HELPING LANDFILL OWNERS ACHIEVE EFFECTIVE, LOW-COST COMPLIANCE WITH FEDERAL LANDFILL GAS REGULATIONS

Work Assignment 1-2, Task 6

Submitted To:

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This document is intended to be an implementation aid for landfill owners and operators. This document does not affect in any way the requirements of the regulations as promulgated on March 12, 1996. Any questions or conflicts between the regulations and this document should be directed to:

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SECTION 1.0 INTRODUCTION

Background

Until recently, emissions of landfill gas--comprised mainly of methane, carbon dioxide, and nonmethane organic compounds (NMOCs)--were not subject to federal regulation. These emissions are now regulated under the Clean Air Act as a result of the landfill New Source Performance Standards (NSPS) and Emissions Guidelines (EG), promulgated by the U.S. Environmental Protection Agency (EPA) on March 12, 1996 (hereinafter "the landfill rule"). Affected municipal solid waste landfills must collect and combust their landfill gas (LFG). There are two compliance options under the landfill rule--installation of a LFG collection system and flare, or installation of a LFG collection system and an energy recovery system.

Due to high methane concentration (typically 40 to 60 percent), landfill gas is a valuable source of fuel. Therefore, the landfill rule presents landfill owners with a unique opportunity to reduce the cost of compliance by converting their methane into energy. EPA can help owners and operators examine the options for profitable gas-to-energy applications through its Landfill Methane Outreach Program (LMOP). The LMOP's mission is to reduce methane emissions from landfills by lowering the barriers to and encouraging development of environmentally and economically beneficial LFG-to-energy projects.

Purpose of this Booklet

This booklet provides the basic information that the owner/operator of a municipal solid waste landfill needs to comply with the landfill rule. This booklet provides a simple explanation of the landfill rule and discusses how landfill gas-to-energy can be an attractive compliance option.

LANDFILL METHANE OUTREACH PROGRAM

The LMOP has partnered with state agencies, utilities, the LFG-to-energy industry, financiers and gas end users through one of three LMOP Ally programs:

- The State Ally Program,
- The Utility Ally Program, and
- The Industry Ally Program.

Through membership in the LMOP, Allies receive:

- Public recognition,
- Technical, financial and regulatory information, and
- Promotion of LFG-to-energy as an economically and environmentally beneficial technology.

The LMOP can help landfill owners and operators affected by the landfill rule identify the best options for achieving maximum environmental protection under the landfill rule at the lowest possible cost.

For the full text of the landfill rule, see Federal Register, March 12, 1996 (Volume 61, Number 49), 40 CFR Parts 51, 52, and 60.

TABLE 1. HOW TO USE THIS DOCUMENT	
Question	**Section to Consult**
• Is my landfill affected by the rule?	Section 2. Determining Applicability Step 1 Is your landfill affected by the landfill rule? Step 2 NSPS or EG - Is your landfill regulated by the NSPS or EG? Step 3 Design Capacity - Does your landfill meet the design capacity threshold? Step 4 Annual NMOC Emissions - What are your landfill's annual NMOC emissions?
• If my landfill is affected, what do I do next?	Section 3. Meeting the Requirements Step 1 Submit Compliance Reports Step 2 Install Gas Collection System Step 3 Destroy LFG at 98 Percent Efficiency Step 4 Operation/Maintenance Step 5 Recordkeeping and Reporting
• What are the deadlines?	Section 4. Meeting the Deadlines
• Could I produce energy from the gas generated at my landfill?	Section 5. Evaluating LFG-to-Energy Options Step 1 Technical Overview Step 2 Making the Economics Work
• How can I find other information regarding the landfill rule and LFG-to-energy?	Section 6. U.S. EPA Landfill Methane Outreach Program Resources

SECTION 2.0 DETERMINING APPLICABILITY

The following sections describe the steps involved in determining whether your landfill is affected by the landfill rule:

Step 1 - Is your landfill affected by the landfill rule?

Step 2 - If so, is your landfill regulated by NSPS or EG?

Step 3 - Does your landfill meet the design capacity threshold?

Step 4 - What are your landfill's NMOC emissions?

