage of landfill gas generation occurs years after closure.⁵⁷ Pursuant to the Clean Air Act,⁵⁸ landfills exceeding certain size and emissions cutoffs are required to install a collection system that captures gas generated by the landfill.⁵⁹

Most landfills that collect landfill gas use flaring to burn the collected methane into the atmosphere instead of using it for energy.⁶⁰ Currently, only half of landfill gas in the United States is captured,

⁵³ *Id.* The regulations require gas monitoring to prevent explosions of highly concentrated methane. *Id.* § 258.23.

⁵⁴ HINKLEY CTR. FOR SOLID & HAZARDOUS WASTE MGMT., FLORIDA BIOREACTOR LANDFILL DEMONSTRATION PROJECT 1 (2008), available at <http://www.bioreactor.org/BioreactorFinalReport/TableofContents.htm>.

⁵⁵ PATRICK SULLIVAN, THE IMPORTANCE OF LANDFILL GAS CAPTURE AND UTILIZATION IN THE U.S. 49 (2010), http://www.seas.columbia.edu/earth/wtert/sofos/Importance_of_LFG_Capture_and_Utilization_in_the_US.pdf.

⁵⁶ U.S. EPA, *supra* note 7.

⁵⁷ SULLIVAN, *supra* note 55, at 49.

⁵⁸ Section 111 of the Clean Air Act requires the EPA Administrator to establish a list of categories of stationary sources that cause, or contribute significantly to, "air pollution which may reasonably be anticipated to endanger public health or welfare" and promulgate regulations establishing federal standards of performance for each category. 42 U.S.C. § 7411(b)(1) (2006). The Administrator made this determination with respect to municipal solid waste landfills and promulgated regulations requiring gas collection systems. Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills, 61 Fed. Reg. 9905 (Mar. 12, 1996).

⁵⁹ Landfills with a design capacity equal to or greater than 2.5 million megagrams and 2.5 million cubic meters and a nonmethane organic compounds emission rate greater than 50 megagrams per year must install a collection system that captures gas generated by the landfill. 40 C.F.R. § 60.752(b) (2012). Landfill gas is collected by vertical and horizontal "wells," or pipes, distributed throughout the landfill, which allow gas generated in the landfill to collect and rise. In a passive collection system, natural variations in the pressure and concentration of gas in the landfill are utilized to collect the gas. In an active collection system vacuums or pumps are used to move the gas through the pipes. U.S. AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY, LANDFILL GAS PRIMER 55 (2001), http://www.atsdr.cdc.gov/HAC/landfill/PDFs/Landfill_2001_ch5.pdf.

⁶⁰ U.S. EPA, *supra* note 6, at 13.

and less than a quarter is used for energy; the remainder is flared.⁶¹ Where collection systems are not in place, gases such as methane, which is lighter than air, migrate upwards or outwards to escape the landfill.⁶² The most significant factors limiting the use of landfill gas-to-energy projects in traditional dry tomb landfills are the “very long, slow rates of waste decomposition and [landfill gas] generation” and the “unpredictability of gas recovery,” both of which lead to a low rate of methane recovery.⁶³ As a result, gas-to-energy projects at dry tomb landfills tend to produce enough methane for only small-scale power generation and cannot achieve economies of scale sufficient to make landfill gas-to-energy projects profitable.⁶⁴

C. *Bioreactors and Their Benefits*

In contrast to dry tomb landfills, which aim to minimize the introduction of liquids to the landfill, bioreactors use the addition of liquids to enhance the microbial process and speed decomposition.⁶⁵ Bioreactors recirculate leachate in the landfill, but also require the addition of further liquids.⁶⁶ EPA regulations define a bioreactor as a landfill that adds liquid other than leachate to reach a minimum average moisture content of forty percent by weight to accelerate the biodegradation of waste.⁶⁷ The enhanced decomposition in a bioreactor landfill provides faster and more reliable landfill gas generation for use as an energy source and additionally offers significant solid waste management and environmental benefits over traditional dry tomb landfills.⁶⁸

1. *Landfill Gas Emissions*

Accelerated decomposition in bioreactors increases the production of landfill gas, which can be used as a source of energy. Current EPA regulations require large landfills to collect landfill gas, and this collection decreases methane emissions to the atmosphere.⁶⁹ Because landfill gas-to-energy projects at traditional dry tomb landfills are not

61 YAZDANI, *supra* note 17, at 3.

62 U.S. AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY, *supra* note 59, at 7.

63 YAZDANI, *supra* note 17, at 3.

64 *See id.*

65 U.S. EPA, *supra* note 6, at 20.

66 *See id.*; YAZDANI, *supra* note 17, at 3.

67 40 C.F.R. § 63.1990 (2012).

68 U.S. EPA, *supra* note 18, at 120.

69 40 C.F.R. § 60.752(b)(2)(ii) (requiring landfills with emissions rates of over 50 megagrams per year to “install a collection and control system that captures the gas generated within the landfill”).

currently profitable, however, most of this collected gas is flared instead of burned for energy.⁷⁰ In a bioreactor landfill, methane recovery and power production are each projected to be thirty-one to forty-three percent higher than in a traditional landfill.⁷¹ As a result, bioreactors make landfill gas-to-energy projects more profitable and would create an incentive for landfill owners and operators to install gas-to-energy projects instead of flaring off collected emissions.⁷²

Bioreactors decrease greenhouse gas emissions in two ways. First, by utilizing landfill gas that might otherwise be released, bioreactors directly reduce methane emissions.⁷³ Second, by providing an alternative energy source, bioreactors displace fossil fuels and indirectly reduce carbon dioxide emissions.⁷⁴ According to EPA, the “indirect environmental benefits of fossil fuel displacement through [landfill gas] energy can amount to nearly 13 percent of the direct greenhouse gas emission reduction benefits from methane combustion.”⁷⁵

Reduced methane emissions can have a particularly important impact in slowing climate change. Methane is a potent greenhouse gas and key contributor to climate change.⁷⁶ It also has a short atmospheric lifespan of just ten years.⁷⁷ Because of its short lifespan, reductions in methane emissions result in “near-term” impacts on mitigating climate change.⁷⁸ A recent study narrowed down 400 climate change mitigation strategies to the 14 that would have the greatest immediate impact on slowing climate change.⁷⁹ Seven of these strategies focused on methane emission reductions, and one of the seven was waste management improvements, including landfill gas

⁷⁰ See *supra* Part I.B; U.S. EPA, *supra* note 6, at 13.

⁷¹ These figures are over a forty-year period of energy recovery. Robert Gardner, *Landfills and Our Future*, MSW MGMT. (Dec. 31, 2009), <http://www.erosioncontrol.biz/MSW/Articles/6165.aspx>. Some have estimated the increased power production to be as high as fifty to one hundred percent. YAZDANI, *supra* note 17, at 10.

⁷² See FOTH & VAN DYKE & ASSOCS., INC., UPDATED RESEARCH REPORT ON BIOREACTOR LANDFILLS, LANDFILL LEACHATE RECIRCULATION AND LANDFILLS WITH METHANE RECOVERY, at ES-v (2004), http://www.co.ramsey.mn.us/NR/rdonlyres/C9000BB9-1C1A-43F5-8E1D-80A0A7E6AF35/5663/PC_Research_Report_on_Bioreactor_Landfills.pdf.

