Municipal Solid Waste Landfills

Economic Impact Analysis for the Proposed New Subpart to the New Source Performance Standards

U.S. Environmental Protection Agency
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1 EXECUTIVE SUMMARY

1.1 Background

The EPA is proposing amendments to the Standards of Performance for Municipal Solid Waste Landfills. Under the Clean Air Act, the EPA must periodically review and revise the standards of performance, as necessary, to reflect improvements in methods for reducing emissions. Based on our review of the standards, we are proposing to lower the annual NMOC emissions threshold from 50 Mg/year to 40 Mg/year. The EPA is also addressing other regulatory issues for sources that have arisen during implementation of Subpart WWW including the definition of landfill gas treatment systems, among other topics. This proposed new subpart, Subpart XXX, applies to new landfills.

In this EIA, the EPA presents a profile of the municipal solid waste industry in the United States and an analysis of the costs and emissions reductions associated with a range of regulatory options, including the option chosen for proposal. The EPA drew upon a comprehensive database of existing landfills to develop model landfills to represent new landfills opening in the first five years after new subpart XXX is proposed (2014-2018). The model future landfills were developed by evaluating the most recently opened existing landfills and assuming that the sizes and locations of landfills opening in the future would be similar to the sizes and locations of landfills that opened in the last 10 years. The impacts shown in this section are expressed as the incremental difference between facilities complying with the current NSPS (40 CFR part 60, subpart WWW) and facilities that would be comply with proposed subpart XXX. All impacts are shown for the year 2023. The analysis also includes the small entity analysis supporting the EPA's certification that there will not be a significant impact on a substantial number of small entities (SISNOSE) arising from this proposal.

1.2 Results for Proposed NSPS

For this executive summary, a summary of the findings of the EIA follows:

Engineering Cost Analysis: To meet the proposed emission limits, a MSW landfill is expected to install the least cost control for combusting the landfill gas. The control costs include the costs to install and operate gas collection. For landfills where the least cost control option was an engine, the costs also include installing and operate one or more reciprocating internal combustion engines to convert the landfill gas into electricity. Revenue from electricity sales was incorporated into the net control costs using state-specific data on wholesale purchase prices. The annualized costs also include testing and monitoring costs. For this proposal, which tightens the emissions threshold, the EPA estimated the nationwide incremental annualized cost in 2023 to be \$471,000 (2012\$). While not quantified, the costs associated with the additionally proposed changes to address other regulatory issues and clarifications are expected to be minimal.

Emissions Analysis: In 2023, this proposal would achieve reductions of 79 Mg NMOC, 12,000 Mg methane, and 308,000 Mg CO_2-equivalents[1] compared to the baseline. These pollutants are associated with substantial health, welfare and climate effects.

Small Entity Analysis: Because the ownership of new landfills in the future is unknown, the EPA performed a screening analysis that assumed new landfills would be physically and financially similar to and have the same type of ownership as recently established landfills. Based upon historical data, the screening analysis predicted that four new landfills would be owned by small entities, but that none would be owned by small governments. Only one of the four small landfills were predicted to be incrementally affected by this proposal. Based upon this analysis, we conclude there will not be a significant economic impact on a substantial number of small entities (SISNOSE) arising from this proposal.

Economic Impacts: Because of the relatively low cost of this proposal and the lack of appropriate economic parameters or models, the EPA is unable to estimate the impacts of the proposal on the supply and demand for MSW landfill services. However, the EPA does not believe the proposal will lead to changes in supply and demand for landfill services or waste disposal costs, tipping fees, or the amount of waste disposed in landfills. Hence, the overall economic impact of the proposal should be minimal on the affected industries and their consumers.

1.3 Organization of this Report

The remainder of this report details the methodology and the results of the EIA. Section 2 presents the industry profile of municipal solid waste landfill industry. Section 3 describes emissions, emissions control options, and engineering costs. Section 4 presents the small entity screening analysis.

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[1] A global warming potential of 25 is used to convert methane to CO_2-equivalents.

2 INDUSTRY PROFILE

2.1 Introduction

Municipal solid waste (MSW) is the stream of garbage collected by sanitation services from homes, businesses, and institutions. MSW typically consists of metals, glass, plastics, paper, wood, organics, mixed categories, and composite products. The majority of collected MSW that is not recycled is typically sent to landfills—engineered areas of land where waste is deposited, compacted, and covered. The New Source Performance Standards (NSPS) and the state and federal plans implementing the emission guidelines for MSW landfills regulate air emissions from landfills that receive household waste as defined in 40 CFR 60.751. Hereinafter these regulations are collectively referred to as the NSPS/EG. These MSW landfills can also receive other types of waste, such as construction and demolition debris, industrial wastes, or nonhazardous sludge. MSW landfills are designed to protect the environment from contaminants which may be present in the solid waste stream and as such are required to comply with federal Resource Conservation and Recovery Act (RCRA) regulations or equivalent state regulations, which include standards related to location restrictions, composite liners requirements, leachate collection and removal systems, operating practices, groundwater monitoring requirements, closure and post-closure care requirements, corrective action provisions, and financial assurance (EPA, 2012a).

EPA estimates the total amount of MSW generated in the United States in 2010 was approximately 250 million tons, a 20 percent increase from 1990. Despite increased waste generation, the amount of MSW deposited in landfills decreased from about 145.3 million tons in 1990 to 135.5 million tons in 2010. This decline is due to a significant increase in the amount of waste recovered for recycling and composting as well as that combusted for energy recovery (EPA, 2011). The number of active MSW landfills in the United States has decreased from approximately 7,900 in 1988 to 1,900 in 2009 (EPA, 2010a).

Landfills are different than many other traditionally regulated emissions source categories. Typically, entities regulated for air emissions are involved in manufacturing or production and their emissions are directly related to processes involved in creating products (e.g., vehicles, bricks) or commodities (e.g., natural gas, oil). When manufacturing or production facilities cease to operate, their emissions typically cease. Landfills are a service industry—a repository for waste that needs to be properly disposed—and their emissions are a by-product of the deposition of that waste. Landfills continue to emit air pollution for many years after the last waste is deposited.

Landfill gas (LFG) is a by-product of the decomposition of organic material in MSW in anaerobic conditions in landfills. LFG contains roughly 50 percent methane and 50 percent carbon dioxide, with less than 1 percent non-methane organic compounds and trace amounts of inorganic compounds. The amount of LFG created primarily depends on the quantity of waste and its composition and moisture content as well as the design and management practices at the site. LFG can be collected and combusted in flares or energy recovery devices to reduce emissions. MSW landfills receive approximately 69 percent of the total waste generated in the United States and produce 94 percent of landfill emissions. The remainder of the emissions is generated by industrial waste landfills (EPA, 2012b).

Entities potentially regulated under Standards of Performance for Municipal Solid Waste Landfills include owners of MSW landfills and owners of combustion devices that burn untreated LFG. At its core, firms engaged in the collection and disposal of refuse in a landfill operation are classified under the North American Industry Classification System (NAICS) codes Solid Waste Landfill (562212) and Administration of Air and Water Resource and Solid Waste Management Programs (924110).

Landfills are owned by private companies, government (local, state, or federal), or individuals. In 2004, 64 percent of MSW landfills were owned by public entities while 36 percent were privately owned (O'Brien, 2006). Affected entities comprise establishments primarily engaged in operating landfills for the disposal of non-hazardous solid waste; or the combined activity of collecting and/or hauling non-hazardous waste materials within a local area and operating landfills for the disposal of non-hazardous solid waste. This industry also includes government establishments primarily engaged in the administration and regulation of solid waste management programs.

Private companies that own landfills range in size from very small businesses to large businesses with billions in annual revenue. Public landfill owners include cities, counties/parishes, regional authorities, state governments, and the federal government (including military branches, Bureau of Land Management, Department of Agriculture, Forest Service, and Department of the Interior - National Park Service).

2.2 Waste Stream Background

2.2.1 Municipal Waste

2.2.1.1 Generation of Municipal Solid Waste

Municipal solid waste (MSW) is generally defined as nonhazardous waste from household, commercial, and institutional sources. These three broad categories of primary MSW generators are described as:

- Household – solid waste from single-and multiple-family homes, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas.
- Commercial – solid waste from stores, offices, restaurants, warehouses, and other nonmanufacturing activities.
- Institutional – solid waste from public works (such as street sweepings and tree and brush trimmings), schools and colleges, hospitals, prisons, and similar public or quasi-public buildings. Infectious and hazardous waste from these generators are managed separately from MSW.

Households are the primary source of MSW, accounting for 55 to 65 percent of total MSW generated, followed by the commercial sector (EPA, 2011). Waste from commercial and institutional locations amounts to 35 to 45 percent of total MSW (EPA, 2011). The industrial sector manages most of its own solid residuals by recycling, reuse, or self-disposal in industrial waste landfills. For this reason industry directly contributes a very small share of the MSW flow, although some industrial waste does end up in MSW landfills.

Various underlying factors influence the trends in the quantity of MSW generated over time. These factors include changes in population, individual purchasing power and disposal patterns, trends in product packaging, and technological changes that affect disposal habits and the nature of materials disposed. Generators of MSW provide most of the demand for services that collect, treat, or dispose of MSW. Fluctuations in the quantity of MSW generated and changes in the cost and pricing structure of disposal services result in varying demand for landfill services.

Most MSW generators are charged a flat fee for disposal services, which can be paid through taxes for household garbage collection. This structure may provide little economic incentive to lower waste disposal or to divert waste through recycling because generators are charged the same price regardless of the quantity of waste disposed. Less common are unit price programs, such as "pay-as-you-throw" (PAYT). In PAYT programs, each unit of waste disposed has an explicit price, such that the total fee paid for MSW services increases with the quantity of waste discarded. Hence, the unit price can act as a disincentive to dispose of excess waste and also encourages recycling (Callan, 2006).

2.2.1.2 Landfills Covered Under the NSPS/EG

The Landfills NSPS/EG applies only to landfills that accept "household waste" as defined in 40 CFR 60.751, which states "household waste means any solid waste (including garbage, trash, and sanitary waste in septic tanks) derived from households (including, but not limited to, single and multiple residences, hotels and motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas)." Some of the MSW landfills subject to the Landfills NSPS/EG may also receive other types of wastes, such as commercial, industrial, and institutional solid waste, nonhazardous sludge, and construction and demolition debris.

2.2.1.3 Trends in Per Capita Waste Sent to Landfills

In 2010, Americans generated about 250 million tons of trash, and recycled nearly 65 million tons of this material, equivalent to a 26 percent recycling rate (EPA 2011). Composting recovered more than 20 million tons of waste (~8 percent of total waste) and about 29 million tons of waste were combusted for energy recovery (~12 percent) (EPA 2011). After recycling, composting, and combustion with energy recovery, the net per capita discard rate to landfills was 2.40 pounds per person per day in 2010 (EPA 2011). This is a 4 percent decrease from the 2.51 per capita discard rate in 1960, when minimal recycling occurred in the United States (see Table 2-1).

Since 1990, the total amount of MSW going to landfills has dropped by almost 10 million tons, from 145.3 million to 135.5 million tons in 2010 (EPA 2011). While the number of U.S. landfills has steadily declined over the years, the average landfill size has increased. At the national level, landfill capacity appears to be sufficient, although it is limited in some areas (EPA 2011).

Table 2-1 Generation and Discards of MSW, 1960 to 2010 (in pounds per person per day) [2]

Activity	1960	1970	1980	1990	2000	2005	2007	2008	2009	2010
Generation	2.68	3.25	3.66	4.57	4.72	4.67	4.64	4.53	4.35	4.43
Discards to landfill [a]	2.51	3.02	3.24	3.19	2.71	2.61	2.52	2.45	2.36	2.40
Discards to landfill (% of total generation)	94%	93%	89%	70%	57%	56%	54%	54%	54%	54%

[a] Discards after recovery minus combustion with energy recovery. Discards include combustion without energy recovery.

2.2.1.4 Composition of MSW Sent to Landfills

Organic materials continued to be the largest component of MSW in 2010. Yard trimmings and food scraps account for 29.1 percent and paper and paperboard account for another 16.2 percent. Plastics comprise 17.3 percent while metals and wood make up 8.8 percent and 8.2 percent, respectively. Textiles account for 6.8 percent and glass accounts for 5.1 percent. Rubber and leather follow at 4.0 percent. Other miscellaneous wastes make up approximately 4.4 percent of the MSW generated in 2010 (EPA 2011). Figure 2-1 displays material composition percentages of the MSW stream in 2010, and Table 2-2 shows the amounts of different materials discarded in the MSW stream from 1960 to 2010.