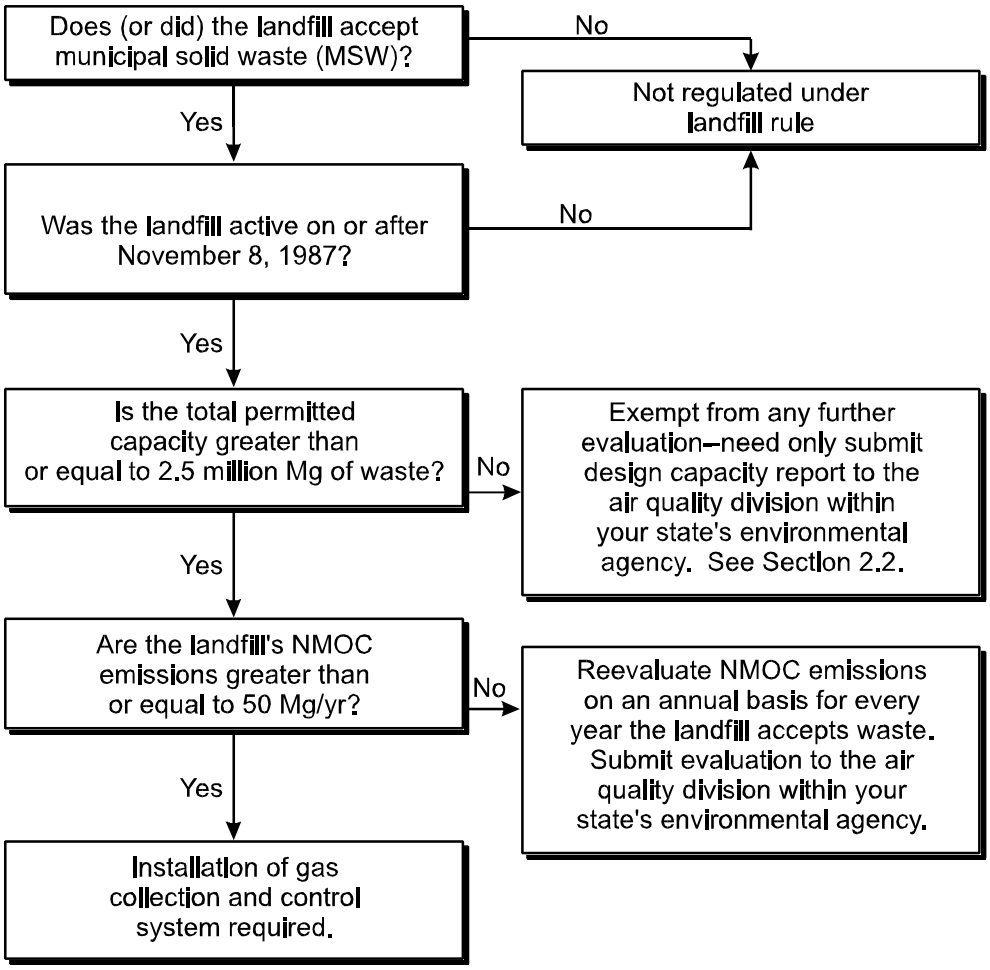
It is critical to remember that your landfill is **not** regulated by the landfill rule unless it meets <u>all</u> of the landfill rule criteria, including:

- Dates of operation;
- Permitted size; and
- NMOC emissions

Step 1: Is Your Landfill Affected by the Landfill Rule?

All municipal solid waste (MSW) landfills that were active on or after November 8, 1987 are potentially affected by the landfill rule. MSW landfills that accepted hazardous waste in the past (i.e., co-disposal landfills) are subject to the landfill rule; however, hazardous waste landfills (RCRA Subtitle C) that accept minimal amounts of municipal waste are not subject to the landfill rule. Figure 1 provides an easy way to determine your landfill's status under the rule.

FIGURE 1
DETERMINING WHETHER YOUR LANDFILL IS AFFECTED BY THE LANDFILL RULE



Step 2: Is Your Landfill Regulated by the NSPS or EG?

Once you have determined that your landfill is affected by the landfill rule, you must determine whether it is regulated by the New Source Performance Standards (NSPS) or Emission Guidelines (EG). Table 2 lists several possible scenarios. Figure 2 can help you determine whether your landfill is considered "new" (and thus regulated by the NSPS) or "existing" (regulated by the EG) under the landfill rule.

The dates that are important in determining whether the landfill is affected by the landfill rule are the date the landfill commenced construction and the dates the landfill has actively accepted waste.

"New landfills" are those that began construction or acceptance of wastes for the first time on or after May 30, 1991 or that made a modification since May 30, 1991 that will increase overall emissions. New landfills are regulated under NSPS and should have submitted initial design capacity reports by June 10, 1996.

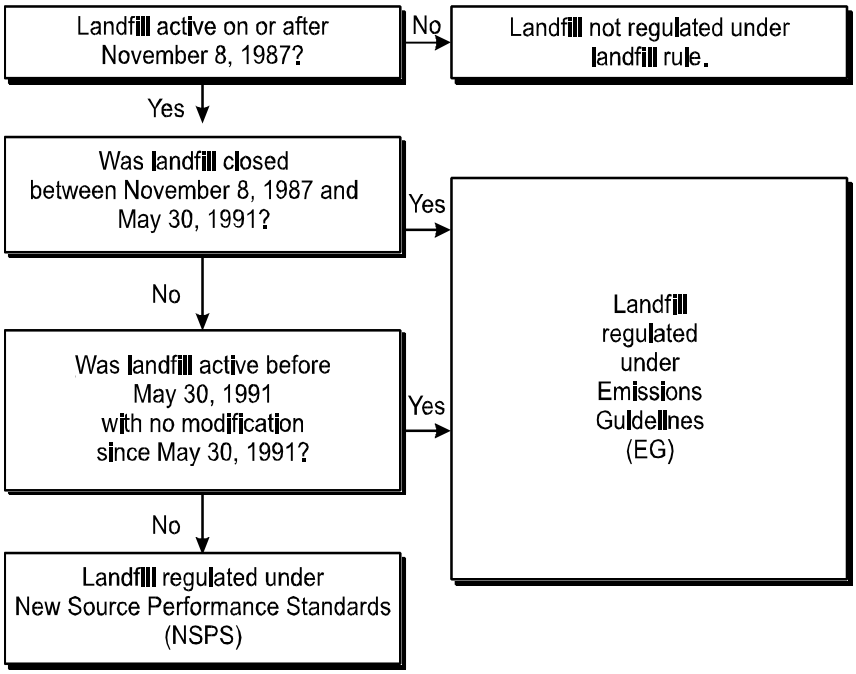
"Existing landfills" are those that were active on or after November 8, 1987 and did not have a design capacity permit modification, or other modification that affects overall emissions, dated since May 30, 1991. Existing landfills are regulated by the EG, and do not have to submit initial design reports until their state develops a plan that is approved by EPA.