⁷³ U.S. EPA, *supra* note 14.

⁷⁴ *LFG Energy Projects*, U.S. EPA, <http://epa.gov/lmop/faq/lfg.html> (last updated July 19, 2012). See *infra* Part III.A on carbon dioxide emissions from gas-to-energy projects.

⁷⁵ *LFG Energy Projects*, *supra* note 74.

⁷⁶ See U.S. EPA, *supra* note 14.

⁷⁷ *Id.*

⁷⁸ *Id.*

⁷⁹ Drew Shindell et al., *Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security*, 335 SCIENCE 183, 183 (2012).

utilization.⁸⁰ This short-term impact is particularly important because many scientists believe that the global climate will reach a tipping point in less than 100 years, representing a point of no return for global warming.⁸¹ Therefore, short-term impacts such as reducing methane emissions from landfills could help prevent the climate from reaching its tipping point.

2. *Saved Space*

Bioreactors offer substantial economic savings in addition to the economic benefits of energy creation. The accelerated decomposition in a bioreactor increases landfill space by twenty to thirty percent.⁸² The saved space means that landfill owners and operators can fit more waste into a smaller amount of land. The increased capacity of the landfill makes bioreactors thirteen to twenty percent less expensive than traditional landfills.⁸³ This increased space means the bioreactor can be used for a longer period of time than a traditional landfill.⁸⁴ In addition to cost savings, this means landfills will take up less green space than would otherwise be needed to expand traditional landfills or build new landfills.⁸⁵

In the future, there is potential for even greater space saving in bioreactors with recovery and reclamation. Recovery of bioreactor landfills means the landfills are excavated after a period of decomposition and the contents are separated into recyclables, compost, and the remaining inert waste.⁸⁶ The compost and recyclables can be sold and the inert portion of waste returned to the landfill.⁸⁷ Then the landfill can be reclaimed.⁸⁸ In other words, more waste can be added to the landfill.⁸⁹ This technology has only been implemented in a few bioreactors but has the potential to make bioreactors an even more profitable technology.⁹⁰

⁸⁰ *Id.*

⁸¹ See SULLIVAN, *supra* note 55, at 69.

⁸² Fickes, *supra* note 19.

⁸³ O'Brien, *supra* note 23.

⁸⁴ See *id.*

⁸⁵ See INTERSTATE TECH. & REGULATORY COUNCIL, CHARACTERIZATION, DESIGN, CONSTRUCTION, AND MONITORING OF BIOREACTOR LANDFILLS 12-13 (2006), <http://www.itrcweb.org/Documents/ALT-3.pdf>.

⁸⁶ FOTH & VAN DYKE & ASSOCS., INC., *supra* note 72, at 6.

⁸⁷ *Id.* at 6, 9-10.

⁸⁸ See *id.* at 14.

⁸⁹ See *id.*

⁹⁰ *Id.* at 6. See generally U.S. EPA, EPA530-F-97-001, LANDFILL RECLAMATION (1997), <http://www.epa.gov/osw/nonhaz/municipal/landfill/land-rcl.pdf>.

3. *Leachate and Wastewater Treatment Savings*

Bioreactors reuse leachate that would otherwise have to be treated as wastewater. Leachate is the liquid that drains from a landfill after percolating through the waste and picking up dissolved, suspended, or microbial contaminants.⁹¹ In a traditional landfill, leachate must be collected and treated before disposal.⁹² In a bioreactor, recirculating leachate reduces toxicity and the amount of treatment required.⁹³ As leachate is circulated, it initially becomes polluted with acids from the decomposition of the solid waste.⁹⁴ As decomposition continues, however, the acids are consumed and converted to methane.⁹⁵ Therefore, the leachate does not need to be transported and treated.⁹⁶ This has saved one landfill \$11,000 a year in transportation and treatment costs.⁹⁷

Along with the recirculation of leachate, bioreactors require the addition of water or other liquids to the landfill.⁹⁸ Bioreactors could use liquid waste from industrial or commercial facilities, wastewater, or municipal sewage.⁹⁹ Because wastewater producers will pay to have their wastewater treated, this would result in an additional revenue source for the landfill and potentially reduce demand on publicly-owned treatment works for wastewater treatment.¹⁰⁰

⁹¹ *Terms & Acronyms—Search Results for Leachate*, U.S. EPA, http://iaspub.epa.gov/sor_internet/registry/termreg/searchandretrieve/termsandacronyms/search.do (last visited Feb. 4, 2013) (search for “leachate”).

⁹² 40 C.F.R. § 258.40 (2012).

⁹³ SULLIVAN, *supra* note 55, at 57.

⁹⁴ YAZDANI, *supra* note 17, at 72–73.

⁹⁵ *Id.*

⁹⁶ *See Leachate Recirculation System Pays for Itself*, CIV. INFRASTRUCTURE MAG., Jan. 2004, <http://www.netafimusa.com/files/applications/wastewater/Leachate-article-reprint.pdf>.

⁹⁷ *Id.*

⁹⁸ U.S. EPA, *supra* note 6, at 20.

⁹⁹ SULLIVAN, *supra* note 55, at 54; Fickes, *supra* note 19; Dan Miller, *The National Association of Counties—Washington DC*, CTI & ASSOCS. (Mar. 2007), http://www.cticompanies.com/news_details.asp?id=28. For helpful guidelines on selecting and monitoring industrial liquids or sludge in a bioreactor, see THABET TOLAYMAT ET AL., U.S. EPA, EPA/600/R-04/301, MONITORING APPROACHES FOR BIOREACTOR LANDFILLS 11 (2004), http://www.scsengineers.com/Pubs-News/bioreactor_Monitoring.pdf. Owners or operators would not be permitted to use hazardous liquid wastes in their bioreactors without complying with the much stricter laws applicable to hazardous waste disposal facilities in subtitle C of RCRA. 42 U.S.C. §§ 6921–6931f (2006).

¹⁰⁰ SULLIVAN, *supra* note 55, at 54.

4. Stabilization

Because waste decomposes faster in bioreactors, the landfill becomes stabilized¹⁰¹ more quickly, potentially reducing postclosure care costs.¹⁰² Bioreactors reduce the waste stabilization period from thirty years or more for dry tomb landfills to five to ten years.¹⁰³ In a traditional dry tomb landfill, the facility must be monitored almost in perpetuity because a break in the liner or other circumstances that allow for the introduction of liquids would risk contaminating groundwater or increasing methane emissions after any collection system in place has been discontinued.¹⁰⁴ Because waste in a bioreactor has biodegraded more at the time the landfill is closed (as compared to a traditional dry tomb landfill), postclosure water flow should not result in further significant gas generation or release of contaminants.¹⁰⁵ This shortens the postclosure period in which potential liability and risk of environmental contamination exist.¹⁰⁶ Additionally, more rapid stabilization and settlement of the waste allows for quicker redevelopment of the landfill area for another use postclosure.¹⁰⁷

5. Additional Economic and Community Benefits

Bioreactors utilizing landfill gas-to-energy projects have additional economic and community benefits. Collecting landfill gas for energy improves air quality by reducing odors and destroying non-methane organic compounds that may create health risks.¹⁰⁸ Addi-

101 Stabilization consists of both biochemical decomposition and physical settlement of the waste in the landfill. See U.S. EPA, MONITORING APPROACHES FOR LANDFILL BIOREACTORS 3-4 (2004), http://www.scsengineers.com/Pubs-News/bioreactor_Monitoring.pdf.

