



Part 3 : Conventional and Emerging Technology Applications for Utilizing Landfill Gas

Presented by:

Linda Nutting

SCS Engineers

June 25, 2001

Training Workshop

Sao Paulo, Brazil

Presentation Outline



- Direct Gas Use/Sale
- Electricity Generation
- Pipeline Upgrades
- Leachate Evaporation
- Micro Turbines
- Vehicle Fuel
- Fuel Cells
- Greenhouses
- Other Technologies
- Conclusions



Why Use Landfill Gas?

- Local, available fuel source
- Easy to capture and use
- Source of renewable energy
- Constant supply, 24 hours a day, 7 days a week
- Reliable technologies exist for using landfill gas
- Uses a source of energy that otherwise would have been wasted
- Helps the environment by reducing uncontrolled emissions of landfill gas

Direct Gas Utilization

- Gas piped to a nearby customer for use in boiler
- 118 projects in the US
- Pipeline length range from .6 - 5 kilometers
 - less than 3km is most feasible
- Gas used on-site



Cleaver Brooks 20,000 lb/hr Boiler

Advantages and Disadvantages



- Advantages
 - Simple technology
 - Minimal processing requirements
 - Most cost effective
- Disadvantages
 - Requires locating a customer within close proximity of the landfill
 - Right of way permits
 - Local terrain not conducive to pipeline installation

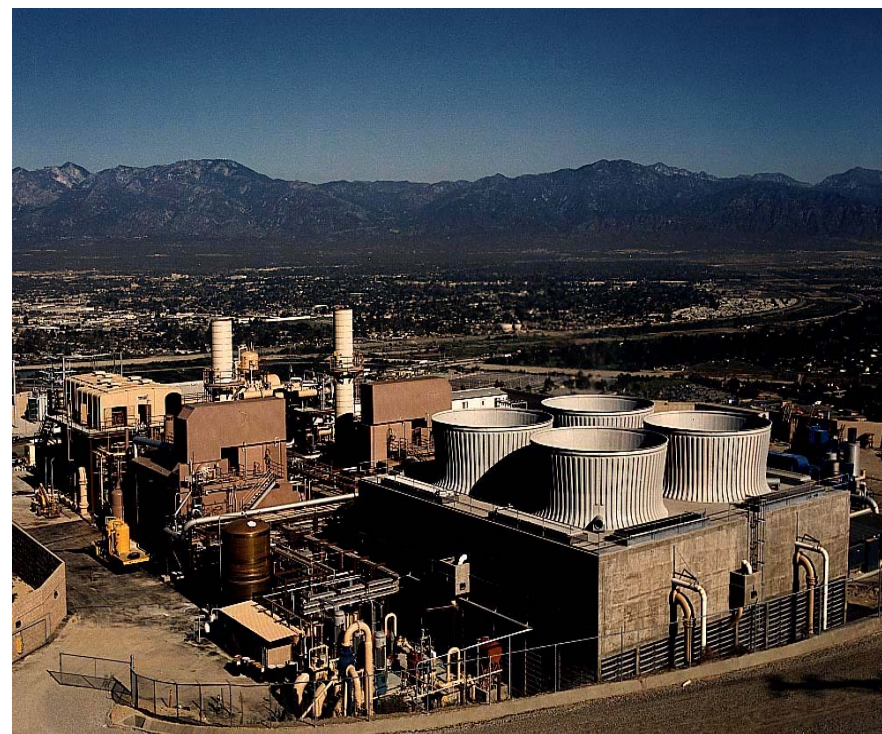
Costs



- US\$1.50 (3.57 Real) to \$3.50 (8.33 Real) per MMBtu, depending on:
 - Pipeline length
 - Collection system in place at landfill
- Other costs
 - Boiler retrofit
 - Operation and Maintenance

Electricity Generation

- Most prevalent in the US
 - In US, 900 MW from over 200 operational projects
- Electricity sold to utility or nearby customer
- Average project size:
500 kW – 50 MW
- Technologies
 - Internal Combustion (IC) Engine, 1-3 MW
 - Gas Turbine, 3-10 MW



50 MW Steam Turbine, Peunta Hills LF, CA

Advantages , Disadvantages and Costs : IC Engine



- Advantages
 - low cost
 - High efficiency
 - most common technology
- Disadvantages
 - Problems due to particulate matter buildup
 - Corrosion of engine parts and catalysts
 - High NO_x emissions
- Costs
 - US\$1,100-1,300 (\$/kW)
(2600 - 3100 RealperkW)



Advantages , Disadvantages and Costs : Gas Turbine

- Advantages

- Corrosion resistant
- Low O&M costs
- small physical size
- Low NO_x emissions

- Disadvantages

- Inefficient at part load
- High parasitic loads , due to high gas compression requirements

- Costs

- US\$1,200-1,700 (\$/kW)
- (\$2800 - 4000 Real per kW)