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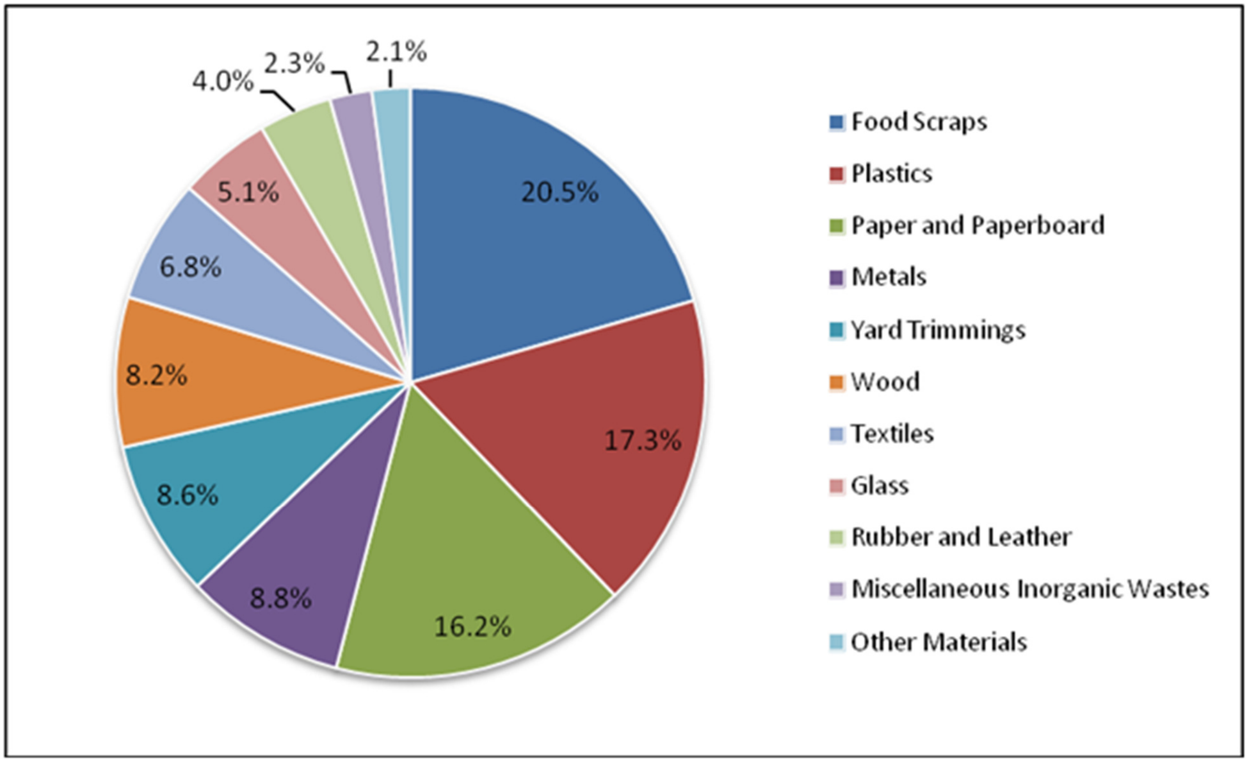
[2] Table adapted from U.S. Environmental Protection Agency. 2011. “Municipal Solid Waste Generation, Recycling, and Disposal in the United States Tables and Figures for 2010.” Table 4. EPA-530-F-11-005. Washington, DC: U.S. EPA. Available at
< http://www.epa.gov/osw/nonhaz/municipal/pubs/2010_MSW_Tables_and_Figures_508.pdf>. As obtained on October 30, 2011.

Figure 2-1 Material Composition of the MSW Stream, 2010[3]



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[3] Figure adapted from U.S. Environmental Protection Agency. 2011. "Municipal Solid Waste Generation, Recycling, and Disposal in the United States Tables and Figures for 2010." Table 3. EPA-530-F-11-005. Washington, DC: U.S. EPA. Available at < http://www.epa.gov/osw/nonhaz/municipal/pubs/2010_MSW_Tables_and_Figures_508.pdf>. As obtained on October 30, 2011.

Table 2-2 Materials Discarded[a] In the MSW Stream, 1960 to 2010 (in thousands of tons)[4]

Wastes	1960	1970	1980	1990	2000	2005	2010
Paper and Paperboard	24,916	37,540	43,420	52,500	50,180	42,880	26,740
Glass	6,620	12,580	14,380	10,470	9,890	9,950	8,400
Metals	10,770	13,350	14,290	12,580	12,340	13,400	14,540
Plastics	390	2,900	6,810	16,760	24,050	27,470	28,490
Rubber and Leather	1,510	2,720	4,070	5,420	5,850	6,200	6,610
Textiles	1,710	1,980	2,370	5,150	8,160	9,670	11,150
Wood	3,030	3,720	7,010	12,080	12,200	12,960	13,580
Other Materials[b]	70	470	2,020	2,510	3,020	3,080	3,380
Food Scraps	12,200	12,800	13,000	23,860	29,130	31,300	33,790
Yard Trimmings	20,000	23,200	27,500	30,800	14,760	12,210	14,200
Miscellaneous Inorganic Wastes	1,300	1,780	2,250	2,900	3,500	3,690	3,840
Total MSW Discarded	82,516	113,040	137,120	175,030	173,080	172,810	164,720

[a] Discards after materials and compost recovery. In this table, discards include combustion with energy recovery. Does not include construction and demolition debris, industrial process wastes, or certain other wastes.

[b] Includes electrolytes in batteries and fluff pulp, feces, and urine in disposable diapers.
Details may not add to totals due to rounding.

2.2.2 Consolidation of Waste Streams

Collection and transportation are necessary components of all MSW management systems regardless of the specific disposal options. Collections of MSW vary by service arrangements between local governments and collectors and by level of service provided to households. Depending on the arrangement type and other considerations for particular jurisdictions, MSW being sent to landfills may be deposited in a local landfill or routed to a regional landfill through a transfer process. Local landfills are generally located in the

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[4] Table adapted from U.S. Environmental Protection Agency. 2011. "Municipal Solid Waste Generation, Recycling, and Disposal in the United States Tables and Figures for 2010." Table 3. EPA-530-F-11-005. Washington, DC: U.S. EPA. Available at
< http://www.epa.gov/osw/nonhaz/municipal/pubs/2010_MSW_Tables_and_Figures_508.pdf>. As obtained on October 30, 2011.

communities in which they serve whereas regional landfills are often located outside of the communities they serve and receive waste from several cities and towns.

Solid waste transfer is the process in which collection vehicles unload their waste at centrally located transfer stations. Transfer stations can minimize hauling costs by decreasing the number of drivers and vehicles hauling waste to disposal sites and reducing the turn-around time of vehicles because they do not have to haul waste to distant regional landfills. Smaller loads are consolidated into larger vehicles, usually tractor-trailer trucks, trains, or barges, which are better suited for the long-distance hauls often required to reach the final disposal site, often a regional landfill. As public opposition to local MSW disposal facilities increases and the cost of disposal at locations near generators rise, long-distance hauls to regional landfills are becoming more common.

2.3 Disposal Facility Background

2.3.1 Technical Background on Landfills as a Source Category

An MSW landfill refers to an area of land or an excavation where MSW is placed for permanent disposal. MSW landfills do not include land application units, surface impoundments, injection wells, or waste piles. Modern MSW landfills are well-engineered disposal facilities that are sited, designed, operated, and monitored to protect human health and the environment from pollutants that may be present in the solid waste stream (EPA, 2012c).

2.3.1.1 Landfill Siting and Permitting

MSW landfills are required to comply with federal regulations contained in Subtitle D of the Resource Conservation and Recovery Act (RCRA) [40 CFR Part 258], or equivalent state regulations. RCRA requirements include location restrictions that ensure landfills are constructed away from environmentally-sensitive areas, including fault zones, wetlands, flood plains, or other restricted areas (EPA, 2012c). Site selection for landfills is an integral part of the design process.

Construction and operating permit applications for new landfills must be submitted to and approved by state and local regulatory agencies as part of the siting and design process. Often, states require a registered professional engineer to design the landfill (Guyer, 2009). Additional permits must be issued for each expansion of the landfill from its originally permitted waste design capacity and footprint area. New or modified landfills may also require air permits under the New Source Review (NSR) permitting program, which includes Prevention of Significant Deterioration (PSD) requirements for landfills sited in attainment areas, or areas where the air quality meets the National Ambient Air Quality Standards (NAAQS), and more stringent NSR requirements for landfills located in non-attainment areas.

Developing a new landfill or expanding an existing landfill has become increasingly difficult, especially in metropolitan areas, due to the urbanization of suitable sites, permitting barriers, elevated land costs, and other factors. If a new landfill is proposed or when expansion plans for existing landfills are announced, adjacent communities may mount opposition that can hinder issuance of required permits and thus development of the landfill (Alva, 2010).

2.3.1.2 Landfill Operations

The two most common methods for active disposal of waste into landfills are the area fill method and the trench method. The area fill method involves waste placement in a large open section of a lined landfill and then spreading and compacting waste in uniform layers using heavy equipment. The trench method of filling waste in a modern landfill involves placing and compacting waste into a trench and then using material from the trench excavation as daily cover. Local conditions often determine the most appropriate method for a particular landfill, and a combination of the two methods can be utilized. The trench method is less commonly used than the area fill method, mostly due to the expense of lining side slopes of the landfill (Guyer, 2009).

As required by Subtitle D of RCRA, cover material is applied on top of the waste mass at the end of each day to prevent odors and fires and reduce litter, insects, and rodents. Materials used as daily cover include soil, compost, incinerator ash, foam, and tarps (NSWMA, 2008). Similarly, intermediate cover is used when an area of the landfill is not expected to receive waste or a cap for an extended period of time. Intermediate covers have traditionally consisted of layers of soil, geotextiles, or other materials. The reasons for using intermediate cover are similar to those for using daily cover and may also include erosion control.

It is important to maintain anaerobic conditions within the landfill waste mass to avoid excess air infiltration that can cause fires. Landfill fires can be avoided by closely monitoring landfill conditions and maintaining the landfill as a controlled facility. If active LFG collection systems are installed, then gas wells are monitored to ensure oxygen is not being pulled into the landfill due to excessive vacuum levels.

2.3.1.3 Landfill Closure

Once an area of the landfill, or cell, has reached its permitted height, that cell is closed and a low permeability cap made of compacted clay or synthetic material is installed to prevent infiltration of precipitation. To divert water off of the top of the landfill, a granular drainage layer is placed on top of the low-permeability barrier layer. A protective cover is placed on top of the filter blanket and topsoil is placed as the final layer to support vegetation. The final cap and cover inhibit soil erosion and provide odor and LFG control (NSWMA, 2008). If an LFG collection and control system is in place, then expansion of the collection system into filled cells or areas of the landfill may require additional gas wells to be installed soon after these cells are closed and capped. Gas collection system design is discussed further in Section 6.

RCRA Subtitle D regulations contain closure and post-closure care requirements, including written closure and post-closure care plans and maintaining the final cover, leachate collection system, and groundwater and LFG monitoring systems. The required post-closure care period is 30 years from site closure, but this can be shortened or extended if approved by state regulatory agencies (EPA, 2012d).

2.3.1.4 Management of Liquids

Leachate is the liquid that passes through the landfilled waste and strips contaminants from the waste as it percolates. Precipitation is the primary source of this liquid. To prevent water pollution and protect soil beneath, RCRA Subtitle D requires liners for landfills as well as leachate collection and removal and groundwater monitoring systems. Composite liner systems are used along the bottom and sides of landfills as impermeable barriers and are typically constructed with layers of natural materials with low permeability (e.g., compacted clay) and/or synthetic materials (e.g., high-density polyethylene) (NSWMA, 2008). Landfill liner systems also help prevent off-site migration of LFG.

Leachate collection systems remove leachate from the landfill as it collects on the liner using a perforated collection pipe placed in a drainage layer (e.g., gravel). Waste is placed directly above the leachate collection system in layers. Collected leachate can be treated on-site or transported off-site to treatment facilities. For landfills with LFG collection systems, LFG condensate can be combined with leachate prior to treatment.