102 O'Brien, *supra* note 23.

103 U.S. EPA, EPA530-R-07-007, BIOREACTOR PERFORMANCE 6 (2007), <http://www.epa.gov/osw/nonhaz/municipal/landfill/bio-perf.pdf>.

104 Joint Statement on Composting and Bioreactor Landfills, Solid Waste Ass'n of N. Am. & U.S. Composting Council (May 2006), <http://compostingcouncil.org/admin/wp-content/uploads/2011/03/jointstatementoncomposting1.pdf>.

105 See John Pacey, *Bioreactor Landfill: An Overview Perspective*, MSW MGMT. (Dec. 31, 2000), <http://www.mswmanagement.com/MSW/Articles/4624.aspx> ("Most external environments should be able to naturally manage long-term waste-related emission or leakage from a well-managed bioreactor landfill.").

106 *Id.* ("Rapid stabilization offers a major long-term environmental benefit in terms of reducing risk: Waste and leachate will have been exposed to all potential detrimental environmental impacts during the operational life of the landfill, rather than during a long postclosure period.").

107 SULLIVAN, *supra* note 55, at 51, 57. Settlement in traditional landfills continues well into the postclosure period. This delays redevelopment and can prevent redevelopment options, due to the instability of the landfill. *Id.* at 51.

108 U.S. EPA, *supra* note 14. The nonmethane organic compounds found in uncombusted landfill gas can cause a variety of medical conditions, including cancer, kidney and liver impair-

tionally, the landfill gas-to-energy project replaces fossil-fuel-generated energy which emits not only carbon dioxide but also key pollutants like sulfur dioxide that can cause acid rain, particulate matter that can create respiratory health problems, and hazardous air pollutants.¹⁰⁹

Bioreactors offer several other community benefits. Landfill gas collection makes landfills safer by preventing the accumulation of gas in certain areas, thereby reducing explosion hazards.¹¹⁰ Bioreactors and landfill gas-to-energy projects create jobs associated with design, construction, and operation of the landfill, liquid recirculation, gas collection systems, and energy systems.¹¹¹ Because landfill gas is generated locally, local communities utilizing energy from their landfills reduce dependence on energy sources outside of their control and reduce energy transmission losses by reducing transmission distances.¹¹²

Because many large landfills are already required to install gas collection systems, bioreactor technology and energy recovery systems can reduce the cost of compliance with these environmental regulations.¹¹³ The accelerated rate of landfill gas emissions can result in better economies of scale for landfill gas-to-energy projects.¹¹⁴ All of the cost savings and potential revenue streams created by bioreactors make them more cost-effective and profitable than traditional dry tomb landfills.¹¹⁵ Bioreactors have been found to be thirteen to twenty percent less costly than traditional landfills, mostly due to the space savings and leachate treatment cost savings.¹¹⁶

The most significant benefit of bioreactors is that they make landfill gas-to-energy facilities effective and profitable. This is a result of increased and more consistent methane emissions and various cost savings associated with bioreactors, including saved space, leachate treatment, and decreased postclosure care costs. In addition to pro-

ment, cardiovascular arrhythmia, dizziness, memory loss, headaches, respiratory problems, and irritation of the eyes, nose, skin, and throat. Pearl Moy, A Health Risk Comparison of Landfill Disposal and Waste-to-Energy Treatment of Municipal Solid Wastes in New York City 6-7 (June 2005) (unpublished M.P.H. thesis, Columbia University), http://www.seas.columbia.edu/earth/wtert/sofos/Moy_ms_thesis.pdf.

¹⁰⁹ SULLIVAN, *supra* note 55, at 25.

¹¹⁰ See U.S. EPA, *supra* note 14.

¹¹¹ *Id.*

¹¹² SULLIVAN, *supra* note 55, at 25.

¹¹³ U.S. EPA, *supra* note 14.

¹¹⁴ See Fickes, *supra* note 19.

¹¹⁵ See O'Brien, *supra* note 23 (citing HINKLEY CTR. FOR SOLID & HAZARDOUS WASTE MGMT., *supra* note 54, at 9-13).

¹¹⁶ *Id.*

viding an alternative source of energy and decreasing the use of fossil fuels, bioreactors offer the environmental and community benefits discussed above, making them a waste management technique that should be fully utilized.

D. Current Regulations Unnecessarily Limit Bioreactors

Current EPA regulations allow for landfill gas-to-energy projects and recirculation of leachate, but do not allow for the introduction of additional liquids necessary to create a bioreactor.¹¹⁷ Under 40 C.F.R. § 258.28(a), “bulk or noncontainerized liquid waste may not be placed in [municipal solid waste landfill] units”¹¹⁸ This encompasses the type of mass liquid additions necessary in a bioreactor.¹¹⁹ These restrictions were initially put in place to prevent the generation of additional quantities of leachate that could contaminate groundwater if released from the landfill.¹²⁰

There are two exceptions to this general prohibition on the introduction of liquids to a landfill; however, neither of these exceptions currently allows landfill operators or owners to create bioreactors.¹²¹ First, under § 258.28(a)(2), leachate recirculation is permitted so long as the facility has a composite liner and leachate collection system.¹²² Bioreactors require additional liquids on top of leachate recirculation,¹²³ so this provision does not allow for bioreactors. Second, § 258.28(a)(3) provides an exemption for “Project XL Bioreactor Landfill Projects.”¹²⁴ This was a national pilot program that allowed for limited regulatory flexibilities for experimental facilities from 1995 to 2002.¹²⁵ Four bioreactors were permitted under this exemption before the pilot program was ended.¹²⁶

¹¹⁷ 40 C.F.R. § 258.28(a) (2012).

¹¹⁸ *Id.*

¹¹⁹ See Fickes, *supra* note 19.

¹²⁰ Solid Waste Disposal Facility Criteria, 56 Fed. Reg. 50,978, 50,988 (Oct. 9, 1991). The rule requires “a wide range of design and management practices aimed at preventing releases from municipal solid waste landfills” including “preventing potential environmental or public health problems” by “minimiz[ing] leachate generation and migration.” *Id.*

¹²¹ The regulations allow for one additional exception for household waste other than septic waste. 40 C.F.R. § 258.28(a)(1).

¹²² *Id.* § 258.28(a)(2). The composite liner and leachate collection system must comply with the regulations set forth in § 258.40(a)(2). Additionally, landfills may only recirculate leachate from the same facility. *Id.* § 258.28(a)(2).

¹²³ See Fickes, *supra* note 19.

¹²⁴ 40 C.F.R. § 258.28(a)(3).