The compliance requirements for the NSPS and the EG are basically the same unless a given state decides to alter its state rule from the EG. Each state should have an approved EG by April 12, 1997. Because NSPS is administered by EPA, whereas EG is implemented by the states, the beginning dates for compliance will be different for NSPS and EG landfills. Section 4.0 provides information regarding compliance timelines.

TABLE 2. APPLICABILITY EXAMPLES

Scenario	Regulation
Landfill closed prior to November 8, 1987	Exempt
Landfill closed between November 8, 1987 and May 30, 1991	EG
Landfill active with design capacity permit issued before May 30, 1991	EG
Landfill active with design capacity permit modification issued after May 30, 1991	NSPS
Landfill accepts first waste after May 30, 1991	NSPS

FIGURE 2
DETERMINING IF YOUR LANDFILL IS REGULATED UNDER NSPS OR EG



Step 3: Does Your Landfill Meet the Design Capacity Threshold?

After you have determined whether your landfill is regulated by the NSPS or EG, the next step in determining if your landfill is affected by the landfill rule is to evaluate the landfill's design capacity. If the total permitted capacity is below 2.5 million Mg of waste (2.75 million tons) or 2.5 million cubic meters (3.27 million cubic yards), the landfill is exempt from further evaluation, and you need only submit a design capacity report to the air quality division within your state's environmental agency.

All landfill cells must be converted to the same units. If, for example, one cell was permitted in tons and an active cell was permitted for cubic yards, convert both cells to the same units and add them together. An amended design capacity report and an emissions report will be required if the design capacity of the landfill is expanded to above 2.5 million Mg.

What is a megagram (Mg) or cubic meter?

- 1 Mg = 1.10 tons
- 1 cubic meter = 1.31 cubic yards.

Step 4: What are Your Landfill's Annual NMOC Emissions?

If your landfill is above the design capacity threshold, you must determine the landfill's annual emissions of non-methane organic compounds (NMOCs). The test methods and procedures to determine NMOC emissions are found in §60.754 of the landfill rule. EPA has developed the Landfill Air Emissions Estimation Model (LAEEM) to help landfill owners calculate their NMOC emissions.

The LAEEM model requires basic information about a landfill--e.g., size, age, and annual waste accepting rate--to calculate annual NMOC emissions. If a landfill's NMOC emissions are greater than or equal to 50 Mg/year, the landfill rule requires the installation of a gas collection and control system.[1]

In addition to basic inputs related to the landfill's operating information, the LAEEM model also allows landfill owners to input site-specific values for their landfill's NMOC concentration. It is important to note that the default NMOC concentration provided in the landfill rule is conservative. Therefore, the landfill rule allows landfill owners to test for site-specific NMOC concentration and enter it into the model.[2] If site testing reveals lower NMOC concentration, the resultant annual NMOC emissions that are calculated from this input value will be lower.

If you plan to do the reports and calculations yourself, it is important to obtain a copy of EPA's Landfill Air Emission Estimation Model. It may be downloaded from the OAQPS-TNN Bulletin Board by dialing (919) 541-5742.

[1] The scope of this booklet does not cover system design. Make sure the system is designed to address the specifics of your site; a system designed for a nearby landfill may not be the most effective design for your site. For more information on system design, you should consult the "Enabling Document for the New Source Performance Standards and Emission Guidelines for Municipal Solid Waste Landfills," developed by U.S. EPA, No. EPA-453/R-96-004. This document is available free of charge through EPA's Technology Transfer Network Bulletin Board System under the Clean Air Act Amendment Technical Information area.

[2] This is known as "Tier 2" calculation. By replacing the default NMOC concentration with a site-specific value, the landfill's estimated NMOC emissions may fall below 50 Mg/year and thus exempt the landfill from the requirement to install a gas collection and control system.

If, after running your landfill's inputs through the LAEEM model, your landfill's NMOC emissions are greater than or equal to 50 Mg/yr, the landfill rule allows you to sub-stitute a site-specific gas generation rate for the default value to calculate NMOC emissions (this is known as Tier 3 Analysis).[3]

However, testing for the site-specific gas generation rate is far more costly than testing site-specific NMOC con-centration during Tier 2 analysis. Therefore, it may not be cost-effective to undertake Tier 3 testing.

Sample report forms for the design capacity report and the emission calculation reports are provided in the landfill rule Enabling Document.

Landfills that are affected by NSPS were required to submit reports as early as June 10, 1996. Compliance schedules for landfills regulated by EG depend on the date that the State Plan for implementing EG requirements is approved by the Administrator.

