United States
Environmental Protection
Agency

EPA-600/R-05/047
May 2005

Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide

HANDOUT #1

Introduction

This document provides step-by-step guidance for using the Landfill Gas Emissions Model (LandGEM), a software application with a Microsoft Excel interface that estimates air pollutants and other gases from municipal solid waste (MSW) landfills. Using this document, you will learn how to

- Enter landfill-specific data,
- Choose between site-specific and default model parameters,
- Estimate emission rates, and
- View and print tabular and graphical results.

Overview of How LandGEM Works

LandGEM is an automated tool for estimating emission rates for total landfill gas, methane, carbon dioxide, nonmethane organic compounds (NMOCs), and individual air pollutants from MSW landfills. Landfill owners and operators can use LandGEM to determine if a landfill is subject to the control requirements of the federal New Source Performance Standards (NSPS) for new MSW landfills (40 CFR 60 Subpart WWW), the federal Emission Guidelines (EG) for existing MSW landfills (40 CFR Subpart Cc), or the National Emission Standards for Hazardous Air Pollutants (NESHAP) for MSW landfills (40 CFR Subpart AAAA).

LandGEM can use either site-specific data to estimate emissions or default parameters if no site-specific data are available. LandGEM contains two sets of default parameters.

CAA Defaults—The CAA defaults are based on requirements for MSW landfills laid out by the Clean Air Act (CAA), including the NSPS/EG and NESHAP. This set of default parameters yields conservative emission estimates and can be used for determining whether a landfill is subject to the control requirements of the NSPS/EG or NESHAP.

Inventory Defaults—With the exception of wet landfill defaults, the inventory defaults are based on emission factors in the U.S. Environmental Protection

HANDOUT #1A

INTRODUCTION

LandGEM - Landfill Gas Emissions Model, Version 3.02

U.S. Environmental Protection Agency

Model Design:

Worksheet Name	Function
INTRO	Contains an overview of the model and important notes about using LandGEM
USER INPUTS	Allows users to provide landfill characteristics, determine model parameters, select up to four gases/pollutants (total landfill gas, methane, carbon dioxide, NMOC, and 46 air pollutants), and enter waste acceptance rates
POLLUTANTS	Allows users to edit air pollutant concentrations and molecular weights for existing pollutants and add up to 10 new pollutants
INPUT REVIEW	Allows users to review and print model inputs
METHANE	Calculates methane emission estimates using the first-order decomposition rate equation
RESULTS	Shows tabular emission estimates for up to four gases/pollutants (selected in the USER INPUTS worksheet) in megagrams per year, cubic meters per year, and user's choice of a third unit of measure (average cubic feet per minute, cubic feet per year, or short tons per year)
GRAPHS	Shows graphical emission estimates for up to four gases/pollutants (selected in the USER INPUTS worksheet) in megagrams per year, cubic meters per year, and user's choice of a third unit of measure (selected in the RESULTS worksheet)
INVENTORY	Displays tabular emission estimates for all gases/pollutants for a single year specified by users
REPORT	Allows users to review and print model inputs and outputs in a summary report

IMPORTANT NOTES!

The following user inputs MUST be completed in the USER INPUTS worksheet:

- Landfill open year
- Landfill closure year or Waste design capacity
- Annual waste acceptance rates from open year to current year or closure year

Other Important Notes:

- LandGEM is based on the gas generated from anaerobic decomposition of landfilled waste which has a methane content between 40 and 60 percent.
- When using LandGEM to comply with the CAA, the methane content of the landfill gas must remain fixed at 50% by volume (the model default value).
- Default pollutant concentrations used by LandGEM have already been corrected for air infiltration, as stated in AP-42. If a user-specified value for NMOC concentration is used based on site-specific data, then it must be corrected for air infiltration.
- When comparing results from LandGEM with measurements of extracted gas collected at a site, the landfill owner/operator must adjust for air infiltration prior to any comparisons.
- One megagram is equivalent to one metric ton.

About LandGEM:

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

USER INPUTS

Landfill Name or Identifier:

Clear ALL Non-Parameter Inputs/Selections

1: PROVIDE LANDFILL CHARACTERISTICS

Landfill Open Year		
Landfill Closure Year		
Have Model Calculate Closure Year?	○ Yes ◉ No	
Waste Design Capacity		*megagrams*

Restore Default Model Parameters

2: DETERMINE MODEL PARAMETERS

Methane Generation Rate, k (*year*$^{-1}$)

CAA Conventional - 0.05

Potential Methane Generation Capacity, L_o (*m^3/Mg*)

CAA Conventional - 170

NMOC Concentration (*ppmv as hexane*)

CAA - 4,000

Methane Content (*% by volume*)

CAA - 50% by volume

3: SELECT GASES/POLLUTANTS

Gas / Pollutant #1 — Default pollutant parameters are currently being used by model.