¹²⁵ *Bioreactors*, U.S. EPA, <http://www.epa.gov/osw/nonhaz/municipal/landfill/bioreactors.htm> (last updated July 24, 2012).

¹²⁶ *Id.*

One additional exemption to the liquids restriction allows for bioreactors but imposes a costly and time-consuming permitting process. The exemption is in § 258.4 for research, development, and demonstration permits.¹²⁷ This provision exempts facilities from the liquids restriction if they receive a permit from the state.¹²⁸ It imposes various prerequisites to obtaining a permit: The landfill must have a “leachate collection system designed and constructed to maintain less than a 30-cm depth of leachate on the liner.”¹²⁹ The landfill can only receive types and quantities of wastes approved by the state.¹³⁰ The owner or operator must submit annual reports to the state on progress, monitoring, testing, and any other operating information specified by the state.¹³¹ Such permits are valid for three years and may be renewed for additional terms of three years for a total permit time of no more than twelve years.¹³²

A state can only issue permits if it receives approval by EPA.¹³³ To obtain approval, a state must amend its rules to specifically reference the federal rule.¹³⁴ State waste management agencies, however, are slow to amend regulations¹³⁵ and currently only twelve states have approved programs.¹³⁶ The permitting authority granted to the states

¹²⁷ 40 C.F.R. § 258.4. Congress authorized such exemptions in 42 U.S.C. § 6985 (2006).

¹²⁸ 40 C.F.R. § 258.4.

¹²⁹ *Id.* § 258.4(a).

¹³⁰ “[T]he [municipal solid waste landfill] unit must receive only those types and quantities of municipal solid waste and non-hazardous wastes which the State Director deems appropriate for the purposes of determining the efficacy and performance capabilities of the technology or process” *Id.* § 258.4(c)(2).

¹³¹ The permits shall:

[r]equire the owner or operator of a [municipal solid waste landfill] unit permitted under this section to submit an annual report to the State Director showing whether and to what extent the site is progressing in attaining project goals. The report will also include a summary of all monitoring and testing results, as well as any other operating information specified by the State Director in the permit

Id. § 258.4(c)(4).

¹³² *Id.* § 258.4(c)(1); *id.* § 258.4(e).

¹³³ *Id.* § 258.4(a)–(b); *id.* § 258.2 (“*Director of an Approved State* means the chief administrative officer of a state agency responsible for implementing the state permit program that is deemed to be adequate by EPA under regulations published pursuant to sections 2002 and 4005 of RCRA.”).

¹³⁴ Gardner, *supra* note 71.

¹³⁵ *Id.* Most states took a minimum of three or four years to adopt the initial subtitle D rules, and the last state to receive authorization for its subtitle D program was Iowa, eight years after the federal rule was promulgated. *Id.*

¹³⁶ Ohio, 76 Fed. Reg. 35,214 (June 16, 2011); Arizona, 76 Fed. Reg. 9772 (Feb. 22, 2011); Alaska, 76 Fed. Reg. 270 (Jan. 4, 2011); New Hampshire, 75 Fed. Reg. 53,220 (Aug. 31, 2010); Iowa, 74 Fed. Reg. 20,227 (May 1, 2009); Virginia, 74 Fed. Reg. 11,540 (Mar. 18, 2009); California, 72 Fed. Reg. 59,288 (Oct. 19, 2007); Michigan, 71 Fed. Reg. 51,614 (Aug. 30, 2006); Wisconsin,

also creates the possibility that states will regulate bioreactors more strictly than the federal standards, “making the cost to research new approaches prohibitive or the monitoring requirements overly strict or cumbersome.”¹³⁷

Even if state approval is obtained, EPA’s signoff on the programs can take up to sixteen months and the permitting process can cost as much as \$300,000.¹³⁸ Costs associated with permitting include: “preparation of a detailed research plan with project goals and quantitative methods to measure progress, contingency and monitoring plans”; “submission of comprehensive progress reports every six months”; fees to state environmental agencies for “permit application evaluation and semi-annual report review”; and “significant daily record-keeping associated with operating systems.”¹³⁹ Some of these permitting requirements are imposed by EPA regulations and some are imposed independently by state permitting agencies.¹⁴⁰

In explaining the short permit period and renewal requirements, EPA noted that: “[T]he purpose of [research, development, and demonstration] permit authority is to allow innovation and experimentation under close state oversight for a limited period. It is not intended to allow permanent operation of a [municipal solid waste landfill] using means outside the scope of the existing criteria.”¹⁴¹ EPA intended for the rule and reporting requirements to encourage research on bioreactor landfills and gather data for further rulemaking.¹⁴²

II. PROPOSED CHANGES IN REGULATIONS TO ALLOW AND REQUIRE BIOREACTORS

This Part sets out a proposed amendment to EPA regulations to allow for bioreactors with gas-to-energy facilities without the costly permitting process imposed by the current regulations. It suggests not only allowing bioreactors to be utilized without the permitting process, but also that EPA require new landfills to be built as bioreactors

sin, 71 Fed. Reg. 14,217 (Mar. 21, 2006); Illinois, 71 Fed. Reg. 4142 (Jan. 25, 2006); Indiana, 70 Fed. Reg. 68,447 (Nov. 10, 2005); Minnesota, 70 Fed. Reg. 7658 (Feb. 15, 2005).

¹³⁷ Gardner, *supra* note 71.

¹³⁸ O’Brien, *supra* note 23. Other sources have estimated that permitting for a bioreactor costs approximately \$10,000 a year. YAZDANI, *supra* note 17, at 125.

¹³⁹ *Central Peninsula Landfill*, KENAI PENINSULA BOROUGH SOLID WASTE DEP’T, <http://www.borough.kenai.ak.us/swd-waste/swd-locations/158-swd-centrallandfill> (last visited Oct. 19, 2012). The state fees for application and report review are \$49 an hour in Alaska. *Id.*

¹⁴⁰ 40 C.F.R. § 258.4(c)(4), (e)(2) (2012).

¹⁴¹ Research, Development, and Demonstration Permits for Municipal Solid Waste Landfills, 69 Fed. Reg. 13,242, 13,250 (Mar. 22, 2004).

¹⁴² *Id.* at 13,250–51.

utilizing landfill gas-to-energy systems. It then explains EPA's legal authority for such regulations.

A. Proposed Regulation

Although only a limited number of bioreactors have been permitted under the research, development, and demonstration exception, these bioreactors have been successful. In 2007, EPA published a study of five full-scale operating bioreactors permitted under state programs.¹⁴³ The study concluded that the bioreactors could successfully comply with existing regulations and that the addition of liquids could be managed with appropriate system design and operation.¹⁴⁴ The success of these bioreactors confirms that EPA should amend its regulations to allow more bioreactors to be built without the administrative hurdles currently required.

First, EPA should add an exception to the liquids restriction in 40 C.F.R. § 258.28 for landfills that use additional liquids to enhance landfill gas production for gas-to-energy facilities. This provision would only allow for the addition of liquids in landfills where the increased emissions caused by the enhanced decomposition will be captured and used for energy. This provision would allow for bioreactor landfills without the cumbersome permitting process and encourage the creation of gas-to-energy facilities.

