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Superfund Landfill Methane Potential Assessment

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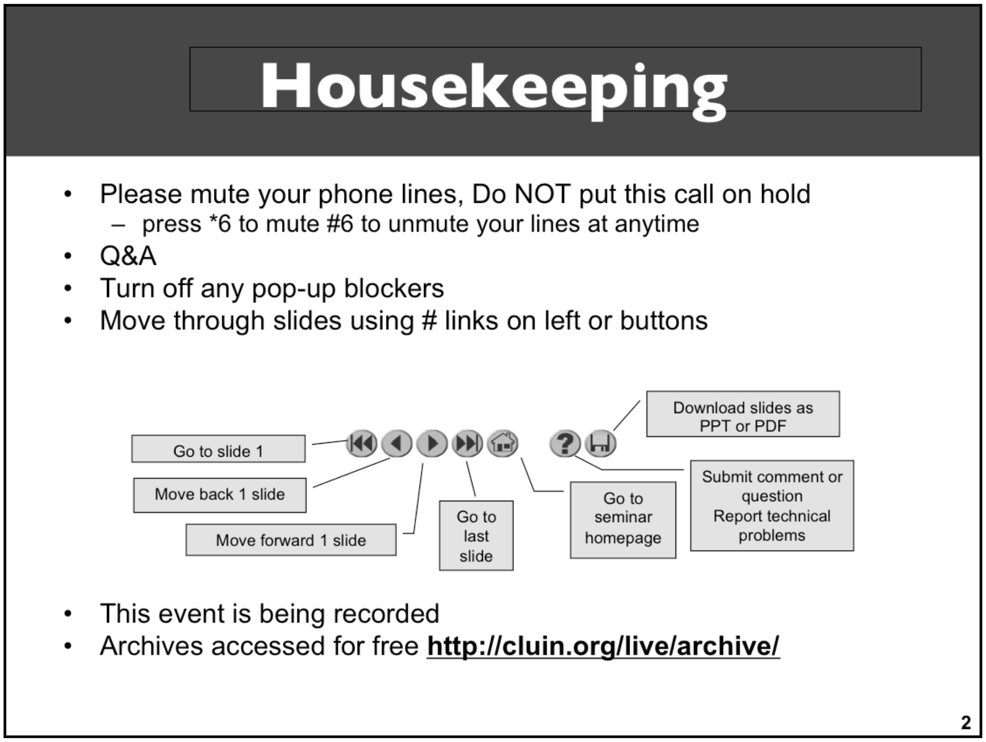

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With that, please move to slide 3.

LFG Energy Project Assessment Tool & LMOP LFG Energy Evaluation of the Fresno Sanitary Landfill

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Goal

- Provide a tool to assist a site manager in assessing the potential cost benefits of using LFG for the production of energy for use on-site or by the surrounding community

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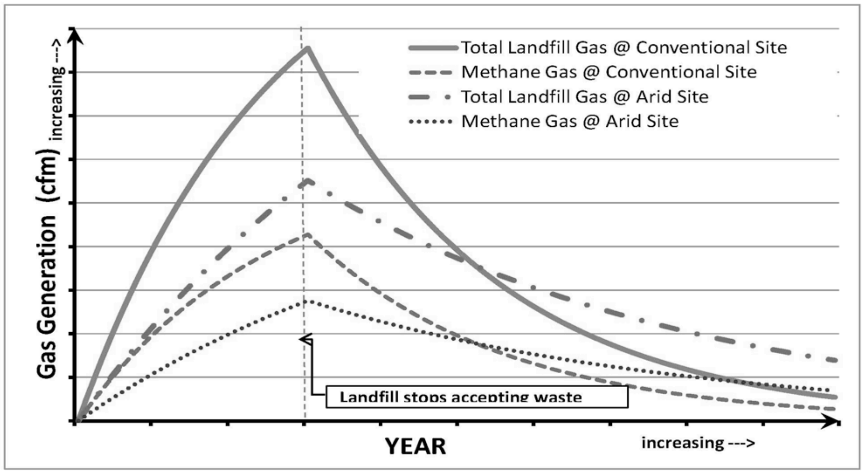
Typical LFG Generation Curves



The gas generation graph depicted does not have values because the actual curves will vary from site to site. What is important to note is that the gas generation drops off after the landfill stops accepting waste. It is important to note that the methane content of the gas is a portion of the total gas; for active and recently closed landfills with properly operated gas collection systems the methane content is typically between 40 and 60 percent. As the landfill ages, the percentage of methane often drops below 40 percent.