Total landfill gas

Gas / Pollutant #2

Methane

Gas / Pollutant #3

Carbon dioxide

Gas / Pollutant #4

NMOC

Edit Existing or Add New Pollutant Parameters

Restore Default Pollutant Parameters

Description/Comments:

http://www.epa.gov/lmop/

EPA United States Environmental Protection Agency

Landfill Methane Outreach Program

Learn how LFG energy projects reduce methane emissions »

1 2 3 4 5

The U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP) is a voluntary assistance program that helps to reduce methane emissions from landfills by encouraging the recovery and beneficial use of landfill gas (LFG) as a renewable energy resource. LFG contains methane, a potent greenhouse gas that can be captured and used to fuel power plants, manufacturing facilities, vehicles, homes and more. By joining LMOP, companies, state agencies, organizations, landfills and communities connect with a vast network of industry experts and practitioners who support LFG energy project development.

Learn about LFG Energy

- Basic information
- Publications/Software tools
- Project Development Handbook
- *LFGcost-Web*
- Funding Guide
- Answers to frequent questions

Connect with LMOP

- Learn more about LMOP
- Sign up to receive updates from the LMOP listserv
- Request information or technical assistance
- Request data from LMOP
- View workshop and conference presentations

Engage with LMOP Partners

- Join the Program
- View current LMOP Partners and endorsers
- Update Partner information
- Read about LMOP award winners
- Access Partner resources (login)

Examine the Benefits of LFG

- Benefits of landfill gas energy
- LMOP accomplishments

Discover LFG Energy Projects

- Candidate landfills
- Existing operational projects
- LFG energy project profiles
- Project Expo sites

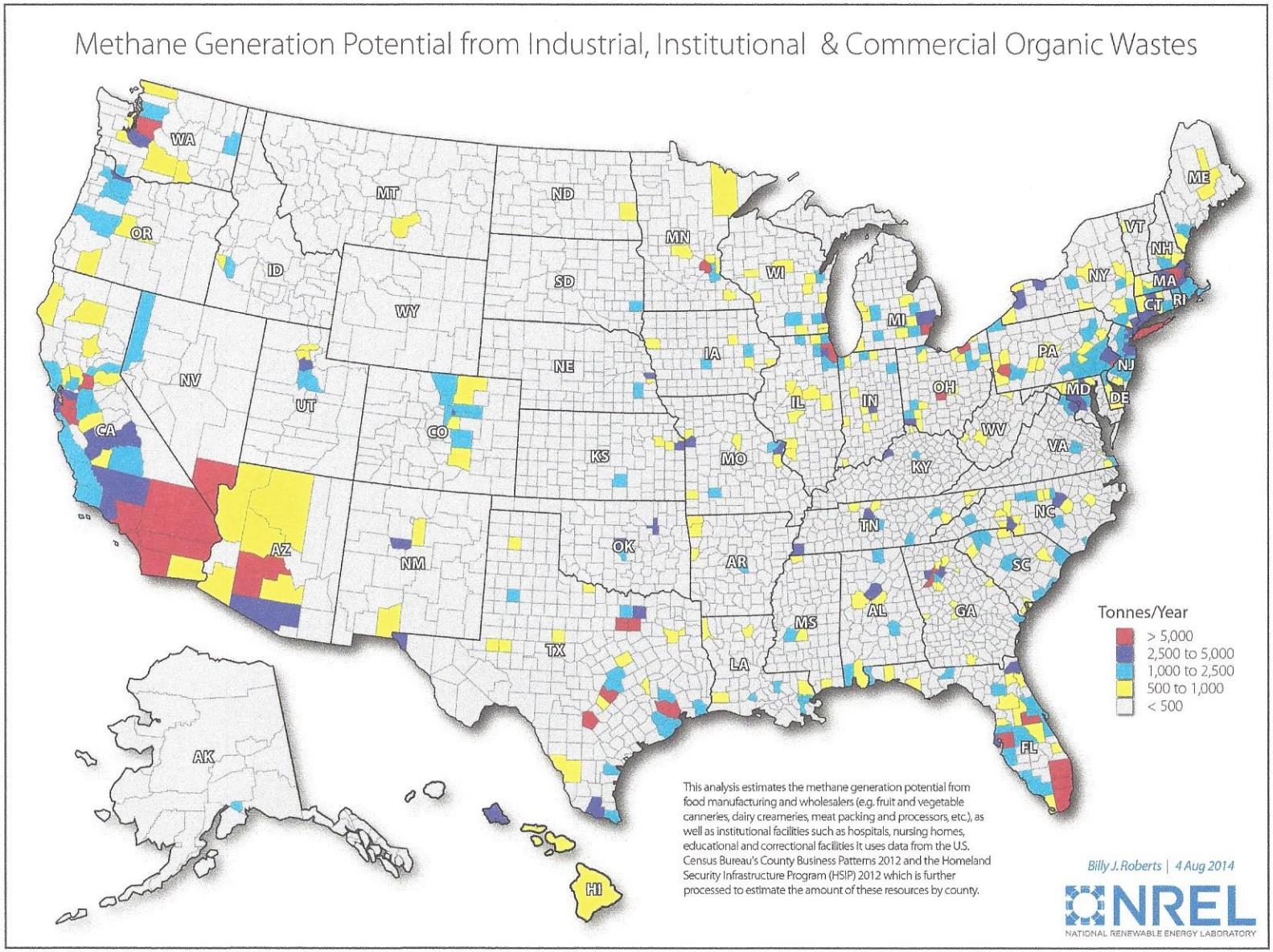
Landfill Gas Energy Projects and Candidate Landfills