Second, EPA should require all new large landfills to be bioreactors and require all active large landfills to be retrofitted with bioreactor technology, including landfill gas-to-energy systems. This provision would apply only to landfills already required to capture landfill gas emissions under 40 C.F.R. § 60.752 based on their size.¹⁴⁵

This threshold will result in an appropriate number of landfills being regulated in order to increase the use of landfill gas energy without being overly burdensome. Approximately sixty percent of current landfill gas-to-energy facilities are subject to the gas collection and control requirements of EPA's Clean Air Act regulations.¹⁴⁶ For the year 2000, an estimated forty-three percent of landfill methane was generated at landfills with gas recovery systems (flaring or electricity generation).¹⁴⁷ The number of landfills in the United States has been

¹⁴³ U.S. EPA, *supra* note 103, at 6.

¹⁴⁴ *Id.* at 27.

¹⁴⁵ See *supra* note 59 and accompanying text.

¹⁴⁶ U.S. EPA, *supra* note 74.

¹⁴⁷ U.S. EPA, *supra* note 18, at 97 n.3.

steadily decreasing, while their sizes have been increasing.¹⁴⁸ As a result, more landfills, and thus more methane emissions, will become subject to these regulations over time. Requiring retrofitting at large active landfills will result in immediate greenhouse gas reductions, while also allowing landfill owners and operators to reap the economic benefits of a bioreactor, because maximum landfill gas generation rates occur at or within two years of closure and decrease over time to insignificant levels.¹⁴⁹

This provision is economically feasible. As discussed above, as-built bioreactors are more profitable than traditional landfills.¹⁵⁰ Additionally, retrofitted bioreactor technology on an existing landfill is only eight percent more expensive than a traditional landfill¹⁵¹ and can still be practical because of accelerated decomposition, enhanced gas generation, and savings on space and leachate management.¹⁵²

Because of the economic benefits to landfill owners and operators, federal funding for bioreactor technology is likely unnecessary. Installing bioreactor technology, however, imposes a large upfront cost on landfill owners or operators, which will not be recoverable for several years. Therefore, the federal government should consider offering a loan program by which operators can receive funds to assist in covering the upfront costs of bioreactor technology. This would ensure that the technology is installed and utilized, while also taking advantage of the inherent economic benefits of bioreactor landfills. Similar loan programs to encourage and advance innovative energy projects are already in place.¹⁵³ These include the Section 1703 Loan Program for clean energy projects and the Section 1705 Loan Program for certain renewable fuels.¹⁵⁴ However, bioreactor projects do not currently meet the requirements for these particular loan programs,¹⁵⁵

148 U.S. EPA, EPA-530-F-11-005, MUNICIPAL SOLID WASTE GENERATION, RECYCLING, AND DISPOSAL IN THE UNITED STATES: FACTS AND FIGURES 10 (2011), http://www.epa.gov/osw/nonhaz/municipal/pubs/msw_2010_rev_factsheet.pdf.

149 SULLIVAN, *supra* note 55, at 14.

150 *See supra* Part I.C.5.

151 HINKLEY CTR. FOR SOLID & HAZARDOUS WASTE MGMT., *supra* note 54, at 9-13.

152 Christopher A. Bareither et al., *Performance of North American Bioreactor Landfills*, 136 J. ENVTL. ENG'G 824, 826 (2010).

153 *Loan Programs Office: Eligibility*, U.S. DEP'T OF ENERGY, https://lpo.energy.gov/?page_id=31 (last visited Oct. 19, 2012).

154 *Id.*

155 Section 1703 loans are unavailable for commercial projects employing technology that has been successful in more than three implementations over five years. *Id.* The Section 1705 program expired in 2011. *Id.*

thus the need for the federal government to establish a loan program for bioreactor technology.

B. EPA's Authority to Enact the Proposed Regulations

The proposed regulations would be promulgated pursuant to RCRA.¹⁵⁶ RCRA was enacted pursuant to Congress's Commerce Clause power.¹⁵⁷ In enacting RCRA, Congress found that inadequate and environmentally unsound waste practices can and have led to pollution and other harms to the environment and human health.¹⁵⁸ Congress concluded that federal action was necessary.¹⁵⁹

The Supreme Court has upheld federal regulation of environmental hazards pursuant to the Commerce Clause,¹⁶⁰ and numerous federal courts have held that RCRA "easily falls within the plenary congressional authority under the commerce clause."¹⁶¹ RCRA, like

¹⁵⁶ 42 U.S.C. §§ 6901–7000 (2006).

¹⁵⁷ Resource Conservation and Recovery Act of 1976, Pub. L. No. 94-580, 90 Stat. 2795; see U.S. CONST. art. I, § 8 ("The Congress shall have Power . . . [t]o regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes."). The Supreme Court first considered the meaning of the Commerce Clause in *Gibbons v. Ogden*, where it held that commerce is intercourse "among the several States" and explained that this encompasses commerce that "concerns more States than one" and not commerce that is entirely internal to one state. *Gibbons v. Ogden*, 22 U.S. (9 Wheat) 1, 189, 194 (1824). Congress's power to regulate commerce was later interpreted to include the power to regulate activities having a "close and substantial relation to interstate commerce." *Hous., E. & W. Tex. Ry. Co. v. United States* (Shreveport Rate Cases), 234 U.S. 342, 351, 355 (1914). In *Wickard v. Filburn*, the Supreme Court held that the Commerce Clause gave Congress the power to regulate private noncommercial activity that, when aggregated, had a substantial effect on interstate commerce. *Wickard v. Filburn*, 317 U.S. 111, 125, 128–29 (1942). More recently, in *United States v. Lopez*, the Supreme Court outlined three categories of activity falling within the Commerce Clause powers of Congress: (1) "the use of the channels of interstate commerce"; (2) "the instrumentalities of interstate commerce, or persons or things in interstate commerce, even though the threat may come only from intrastate activities"; and (3) "activities having a substantial relation to interstate commerce." *United States v. Lopez*, 514 U.S. 549, 558–59 (1995).

¹⁵⁸ See, e.g., 42 U.S.C. § 6901(b)(2) (2006) ("[D]isposal of solid waste and hazardous waste in or on the land without careful planning and management can present a danger to human health and the environment . . ."); *id.* § 6901(b)(3) ("[I]nadequate and environmentally unsound practices for the disposal or use of solid waste have created greater amounts of air and water pollution and other problems for the environment and for health . . .").

¹⁵⁹ *Id.* § 6901(a)(4) ("[T]he problems of waste disposal as set forth above have become a matter national in scope and in concern and necessitate Federal action . . .").

¹⁶⁰ *Hodel v. Va. Surface Mining & Reclamation Ass'n*, 452 U.S. 264, 282 (1981) ("[W]e agree with the lower federal courts that have uniformly found the power conferred by the Commerce Clause broad enough to permit congressional regulation of activities causing air or water pollution, or other environmental hazards that may have effects in more than one State.").