SECTION 3.0 MEETING THE REQUIREMENTS OF THE LANDFILL RULE

Figure 3 (see next page) outlines the requirements for compliance with the landfill rule. The five main requirements for complying with the rule are:

- Submitting compliance reports,
- Installing a gas collection system,
- Destroying the LFG at 98 percent efficiency,
- Adhering to specified operation and maintenance procedures, and
- Following specific recordkeeping and reporting requirements.

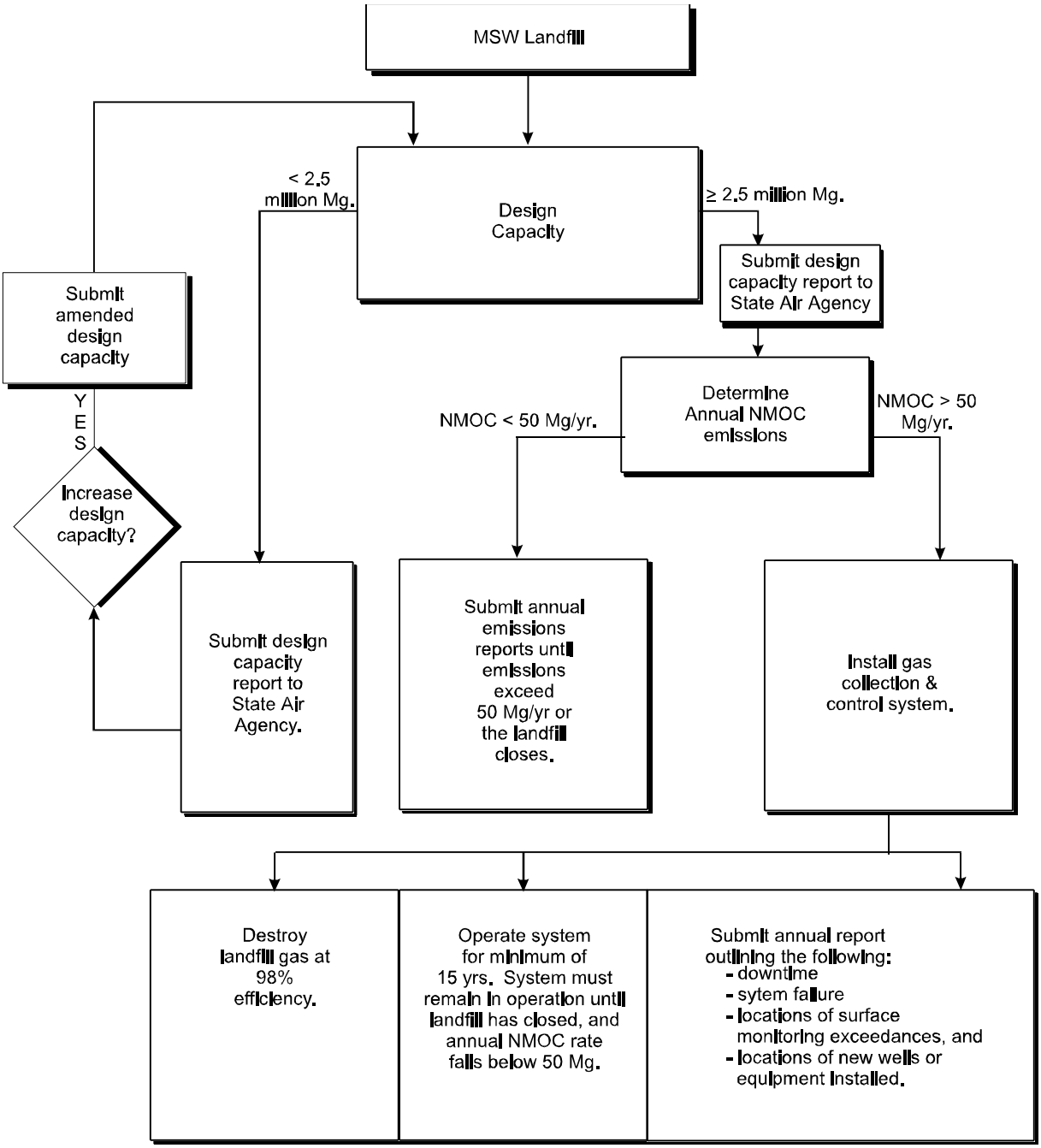
Each of these is discussed in the following sections.

Step 1: Submitting Compliance Reports

As mentioned previously, if a landfill's design capacity is below 2.5 million Mg or its annual NMOC emissions are below 50 Mg, the landfill owner is only required to sub-mit a design capacity report to the State air agency. If the design capacity is at or above 2.5 million Mg, the landfill must submit annual emission reports until emissions exceed 50 Mg/yr or the landfill closes.

[3] By replacing the default gas generation rate with a measured site-specific value, the landfill's estimated NMOC emissions may fall below 50 Mg/year and thus exempt the landfill from the requirement to install a gas collection and control system.

FIGURE 3. THE LANDFILL RULE COMPLIANCE REQUIREMENTS



If you plan to test your landfill's NMOC concentration or gas generation rate (e.g., perform a Tier 2 or Tier 3 analysis), you should begin this process as early as possible to provide sufficient time to evaluate emissions, submit reports, and design the gas mitigation system, if necessary.