Although traditional landfills tend to minimize the infiltration of liquids into a landfill using liners, covers, and caps (sometimes referred to as "dry tombs"), some landfills recirculate all or a portion of leachate collected to increase the amount of moisture within the waste mass. This practice of leachate recirculation results in a faster anaerobic biodegradation process and increased rate of LFG generation. Similarly, landfills may introduce liquids other than leachate, such as sludge and industrial wastewater. Conventional landfills typically have in-situ moisture contents of approximately 20 percent, whereas landfills recirculating leachate or other liquids may maintain moisture contents ranging from 35 to 65 percent (EPA, 2012e). Often, landfills injecting or recirculating liquids are termed bioreactors, but bioreactor landfills are defined differently amongst industry and regulatory agencies. In addition, bioreactor landfills may have air injected in a controlled manner to further accelerate biodegradation of the waste, which occurs for aerobic and hybrid bioreactor configurations.

2.3.2 Ownership and Characteristics of Landfills

Since the 1980's, the number of active MSW landfills in the United States has decreased by approximately 75 percent (from ~7,900 in 1988 to ~1,900 in 2009) and the share of sites that are publicly owned has also decreased—from 83 percent in 1984 to 64 percent in 2004 (EPA, 2010b; O'Brien, 2006). However, the overall volume of disposal capacity has remained fairly constant, indicating a trend of growing individual landfill capacity (SWANA, 2007). In 2004, privately owned sites represented 83 percent of the permitted MSW landfill capacity and 77 percent of the MSW landfilled in that year, an indication that private landfills are likely to be significantly larger than public ones (O'Brien, 2006). In 2004, the average daily amount of MSW disposed at public sites was just under 200 short tons, whereas the average private site landfilled nearly 1,200 short tons of MSW per day—further evidence that publicly owned landfills are generally much smaller than their private counterparts (O'Brien, 2006).

EPA recognized as early as 2002 that a nationwide trend in solid waste disposal is toward the construction of larger, more remote, regional landfills. Economic considerations, influenced by regulatory and social forces, are compelling factors that likely led to the closure of many existing sites and to the idea of regional landfills (EPA, 2002b). The passage of federal environmental regulations that affected landfills (e.g., RCRA in 1976, Subtitle D of RCRA in 1991), established requirements which made it more expensive to properly construct, operate, maintain, and close landfills (O'Brien, 2006; EPA 2012f; EPA, 2002b). Large, private companies are better able to accommodate the increased costs of owning a landfill, since owning multiple sites, many of which have large capacities, provides an economy of scale for cost expenditures (O'Brien, 2006). To offset the high cost of constructing and maintaining a modern landfill, facility owners construct large facilities that attract high volumes of waste from a large geographic area. By maintaining a high volume of incoming waste, landfill owners can keep tipping fees relatively low, which subsequently attracts more business (EPA, 2002b).

As older, public landfills near their capacities, communities must decide whether to construct new landfills or seek other options. Many find the cost of upgrading existing facilities or constructing new landfills to be prohibitively high, and opt to close existing facilities. Also, public opposition often makes siting new landfills near population centers difficult and adequate land may not be available near densely populated or urban areas. Many communities are finding that the most economically viable solution to their waste disposal needs is shipping their waste to regional landfills. In these circumstances, a transfer station serves as the critical link in making the shipment of waste to distant facilities cost-effective (EPA, 2002b).

Waste transfer stations are facilities where MSW is unloaded from collection vehicles and reloaded into long-distance transport vehicles for delivery to landfills or other treatment/disposal facilities. By combining the loads of several waste collection trucks into a single shipment, communities and waste management companies can save money on the labor and operating costs of transporting waste to a distant disposal site. They can also reduce the total number of vehicular miles traveled to and from the disposal site(s) (EPA, 2012g). Given the dramatic decrease in the number of active landfills in the past 20 years, transfer stations play an important part in facilitating the movement of solid waste from the areas in which it originates to its end location, often a large, centrally located landfill. The role of transfer stations in waste management has become even more prominent with the increase in the number of "regional" landfills—sites with very large capacities, often located in remote areas, and usually privately owned. As more and more publicly owned landfills reach capacity and close, the waste must go somewhere, and often that is to a regional landfill by way of a transfer station.

There are more than 200 private companies that own and/or operate landfills, ranging from large companies with numerous landfills throughout the country to local businesses that own a single landfill (EPA, 2012b). The handling of MSW in the United States generated $55 billion of revenue in 2011 (EBI, 2012). In terms of 2011 revenue, the top two companies that own and/or operate MSW landfills in the United States were Waste Management ($13.38 billion) and Republic Services ($8.19 billion), which together accounted for 39 percent of the revenue share in 2011 (Bloomberg, 2012WM; Bloomberg, 2012RSG). The next tier of companies involved in landfill management includes Veolia Environmental Services North America Corp. ($1.88 billion), Progressive Waste Solutions ($1.84 billion), and Waste Connections ($1.51 billion) (Gerlat, 2012; Bloomberg, 2012BIN; Bloomberg, 2012WCN). Table 2-3 contains a summary of the 2011 revenue for the top five companies, as well as information about their MSW landfills and transfer stations.

Table 2-3 Top 5 Waste Management Companies That Own or Operate MSW Landfills in 2011

Company	2011 Revenue (billion $)	No. of MSW Landfills Owned and/or Operated	MSW Received at Landfills (million tons)	No. of Transfer Stations Owned and/or Operated
Waste Management (Bloomberg, 2012WM)	13.38	266	91.2	287
Republic Services (Bloomberg, 2012RSG)	8.19	191 active/ 130 closed	NA	194
Veolia Environmental Services North America Corp. (Gerlat, 2012)[a]	1.88	29	NA	43

Table 2-3 Top 5 Waste Management Companies That Own or Operate MSW Landfills in 2011

Company	2011 Revenue (billion $)	No. of MSW Landfills Owned and/or Operated	MSW Received at Landfills (million tons)	No. of Transfer Stations Owned and/or Operated
Progressive Waste Solutions (Bloomberg, 2012BIN)	1.84	NA	NA	NA
Waste Connections (Bloomberg, 2012WCN)	1.51	46	14.9	58

[a] In 2012, VESNA agreed to sell its U.S. solid waste operations, Veolia ES Solid Waste, Inc., to Star Atlantic Waste Holdings LP, a unit of Highstar Capital; the sale is to be completed by end of 2012. Highstar also owns Advanced Disposal Services Inc. and Interstate Waste Services Inc.
NA = Not available.

The industry that deposits MSW in landfills encompasses a wide range of job types, including garbage collectors, truck drivers, heavy equipment operators, engineers of various disciplines, specialized technicians, executives, MSW department directors, administrative staff, weigh scale operators, salespersons, and landfill operations managers. In 2007, 1,501 private establishments had 21,766 employees in the continental United States under NAICS 562212 (Solid Waste Landfill) (Census, 2012). In 2011, solid waste management departments of local governments reported 98,957 full-time employees and 14,679 part-time employees (Census, 2011); however, statistics are not readily available solely for landfill-related aspects of these departments. As the population continues to grow in the United States the amount of waste generated will continue to increase, but the amount of waste landfilled may remain the same or decrease (EPA, 2012h). Employment within the waste management industry overall will likely remain strong, perhaps with an increased shift of employees from the public sector to the private sector.

2.4 Costs and Revenue Streams for Landfills

2.4.1 Major Cost Components for Landfills

EPA promulgated Criteria for Municipal Solid Waste Landfills (40 CFR Part 258) under the RCRA on October 9, 1991 (EPA, 2012i). The law requires that non-hazardous MSW be disposed of in specially designed sanitary landfills. The criteria include location restrictions, design and operating standards, groundwater monitoring requirements, corrective actions, financial assurance requirements, landfill gas (LFG) migration controls, closure requirements, and post-closure requirements (EPA, 2012j). It can cost more than $1 million per acre to construct, operate, and close a landfill in compliance with these regulations (Fitzwater, 2012).

Landfill costs are site specific and vary based on factors such as terrain, soil type, climate, site restrictions, regulatory issues, type and amount of waste disposed, preprocessing, and potential for groundwater contamination. Landfill costs fall into the following categories: site development, construction, equipment purchases, operation, closure, and post-closure.

Site development includes site surveys, engineering and design studies, and permit package fees. Surveys are necessary to determine if a potential site is feasible. Permits are required from local, state, and federal governments. As an example, engineering design and a permit application for an MSW landfill in Kentucky can cost approximately $750,000 to $1.2 million (KY SWB, 2012).

Construction costs encompass building the landfill cells as well as development of permanent on-site structures needed to operate the landfill. Cortland County, New York estimated that the cost for site development and cell construction (not including on-site building construction) for a 224.5-acre site would be approximately $500,000 per acre (EnSol, 2010). In 2005, a series of articles was written that estimated costs for a hypothetical landfill based on known market conditions and cost data. The theoretical landfill had a design capacity of 4 million cubic yards and a footprint of 33 acres. The study determined that the cost of constructing a landfill of this size would be between $300,000 and $800,000 per acre. Table 2-4 summarizes typical construction costs per acre by individual task for this example site (Duffy, 2005a).

Table 2-4 Typical Costs Per Acre for Components of Landfill Construction (Duffy, 2005a)

Task	Low End	High End
Clear and Grub	$1,000	$3,000
Site Survey	$5,000	$8,000
Excavation	$100,000	$330,000
Perimeter Berm	$10,000	$16,000
Clay Liner	$32,000	$162,000
Geomembrane	$24,000	$35,000
Geocomposite	$33,000	$44,000
Granular Soil	$48,000	$64,000
Leachate System	$8,000	$12,000
QA/QC	$75,000	$100,000
TOTAL	**$336,000**	**$774,000**

Excavation of the landfill site comprises a notable portion of the construction costs. Installation of a landfill liner can vary greatly in cost depending on the site's geology. Most states require only a single liner and leachate collection system for MSW, but requirements vary for the minimum thickness of clay liners. Landfill sites may have good quality clay located on-site that would significantly lower the cost of a clay liner. The QA/QC task in Table 2-4 refers to management and quality oversight which is usually performed by independent third-party consultants.

For the hypothetical landfill in the study, total building and additional structure costs could total between $1.165 million and $1.77 million. Operation of the landfill requires a truck scale, scale house, wheel wash facility, and buildings to accommodate an office and provide space for maintenance. The cost of each building structure varies depending on its functions and could range from $10 to $100 per square foot. Office buildings cost more while maintenance buildings and tool sheds cost less. In addition, fencing around the facility and roadways are required and add to the costs (Duffy, 2005a).

Operating costs of the example landfill include staffing, equipment (payments and maintenance), leachate treatment, and facilities and general maintenance. Landfill operations and maintenance activities are performed using a variety of heavy construction equipment with operating costs dependent on fuel, repairs, and maintenance. Operating costs are relatively small when compared to the capital costs; estimated annual operating costs from this study are (Duffy, 2005a):

- Operations (equipment, staff, facilities and general maintenance): $500,000.
- Leachate collection and treatment (assumes sewer connection and discharge cost of $0.02/gallon): $10,000.
- Environmental sampling and monitoring (groundwater, surface water, air gas, leachate): $30,000.
- Engineering services (consulting firms and in-house staff): $60,000.

Once a landfill no longer accepts waste, the closure process includes the installation of a final cover and cap. Capital costs for installation of a cap can run between $80,000 and $500,000 per acre. For example, at a Maryland sanitary landfill costs were $150,000 per acre (MDE, 2012). The capping costs for a 249.4-acre site in Cortland County, New York were estimated to be approximately $134,000 per acre. Factors influencing these costs include the materials used for the cap, site topography, and the availability of clay or soil suitable for use as the cover. Similar to the costs of the clay liner during the construction of the landfill, availability of nearby clay would significantly reduce this cost (EnSol, 2010).

The closure process can include the installation of an LFG collection system which is necessary to collect and destroy or beneficially use the methane gas that is generated. (However, many landfills install gas collection and control systems as the landfill is being filled, or as areas within the landfill reach final grade, rather than waiting until closure to begin gas collection system installation.) The costs associated with an LFG collection and flare system are minimal as compared to the capital costs for landfill construction, annual landfill operating costs, and other closure costs. Section 6 discusses average installation costs for gas collection systems and flares.

Post-closure care requires maintenance to ensure the integrity and effectiveness of the final cover system, leachate collection system, groundwater monitoring system, and methane gas monitoring system. These activities prevent water and air pollution from escaping into the surrounding environment. The required post-closure care period is 30 years from site closure, and can be shortened or extended by the director of an approved state program as necessary to ensure protection of human health and the environment. Over a 30-year period, post-closure care and maintenance can cost from $64,000 to $88,000 per acre (Duffy, 2005b).