¹⁶¹ *United States v. Rogers*, 685 F. Supp. 201, 203 (D. Minn. 1987) ("When Congress has determined that an activity affects interstate commerce the judicial inquiry is limited to whether such a finding is rational."); see also *Williams v. Ala. Dep't of Transp.*, 119 F. Supp. 2d 1249, 1253

other environmental statutes, is valid under the Commerce Clause because environmental harms have interstate effects.¹⁶² A landfill in one state could pollute the groundwater in another state. Odors or toxic emissions from a landfill in one state could have effects on individuals across the border. And finally, much of the waste deposited at landfills has crossed state borders, moving in interstate commerce.¹⁶³ The regulations on landfill design would be upheld as “an essential part of a larger regulation of economic activity, in which the regulatory scheme could be undercut unless the intrastate activity were regulated.”¹⁶⁴

Although some court cases have called waste management a “traditional local government function,”¹⁶⁵ federal regulation of waste is appropriate and constitutional. In enacting RCRA, Congress explicitly recognized the role of the states but also the necessity of federal regulation. In 42 U.S.C. § 6901(a)(4), Congress recognized that

while the collection and disposal of solid wastes should continue to be primarily the function of State, regional, and local agencies, the problems of waste disposal . . . have become a matter national in scope and in concern and necessitate Federal action through financial and technical assistance and leadership in the development, demonstration, and application of new and improved methods and processes to reduce the amount of waste and unsalvageable materials and to provide for proper and economical solid waste disposal practices.¹⁶⁶

Because Congress clearly recognized it was regulating a traditional state function and explicitly granted EPA the authority to regu-

(M.D. Ala. 2000); *Burnette v. Rowland*, No. 3:94-CV-00420 (EBB), 1998 WL 264808, at *3 (D. Conn. May 5, 1998) (“Congress enacted RCRA . . . pursuant to the Commerce Clause.”); *Rowlands v. Pointe Mouillee Shooting Club*, 959 F. Supp. 422, 426 (E.D. Mich. 1997).

¹⁶² ROBERT L. GLICKSMAN ET AL., ENVIRONMENTAL PROTECTION 85, 92 (2011).

¹⁶³ *United States v. Lopez*, 514 U.S. 549, 550 (1995).

¹⁶⁴ *Lopez*, 514 U.S. at 561; *Gibbs v. Babbitt*, 214 F.3d 483, 497 (4th Cir. 2000); see also Silvio J. DeCarli, Note, *Non-Statutory Pollution Remedies in the Wake of City of Milwaukee v. Illinois*, 35 RUTGERS L. REV. 595, 625–26 (1983) (finding it highly unlikely that courts would find comprehensive solid waste control legislation unconstitutional on Tenth Amendment grounds).

¹⁶⁵ *United Haulers Ass’n v. Oneida-Herkimer Solid Waste Mgmt. Auth.*, 550 U.S. 330, 344 (2007); *United Haulers Ass’n v. Oneida-Herkimer Solid Waste Mgmt. Auth.*, 261 F.3d 245, 264 (2d Cir. 2001). But see *United Haulers Ass’n*, 550 U.S. at 369 (Alito, J., dissenting) (finding that waste disposal is not typically a local government function because most garbage is managed by the private sector).

¹⁶⁶ 42 U.S.C. § 6901(a)(4) (2006).

late waste management, EPA's rules regarding landfills are consistent with this intent and would not be invalid.¹⁶⁷

Moreover, RCRA does not violate the Tenth Amendment by requiring the state to regulate in a certain manner. Like many other environmental statutes, RCRA allows states to adopt their own regulations in conformance with the federal minimums;¹⁶⁸ however, it does not compel such regulation. If states do not adopt solid waste management regulation, the federal regulations simply apply in that state.¹⁶⁹ RCRA does provide financial assistance to those states implementing their own regulations,¹⁷⁰ but courts have held that such financial assistance does not amount to coercion violating the Tenth Amendment.¹⁷¹

The proposed regulation is within EPA's authority under RCRA. RCRA authorizes (and requires) EPA to "develop and publish suggested guidelines for solid waste management."¹⁷² More specifically related to landfills, 42 U.S.C. § 6944(a) requires the EPA Administrator to "promulgate regulations containing criteria for determining which facilities shall be classified as sanitary landfills and which shall be classified as open dumps" and prohibited under § 6944(b).¹⁷³ The current regulations on landfill design, as well as the proposed regulation, all fall under this statutory authority. In addition to the restrictions on liquids, EPA has promulgated regulations requiring cover on landfills, requiring fencing, requiring measures to control disease vectors, and restricting the location of landfills in floodplains, wetlands,

¹⁶⁷ Cf. *Solid Waste Agency v. U.S. Army Corps of Eng'rs*, 531 U.S. 159, 160–61 (2001) (administrative interpretation of statute not given deference where the regulated activity was a traditional state function and Congress did not explicitly authorize its regulation).

¹⁶⁸ *New York v. United States*, 505 U.S. 144, 167–68 (1992).

¹⁶⁹ Leslie Allen, *Who Should Control Hazardous Waste on Native American Lands? Looking Beyond* Washington Department of Ecology v. EPA, 14 *ECOLOGY L.Q.* 69, 82 n.97 (1987) ("Recent Supreme Court cases indicate that RCRA and other environmental statutes do not impermissibly coerce state action in violation of the [T]enth [A]mendment because states are not compelled to participate; rather, the statutes establish a program of cooperative federalism." (internal quotation marks omitted)); Joseph D. Lee, *RCRA's State Program Provisions and the Tenth Amendment: Coercion or Cooperation?*, 9 *ECOLOGY L.Q.* 579, 593–94 (1981) (explaining that RCRA state implementation provisions and waste regulations do not violate the Tenth Amendment because the federal interest in uniform waste management outweighs the state interest in regulating its own waste).

¹⁷⁰ 42 U.S.C. § 6947(b)(1) (providing that states are eligible for financial assistance if they adopt state implementation plans).

¹⁷¹ *New York*, 505 U.S. at 166–69.

¹⁷² 42 U.S.C. § 6907(a).

¹⁷³ *Id.* § 6944(a).

unstable areas, or earthquake zones.¹⁷⁴ The proposed regulation is substantially similar and rests on the same authority as these regulations, which have not been invalidated by courts. Like the regulations already promulgated, this regulation would prescribe design criteria applicable to certain landfills, which is provided for in 42 U.S.C. § 6944(a).¹⁷⁵ Therefore, the proposed regulation is constitutional under the Commerce Clause and an appropriate use of EPA's authority under RCRA.

III. COUNTERARGUMENTS

Having addressed the potential legal obstacles to the proposed regulation in the previous Part, this Part acknowledges and addresses several potential arguments against bioreactors and explains why they are invalid. This Part first explains why bioreactors will not result in any increase in methane emissions to the atmosphere and then addresses the argument that bioreactors could cause additional air quality concerns. It then addresses the compatibility of bioreactors with composting and issues of slope stability. Finally, this Part addresses the potential for the proposed regulation to encourage small landfills, which fall below the regulatory threshold, and the proposed regulation's impact on small or rural communities.