If a landfill owner intends to put in a gas collection and control system, the design phase may be commenced at any time and the landfill does not need to test the gas concentration or flow rate. However, knowledge of the gas concentration and expected flow rate provides more information to the engineers designing the system; therefore, early tests could save the landfill owner money in the long run.

Step 2: Installing a Gas Collection System

A typical landfill gas collection system consists of:

- Vertical extraction wells,
- A header system,
- A blower,
- Water (or condensate) knockout equipment, and
- An energy-producing combustion device or gas flare.

Figure 4 shows a typical gas **extraction well**. The extraction wells generally are drilled to approximately 75 percent of the refuse depth. The **header system** is a network of pipes that ties the wells together. The **blower** extracts gas from the wells through the header system to either a **flare** that burns the gas or to an **energy-producing combustion device** (such as internal combustion engines or gas turbines). Because LFG moisture content is much greater than natural gas, **condensate traps** are important to remove condensate that collects in the system. Figure 5 depicts the major components of a collection and control system. It is important to note that LFG mitigation systems generally are tailored to site-specific details. For example, if you plan to install future cells on top of existing cells, horizontal collectors could be placed so that the controls are outside of the refuse. This allows system monitoring and wellhead adjustment to continue even though refuse is placed on top of extraction wells. Additionally, surface extraction wells should be used if the landfill's water level is very high. Vertical wells are more effective in deep (over 40 feet) refuse with a low water level. Installing a synthetic cover reduces cover maintenance, the number of wells required, and the surface monitoring frequency. Professional engineers must certify the design of the LFG collection system. Qualified engineers can help owners/operators reduce costs and insure system reliability.

FIGURE 4. SCHEMATIC OF A TYPICAL GAS EXTRACTION WELL

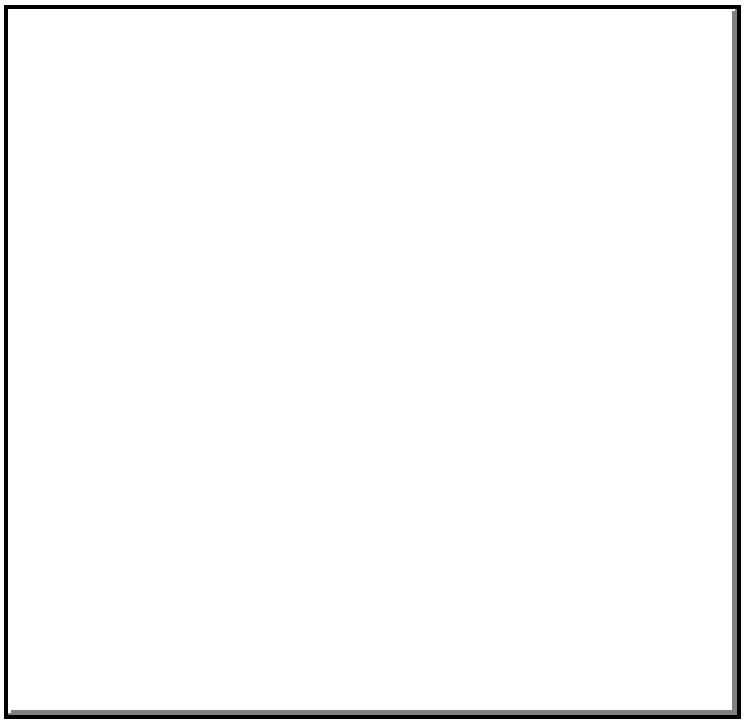


FIGURE 5. SCHEMATIC OF A TYPICAL LFG COLLECTION SYSTEM

Step 3: Destroying LFG at 98 Percent Efficiency

Under the landfill rule, the gas collection and control system constructed is required to destroy the landfill gas at an efficiency of 98 percent. The landfill rule also requires surface monitoring to evaluate collection system efficiency. The two principal LFG destruction methods are LFG energy recovery and flaring. LFG-to-energy should be evaluated at each landfill site to determine whether it is cost-effective, as it offers landfill owners an opportunity to mitigate the costs of compliance with the landfill rule. As with the collection system design, the LFG destruction/control device should be chosen with the landfill's specific characteristics in mind. See Section 5.0 to learn how to evaluate LFG-to-energy at your landfill.

Note that the rule does not require minimum efficiency for the collection system, as it is difficult, if not impossible, to measure.

If energy recovery is not an option, the other acceptable LFG destruction method is to flare the gas. Both open and enclosed flares are acceptable; however, open flares have the following disadvantages: less efficient combustion, aesthetic complaints, and the difficulty of testing emissions. Enclosed flares, on the other hand, while being more expensive, tend to be more reliable and efficient because the landfill operator can adjust the air flow to reduce unburned hydrocarbon and other volatile emissions.

Step 4: Adhering to Operation/Maintenance Procedures

Compliance with the landfill rule extends beyond the installation of a gas collection and control system. Once the gas collection system is operational, it can be shut down only if it has been running at least 15 years, the landfill is closed and the annual NMOC emission rate is less than 50 Mg. Note that all three conditions must be satisfied before a gas collection system can be shut down under the landfill rule.