Figure 2-2 shows that landfill costs peak prior to the landfill opening and again following the landfill closing (EPA, 1997).

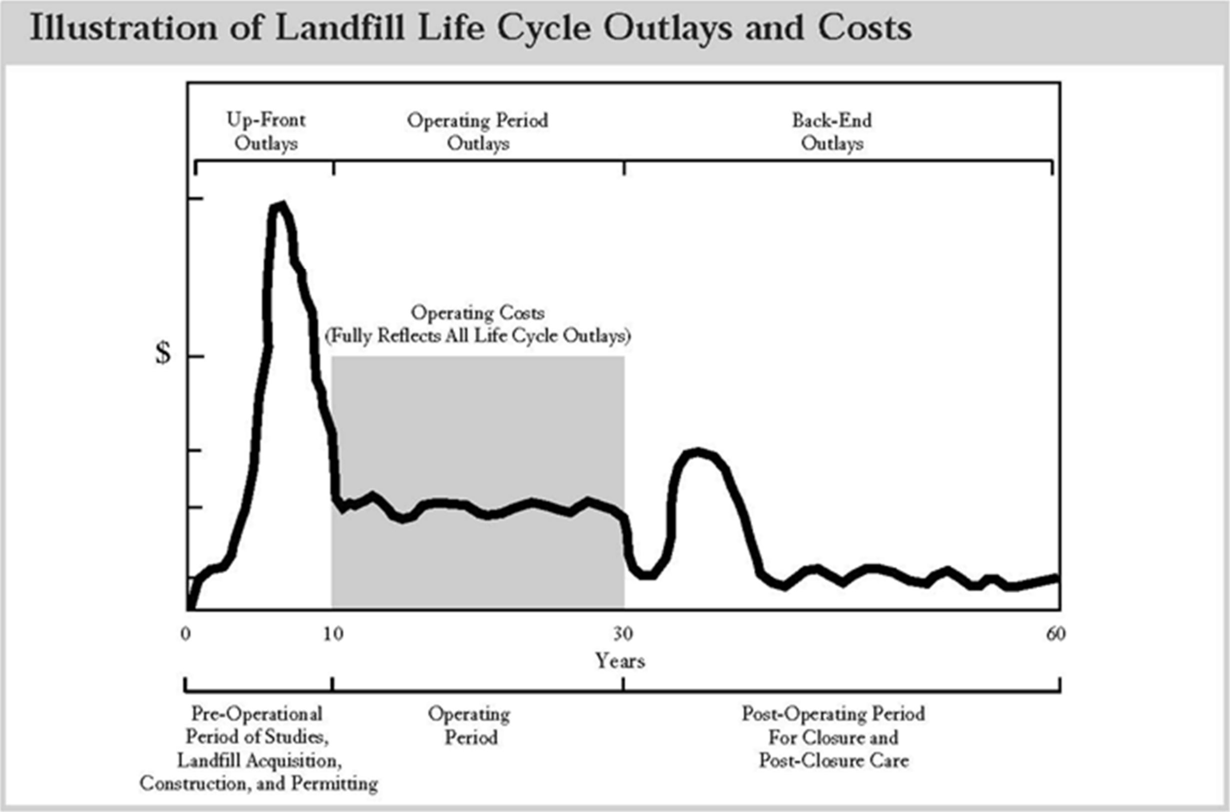


Figure 2-2 Landfill Cost Life Cycle

2.4.2 Landfill Revenue Sources

The cost to dispose of MSW at a landfill is commonly known as a "tip fee" or "gate fee". Typically, reported tip fees represent the "spot market" price for MSW disposal, i.e., the drive-up cost to dispose of a ton of waste (NSWMA, 2011). Other tip fees exist at MSW facilities (e.g., waste accepted under a long-term contract, volume discounts, and special wastes); these fees may be higher or lower than the spot market price (Repa, 2005). In September 2012, the average national spot market price to dispose of one ton of waste in a U.S. landfill was roughly $45, up 3.5 percent over 2011 (WBJ, 2012). This compares to average national tip fees of approximately $32 in 1998 (EPA, 2002) and $8 in 1985 (NSWMA, 2011).

Average tip fees vary by region of the country, as shown in Table 2-5. Tip fees in northeastern states have historically been and continue to be higher than those in other regions.

The next most expensive areas, on average, are the Mid-Atlantic and western states. Tip fees tend to be higher near large population centers (Wright, 2012); this is likely influenced by the fact that metropolitan areas have less land area for waste disposal and therefore, fewer landfills. There is variation in tip fees within states as well, depending on landfill ownership (public or private) and proximity of other landfills.

Table 2-5 Average Regional and National Per-Ton Tip Fees (Rounded): 1995-2012

U.S. Region	1995[a]	1998[a]	2000[a]	2002[a]	2004[a]	2008[b]	2010[c]	2012[d]
Northeast	$73	$67	$70	$69	$71	$67	NA	$73
Mid-Atlantic	$46	$44	$46	$45	$46	$56	NA	NA
South	$29	$31	$31	$30	$31	$32	NA	NA
Midwest	$31	$31	$33	$34	$35	$39	NA	NA
South Central	$20	$21	$22	$23	$24	$34	NA	NA
West Central	$23	$23	$22	$23	$24	$39	NA	NA
West	$38	$36	$35	$39	$38	$44	NA	NA
National	$32	$32	$32	$34	$34	$42	$44	$45

Northeast: CT, ME, MA, NH, NY, RI, VT
Mid-Atlantic: DE, MD, NJ, PA, VA, WV
South: AL, FL, GA, KY, MS, NC, SC, TN
Midwest: IL, IN, IA, MI, MN, MO, OH, WI
South Central: AZ, AR, LA, NM, OK, TX
West Central: CO, KS, MT, NE, ND, SD, UT, WY
West: AK, CA, HI, ID, NV, OR, WA

[a] Source: Repa, 2005.

[b] Source: Data from Biocycle, 2010. Data were not available for all states. For nine states, 2006 or 2009 data were substituted for missing year 2008 data.

[c] Source: WBJ, 2010.

[d] Source: WBJ, 2012.

Publicly owned landfills set tip fees based on the need to cover landfill and other waste management-related costs, while privately owned landfills' tip fees are set based on competition or the lack thereof (Wright, 2012). For municipalities that depend on landfill tip fees to fund programs and services, more waste disposed in the local community-owned landfill means more money generated to fund their solid waste systems, including non-disposal services like recycling. Conversely, if more waste starts going to private landfills instead, less revenue is generated for community programs. An increasing presence of private facilities that can set competitive tip fees has caused some communities to reduce their own tip fees in an effort to attract enough disposal volume to keep revenues at a sufficient level (Burgiel, 2003).

Historically, the construction and operating costs of public MSW landfills have been funded by tip fees, tax revenues (e.g., county/city property tax revenue that goes into a general fund), or a combination of these. Factors influencing tip fee values have included population and economic growth, recycling rates, operating and transportation costs, land values, and legislation. Traditionally, 30 percent of landfills receive all revenue from tip fees, 35 percent receive all revenue from taxes, and 35 percent cover the costs of waste disposal through a combination of tip fees and taxes. The use of taxes as a revenue source rather than tip fees has implications on waste disposal services. When disposal costs are included in taxes, most people are not aware of the actual costs involved and there is little incentive to reduce waste generation rates. Also, tax-supported facilities are typically underfunded relative to actual disposal costs, resulting in poorer operation than fully funded landfills supported by tip fees. Factors that influence the choice of revenue sources include landfill size and ownership. Landfills receiving small quantities of waste are likely to rely heavily on taxes for their revenue while larger landfills rely on both taxes and tip fees (EPA, 2002a).

Private owners of landfills rely heavily on tip fees relative to other landfill owners. It remains unclear whether private landfills rely on tip fees because they are larger, or larger landfills rely heavily on tip fees because they are private (EPA, 2002a).

As shown in Table 2-5, average tip fees by region remained fairly steady between 1995 and 2004, with minor declines in some years but with a gradual upward trend. The greatest increases in average tip fees occurred between 1985 and 1995, with the national average tip fee increasing by $24 (293 percent) or an average of $2.40 per year. By contrast, between 1995 and 2004, the national average tip fee increased by only 7 percent, or an average of 23 cents per year. Tip fees are expected to continue to increase gradually, based on recent data and given rising fuel costs, insurance costs, and other operating costs (Wright, 2012).

A landfill can also generate revenue by entering an agreement to sell carbon credits for voluntary destruction of methane, entering a gas sales agreement to sell LFG for beneficial use, or entering a power purchase agreement to sell electricity generated from LFG and/or renewable energy credits from the generation of that electricity. These types of revenue are small relative to tip fees and total landfill revenues, but can help offset some landfill expenses, for example, the cost of installing a gas collection system or energy recovery equipment. More information about these potential revenue sources is available in Section 6.

2.5 Air Pollutant Emissions from Landfills

Municipal solid waste (MSW) landfills are a source of non-methane organic compounds (NMOC) which include volatile organic compounds (VOC) , methane, a potent greenhouse gas (GHG), and hazardous air pollutants. LFG is formed during the decomposition of landfilled waste and, if not controlled, can emit numerous pollutants into the air. Several factors affect the amount of LFG generated and its components, including the age and composition of the waste, the amount of organic compounds in the waste, and the moisture content and temperature of the waste (EPA, 2012k). LFG generated from established waste (waste that has been in place for at least a year) is typically composed of roughly 50 percent methane (CH_4) and 50 percent carbon dioxide (CO_2) by volume, with trace amounts of non-NMOC and inorganic compounds (e.g., hydrogen sulfide) (EPA, 2010c; EPA, 2012k).

2.5.1 NMOC in LFG

The NMOC portion of LFG, while a small amount of LFG by volume, can contain a variety of significant air pollutants. NMOC include various organic hazardous air pollutants (HAPs) and VOC. If left uncontrolled, VOC can contribute to the formation of ground-level ozone, a common pollutant with adverse health impacts. Nearly 30 organic hazardous air pollutants have been identified in uncontrolled LFG, including benzene, toluene, ethyl benzene, and vinyl chloride (EPA, 2012k).

NMOC in LFG results mainly from the volatilization of organic compounds contained in the landfilled waste, while some NMOC may be formed by biological processes and chemical reactions within the waste (EPA, 1998). Waste materials that contribute to the formation of NMOC include items such as household cleaning products and materials coated with or containing paints and adhesives; during decomposition, NMOC can be stripped from these materials by other gases (e.g., CH_4 or CO_2) and become part of the LFG (EPA, 2012k).

The concentration of NMOC in uncontrolled LFG depends on several factors, including waste types in the landfill and the local climate. EPA’s Compilation of Air Pollutant Emission Factors (AP–42) provides a default NMOC concentration of 595 parts per million by volume (ppmv), of which 110 ppmv are considered HAP compounds. The total uncontrolled organic HAPs volume in LFG from MSW landfills is typically less than 0.02 percent of the total LFG (EPA, 2012k).

2.5.2 Methane in LFG

Methane is 25 times more effective at retaining heat in the earth's atmosphere than CO_2 and therefore is considered a potent GHG (IPCC 2007). The CO_2 generated from MSW landfills is deemed biogenic because the CO_2 would have been generated anyway as a result of natural decomposition of the organic waste materials if they had not been deposited in the landfill (EPA, 2010c).

When waste is first placed in a landfill, it enters an aerobic decomposition stage during which little CH_4 is produced. However, within a year or less, the waste environment becomes anaerobic, CH_4 generation increases, and the amount of CO_2 produced begins to level out (EPA, 2010c). Figure 2-3 presents a sample LFG generation curve over time for a typical MSW landfill. Significant CH_4 generation can continue for 10 to 60 years after initial waste placement (EPA, 2012k).