What's New

- March 30 – LMOP National Landfill Gas Energy Workshop Presentations Posted
- March 23 – EPA Recognizes LMOP Partners for Landfill Gas Energy Achievements
- March 13 – Data for Energy Projects and Candidate Landfills Updated
- February 18 – New edition of the LFG Energy Project Development Handbook (PDH) Released
- February 6 – Presentation posted for the LMOP Webinar — *LFGcost-Web*
- December 23 – *LFGcost-Web*, Version 3.0, Released

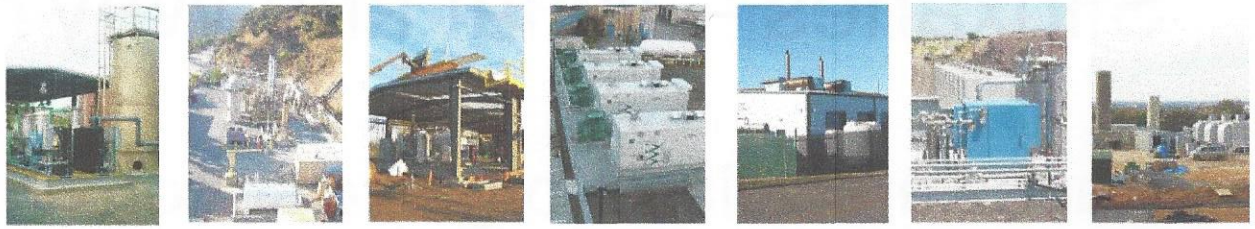
In Focus

HANDOUT #2


Methane Generation Potential from Industrial, Institutional & Commercial Organic Wastes
WA
OR
CA
ID
NV
MT
WY
UT
AZ
CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MS
MI
IN
KY
TN
AL
OH
WV
GA
FL
SC
NC
VA
PA
NY
MD
DE
NJ
CT
RI
MA
VT
NH
ME
AK
HI
Tonnes/Year
> 5,000
2,500 to 5,000
1,000 to 2,500
500 to 1,000
< 500
This analysis estimates the methane generation potential from food manufacturing and wholesalers (e.g. fruit and vegetable canneries, dairy creameries, meat packing and processors, etc.), as well as institutional facilities such as hospitals, nursing homes, educational and correctional facilities It uses data from the U.S. Census Bureau's County Business Patterns 2012 and the Homeland Security Infrastructure Program (HSIP) 2012 which is further processed to estimate the amount of these resources by county.
Billy J. Roberts | 4 Aug 2014
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

HANDOUT #3

SCS ENERGY



Siloxane Sampling, Analysis and Data Reporting Recommendations on Standardization for the Biogas Utilization Industry

Jeffrey L. Pierce, P.E.
Senior Vice President
SCS Energy

14th Annual EPA LMOP Conference and Project Expo
January 18-20, 2011
Baltimore, Maryland

HANDOUT #4

Siloxanes – What and Why?

- Siloxanes are volatile organic silicon compounds (VOSCs)
- Widely used in personal health and beauty products and in commercial applications
- Found in the ppmv level in landfill gas and WWTP digester gas
- When burned as a fuel, the silicon (Si) in siloxane oxidizes to silica (SiO_2)
- Silica deposits cause performance and maintenance problems with LFGE equipment

LANDFILL METHANE OUTREACH PROGRAM

Electricity – Combined Cycle
Olinda Alpha LF, Brea, CA

ORANGE COUNTY OC Waste&Recycling
Our Community. Our Commitment.

BROADROCK RENEWABLES™ LLC

DCO Energy

ANAHEIM PUBLIC UTILITIES
ANAHEIM.NET/UTILITIES

- High-efficiency (45%) combined cycle process captures waste exhaust heat from (4) gas turbines to create additional electricity – 32.5 MW total
- 2-stage siloxane removal system & post-combustion SCR for NO_x control
- $10 million ARRA funding & Section 1603 grant
- Annual County revenues ~$2.75 million
- Innovative re-use of water saves 32,000 gal/day

LMOP 2012 Project of the Year

Solar Turbines
A Caterpillar Company

HANDOUT #5