The Assessment Tool

- Organized into 4 steps
- Step 1: estimate the LFG supply
- Step 2: assess the adequacy of the gas supply
- Step 3: evaluate the project costs
- Step 4: evaluate options to improve project costs benefits

Determining LFG Generation

- Gas generation potential is a function of
  - Years landfill accepted waste
  - Age of the waste
  - Climate conditions
- Superfund landfill assumptions
  - 60% collection system efficiency
  - 40% methane concentration

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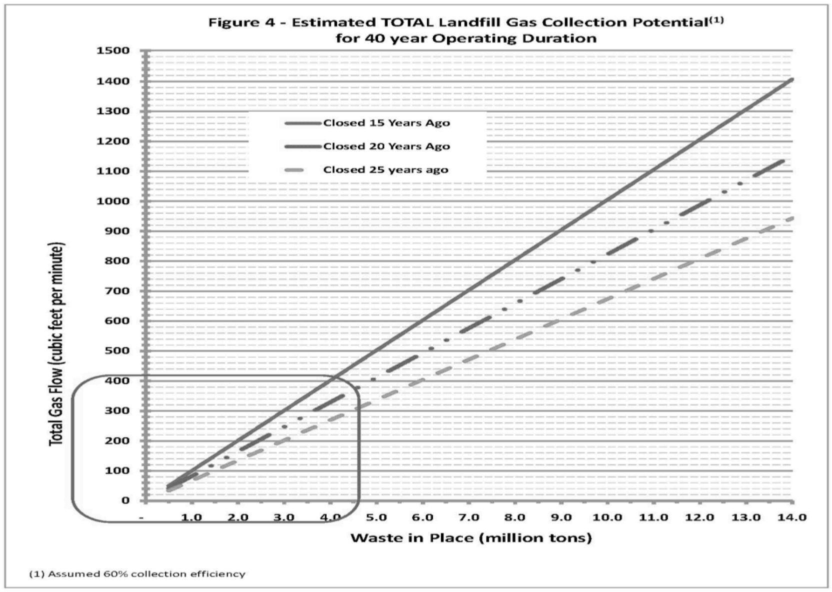
Correlation Between Waste Acceptance Rates and Total Gas Flow



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LFG Energy Project Assessment Tool Assumptions & Conclusions

- LFG modeling assumes a certain methane concentration (models do not calculate it)
- LFG generated by sites with < 1 million tons of waste will be minimal
- The more recent the site has been closed the more gas produced
- If two landfills have equivalent amounts of waste-in-place and similar closure years, the site with the shorter operating period will have higher gas generation rates

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Future Gas Generation Potential & Collection Efficiency

- LFG flow rates decrease about 4% annually after landfill closure
- LFG energy projects are typically sized to 60% (or less) of the initial flow rate
- For Superfund landfills, LFG collection efficiency is assumed to be 60%
  – These sites tend to be unlined or not fully capped with soil
  – Further reductions to collection efficiency may be necessary

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Step 1 – Estimate the Landfill Gas Supply

Site Name: __**Fresno Sanitary Landfill**_

Step 1 - Estimate the Landfill Gas Supply

If the landfill has a gas collection system and the flow rate has been measured in the past couple of years, proceed to Step 2.

Calculate the amount of municipal waste in place.

Line A.1: Solid waste in place (yd^3) = Area of waste (ft^2) x Ave. depth of waste (ft.) x 1 yd^3/27 ft^3

= (__________ x __________) / 27 = ______________

Line A.2: Municipal waste in place (yd^3) = Solid waste in place (yd^3) x Fraction of municipal waste in landfill

= ______8,000,000_____ x ___80%____ = ___6,400,000___*Calculated from Line A.1*

Line A.3: Municipal waste in place (tons) = Municipal waste in place (yd^3) x 0.6 tons/ yd^3

= ____6,400,000_____x 0.6 = ___3,800,000___

Calculated from Line A.2

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Step 1 – Estimate the Landfill Gas Supply (cont.)