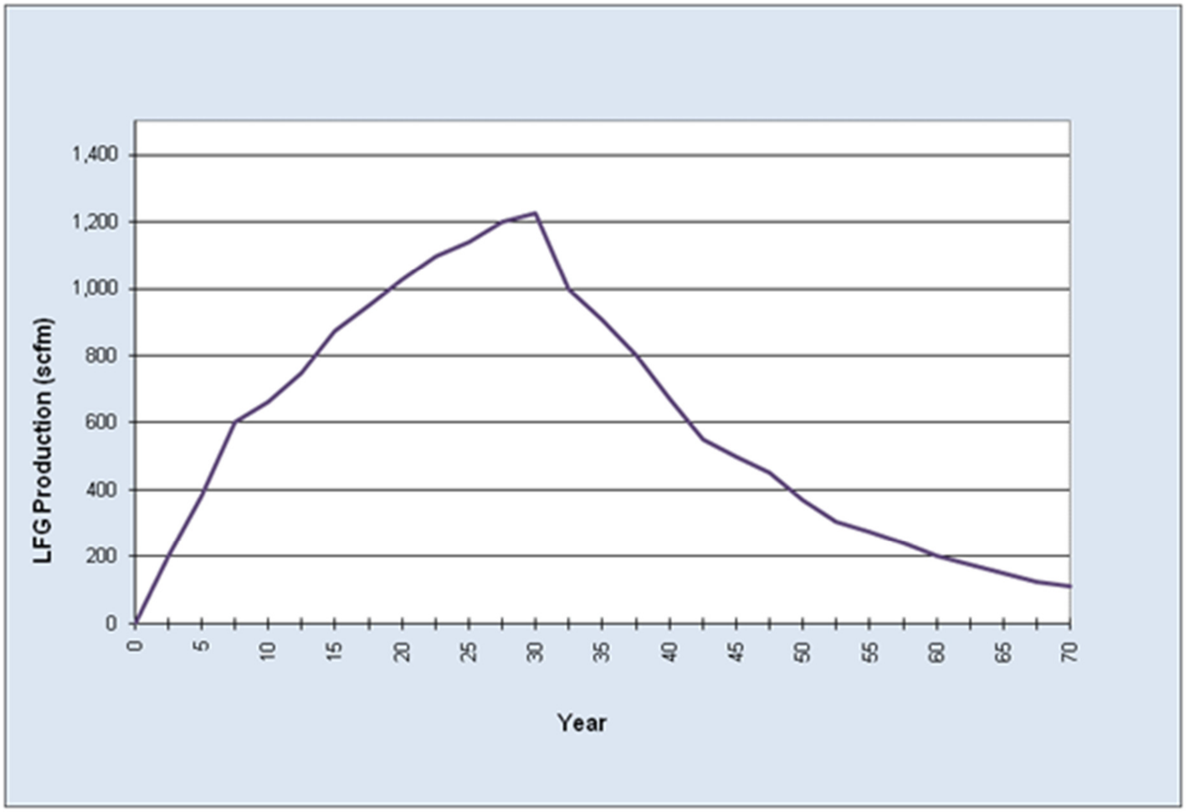


Figure 2-3 Typical LFG Generation Curve

In 2012, landfills were the third-largest anthropogenic source of CH_4 emissions in the United States, accounting for approximately 18 percent (EPA, 2014). Increasing attention is being given to mitigation of CH_4, given its global warming potential 25 times greater than CO_2 and its relatively short atmospheric lifetime of about 12 years (as compared to 50-200 years for CO_2) (EPA, 2014).

2.5.3 Criteria Pollutants from Combustion of LFG

While collection and combustion of LFG in a flare or energy project equipment (e.g., reciprocating engine, boiler, turbine) greatly reduces emissions of methane and NMOC (including VOC and organic HAP), the combustion process generates criteria pollutants including carbon monoxide (CO), nitrogen oxides (NO_X), sulfur dioxide (SO_2), and particulate matter (PM) (EPA, 1998). NO_X formation is strongly tied to the combustion temperature in the equipment, while CO and PM emissions are primarily the result of incomplete combustion of the gas. SO_2 production depends upon the amount of sulfur in the LFG (EPA, 2000). More information about LFG combustion devices is available in Section 6.

2.6 Techniques for Controlling Emissions from Landfills

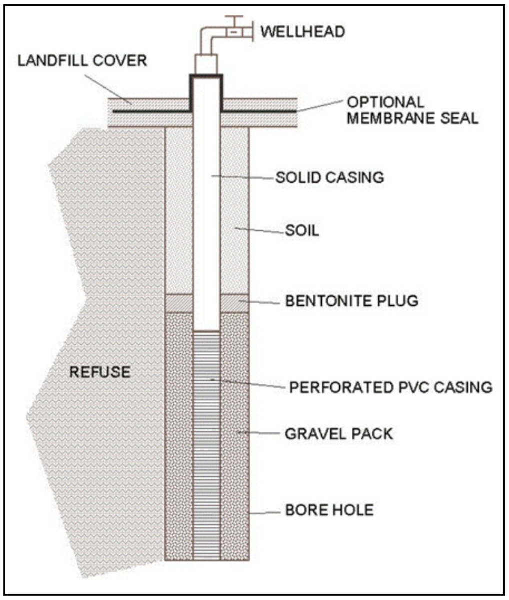
2.6.1 Introduction

Emissions from landfills can be controlled by installing gas collection systems and either flaring the LFG or utilizing it as an energy source. Large landfills with emissions exceeding 50 megagrams per year (Mg/yr) of nonmethane organic compounds (NMOC) are required by the MSW landfills NSPS to control and/or treat LFG to significantly reduce the amount of toxic air pollutants released. However, many landfills voluntarily choose to control emissions, in part because of the economic benefits of LFG energy projects.

This section describes the equipment and costs associated with LFG emission controls. The control technologies are divided into three categories: gas collection systems, destruction, and utilization. Much of the information in this section was obtained from the U.S. EPA's Landfill Methane Outreach Program (LMOP) *Landfill Gas Energy Project Development Handbook* (EPA 2010d).

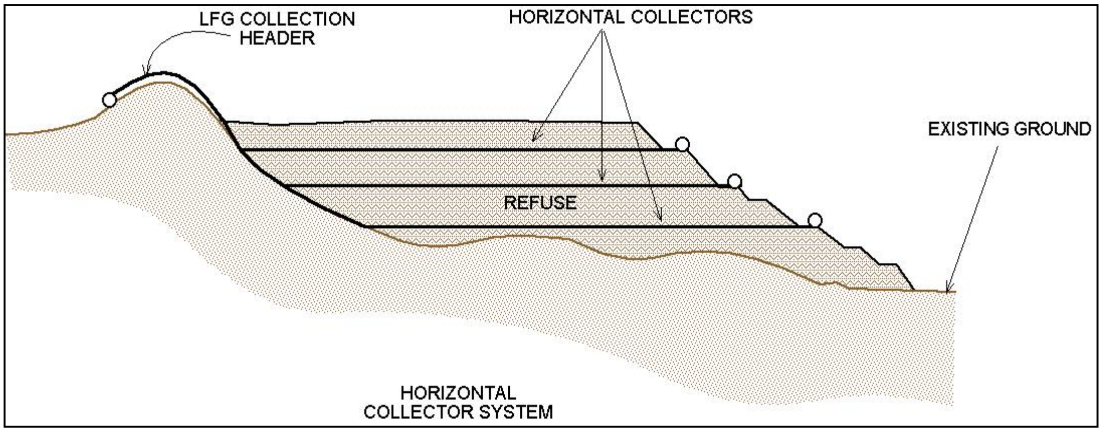
2.6.2 Gas Collection Systems

LFG collection typically begins after a portion of the landfill (known as a "cell") is closed to additional waste placement. Gas vents are installed to collect LFG from the closed cell. The gas vents may be configured as vertical wells or horizontal trenches, and some collection systems involve a combination of the two. Vertical wells (Figure 2-4) are the most common method of LFG collection and involve drilling wells vertically in the waste to collect gas. Horizontal trenches (Figure 2-5) use piping laid horizontally in trenches in the waste; these systems are useful in deeper landfills and in areas of active filling. Both types of collection systems connect the wellheads to lateral piping that transports the gas to a collection header.



Source: EPA, 2010d

Figure 2-4 Vertical Well LFG Collection



Source: EPA, 2010d

Figure 2-5 Horizontal Trench LFG Collection

Collection from the gas vents may be either passive or active. Passive systems rely on the natural pressure gradient between the waste mass and the atmosphere to move gas to collection systems. Most passive systems intercept LFG migration and the collected gas is vented to the atmosphere. Active systems use mechanical blowers or compressors to create a vacuum that optimizes LFG collection (ATSDR, 2001).

Collection efficiency is a measure of the ability of a gas collection system to capture generated LFG. Although rates of LFG capture can be measured, rates of actual generation in a landfill cannot be measured; therefore, considerable uncertainty exists regarding actual collection efficiencies achieved at landfills. Collection efficiencies at landfills with comprehensive gas collection systems typically range from 60 to 85 percent, with an average of 75 percent most commonly assumed (EPA, 1998).

Total collection system costs vary widely, based on a number of site-specific factors. For example, if the landfill is deep, collection costs tend to be higher because well depths will need to be increased. Collection costs also increase with the number of wells installed. Based on data from the LMOP's Landfill Gas Energy Cost Model (LFGcost), the estimated capital cost (in 2008 $'s) required for a 40-acre collection system designed for 600 cubic feet per minute (cfm) of LFG is $784,000, assuming one well is installed per acre. Typical annual operation and maintenance (O&M) costs (in 2008 $'s) for collection systems are $2,250 per well. If an LFG energy project generates electricity, a landfill will often use a portion of the electricity generated to operate the system and sell the rest to the grid in order to offset these operational costs.

2.6.3 Destruction

Collected LFG is typically combusted in flares or combustion devices that recover energy, such as boilers, internal combustion engines, and gas turbines. Properly designed and operated combustion equipment generally reduces NMOC by 98 percent or to a 20 ppmv outlet concentration, as specified in the current MSW landfill NSPS (40 CFR 60.752). Combustion also destroys over 98 percent of the methane.

Flares are the most common control device used at landfills. Flares are also a component of each energy recovery option because they may be needed to control LFG emissions during energy recovery system startup and downtime and to control any gas that exceeds the capacity of the energy conversion equipment. In addition, a flare is a cost-effective way to gradually increase the size of the energy recovery system at an active landfill. As more waste is placed in the landfill and the gas collection system is expanded, the flare is used to control excess gas between energy conversion system upgrades (e.g., before addition of another engine).

Flare designs include open (or candlestick) flares and enclosed flares. Open flares employ simple technology where the collected gas is combusted in an elevated open burner. A continuous or intermittent pilot light is generally used to maintain the combustion. Enclosed flares typically employ multiple burners within fire-resistant walls, which allow them to maintain a relatively constant and limited peak temperature by regulating the supply of combustion air (ATSDR, 2001b). Enclosed flares are more expensive but may be preferable (or required by state regulations) because they provide greater control of combustion conditions, allow for stack testing, and might achieve slightly higher combustion efficiencies than open flares. They can also reduce noise and light nuisances.

Flare costs vary based on the gas flow of the system. LFGcost estimates for flares include condensate collection and blowers. Condensate collection (also called knockout devices) is necessary because condensate forms when warm gas from the landfill cools as it travels through the collection system. If condensate is not removed, it can block the collection system. Blowers are needed to ensure a steady flow of gas to the flare. The size, type, and number of blowers needed depend on the gas flow rate and distance to downstream processes.

Based on data from LFGcost (in 2008 $'s), a flare for a system with an average of 600 cfm of LFG will cost $207,000 (including condensate collection and blowers). Typical annual O&M costs are approximately $4,500 per flare. Electricity costs to operate the blower for a 600 cfm active gas collection system average $44,500 per year.

2.6.4 Utilization

After collection, LFG may be used in an energy recovery system to combust the methane and other trace contaminants. LMOP's Landfill and LFG Energy Project Database, which tracks the development of U.S. LFG energy projects and landfills with project development potential, indicates that approximately 600 LFG energy projects are currently operating in 48 states. Roughly three-fourths of these projects generate electricity, while one-fourth are direct-use projects in which LFG is used for its thermal capacity (EPA, 2012m).

This section summarizes LFG utilization technologies in four general categories: power production, cogeneration, direct use, and alternative fuel. This section also provides a discussion of the economic benefits of LFG utilization projects.

2.6.4.1 Technologies

It is important to note that all of the technologies discussed below typically require treatment of LFG prior to entering the control device to remove moisture, particulates, and other impurities. (While “treatment” has a specific meaning within the MSW landfill NSPS, the term is used more generally in common usage and as discussed here.) The level of treatment can vary depending on the type of control and the types and amounts of contaminants in the gas. LFG is typically dehumidified, filtered, and compressed before being sent to energy recovery devices. For most boilers and internal combustion engines, no additional treatment is used. Some internal combustion engines and many gas turbine and microturbine projects apply siloxane removal using adsorption beds after the dehumidification step.