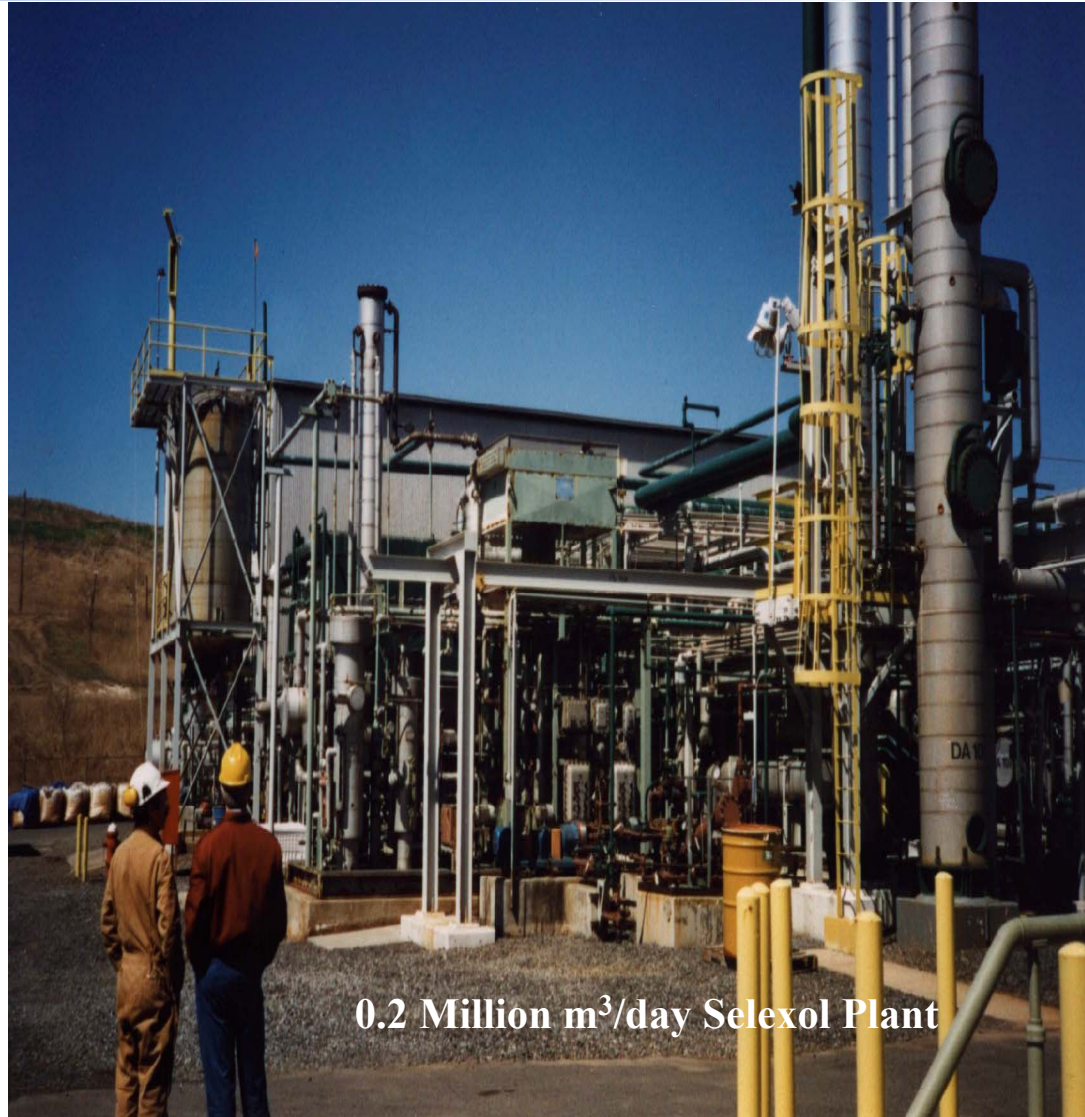


Solar 3 MW Gas Turbine

Pipeline Quality Gas Upgrade



- Gas is upgraded to a medium or high quality gas product
- Injected into a natural gas pipeline
- Generally at landfills with greater gas flows
- 11 operational projects in the US



0.2 Million m³/day Selexol Plant

Advantages , Disadvantages and Costs



● Advantages

- All gas recovered from the landfill is used
- Cost effective for landfills with high volumes of gas
- Beneficial in areas where natural gas prices are high

● Disadvantages

- Extensive treatment of landfill gas
- Additional quality control requirements
- Higher capital costs
- Higher compression of gas is required

● Costs

- US \$3.60 to \$4.15 per MMBtu (\$8.60 to 9.90 Real per MMBtu)

Leachate Evaporation



- Utilize LFG to treat leachate
- Commercially available technology
- Units operating in the US and internationally