See the full text of the LF rule for exact specifications for system monitoring (40 CFR Part 60.755). This text is available free of charge through EPA's Technology Transfer Network Bulletin Board System under the Clean Air Act Amendment Technical Information area.

Each LFG well head or trench must be monitored on a monthly basis for pressure, temperature, and gas quality (i.e., concentrations of methane, nitrogen, and oxygen). The operator must also ensure that the system is operating with a vacuum at each extraction point and is operating with minimal air infiltration. In

addition, the operator must monitor the landfill surface regularly to ensure that the methane concentration is less than 500 ppm above background at the surface of the landfill. Both the well monitoring and surface monitoring require certain procedures to correct any unacceptable emissions rates. Such procedures may include wellfield or wellhead adjustments, and/or the installation of additional extraction points.

The Annual Report must outline the following:

- Downtime;
- System Failure;
- Location of surface monitoring exceedances; and
- Location of new wells or equipment installed.

Step 5: Following Recordkeeping and Reporting Requirements

The landfill rule contains specific recordkeeping and reporting requirements, including the type of information that must be recorded from the landfill's monitoring program. The landfill operator must submit an annual report outlining downtime, system failure, locations of surface monitoring exceedances, and locations of new wells or equipment installed. Reports must be kept in accessible files. Consult the rule in the 40 CFR Parts 60.756 and 60.757 for more information on recordkeeping and reporting requirements.

SECTION 4.0 MEETING THE DEADLINES

A timeline for compliance was established for NSPS landfills based on the March 12, 1996 publication date of the final landfill rule. Table 3 lists the important compliance dates for the NSPS. Existing landfills can wait until a timeline is established by their state. However, because it will take approximately one year for states to establish their plans, EG landfill owners can add one year to the following dates to get a rough estimate of what their EG compliance dates might be.

TABLE 3. COMPLIANCE DATES FOR AN NSPS LANDFILL

REPORT/ACTIVITY	DUE DATE
Design capacity and NMOC emission report	06/10/96
NMOC report with gas concentration test(optional)	12/07/96
NMOC report with gas generation rate test (optional)	06/10/97
Design plans for collection and control system	06/10/97
System installation	12/10/98
Performance test/1st annual report	06/10/99

SECTION 5.0 EVALUATING LFG-TO-ENERGY OPTIONS

Step 1: Technical Overview

As discussed in Section 4, the landfill rule requires that collection systems convey LFG to a control device that is capable of destroying 98 percent of NMOC's found in LFG. While landfill owners need only install a flare to comply with the landfill rule, they should investigate the options for energy recovery wherever possible. The Landfill Methane Outreach Program has developed the *Project Development Handbook* specifically to help landfill owner/operators evaluate whether gas-to-energy is an attractive option for their landfill.

Because the LFG is 50 percent methane--a valuable source of energy--collected landfill gas may be harnessed for fuel, which can be sold to mitigate the cost of installing the collection system and can even generate a profit. The most common energy recovery options are local gas use, electricity generation, and pipeline injection.

Assessment of the requirements for energy at the site and in the surrounding area, and evaluation of the project economics help to determine the appropriate option for a specific landfill. Additional information regarding the main energy recovery options is provided below.

Local Gas Use. Local gas use is the simplest and most cost-effective option for using the recovered gas. Medium-Btu LFG is delivered via pipeline from the landfill to nearby equipment, such as boilers and engines. Prior to transporting LFG to a user, condensate and particulates must be removed through a series of filters and/or driers to clean and upgrade the LFG to a minimum of 35 percent methane. The feasibility of this option is generally determined by the distance needed to transport the gas to a potential end user. In general, distances up to 5 miles are feasible. If local gas use appears favorable, the first step is to contact potential end users to determine their interest.

The LMOP's *Project Development Handbook* contains detailed information on LFG-to-energy technology options and costs, assessing project economics, identifying services, and obtaining a permit, among other things, and can be obtained by calling 1-888-STAR-YES (toll free).

Electricity Generation. LFG also can be used to generate electricity for on-site use or for distribution through the local electric power grid. The two most commonly used technologies for generating electricity are internal combustion (IC) engines and gas turbines.

IC engines are stationary engines, similar to conventional automobile engines, that can use medium-quality gas to generate electricity. An advantage of IC engines is that a number of them may be utilized at the start of a recovery project and phased out or moved to alternative utilization sites as gas production decreases. IC engines can also be easily turned on and off and are therefore suitable for supplying intermittent power needs. This flexibility makes IC engines a more attractive option for smaller landfills. One disadvantage of IC engines is that they have higher emissions of nitrogen oxide (NOx) than gas turbines.

Gas turbines typically require higher gas flows and are therefore more suitable at large landfills. Because gas turbines must run constantly, they are used to generate electricity that will be distributed through the electric power grid on a continuous basis. Gas turbines are relatively compact, have low operations and maintenance costs, and have lower emissions of NOx than IC engines.

Emerging technologies for electricity generation, such as steam turbines and fuel cells, are being tested for use with LFG. In addition, some landfills are beginning to use landfill gas as a vehicle fuel, where they convert the LFG into liquified natural gas, compressed natural gas, or methane. Steam turbines consist of a conventional gas/liquid fuel boiler and a generator that produces electricity. They are currently only used at very large landfills--i.e., those where gas flows are greater than five million cubic feet per day (MMcfd).