A. *Increased Greenhouse Gas Emissions*

One concern with bioreactors is that because they accelerate decomposition and enhance landfill gas production, they may lead to increased greenhouse gas emissions to the atmosphere if landfill gas is not collected or not collected properly.¹⁷⁶ EPA regulations, however, already require collection of gas at large landfills and the proposed regulation would only allow for the use of bioreactor technology where the methane is being collected and utilized for energy. EPA regulations require landfills with emissions rates of over fifty megagrams per year to “[i]ninstall a collection and control system that captures the gas generated within the landfill.”¹⁷⁷ This still leaves landfill operators with the option of flaring off the methane without installing a gas-to-energy system. In order to reduce flaring, the proposed regulation would only exempt those landfills from the liquid restriction that install a landfill gas collection system and use it for an

¹⁷⁴ 40 C.F.R. § 258 (2012).

¹⁷⁵ 42 U.S.C. § 6944(a).

¹⁷⁶ See SULLIVAN, *supra* note 55, at 18–19.

¹⁷⁷ 40 C.F.R. § 60.752(b)(2)(ii).

energy facility. As a result, bioreactors under the proposed regulation will decrease—not increase—greenhouse gas emissions.

Although landfill gas-to-energy projects capture roughly sixty to ninety percent of the methane emitted from the landfill,¹⁷⁸ burning the methane for energy still results in carbon dioxide emissions. Carbon dioxide, however, is a less potent greenhouse gas than methane and “CO₂ emissions from [municipal solid waste] landfills are not considered to contribute to global climate change because the carbon was contained in recently living biomass. The same CO₂ would be emitted as a result of the natural decomposition of the organic waste materials outside the landfill environment.”¹⁷⁹ The carbon was absorbed by the plant or other organic being and eventually that organism would have died and emitted the same carbon as it decomposed, regardless of whether it was located in a landfill or on a farm or in a forest.¹⁸⁰

The last potential criticism stems from concerns that there is a risk of increased landfill gas emissions to the environment before a gas collection system is in place or postclosure.¹⁸¹ However, it can take months to years for waste to begin producing methane, and for many landfills all waste is subject to landfill gas collection within two years by federal regulations.¹⁸² Additionally, daily cover of waste impedes emissions.¹⁸³ As for postclosure concerns, maximum landfill gas generation rates occur at or within two years of closure and decrease over time to insignificant levels.¹⁸⁴ Current regulations require landfill owners and operators to monitor and maintain landfill cover for thirty

¹⁷⁸ U.S. EPA, *supra* note 14.

¹⁷⁹ *Id.*

¹⁸⁰ See U.N. ENV'T PROGRAMME, WASTE AND CLIMATE CHANGE: GLOBAL TRENDS AND STRATEGY FRAMEWORK 13 (2010), <http://www.unep.or.jp/ietc/Publications/spc/Waste&ClimateChange/Waste&ClimateChange.pdf>. Although the Intergovernmental Panel on Climate Change and EPA use this method of inventorying carbon emissions from landfills, the U.N. report offers several criticisms. *Id.* See generally 5 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES 1.5–.11 (Simon Eggleston et al. eds., 2006), available at <http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html> (describing in detail methodologies for greenhouse gas inventories).

¹⁸¹ SULLIVAN, *supra* note 55, at 14, 18.

¹⁸² *Id.* at 18–19 (noting that federal standards “require [landfill gas] collection within two years after the first waste placed in a landfill reaches final grade”).

¹⁸³ *Id.* (“Surface emissions monitoring data . . . have shown no appreciable difference in emissions for the active face of the landfill where recent disposal has occurred versus other areas under intermediate cover with active [landfill gas] collection.”); see also *supra* note 48 and accompanying text regarding daily cover.

¹⁸⁴ SULLIVAN, *supra* note 55, at 14.

years following closure, greatly reducing the risk of any cover failure that might allow methane to escape into the atmosphere.¹⁸⁵

B. Other Air Pollutant Emissions

Although landfill gas-to-energy projects reduce greenhouse gas emissions overall, they have the potential to increase emissions of certain air pollutants.¹⁸⁶ Studies have shown, however, that although landfill gas-to-energy facilities produce some air pollution—making them less environmentally friendly than wind or solar power—the air pollutants produced by landfill gas-to-energy facilities are preferable to those produced by coal-fired power plants.¹⁸⁷

The Natural Resources Defense Council has analyzed the air pollution impacts of landfill gas-to-energy projects compared to the alternatives of flaring the gas or not collecting it at all.¹⁸⁸ Burning landfill gas, whether via flaring or in a gas-to-energy project, destroys the vast majority of hazardous or toxic air pollutants present in landfill gas.¹⁸⁹ Although combustion creates small amounts of dioxins, releasing landfill gas to the atmosphere without burning it is “approximately 24 times more carcinogenic to human health than landfill gas combustion exhaust.”¹⁹⁰ Therefore, flaring or using landfill gas for energy is immensely more beneficial in terms of air pollution impacts than allowing the landfill gas to go uncollected and escape into the atmosphere.¹⁹¹

The study next analyzed the air pollution impacts of flaring versus landfill gas-to-energy projects and found that gas-to-energy projects emitted less air pollutants.¹⁹² An important caveat to this finding is

¹⁸⁵ 40 C.F.R. § 258.61 (2012); see also *supra* note 52 and accompanying text describing post-closure care.

¹⁸⁶ CLIFF CHEN & NATHANAEL GREENE, NATURAL RES. DEF. COUNCIL, IS LANDFILL GAS GREEN ENERGY? 11–14 (2003), <http://www.nrdc.org/air/energy/lfg/lfg.pdf>.

¹⁸⁷ *Id.* at 16.

¹⁸⁸ *Id.* at 16–17. This report concludes that landfill gas is not green energy because landfills should not be used as a waste disposal method. It acknowledges, however, that if landfills are going to be used, the gas should be collected and burned for energy. *Id.* at 21. For more on this issue, see *infra* Part III.C on composting.

¹⁸⁹ CHEN & GREENE, *supra* note 186, at 7, 10 (noting that the EPA National Air Toxics Program designated municipal landfills as one of the twenty-nine most significant area sources of hazardous air pollutants in 2000, resulting in regulations requiring that at least ninety-eight percent of these pollutants be destroyed, which is achieved through flaring or combustion in gas-to-energy projects). Air pollutants present in landfill gas but largely destroyed in combustion include among others, trichloroethylene, ethylene dibromide, and chloroform. *Id.*

¹⁹⁰ *Id.* at 11.

¹⁹¹ *Id.* at 12.