Estimate the current methane generation rate

Line B.1: Number of years the landfill accepted waste = ___51___
Line B.2: Number of years since the landfill's closure = ___24___
Line B.3: Current landfill gas generation rate (scfm) = ___260___
(Applying Lines B.1 & B.2 to Figures 2, 3 or 4)

Estimate the future landfill gas generation rate (after ten years)

Line C.1: Future landfill gas generation rate (scfm) = Current landfill gas generation rate (scfm) x 0.60

= _____260________ x 0.60 = _____156______*From Line B.3*

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Assessing Gas Quality

- Gas quality is measured using a LFG analyzer
- LFG projects work best when gas flow rates closely match the end-use demands
- Electricity projects can operate using LFG with as little as 35% methane, although the higher the methane concentration the better (typically >40%)

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Step 2: Assess the Adequacy of the Gas Supply

Step 2 – Assess the Adequacy of the Landfill Gas Generation Rate

A. Assess the Landfill Gas Generation Rate
To determine if landfill gas generation could be adequate to support a commercial-scale methane-to-energy project, proceed to Line A.1. If the landfill gas will be used on-site to generate electricity or feed a combustion device, proceed to Line A.2 or Line A.6, respectively

Line A.1: Is the adjusted future landfill gas generation rate from Step 1 Line C.1 greater than 400 scfm? (*Note: A flow rate of approximately 400 scfm at 40% methane corresponds to the production of 1 MW of electricity or 10 mmBTU/hr of heat***)**

_____ Yes. Commercial sale <u>may be</u> viable if the gas quality is adequate (Proceed to Step 3).

__X___ No. Commercial sale <u>may not be</u> viable. Refer to Step 4 in the Tool Document for potential ways to improve gas flow and/or methane concentration.

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Step 2: Assess the Adequacy of the Gas Supply (cont.)

For generating electricity for use on-site, proceed to Line A.2. For direct use in an on-site boiler or furnace proceed to Line A.6.

<u>For electricity production</u>

Line A.2: Current electric load (kW) = Highest monthly electricity usage (kWh) (Obtained from the utility bill) / 744 hours per month (31 days @ 24 hrs/day)

= ____100,800_______________ / 744 = ___135_________kW

Line A.3: Electricity that can be produced for on-site use (kW) = ____290_____ (Applying Step 1, Line C.1 to Figure 5)

Line A.4: Compare the electricity produced (from Line A.3) to the current electric load (from Line A.2) to determine the percentage of produced electricity that can be utilized on-site. [*Note: The excess electricity might be purchased by the servicing utility and provide a potential revenue stream for the project. The economics of doing so will depend on the utility's buy back rate, the cost of tying into the electric grid, and other factors.*]

<u>For direct use in on-site boilers or furnaces</u>

Line A.6: Current heating demand (mmBTU/hr) = Highest monthly total usage (mmBTU) (Obtained from the local utility bill) / 744 hours per month (31 days @ 24 hrs/day)

= ___________________ / 744 = ___________mmBTU/hr

Line A.7: Energy that can be produced for on-site use (mmBTU/hr) = _______________ (Applying Step 1, Line C.1 to Figure 5)

Line A.8: Compare the Energy (from Line A.6) to the current energy availability (from Line A.7) to determine the percentage of the produced energy that can be utilized on-site.