2.6.4.1.1 Power Production

Producing electricity from LFG continues to be the most common beneficial-use application, accounting for about three-fourths of all U.S. LFG energy projects (EPA, 2012m). Electricity can be produced by burning LFG in an internal combustion engine, a gas turbine, or a microturbine.

The majority (more than 70 percent) of LFG energy projects that generate electricity do so by combusting LFG in internal combustion engines. Advantages of this technology include: low capital cost, high efficiency, and adaptability to variations in the gas output of landfills. Internal combustion engines are well-suited for 800 kilowatt (kW) to 3 megawatt (MW) projects, but multiple units can be used together for projects larger than 3 MW. Internal combustion engines are relatively efficient at converting LFG into electricity, achieving efficiencies in the range of 25 to 35 percent.

Gas turbines are more likely to be used for large projects, where LFG volumes are sufficient to generate a minimum of 3 MW and typically more than 5 MW. Unlike most internal combustion engine systems, gas turbine systems have significant economies of scale. The cost per kW of generating capacity drops as gas turbine size increases, and the electric generation efficiency generally improves as well.

Microturbines, as their name suggests, are much smaller than turbines, with a single unit having between 30 and 250 kW in capacity, and thus are generally used for projects smaller than 1 MW. Small internal combustion engines are also available for projects in this size range and are generally less costly. Microturbines may be selected for certain projects (rather than internal combustion engines) because they can operate with as little as 35 percent methane and less than 300 cfm, and also produce low nitrogen oxide emissions.

An LFG energy project may use multiple units to accommodate a landfill's specific gas flow over time. For example, a project might have three internal combustion engines, two gas turbines, or an array of 10 microturbines, depending on gas flow and energy needs.

The costs of energy generation using LFG vary greatly; they depend on many factors including the type and size of electricity generation equipment, the necessary compression and treatment system, and the interconnect equipment. Table 2-6 presents examples of typical costs for several technologies, including costs for a basic gas treatment system typically used with each technology.

Table 2-6 Average LFG Power Production Technology Costs

Technology	Typical Capital Costs ($/kW)[a]	Typical Annual O&M Costs ($/kW)[a]
Internal combustion engine (>800 kW)	$1,700	$180
Small internal combustion engine (<1 MW)	$2,300	$210
Gas turbine (>3 MW)	$1,400	$130
Microturbine (<1 MW)	$5,500	$380

Source: EPA 2010d
[a] 2010 $'s

2.6.4.1.2 Cogeneration

LFG energy cogeneration applications, also known as combined heat and power (CHP) projects, provide greater overall energy efficiency and are growing in number. In addition to producing electricity, these projects recover and beneficially use the heat from the unit combusting LFG. LFG cogeneration projects can use internal combustion engine, gas turbine, or microturbine technologies.

Less common LFG electricity generation technologies include a few boiler/steam turbine applications in which LFG is combusted in a large boiler to generate steam which is then used by a steam turbine to create electricity. A few combined cycle applications have also been implemented. These combine a gas turbine that combusts LFG with a steam turbine that uses steam generated from the gas turbine's exhaust to create electricity. Boiler/steam turbine and combined cycle applications tend to be larger in scale than the majority of LFG electricity projects that use internal combustion engines.

2.6.4.1.3 Direct Use

The simplest and often most cost-effective use of LFG is direct use as a fuel for boilers and other direct thermal applications to produce useful heat or steam. However, this is only an option if there is an end user located near the landfill who is willing and able to use the LFG. An end user’s energy requirements are an important consideration when evaluating the sale of LFG for direct use. Because no economical way to store LFG exists, all gas that is recovered must be used as available; gas that cannot be immediately used in energy recovery equipment is flared and the associated revenue opportunities are lost. The ideal gas customer, therefore, will have a steady annual gas demand compatible with the landfill’s gas flow. When a landfill does not have adequate gas flow to support the entire needs of a facility, LFG can still be used to supply a portion of the needs. The number and diversity of direct-use LFG applications is continuing to grow.

Boilers are the most common type of direct use, and LFG is used in boilers at a wide variety of industrial manufacturing facilities as well as commercial and institutional buildings. Boilers can often be easily converted to use LFG alone or in combination with fossil fuels. Equipment modifications or adjustments may be necessary to accommodate the lower Btu value of LFG, and the costs of modifications will vary. If retuning the boiler burner is the only modification required, costs will be minimal. However, retrofitting an existing natural gas boiler to include LFG may cost between $100,000 and $400,000, depending on the extent of the retrofit.

Direct thermal applications include kilns (e.g., cement, pottery, and brick), tunnel furnaces, process heaters, and blacksmithing forges. In addition, infrared heaters can use LFG to fulfill space heating needs. Greenhouses can combust LFG in boilers to provide heat for the greenhouse and to heat water used in hydroponic plant culture. LFG can be used to heat the boilers in plants that produce biofuels including biodiesel and ethanol.

Table 2-7 presents typical cost ranges for the components of a direct-use project. The costs shown below for the gas compression and treatment system include compression, moisture removal, and filtration equipment typically required to prepare the gas for transport through the pipeline and for use in a boiler or process heater. If more extensive treatment is required to remove other impurities, costs will be higher. The gas pipeline costs also assume typical construction conditions and pipeline design. Pipelines can range from less than a mile to more than 30 miles long, although most are shorter than 10 miles because length has a major effect on costs. In addition, the costs of direct-use pipelines are often affected by obstacles along the route, such as highway, railroad, or water crossings. End users will likely need to modify their equipment to make it suitable for combusting LFG, but these costs are usually borne by the end user and are site-specific to their combustion device.

Table 2-7 Average LFG Direct-use Project Components Costs

Component	Typical Capital Costs[a]	Typical Annual O&M Costs[a]
Gas compression and treatment	$960/scfm	$90/scfm
Gas pipeline and condensate management system	$330,000/mile	Negligible

Source: EPA 2010d

[a] 2010 $'s, based on a 1,000 scfm system

scfm: standard cubic feet per minute

2.6.4.1.4 Alternative Fuel

Production of alternative fuels from LFG, by upgrading the gas using high-Btu conversion technologies, is becoming more prevalent. LFG can be used to produce the equivalent of pipeline-quality gas (natural gas), compressed natural gas (CNG), or liquefied natural gas (LNG). Pipeline-quality gas can be injected into a natural gas pipeline and used by residential, commercial, or industrial end users along the pipeline. CNG and LNG can be used to fuel vehicles at the landfill (e.g., water trucks, earthmoving equipment, light trucks, autos), fuel refuse-hauling tucks (long-haul refuse transfer trailers and route collection trucks), and supply the general commercial market. Although only a handful of these projects are currently operational, several more are in the construction or planning stages.

LFG can be converted into a high-Btu gas by increasing its methane content and, conversely, reducing its carbon dioxide, nitrogen, and oxygen content. In the United States, three methods have been commercially employed (i.e., beyond pilot testing) to remove carbon dioxide from LFG, including membrane separation, molecular sieve (also known as pressure swing adsorption or PSA), and amine scrubbing.

Recent capital costs of high-Btu processing equipment have ranged from $2,600 to $4,300 per standard cubic foot per minute (scfm) of LFG. The annual cost to provide electricity to, operate, and maintain these systems ranges from $875,000 to $3.5 million (EPA 2010d). Costs will depend on the purity of the high-Btu gas required by the receiving pipeline or energy end user as well as the size of the project, since some economies of scale can be achieved when producing larger quantities of high-Btu gas.

2.6.4.2 Revenues and Incentives

Landfill owners can receive revenue from the sale of carbon credits, the sale of electricity generated from LFG to the local power grid, or from the sale of LFG to a direct end user or pipeline. However, the revenue received represents only a small percentage of the operating costs of a landfill.

2.6.4.2.1 Greenhouse Gas Credits

Voluntary greenhouse gas trading programs purchase credits from landfills that capture LFG to destroy or convert methane contained in the gas and obtain credit for the reduction of greenhouse gas in terms of carbon equivalents. In order to qualify for these programs, the emission reductions must be in addition to regulated actions and have recent project installation. Examples of companies operating on the voluntary carbon market include Climate Action Reserve, EcoSecurities, Evolution Markets, AgCert, Blue Source, GE/AES, and Chicago Climate Exchange (EPA 2012a).

Bilateral trading and greenhouse gas credit sales are other voluntary sources of revenue. Bilateral trades are project-specific and are negotiated directly between a buyer and seller of greenhouse gas credits. In these cases, corporate entities or public institutions, such as universities, may wish to reduce their “carbon footprint” or meet internal sustainability goals, but do not have direct access to developing their own project. Therefore, a buyer may help finance a specific project in exchange for the credit of offsetting greenhouse gas emissions from their organization.

Many state and regional government entities are establishing their own greenhouse gas initiatives to cap or minimize greenhouse gas emissions within their jurisdictions. Examples include the Regional Greenhouse Gas Initiative (RGGI), the Washington carbon dioxide offset program, and the Massachusetts carbon dioxide reduction from new plants. Some of these programs establish a cap-and-trade program on carbon dioxide emissions, while others require new fossil-fueled boilers and power plants to either implement or contribute to funding of offset projects, including LFG.

Certain LFG energy projects may qualify for participation in nitrogen oxides cap-and-trade programs, such as the nitrogen oxides State Implementation Plan (SIP). The revenues for these incentives vary by state and will depend on factors such as the allowances allocated to each project, the price of allowances on the market, and if the project is a CHP project (typically CHP projects receive more revenue due to credit for avoided boiler fuel use).

2.6.4.2.2 Electricity Project Revenue

The primary revenue component of the typical electricity project is the sale of electricity to the local utility. This revenue stream is affected by the electricity buy-back rates (i.e., the rate at which the local utility purchases electricity generated by the LFG energy project). Electricity buy-back rates for new projects depend on several factors specific to the local electric utility and the type of contract available to the project, but typically range between 2.5 and 7 cents per kilowatt-hour (kWh) (EPA, 2010d).

When assessing the economics of an electricity project, it is also important to consider the avoided cost of the electricity used on-site. Electricity generated by the project that is used in other operations at the landfill is, in effect, electricity that the landfill does not have to purchase from a utility. This electricity is not valued at the buy-back rate, but at the rate the landfill is charged to purchase electricity (i.e., retail rate). The retail rate is often significantly higher than the buy-back rate.

LFG energy projects can potentially use a variety of additional environmental revenue streams, which typically take advantage of the fact that LFG is recognized as a renewable, or “green,” energy resource. These additional revenues can come from premium pricing, tax credits, greenhouse gas credit trading, or incentive payments. They can be reflected in an economic analysis in various ways, but typically, converting to a cents/kWh format is most useful. LFGcost accommodates four common types of electric project credits: a direct cash grant, a renewable energy tax credit expressed in dollars per kWh, a direct greenhouse gas (carbon) credit expressed in dollars per metric ton of carbon dioxide equivalent (discussed in Section 6.3.2.1), and a direct electricity tax credit expressed in dollars per kWh. This section includes discussion of the available environmental revenue streams that an LFG electricity project could possibly use.

Premium pricing is often available for renewable electricity (including LFG) that is included in a green power program, through a Renewable Portfolio Standard (RPS), a Renewable Portfolio Goal (RPG), or a voluntary utility green pricing program. These programs could provide additional revenue above the standard buy-back rate because LFG electricity is generated from a renewable resource.

Renewable energy certificates (RECs) are sold through voluntary markets to consumers seeking to reduce their environmental footprint. They are typically offered in 1 megawatt-hour (MWh) units, and are sold by LFG electricity generators to industries, commercial businesses, institutions, and even private citizens who wish to achieve a corporate renewable energy portfolio goal or to encourage renewable energy. If the electricity produced by an LFG energy project is not being sold as part of a utility green power program or green pricing program, the project owner may be able to sell RECs through voluntary markets to generate additional revenue.

Tax credits, tax exemptions, and other tax incentives, as well as federal and state grants, low-cost bonds, and loan programs are available to potentially provide funding for an LFG energy project. For example, Section 45 of the Internal Revenue Code provides a per-kWh federal production tax credit for electricity generated at privately owned LFG electricity projects. To qualify for the credit, which was 1.1 cent per kWh for the 2009 taxable year, all electricity produced must be sold to an unrelated person during the taxable year. Under legislation passed in February 2009, the placed-in-service date deadline for LFG energy projects to be eligible for the first 10 years of production is December 31, 2013. Another popular funding option is the Clean Renewable Energy Bond (CREB) program, which allows electric cooperatives, government entities, and public power producers to issue bonds to finance renewable energy projects including LFG electricity projects. The borrower pays back the principal of the CREB, and the bondholder receives federal tax credits in lieu of the traditional bond interest.