¹⁹² *Id.* at 17.

that the study assumed that the energy from landfill gas would displace energy from other sources and thus prevent pollution associated with other forms of energy.¹⁹³ The analysis concluded that the use of landfill gas-to-energy projects would result in reductions in air pollution when compared to flaring the gas and generating the energy through traditional coal-fired power plants.¹⁹⁴ Although air emissions from landfill gas energy make noncombustion renewable energy—such as wind and solar power—more favorable than landfill gas, using landfill gas for energy is preferable to flaring it or allowing for its release and using coal-fired plants instead.¹⁹⁵ Because renewable energy accounts for only seven percent of energy consumption in the United States, significant benefits in air quality could be achieved by using landfill gas energy to replace coal-fired power plants, at least until such time as renewable energy sources can account for a larger portion of our energy portfolio.¹⁹⁶

C. *Compatibility with Composting*

Another potential objection to bioreactor landfill gas-to-energy projects is that they rely on organic materials decomposing to create landfill gas, and the best use of organic materials is recycling them via composting, not landfilling.¹⁹⁷ Composting advocates would argue—and this Note does not dispute—that the end goal of waste management should be the elimination of landfills to the greatest extent possible.¹⁹⁸ The fact remains, however, that Americans sent 136 million tons of solid waste to landfills in 2010.¹⁹⁹

Until landfills can be eliminated, composting and bioreactors can be compatible waste management techniques.²⁰⁰ Composting can be

¹⁹³ *Id.* at 15, 17.

¹⁹⁴ *Id.* at 17.

¹⁹⁵ *Id.* The study drew uncertain conclusions regarding the potential benefits of landfill gas energy over new natural gas-fired plants though. *Id.*

¹⁹⁶ *Energy Basics: Renewable Energy Technologies*, U.S. DEP'T OF ENERGY, http://www.eere.energy.gov/basics/renewable_energy/index.html (last updated Aug. 12, 2011); see also Kevin Doran & Adam Reed, *Natural Gas and Its Role in the U.S. Energy End Game*, YALE ENV'T 360 (Aug. 13, 2012), http://e360.yale.edu/feature/natural_gas_role_in_us_energy_endgame/2561/ (arguing for leveraging increased natural gas use to develop effective renewable energy systems).

¹⁹⁷ See Nora Goldstein, *Composting and Organics Recycling vs. Bioreactors: Another Perspective*, 44 *BIOCYCLE* 35 (2003) (arguing for the use of composting and recycling over bioreactor landfills).

¹⁹⁸ See, e.g., *No Burying & No Burning*, GRASSROOTS RECYCLING NETWORK, <http://www.grrn.org/page/no-burying-no-burning> (last visited Oct. 19, 2012) (arguing for the use of composting and elimination of waste).

¹⁹⁹ U.S. EPA, *supra* note 148, at 2.

²⁰⁰ One study has even found that landfill gas generation in a bioreactor is more favorable

promoted as a primary goal for organic waste, but some organic waste will inevitably still end up in landfills.²⁰¹ Landfills currently contain more than 5 billion tons of organic waste, and over 125 million tons of organic waste are added each year.²⁰² Organic collection and composting systems often target green and yard waste, but many other organics make it to landfills.²⁰³ This waste should be managed in the most environmentally responsible way, which bioreactors achieve.²⁰⁴

D. Slope Stability

Another potential concern related to bioreactors is that the increased moisture content of the landfill will destabilize the structure;²⁰⁵ however, slope stability has not been a major issue at bioreactors currently in use and can be prevented with adequate controls.²⁰⁶ Slope instability can be prevented by simply creating more gradual slopes on the landfill and by preventing pressure on the slopes.²⁰⁷ This pressure can be caused by leachate injection too close to the sides of the landfill.²⁰⁸ Positioning leachate lines away from the side slopes will help prevent instability.²⁰⁹

Finally, EPA could require the completion of a stability analysis before the introduction of liquids into the landfill. This is already required for bioreactors receiving permits for research, development, and demonstration.²¹⁰ In order to prevent the permitting delays and costs associated with the research, development, and demonstration permits, EPA should only require that each landfill owner or operator complete an analysis, as opposed to requiring a permit.

E. Encourages Small Landfills

It is possible that because the proposed regulation only applies to large landfills, landfill owners and operators will reduce the size of

than composting in terms of cost, overall energy use, and emissions. Maria Theresa I. Cabaraban et al., *Aerobic In-vessel Composting Versus Bioreactor Landfilling Using Life Cycle Inventory Models*, 10 CLEAN TECHS. ENVTL. POL'Y 39, 51 (2008).

²⁰¹ FOTH & VAN DYKE & ASSOCS., INC., *supra* note 72, at 15.

²⁰² *Id.*

²⁰³ *Id.*

²⁰⁴ See generally Solid Waste Ass'n of N. Am. & U.S. Composting Council, *supra* note 104.

²⁰⁵ See U.S. EPA, *supra* note 103.

²⁰⁶ See *id.*

²⁰⁷ See *id.*

²⁰⁸ *Id.*

²⁰⁹ *Id.*

²¹⁰ 40 C.F.R. § 258.4 (2012); Research, Development, and Demonstration Permits for Municipal Solid Waste Landfills, 69 Fed. Reg. 13,242, 13,247 (Mar. 22, 2004).

landfills to avoid having to comply; however, it is likely that the loss in profits from decreased landfill capacity will outweigh the costs of complying with the proposed regulation. As discussed above, bioreactors are actually more cost effective than traditional landfills.²¹¹ Additionally, the regulations requiring landfill gas collection utilize a size threshold and have been in place for fifteen years now, and there is no evidence that these regulations have had an impact on landfill size. Current data indicate that the number of operating landfills is dramatically decreasing, while the size of landfills is increasing.²¹² In order to promote smaller landfill size, the proposed regulation would have to overcome and reverse this trend, which seems unlikely given the cost savings associated with large landfills and bioreactors.

F. Impact on Small or Rural Communities

Bioreactor requirements could potentially have a negative impact on small or rural communities that may not have large enough markets to support the sale of landfill gas energy or resources to implement bioreactor technology; however, because the proposed regulation will only apply to large facilities,²¹³ such landfills will likely not be subject to the regulation. If there are facilities that are subject to the proposed regulation yet rural enough that landfill gas energy is not feasible, RCRA already provides for assistance in planning and financing such facilities. Under 42 USC § 6908(a), the EPA Administrator is required to “establish a program to assist small communities in planning and financing environmental facilities,” and under 42 USC § 6949(a), the EPA Administrator is required to make grants to states to provide assistance to small municipalities or counties for upgrading their existing landfills.²¹⁴

CONCLUSION

Current regulations unnecessarily restrict the use of bioreactor technology, which has the potential to decrease greenhouse gas emissions and supply an alternative to fossil-fuel energy. EPA should amend its regulations to allow for the addition of liquids in landfills

²¹¹ See *supra* Part I.C.5.

²¹² U.S. EPA, MUNICIPAL SOLID WASTE GENERATION, RECYCLING, AND DISPOSAL IN THE UNITED STATES: FACTS AND FIGURES FOR 2005, at 7 (2005), <http://www.epa.gov/osw/nonhaz/municipal/pubs/msw-2005.pdf>.

²¹³ See *supra* Part II.A.

²¹⁴ This assistance is “for solid waste management facilities (including equipment) necessary to meet the requirements of section 6945 of this title” which requires the closing or upgrading of existing landfills that do not comply with the regulations. 42 U.S.C. § 6949(a) (2006).

utilizing gas-to-energy systems. EPA should additionally require landfill gas-to-energy systems on all landfills subject to the current gas collection regulations. These regulatory changes will decrease the amount of methane emissions from landfills, provide an alternative source of energy, and provide numerous environmental and economic benefits. These results will contribute to slowing global climate change and protecting the environment.