Fuel cells create energy by combining the hydrogen found in LFG with oxygen in an electrochemical reaction. Their modularity, small capacity, high efficiency, quiet operation, and low environmental impact may make them the ideal technology for power generation with LFG. However, fuel cells are not as cost-effective as the other energy recovery options.

Gas-to-Energy Case Study

Puente Hills Landfill, Whittier, California

Puente Hills is the largest landfill energy recovery power project in the United States. It has been operational since the early 1980s.

The landfill receives 12,500 tons of waste per day, and collects over 30 MMcfd from 400 vertical wells and 50 miles of horizontal collection piping.
The Los Angeles County Sanitation District, which operates the landfill, uses the landfill gas in three ways:

- to generate almost 50 MW of power in a boiler/steam tur-bine configuration, located at the landfill;
- as vehicle fuel, in the form of compressed natural gas;
- as fuel for a boiler at Rio Hondo College, located one mile away.

Upgrade to High-Btu Gas. If a pipeline carrying medium- or high-quality gas is nearby and there is no local gas user available, pipeline injection may be an attractive option. To assess the feasibility of pipeline injection, the proximity, capacity, and gas quality specifications of the pipeline should be determined. Upgrade to high-Btu gas also requires treatment of the LFG to remove carbon dioxide and other impurities. As a result, this option is more expensive than local gas use or electricity generation.

Gas-to-Energy Case Study

The Battleboro Landfill, Vermont

This is one of the oldest landfill gas recovery projects in the country. When energy recovery began in 1983, the landfill contained less than 1 million tons of waste. The approximately 11,000 cubic meters of gas collected per day in the landfill are used in IC engines to generate less than 1 MW of electricity, which is sold to the local utility.

Step 2: Making The Economics Work

EPA estimates that over 700 landfills in the U.S. can cost-effectively install LFG energy recovery systems. Only about 140 projects in the U.S. are currently converting LFG into energy. With the landfill rule in place, many more projects will come online in the next few years. Each landfill owner needs to assess whether they can make the economics work at their landfill. Assessing project economics involves estimating the costs and revenues, developing a cash flow model, and obtaining appropriate financing.

Gas Utilization Costs. Gas or electricity sales offset the total expense of a gas collection system and energy recovery equipment. If your landfill is required under the landfill rule to install a gas collection and control system, you should consider the expenditure as a sunk cost. Costs of recovering and using LFG are dependent on the amount of gas involved and the energy recovery technology used.

Energy Sales Revenues. Depending upon the type of energy produced, a landfill owner may realize one of several revenue streams, as seen in Table 4.

Financing Approaches. There are several sources of capital for landfill gas-to-energy projects, including private equity financing, project financing, municipal bonds, or direct municipal funds. In addition, EPA is working with utilities and states to develop innovative and alternative financing mechanisms.

The LMOP has developed "E-Plus" software which helps landfill owners assess the economic potential of various LFG-to-energy options at their landfill. To order this software, call toll free 1-888-STAR-YES (1-888-782-7937)

TABLE 4. ENERGY RECOVERY COST COMPARISON

Energy Recovery Option	Equipment	Approximate Price	Potential Revenues
Local Gas Use	Gas Utilization Equipment (boilers, engines, etc.)	$120,000 for 10,000 lb/hr boiler to $300,000 for an 80,000 lb/hr boiler	The savings that are achieved by offsetting energy purchases. Typical gas price: $2 - $5 per MMBtu
	Pipeline	$100,000 - $200,000 per kilometer	
	Operation & Maintenance (O&M)	Similar to O&M costs associated with using conventional fuels	
Electricity Generation	IC Engines (including auxiliary equipment, interconnections, gas compressor, construction, and engineering)	$900 to $1,200 per net kW output	Electric Buyback Rate: $0.02/kWh to $0.06/kWh Displacement of On-Site Energy Purchases Thermal Energy Revenues: $1.5/MMBtu to $6/MMBtu for steam Tax Credits/Subsidies
	Gas Turbines (including auxiliary equipment, interconnections, gas compressor, construction, and engineering)	$1,100 to $1,300 per net kW output (for landfills with less than 5 million tons waste in place)	
	Operating Costs	$0.01 to $0.025 per kWh of electricity produced	
Pipeline Injection	Pipeline Construction	$100,000 - $200,000 per kilometer	Local distribution companies will purchase processed LFG for same price as natural gas. Typical gas price: $1.5 to $3.0 per MMBtu
	Gas Cleaning and Compression Equipment	$25,000 per m^3/minute of gas flow (assuming LFG is 50 percent methane)	
	Operating Costs	$600 per hp (for compression costs - 7.2 hp/m^3/min is required to compress the gas to 100 psi)	

Sources: U.S. EPA (1995), *Turning a Liability into an Asset: A Landfill Gas-to-Energy Project Development Handbook*, Atmospheric Pollution Prevention Division, Office of Air and Radiation, Washington, DC, 1995.

U.S. EPA (1996), *A Guide for Methane Migration Projects, Gas-to-Energy at Landfills and Open Dumps*, Atmospheric Pollution Prevention Division, Office of Air and Radiation, Washington, DC, 1996.