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Evaluating Project Costs – Electricity Generation

- Electricity generation
  - Requires technology/equipment to compress and dehydrate the LFG
  - Engine generator along with switchgear
- In utilizing LFG for onsite electricity generation, the cost of production must be less than the price paid for electricity
- For landfills planning to sell electricity offsite, the buy back rate must be higher than the production cost

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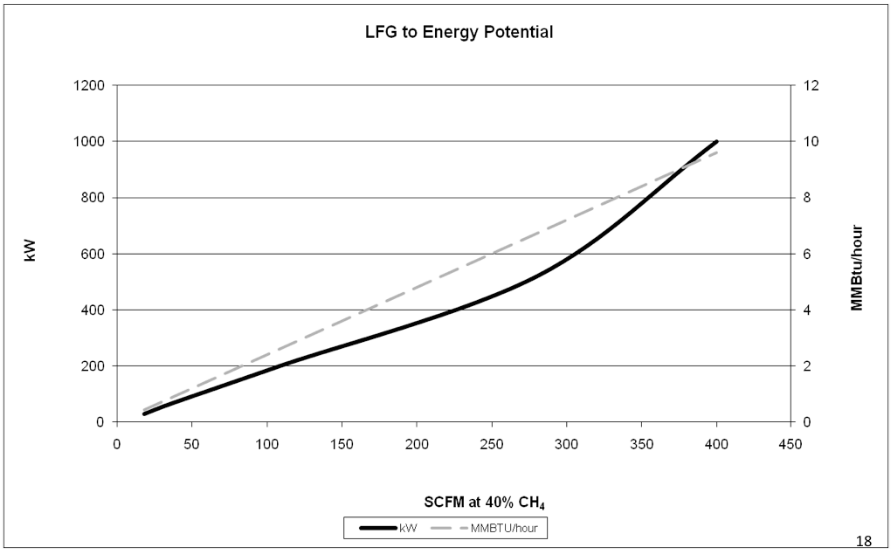
Correlation Between LFG Flow and Energy Potential



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Step 3: Evaluate the Project Costs

Step 3: Evaluate the Project Costs
Figure 6 and Table 1 can be used to estimate the breakeven rate of producing electricity or utilizing gas directly in boilers or furnaces. To estimate the break even rate for producing electricity proceed to Line A.1 and for utilizing the energy content in boilers or furnaces (direct use) proceed to Line A.3.

For Eletricity Generation Projects

Line A.1: Break even rate ($/kWh) = ____**0.125**_____ (Applying Step 2, Line A.3 to Figure 6)

Line A.2: Is the break even rate from Line A.1, above, equal or less than the current electric cost?

____ Yes. The methane-to-energy project may be cost effective.

__X__ **No. The methane-to-energy project may not be cost effective**. Refer to Step 4 in the Tool Document for potential ways to improve gas flow and/or methane concentration.

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Step 3: Evaluate the Project Costs (cont.)

For Non-Commercial Scale Direct Use Projects

Line A.3: Break even rate ($/mmBTU) = _____________________ (Applying Step 1, Line C.1 to Table 1)

Line A.2: Is the break even rate from Line A.3, above, equal or greater than the current natural gas cost that is or would be supplied to the combustor?

_____ Yes. The methane-to-energy project may be cost effective.

_____ No. The methane-to-energy project may not be cost effective. Refer to Step 4 in the Tool Document for potential ways to improve gas flow and/or methane concentration.

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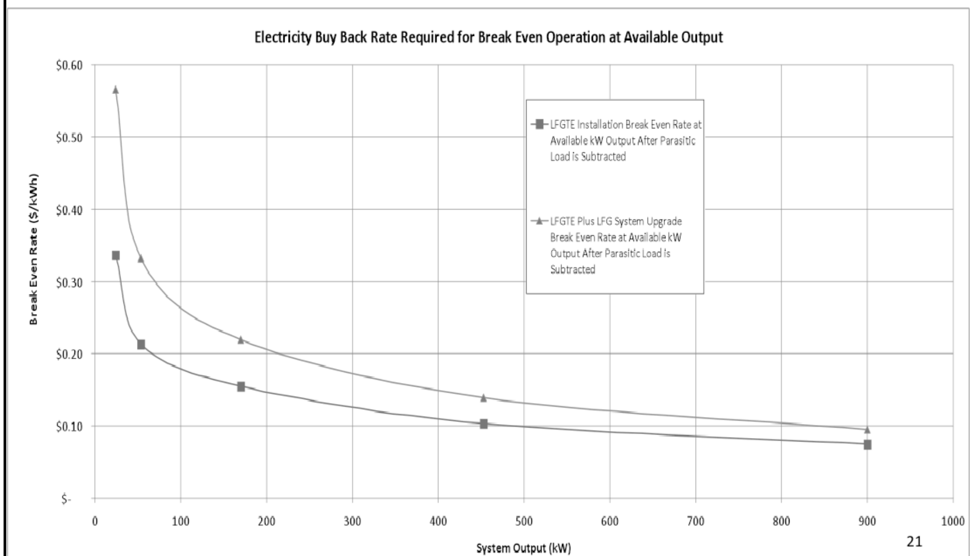
Electricity Buy Back Rate Required for Break Even Operation at Available Output