2.6.4.2.3 Direct-use Project Revenues

The primary source of revenue for direct-use projects is the sale of LFG to the end user; the price of LFG, therefore, dictates a project’s revenue. Often LFG sales prices are indexed to the price of natural gas, but prices will vary depending on site-specific negotiations, the type of contract, and other factors. In recent years, typical LFG prices have ranged from $4.00 to $8.00 per million British thermal units (MMBtu) or 0.38¢ to 0.75¢ per megajoule. In general, the price paid by the end user must provide an energy cost savings that outweighs the cost of required modifications to boilers, process heaters, kilns, and furnaces in order to burn LFG.

Federal and state tax incentives, loans, and grants are available that may provide additional revenue for direct-use projects. Greenhouse gas emissions trading programs are also potential revenue streams for direct-use projects.

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3 REGULATORY PROGRAM COSTS AND EMISSIONS REDUCTIONS

3.1 Introduction

Currently, the NSPS requires landfills of at least 2.5 million megagrams (Mg) capacity and 2.5 million cubic meters in size with estimated nonmethane organic compounds (NMOC) emissions of at least 50 Mg per year to collect and control or treat landfill gas (LFG). Landfills which meet the design size requirements but do not emit at least 50 Mg NMOC per year are required to test and monitor. As part of this review, the EPA evaluated the emission reductions and costs associated with a series of regulatory options. This section of the EIA includes three sets of discussions related to the proposed new subpart of the NSPS:

- Emissions Analysis
- Engineering and Administrative Cost Analysis
- Regulatory Option Analysis

This discussion of the emissions and cost analyses is meant to assist the reader of the EIA to better understand the economic impact analysis. However, we provide references to the technical memoranda prepared by the Office of Air Quality Planning and Standards (OAQPS) for the reader interested in a greater level of detail.

3.2 General Assumptions and Procedures

The proposed new subpart will affect new landfills. New landfills are defined as landfills that commence construction, reconstruction, or modification after the publication of this proposed rule. The EPA is unable to exactly predict the physical attributes, location, and ownership of landfills opened in the future. To assess the impacts of the proposal, the EPA drew upon a comprehensive database of existing landfills to develop model landfills to represent new landfills opening in the first 5 years after new subpart XXX is proposed (2014-2018). The model future landfills were developed by evaluating the most recently opened existing landfills and assuming that the sizes and locations of landfills opening in the future would be similar to the sizes and locations of landfills that opened in the last 10 years. Based on this assessment, The EPA created a total of 21 model landfills to represent landfills opening during the five years after proposal. The creation of the landfill dataset is detailed in the docketed memorandum, "Summary of Landfill Dataset Used in the Cost and Emission Reduction Analysis of Landfill Regulations. 2014." Data for existing landfills were obtained from a database maintained by EPA's Landfill Methane Outreach Program, voluntary data submitted to the EPA by the landfill industry as part of this rulemaking effort, and data from the EPA Greenhouse Gas Reporting Program.

To estimate the cost and emission impacts of each regulatory option, EPA determined which of these model landfills met the design capacity and emission rate thresholds for each regulatory option, then calculated the emission reductions and costs for each model landfill under each regulatory option in 2023 using the methods described below. The resulting costs and emission reductions incurred by each landfill were used to assess the overall impacts of the current NSPS in the baseline and the incremental impacts of the regulatory options considered. The emission reduction and cost and revenue equations and assumptions are detailed in the docketed memorandum from ERG to EPA, "Methodology for Estimating Cost and Emission Impacts of Proposed MSW Landfill Regulations. 2014."

Although NSPS impacts are frequently examined over the first five years of rule implementation, the EPA reviewed ten years (2014-2023) for this analysis and presents costs and emission reductions for the year 2023. Due to the emission characteristics of landfills, five years would not provide a representative population of landfills for evaluating alternative standards. Landfills do not become subject to the control requirements of the standards on the date that they begin operation. Instead, landfills exceeding the design capacity threshold become subject to control requirements 30 months after the emissions exceed 50 Mg NMOC per year. It may take well over five years for a newly constructed landfill to exceed the NMOC threshold, depending on the rate of waste acceptance and other site-specific factors. Therefore, a five-year period for evaluation of the rule would not capture the control costs incurred by landfills constructed during the five-year period that would ultimately be subject to the landfills NSPS. Because the applicability provisions are triggered relatively late in the ten year period considered, the EPA presents costs and emission reductions for the year 2023. This is more representative of the impacts of the rule than an annual average over this 10-year period, which would understate the costs and emission reductions since many of the early years of this period (2014-2019) represent no emission reductions or control costs.

The emissions and cost modeling was based upon the following basic assumptions:

- The baseline represents the emission reductions and costs associated with the requirements of Subpart WWW. Each regulatory option was compared to this baseline.
- Each landfill would install gas collection and control systems (GCCS) when the landfill exceeds the emission rate and design capacity threshold.
- Each landfill would remove GCCS when the actual emissions are below the emissions threshold, the landfill is closed, and the controls have been in place for at least 15 years.
- Costs were annualized using a 7 percent interest rate, which is consistent with EPA guidance for cost evaluations.

Alternative regulatory options varied the emission rate thresholds and design capacity thresholds.

3.3 Emissions Analysis

To estimate emission reductions, the amount of LFG and NMOC emitted at each landfill was estimated using a model programmed in Microsoft® Access. The model assumes that the collection equipment is installed and operational at the landfill 30 months after the emissions exceed the NMOC emission threshold in each option. As the landfill is filled over time, the model assumes the landfill expands the GCCS into new areas of waste placement in accordance with the expansion lag time of the standard. Once the landfill has reached the maximum gas production and the gas production starts to decrease, the analysis assumes that the GCCS will collect all of the collectable gas. The emission reductions are equal to the amount of collected NMOC or methane that is combusted, which is estimated by multiplying the amount of collected gas by a destruction efficiency of 98 percent.

3.4 Engineering and Administrative Cost Analysis

The evaluation will assume that landfills will install and remove LFG controls as required by the rule. Landfills are required to install controls when the landfill exceeds the emission rate and design capacity thresholds. Landfills are allowed to remove controls when the actual emissions are below the emissions threshold, the landfill is closed, and the controls have been in place for at least 15 years.

The EPA derived the cost equations used in the evaluation from the EPA's Landfill Gas Energy Cost Model (LFGcost), version 2.2, which was developed by the EPA's Landfill Methane Outreach Program (LMOP). LFGcost estimates gas collection, flare, and energy recovery system costs and was developed based on cost data obtained from equipment vendors and consulting firms that have installed and operated numerous gas collection and control systems. LFGcost encompasses the types of costs included in the EPA OAQPS control cost manual including capital costs, annual costs, and recovery credits. Total capital costs include purchased equipment costs, installation costs, engineering and design costs, costs for site preparation and buildings, costs of permits and fees, and working capital. Total annual costs include direct costs, indirect costs, and recovery credits. Direct annual costs are those that are proportional to a facility-specific metric such as the facility's productive output or size. Indirect annual costs are independent of facility-specific metrics and may include categories such as administrative charges, taxes, or insurance. Recovery credits are for materials or energy recovered by the control system.

For this evaluation, the EPA assessed costs in 2012$. The costs included in LFGcost are in 2008$. Therefore, the EPA multiplied all costs that are based on LFGcost data by an escalation factor to convert them to 2012$. The EPA used an interest rate of 7% to annualize the capital costs in this evaluation to estimate the annual capital cost of flares, wells, wellheads (including piping to collect gas), and engines over the lifetime of the equipment. The EPA assumes that the equipment will be replaced when its lifetime is over, so the annualized capital costs are incurred as long as the landfill still has controls in place. In order to calculate the annualization factors, the EPA assumes that flares, wells, well heads, and engines have a 15-year lifetime. In addition, there is a mobilization/installation charge to bring well drilling equipment on site each time the gas collection system is expanded. Because the landfill will be drilling wells to expand the control system during the expansion lag year, EPA assumes that this capital installation cost has a lifetime equal to the expansion lag time.

A number of the capital costs equations are dependent upon the number of wells at each landfill. In order to estimate the number of wells at each landfill, EPA estimated the number of acres that have been filled with waste for each landfill for each year. We assumed that the percentage of design area filled (acres) would track the ratio of waste in place/design capacity (e.g., is a landfill has a waste-in-place amount equivalent to 40% of design capacity, then 40% of the planned acreage is filled). EPA assumed that each landfill would install one well per acre and that the number of wells would increase periodically based on expansion lag time.

Engines are assumed to be installed only at landfills that produce enough LFG to power the engine and only when the electricity buyback rates allow the operation of the engine to be profitable. Standard engines used at landfills have approximately 1 MW capacity, which equates to 195 million ft^3 per year of collected LFG (at 50 percent methane). Therefore, engines are assumed to be installed at landfills that have at least 195 million ft^3 per year of collected LFG for at least 15 years.

EPA calculated and summed the engine capital and operation and maintenance (O&M) equations to determine at what electricity buyback rate an engine is profitable. The profitable electricity buyback rates are rates that are greater than $0.0457 per kWh at 7%. Engines were only assumed to be installed in states with buyback rates exceeding those values.

Multiple engines may be present at a landfill when there is sufficient gas flow to support additional engines. As noted above, one engine requires 195 million ft^3 per year of collected LFG, so in order to have two engines on-site, the landfill must have double that amount of LFG (390 million ft^3 per year) for at least 15 years.

The capital costs for engines are based on the capital costs for standard reciprocating engine-generator sets in LFGcost. These costs include gas compression and treatment to remove particulates and moisture (e.g., a chiller), reciprocating engine and generator, electrical interconnect equipment, and site work including housings, utilities, and total facility engineering, design, and permitting.

3.5 Regulatory Baseline and Options

As mentioned before, the alternative regulatory options differ from the baseline by varying in the design capacity thresholds and emission rate thresholds:

- **Baseline:** design capacity retained at 2.5 Mg, emission threshold retained at 50 Mg NMOC/year
- **Alternative Option 3.0/40:** raises design capacity to 3.0 Mg and emission threshold to 40 NMOC Mg/yr

- **Proposed Option 2.5/40:** design capacity retained at 2.5 Mg, lowers emission threshold to 40 NMOC Mg/yr
- **Alternative Option 2.0/40:** lowers design capacity to 2.0 Mg, emission threshold retained at 40 Mg NMOC/year

The baseline reflects the parameters of the current NSPS. In the baseline, the NSPS affects 17 new landfills, meaning that 17 of the 21 model landfills predicted using the methods described earlier meet the design capacity thresholds of each option and would at a minimum have to report their emissions during this period. In the baseline, 8 of these landfills would also install controls by 2023. Additionally, while not quantified, the costs associated with the additionally proposed changes to address other regulatory issues and clarifications are expected to be minimal.

Based on the characteristics of the projected landfills, the additional options presented in Table 3-1 would require 11 landfills to install controls by 2023. Thus, 11 landfills would incur costs and achieve emission reductions by 2023 under all of the more stringent options, compared with 8 landfills under the baseline option.

Table 3-1 Number of Affected New Landfills under the Baseline and Alternative Options

	Affected New Landfills (no.)		
	Landfills Affected*	Landfills Reporting but Not Controlling Emissions	Landfills Controlling Emissions
Current NSPS = 2.5 million Mg and m^3 design capacity and 50 Mg/yr NMOC			
Baseline	17	9	8
Incremental values versus the current NSPS			
Alternative option 3.0/40	0	-3	3
Proposed option 2.5/40	0	-3	3
Alternative option 2.0/40	1	-2	3

* Not all new projected new landfills are predicted to be affected by the NSPS in the baseline.

Although only three additional landfills require control in the alternative options when compared to the baseline, each of these options would reduce emissions from other landfills because lower NMOC emission thresholds would subject landfills to the control requirements at an earlier date.

Under the proposed option 2.5/40 and the two alternative options considered (alternative options 3.0/40 and 2.0/40), three additional landfills would be required to install controls by 2023. The reductions achieved under each option are the same because each option has the same NMOC threshold trigger of 40 Mg/yr. The corresponding emission reductions would be an additional 79 Mg NMOC, 12,000 Mg methane, and 308,000 Mg CO_2-e compared the baseline in 2023. The wide range in magnitude of emission reductions among pollutants is due to the composition of landfill gas: NMOC represents less than 1 percent of landfill gas, while methane represents approximately 50 percent. Each of these options represents approximately a 13 percent reduction beyond the current NSPS.