- Private Equity Financing - Private equity financing involves an investor who is willing to fund part or all of the landfill gas-to-energy project in return for a significant share of project ownership. Potential equity investors include equipment vendors, fuel suppliers, and industrial companies. Landfill owners should keep in mind that equity investors will likely expect to receive benefits--such as equipment sales, service contracts, or energy supplies--in addition to a portion of the project's cash flow.

- Project Finance - Project finance is a method for obtaining commercial debt financing where lenders look to a project's projected revenue stream rather than the assets of the developer/sponsor to ensure repayment. The biggest advantage of project finance is the ability to use others' funds for financing without giving up ownership control. The best opportunities for landfill gas projects to secure project financing are generally with the project finance groups at smaller investment capital companies, banks, and law firms, or at one of several energy investment funds. The primary disadvantages of project finance are the high transaction costs and lender's high minimum threshold for investment.

- Municipal Bond Financing - Municipally owned landfills occasionally issue tax-preferred municipal bonds to finance gas-to-energy projects. The biggest benefits of using this financing method are that it is the most cost-effective financing method--the resulting debt has an interest rate that is often 1 to 2 percent below commercial debt--and the debt repayment can be extended over the life of the facility (typically 20 or more years). Terms for securing municipal bond financing vary according to the type of bond, method of qualification and the state or municipality in which the bond is issued. The primary disadvantage of municipal bond funding is the barriers faced by municipalities in issuing bonds.

Assess Project Economics

- Cost Analysis: develop estimates for capital costs, operations and maintenance expenses.
- Benefits Analysis: compare revenues generated, emissions avoided.
- Create an analysis of cash flows.
- Compare project costs and benefits to assess economic feasibility.
- Compare options.

- Direct Municipal Funding - Landfill gas energy projects can also be funded directly through the operating budget of a city, county, landfill authority, or other municipal government. The advantages of this financing method are that it eliminates interest charges on project debt and has less lender due diligence requirements; the disadvantage is that municipalities may face difficulties raising revenues.

- Other Options - The LMOP is also working with its State and Utility Allies to develop sources of financing for LFG-to-energy projects. For example, the LMOP is currently investigating the feasibility of state-sponsored revolving funds for landfill gas-to-energy projects. These funds could be capitalized through the issuance of tax-exempt bonds and would offer low interest loans to landfill owners looking to finance landfill gas collection and energy recovery systems. The fund would "revolve," that is, continue to supply financing to new landfill gas projects as previous projects make good on their loans.

Examples of Capital Cost Elements

- LFG Equipment
- Construction
  - Wellfield
  - Blower Station
  - Other Construction
- Emissions Controls
- Interconnections
- Gas Compression and Treatment
- Engineering
- Soft Costs

Tax Credits and Incentives. Tax credits and federal incentive payments can significantly improve project economics. Currently, Section 29 of the Internal Revenue Code offers tax credits for the recovery and use of landfill gas. Additionally, the U.S. Department of Energy's Renewable Energy Production Incentive (REPI) program provides an incentive to publicly-owned facilities that generate electricity from renewable energy sources (including landfill gas.)

- Section 29 - The Section 29 tax credit is available to landfill gas projects that have their collection system installed and in operation by July 1, 1998. The tax credits apply only to landfill gas that is produced and then sold to an unrelated third party. In order to take advantage of Section 29 credits, project developers may create a separate company, or bring in another party. The current value of the credit is $1.005 per MMBtu.

Currently, Section 29 tax credits are only available to projects that signed a gas rights contract by December 31, 1996, and that actually install an operational collection system by June 30, 1998.

- REPI - Section 1212 of the Energy Policy Act of 1992 provides a subsidy of 1.5 cents per kilowatt hour to renewable energy electrical power projects owned by a state or local government or nonprofit electric cooperative. NOTE: The availability of funding for REPI payments is subject to annual appropriation by Congress.

SECTION 6.0 U.S. EPA LANDFILL METHANE OUTREACH PROGRAM RESOURCES

A key objective of the Landfill Methane Outreach Program (LMOP) is to provide landfill owners and operators, developers of landfill gas-to-energy projects, utilities, and other potential project participants with information to increase awareness of project opportunities and enhance understanding of the energy, environmental, and economic benefits of landfill energy recovery. Various technical outreach materials have been developed to overcome informational barriers to the development of energy recovery projects.

Contact the LMOP Hotline or utilize the LMOP Home Page to request outreach materials or to obtain more information. Information currently available through LMOP includes:

- Fact Sheets
  - Utility Ally Program
  - Industry Ally Program
  - Landfill Gas Direct Use
- Documents
  - Landfill Gas-to-Energy Project Development Handbook
  - Landfill Gas Energy Recovery Financing Workshop Proceedings
  - Profiles of Candidate Landfills for Selected States
- Software
  - Landfill Gas Energy Recovery Project Evaluation Software (E-Plus)

For more information, contact:

EPA Landfill Methane Outreach Program
U.S. EPA, 401 M Street, SW,
Mail Stop 6202J
Washington, DC 20460

Hotline: 888-STAR-YES (1-888-782-7937)
Fax: (703) 934-3895

Internet Home Page:
http://www.epa.gov/lmop.html