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Evaluating Project Costs – Direct Use

- Onsite utilization
  - Thermal energy for space heating
  - Use in a heater or boiler

- Offsite utilization
  - Use in heaters or boilers
  - Applications requiring year-around gas flows of at least 300 to 500 scfm typically work best
  - Projects usually require elevated methane concentrations
  - Significant pipeline installation costs – typically the closer the end-user to landfill the more economical the project

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Cost to Produce Landfill Gas for Direct Use Projects

LFG Flow Rate @ 40% CH_4 (scfm)	Pipeline Distance (miles)	Cost to Produce the LFG ($/mmBtu)
100	0.5	12.83
100	1	14.84
100	1.5	16.85
300	0.5	5.33
300	1	6.65
300	1.5	7.33
500	1	4.09
500	2	4.9
500	3	5.71
500	4	6.52

Step 4: Evaluate Options to Improve Project Cost Benefits

- Cost benefits of a LFG project can be improved:
  - Increase the size of the project
  - Use waste heat from the engine/turbine for onsite thermal needs
  - Qualify for grants, tax credits, carbon credits, or other incentive programs

- LMOP maintains a Funding Guide that summarizes incentive programs available to LFG energy projects -- http://www.epa.gov/lmop/publications-tools/funding-guide/index.html

- Additional resources are available from EPA at http://www.epa.gov/renewableenergyland/

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Recommendations for Further Analysis

- Strategies for improving gas quality and collection:
  - Balance the gas collection well field
  - Take gas collection wells offline
  - Reduce water levels in gas collection wells
  - Reduce nitrogen and oxygen
  - Reduce header vacuum and flow
  - Well maintenance
- These measures are not expected to yield significant results (5 to 10% increase in methane concentration)

LANDFILL METHANE OUTREACH PROGRAM

EPA's Landfill Methane Outreach Program

- Established in 1994
- Voluntary program that creates alliances among states, energy users/ providers, the landfill gas industry, and communities

Mission: To reduce methane emissions by lowering barriers and promoting the development of cost-effective and environmentally beneficial landfill gas (LFG) energy projects.

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Landfill Gas 101

- LFG is a by-product of the decomposition of municipal solid waste (MSW):
  - ~50% methane (CH_4)
  - ~50% carbon dioxide (CO_2)
  - <1% non-methane organic compounds (NMOCs)
- For every 1 million tons of MSW:
  - ~0.78 megawatts (MW) of electricity
  - ~432,000 cubic feet per day of LFG
- If uncontrolled, LFG contributes to smog and global warming, and may cause health and safety concerns

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LANDFILL METHANE OUTREACH PROGRAM

Why EPA is Concerned about Landfill Gas

- Why is methane a greenhouse gas?
  - Methane absorbs terrestrial infrared radiation (heat) that would otherwise escape to space (GHG characteristic)
- Methane as a GHG is over 20x more potent by weight than CO_2
- Landfills are the *third* largest human-made source of methane in the United States
- Methane is more abundant in the atmosphere now than anytime in the past 400,000 years and 150% higher than in the year 1750

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LANDFILL METHANE OUTREACH PROGRAM

Fresno Sanitary Landfill Site Characteristics for LandGEM

Landfill Information	Value	Units
Landfill Open Year*	1950	----
Landfill Closure Year	1987	----
Annual Waste Acceptance Rate (in 1987)	430,800	tons/year
Estimated Waste in Place	4,805,670	tons
Annual Rainfall	10.94	inches/year

