Usage of Landfill Biogas

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Options for Using LFG

- Electricity production
  - reciprocating engines
  - combustion turbines
  - external combustion engine (future)

- Direct use as a boiler, furnace, or kiln fuel
- Upgrade to pipeline quality gas
- Microturbines and fuel cells
- Niche alternatives
Technology Trends

- **Electricity Generation**
  - Currently 2/3 of US operational projects generate electricity
  - These projects represent over 1,000 MW of capacity
  - 80+ electricity projects in construction or planning

- **Direct Use**
  - Trend toward more direct-use projects
  - 21 operational in 1990
  - 106 operational in 2001
  - Expect dramatic increase in future
Direct Gas Utilization

- Use of LFG as fuel in brick/cement kilns and furnaces
- Gas conveyed to nearby customer for use in boiler
- Space heating (limited)
- Over 75 projects
- Pipelines 1 to 15 miles
LFG Direct Use

◆ **Advantages**
  - Simplest technology
  - Generally, minimal processing requirements
  - Able to use gas as it becomes available
  - Most cost effective
  - Two party agreement
  - Higher priced commodity

◆ **Disadvantages**
  - Requires locating an end user
  - Could require utility status classification
  - Easements may need to run through urban areas
Electricity Generation

- Most prevalent application
- Electricity sold to utility or nearby customer (rare)
- Size: 500 kW to 50 MW
- Caterpillar, Jenbacher, Deutz, Waukesha
- Requires min. gas cleaning
Electricity Generation

- Advantages
  - No local end user needed
  - Power could be used on-site
  - Allows waste heat recovery

- Disadvantages
  - Higher capital and costs
  - Utilities can be difficult to deal with
  - Long term agreement necessary
  - Some markets not competitive enough
Pipeline Quality Gas Upgrade

- **Advantages**
  - Cost effective only for landfills with high gas volumes
  - Beneficial in areas where natural gas prices are high
  - Potential to produce “Dry Ice” (Liquid CO₂) for sale
  - High maintenance requirements

- **Disadvantages**
  - High capital costs due to substantial processing requirements
  - Extensive treatment (remove nitrogen, CO₂, and other constituents)
  - Conform to strict quality specifications
  - Economics only work for large landfills
Gas Price History

Source: Energy Information Administr
Pipeline Quality Gas Upgrade

Technology Advances

- New, lower cost technologies entering the market
- Physical and/or chemical removal of impurities
Pipeline Quality Gas Upgrade

Ukrainian technology installed in Alabama (US)
Simplified Biogaz System
Membrane Module

Raw Feed

$\text{CO}_2, \text{H}_2\text{O}, \text{H}_2\text{S}$

$\text{CH}_4$
Microturbine Overview

- A high speed turbo-charged generator that produces stationary power
- Proven within aviation industry
- Available in sizes ranging between 25 kW to 75 kW
Microturbines

- Advantages
  - Low emissions
  - Multiple fuel capacity
  - Light weight/small size
  - Requires a lower degree of pretreatment than high BTU or fuel cell systems
  - Lower maintenance costs
  - Modules can be linked to increase in gas flow

- Disadvantages
  - Low efficiencies
  - Has been tested mostly for natural gas applications
  - Limited track record of performance
  - Requires gas cleaning
Fuel Cells

- Chemically convert gas to electricity
- Extensively used in NASA space applications
- Demonstration phase for LFG
- May be possible to extract hydrogen
Fuel Cells

**Advantages**

- High efficiency
- Minimal emissions
- Modular
- Mature technology when used with natural gas

**Disadvantages**

- Limited track record of performance on LFG
- Extensive pretreatment required for LFG
- High Cost
Niche Alternatives

- Greenhouses
  - use of CO$_2$
- Vehicle Fuel
  - CNG
  - LNG
- Leachate Evaporation
- Pottery and glass blowing
Summary of Technology Trends

- Growth in direct use projects
- Greater diversity in project types
- Many proven/cost effective ways to use LFG
- Selection of technology is site specific
- Technologies exist for low and high volumes of gas
- Alternatives are emerging