Table 3-2 Estimated Annual Average Emissions Reductions for the Baseline and Alternative Options

	Annual Average Reduction (Mg)		
	NMOC	Methane	Methane (in CO_2-equivalents)*
Current NSPS = 2.5 million Mg and m^3 design capacity and 50 Mg/yr NMOC			
Baseline	610	95,000	2,400,000
Incremental values versus the current NSPS			
Alternative option 3.0/40	79	12,000	308,000
Proposed option 2.5/40	79	12,000	308,000
Alternative option 2.0/40	79	12,000	308,000

*A global warming potential of 25 is used to convert methane to CO_2-equivalents.

Under the proposed option 2.5/40 and the alternative option 3.0/40, the additional cost in 2023 would be $471,000 (Table 3-3). The cost is identical for these two options because all of the projected new landfills that exceed the NMOC thresholds have a design capacity greater than 3.0 million Mg. Based on the characteristics of recently constructed landfills, it is likely that most new landfills will be larger sites and therefore reducing the design capacity threshold is not likely to have any impact. The 2023 cost of alternative option 2.0/40 is only $1,700 higher, at $473,000 due to additional reporting costs for one landfill that is projected to exceed the lowered design capacity thresholds but not the NMOC threshold. All of these options represent approximately 17 percent in additional costs beyond the baseline.

Table 3-3 Estimated Engineering Compliance Costs for the Baseline and Alternative Options

	Estimated Annualized Net Cost (2012 dollars)			
	Testing and Monitoring Costs	Control Costs	Revenue from Beneficial Projects	Net Cost
Current NSPS = 2.5 million Mg and m^3 design capacity and 50 Mg/yr NMOC				
Baseline	66,000	24,000,000	21,300,000	2,700,000
Incremental values versus the current NSPS				
Alternative option 3.0/40	6,000	3,200,000	2,700,000	471,000
Proposed option 2.5/40	6,000	3,200,000	2,700,000	471,000
Alternative option 2.0/40	7,600	3,200,000	2,700,000	473,000

Note: all total are independently rounded and might not sum.

In terms of cost effectiveness, the overall average cost effectiveness for NMOC reductions is $4,400 per Mg NMOC under the baseline and $6,000 per Mg NMOC under the proposed option 2.5/40 and alternative option 3.0/40 (Table 3-4). For alternative option 2.0/40, however, there are additional reporting requirements for one landfill affected by this option that would result in marginally higher actual cost effectiveness than the proposed option 2.5/40. The docketed memo "Methodology for Estimating Testing and Monitoring Costs for MSW Landfill Regulations. 2014." contains the details for determining the costs that a landfill would incur to conduct testing and monitoring.

Table 3-4 Estimated Cost-effectiveness for the Baseline and Alternative Options

	Cost-effectiveness (2012 dollars per Mg)*		
	NMOC	Methane	Methane (in CO_2-equivalents)*
Current NSPS = 2.5 million Mg and m^3 design capacity and 50 Mg/yr NMOC			
Baseline	4,400	29	1.1
Incremental values versus the current NSPS			
Alternative option 3.0/40	6,000	38	1.5
Proposed option 2.5/40	6,000	38	1.5
Alternative option 2.0/40	6,000	38	1.5

Note: The cost-effectiveness of NMOC and methane are estimated as if all of the control cost were attributed to each pollutant separately.

The average cost-effectiveness of controlling methane is significantly lower than for NMOC because methane constitutes approximately 50 percent of landfill gas, while NMOC represents less than 1 percent of landfill gas.

The EPA considered even more stringent alternatives in its analysis of control options that may achieve additional reductions of NMOC and methane. For example, reducing the NMOC threshold further from the 40 Mg/yr in option 2.0/40 to 34 Mg/yr in an alternative option 2.0/34 would achieve additional NMOC and methane reductions over the next 10 years. Additional emission reductions would be achieved because the lower NMOC threshold would require earlier installation of controls. The average annualized cost to implement alternative option 2.0/34 would be higher than proposed option 2.5/40 over a 10-year period.

4 ECONOMIC IMPACT ANALYSIS AND DISTRIBUTIONAL ASSESSMENTS

4.1 Economic Impact Analysis

The impacts shown of the proposal reflect the incremental difference between facilities in the baseline and for an option that reduces the NMOC emission rate threshold to 40 Mg/yr from the current NSPS level of 50 Mg/yr (proposed option 2.5/40). The proposal retains the design capacity threshold of 2.5 million Mg or 2.5 million cubic feet.

Because the proposed option 2.5/40 tightens the criteria for installing and expanding the gas collection and control system, there are incremental costs associated with capturing and/or utilizing the additional LFG under this more stringent option. These costs were shown in Section 3 of this EIA to be about $471,000 in 2023.

Because of the relatively low cost of proposed option 2.5/40 and the lack of appropriate economic parameters or model, the EPA is unable to estimate the impacts of the options on the supply and demand for MSW landfill services. Additionally, while not quantified, the costs associated with the additionally proposed technical amendments to address other regulatory issues and clarifications are expected to be minimal.

Because the relatively low incremental costs of the proposed option 2.5/40, the EPA does not believe the proposal would lead to changes in supply and demand for landfill services or waste disposal costs, tipping fees, or the amount of waste disposed in landfills. Hence, the overall economic impact of the proposal should be minimal on the affected industries and their consumers.

4.2 Small Business Impacts Analysis

The Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) generally requires an agency to prepare a regulatory flexibility analysis of any rule subject to notice and comment rulemaking requirements under the Administrative Procedure Act or any other statute, unless the agency certifies that the rule will not have a significant economic impact on a substantial number of small entities. Small entities include small businesses, small governmental jurisdictions, and small not-for-profit enterprises.

After considering the economic impact of the final rules on small entities for the proposal, the analysis indicates that this rule will not have a significant economic impact on a substantial number of small entities (or "SISNOSE"). The supporting analyses for these determinations are presented in this section of the EIA.

For purposes of assessing the impact of the proposed amendments on small entities, a small entity is defined as: (1) A small business that is primarily engaged in the collection and disposal of refuse in a landfill operation as defined by NAICS codes 562212 with annual receipts less than $35.5 million; (2) a small governmental jurisdiction that is a government of a city, county, town, school district or special district with a population of less than 50,000, and (3) a small organization that is any not-for-profit enterprise that is independently owned and operated and is not dominant in its field.

The analysis provides the EPA with an estimate of the magnitude of impacts the proposal may have on the entities that own facilities the EPA expects might be impacted by the rule. The analysis focuses on small entities because they may have more difficulty complying with a new regulation or affording the costs associated with meeting the new standard. This section presents the data sources used in the analysis, the methodology we applied to develop estimates of impacts, the results of the analysis, and conclusions drawn from the results.

This small entity impacts analysis relies upon a series of firm-level sales tests for entities that are likely to be associated with NAICS code 562212. Because the exact specifications of future landfills are unknown, EPA developed 21 model landfills and assumed that these landfills would be financially and operationally similar to those that have opened in the preceding 10 years. For this analysis, the EPA obtained firm-level employment and revenues for all 21 model landfills from Hoovers, a database of business information. Based on these historical data, the EPA identified four model landfills that would be classified as small entities and none that would be classified as small governments. The EPA then estimated firm-level compliance cost impacts and calculated cost-to-revenue ratios to identify small firms that might be significantly impacted by the rules.

For the sales test, we divided the estimates of annualized establishment compliance costs by estimates of firm revenue. This is known as the cost-to-revenue ratio, or the "sales test." The "sales test" is the impact methodology the EPA employs in analyzing small entity impacts as opposed to a "profits test," in which annualized compliance costs are calculated as a share of profits. The use of a "sales test" for estimating small business impacts for a rulemaking such as this one is consistent with guidance offered by the EPA on compliance with SBREFA[5] and is consistent with guidance published by the U.S. SBA's Office of Advocacy that suggests that cost as a percentage of total revenues is a metric for evaluating cost increases on small entities in relation to increases on large entities.[6]

The small entities subject to the requirements of this proposed rule may include private small businesses and small governmental jurisdictions that own or operate landfills. Although it is unknown how many new landfills will be owned or operated by small entities, recent trends in the waste industry have been towards consolidated ownership among larger companies. The EPA has determined that approximately 10 percent of the existing landfills subject to similar regulations (40 CFR Part 60 subparts WWW and Cc or the corresponding State or Federal plan) are small entities.

Only one of the four small landfills was predicted to be incrementally affected by the proposal in 2023. The screening analysis compared estimated compliance costs in 2023 for the proposal to company sales based on historical data. The ratio of compliance cost to company revenue was 12 percent in 2023 for the incrementally affected small entity.

To determine whether the impacts estimated for 2023 are representative of longer-term impacts to small landfills, the EPA further investigated 30 years of cost information (2014-2043) for the four small model landfills. Over the 30-year time frame, two small landfills are never incrementally affected by the proposal. Descriptive statistics for the two impacted landfills are shown in Table 4-1. One landfill has impacts of up to 12 percent (as described above), but impacts of this magnitude only occur in two years of the 30 years. In general, average impacts over the 30-year timeframe are approximately 1 percent or less and maximum impacts are less than 3 percent. In some years, incremental impacts are negative, indicating that the proposed provisions are less costly than the baseline NSPS.

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[5] The SBREFA compliance guidance to EPA rulewriters regarding the types of small business analysis that should be considered can be found at <http://www.epa.gov/sbrefa/documents/rfaguidance11-00-06.pdf>

[6] U.S. SBA, Office of Advocacy. A Guide for Government Agencies, How to Comply with the Regulatory Flexibility Act, Implementing the President's Small Business Agenda and Executive Order 13272, June 2010.

Table 4-1. Descriptive Statistics for Impacts to Small Entities, 2014-2043

		2014-2023	2024-2033	2034-2043
Future Landfill 9	Average	-	0.9%	-0.01%
	Minimum	-	-	-0.01%
	Maximum	-	2.3%	-0.01%
Future Landfill 19	Average	1.2%	0.8%	0.0%
	Minimum	-	-3.2%	-2.7%
	Maximum	11.9%	11.9%	2.8%

The impacts presented in Table 4-1 do not include testing and monitoring costs because this information is only available for 2023. Because these are low relative to the other costs of the rule, we do not expect this would impact the overall conclusions of the analysis. Additionally, impacts are calculated for all years using a single year of revenue for the model landfill. The actual impacts will be affected by future changes in revenue.

Based upon this analysis, we conclude there will not be SISNOSE arising from this proposal. First, these proposed revisions do not impact a substantial number of small entities. Only two small entities are potentially impacted, which does not constitute a substantial number. Additionally, the impacts to these small entities are not significant. Only one of the two landfills has impacts greater than 3 percent of sales in two of the 30 years examined. The costs incurred by small entities are the result of having to install controls earlier than would have been the case under the existing NSPS. (These costs would have been incurred in later years under the existing NSPS.) There will continue be a lag between the opening of the landfill and the implementation of controls during which the site will be generating revenue through tipping fees. This analysis only considers control costs and revenues associated with the collection of landfill gas and does not estimate the future collection of tipping fees which will be set at a level adequate to plan for known, future requirements.

Given the trend toward larger landfills owned by large entities, it is likely that there will be fewer small landfills in the future than in data from the past five years. Additionally, while we assume that the new landfills will be financially and operationally similar to recently opened landfills, numerous factors could influence the actual size, location, and revenue of landfills that open in the future. The model landfills are based on landfills currently in operation that will not be subject to the proposed revisions. All small landfills that will be subject to these proposed revisions will make decisions about their development and operations with full knowledge of the requirements proposed.

Although not required by the RFA to convene a Small Business Advocacy Review (SBAR) Panel because the EPA has now determined that this proposal would not have a significant economic impact on a substantial number of small entities, EPA had originally convened a panel to obtain advice and recommendations from small entity representatives potentially subject to this rule’s requirements. The panel was not formally concluded; however a summary of the outreach conducted and the written comments submitted by the small entity representatives that the SBAR Panel consulted can be found in the docket for this rulemaking.[7] Although this proposed rule will not have a significant economic impact on a substantial number of small entities, the EPA nonetheless has tried to reduce the impact of this rule on small entities.

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[7] See Docketed memorandum: Small Entity Outreach. 2014.