* For purposes of LandGEM, LMOP assumes a landfill opening year of 1950

LANDFILL METHANE OUTREACH PROGRAM

Fresno Sanitary Landfill LandGEM Input Parameters

Data/Model Parameter	**Value**	**Units**
Estimated LFG Collection Efficiency	83	%
Model k value (methane generation rate constant)	0.020	1/year
Model Lo value (methane generation potential)	3,204	f^3/ton

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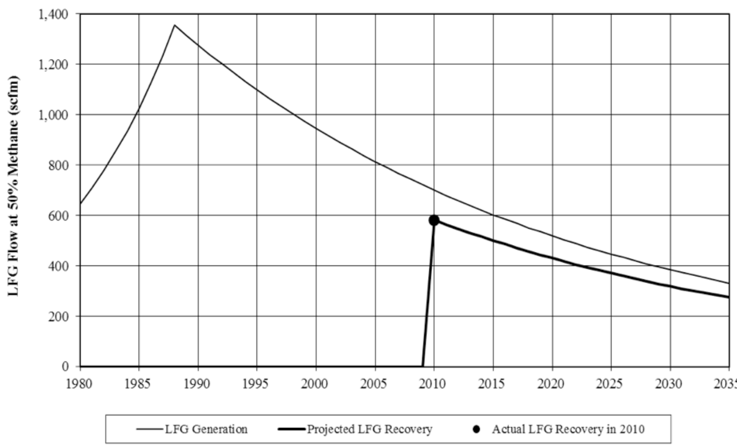
Landfill Gas Generation and Recovery Rates



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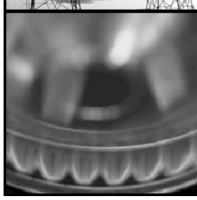


LANDFILL METHANE OUTREACH PROGRAM

LFGcost – Example Inputs and Outputs

INPUTS / OUTPUTS **Enter Landfill Name or Identifier:** Example Landfill

Print Summary Report

Required User Inputs:

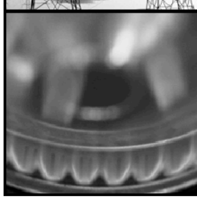
Type of Input Required		Input Data
Year landfill opened		1960
Year of landfill closure		2020
Area of landfill waste for LFG to be collected (acres)		100
Method for entering waste acceptance data [CHOOSE ONLY ONE METHOD]:	Average annual waste acceptance rate (tons/yr)	200,000
	Waste acceptance rate calculator (in WASTE worksheet)	Go to WASTE
	Annual waste disposal history (in WASTE worksheet)	Go to WASTE
LFG energy project type: (D)irect use, (T)urbine, (E)ngine, (L)NG, microtu(R)bine, small en(G)ine, or lea(C)hate evaporator?		E
Will LFG energy project cost include collection and flaring costs? (Y)es or (N)o		N
For leachate evaporator projects only: Amount of leachate collected (gal/yr)		
Year LFG energy project begins operation		2005
Expected LFG energy project lifetime (years)		15

Outputs:

Type of Output	Output Data
Economic Analysis:	
Average project size for projects NOT generating electricity: (million ft^3/yr)	0.000
[based on actual LFG use] (ft^3/min)	0.000
Average project size for projects generating electricity (kWh/yr)	34,992,195
Total installed capital cost for year of construction ($)	$5,493,824
Annual costs for initial year of operation ($)	$696,312
Internal rate of return (%)	14%
Net present value at year of construction ($)	$569,101
Net present value payback* (years after operation begins)	13

LFGcost Assumptions for Fresno Sanitary Landfill

- Microturbine technology
  - Estimated generation capacity of 1 MW
- 35% LFG methane content
- 83% LFG collection efficiency
- 10 year project life
- Assumes project is paid for in cash
  - Financed through budget - no loan
  - Discount rate of 6%
- Assumes an electricity price of $0.06/ kWh



LFGcost Results for Fresno Sanitary Landfill

- Project Type: Microturbine Technology
- Net Present Value: $1,068,202
- Internal Rate of Return: 20%
- Net Present Value Payback: 6 years
- Capital Costs*: $1,484,062
- Annual O&M Costs: $79,680

*Does not include installation costs of GCCS and blower/flare station

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