Advantages and Disadvantages

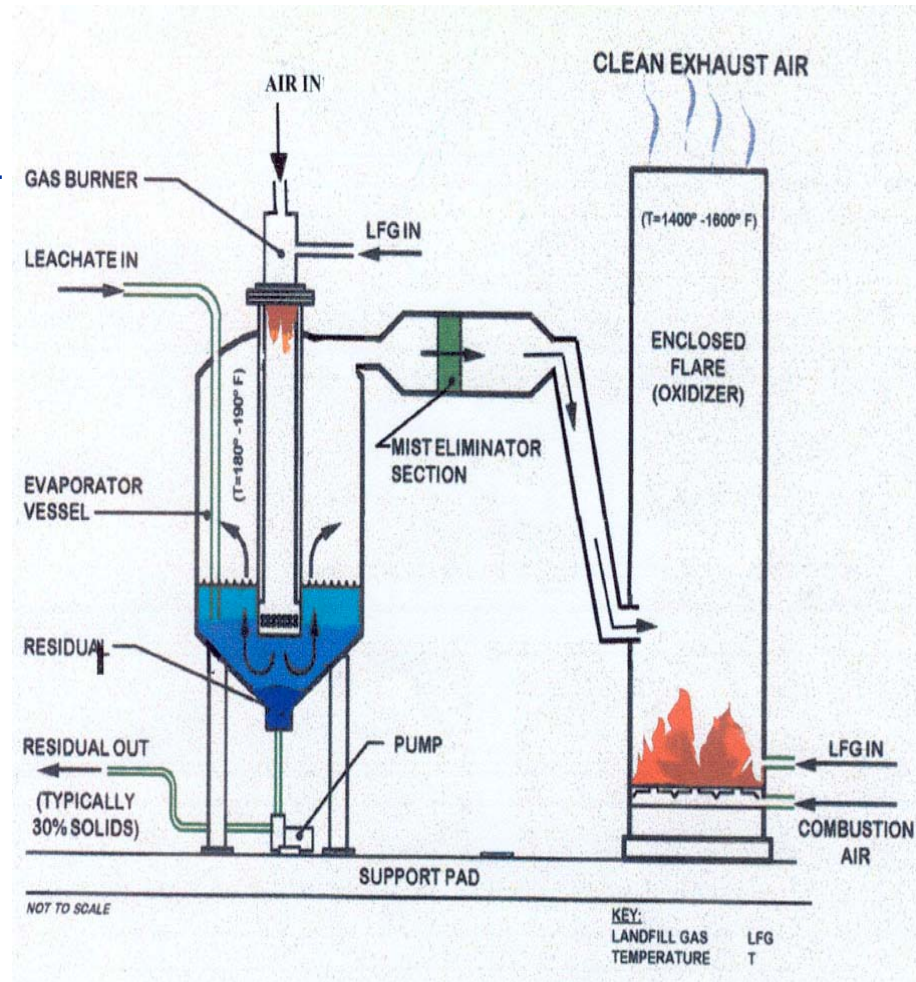


Advantages

- Applicable to landfills that have limited leachate treatment options and high leachate disposal costs
- Proven technology
- Meets local air quality requirements

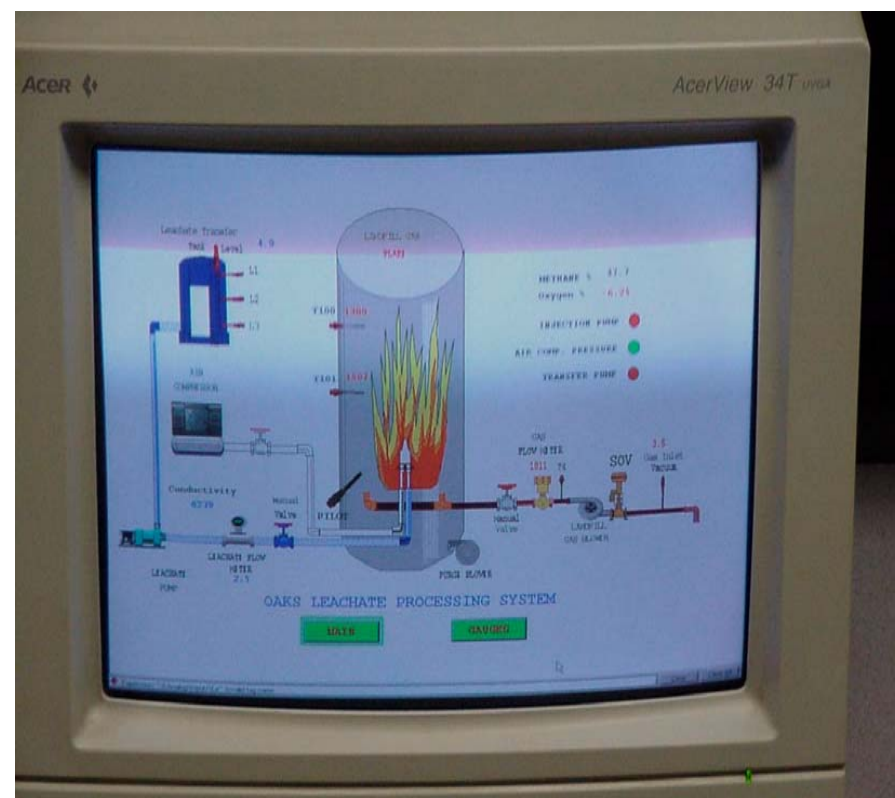
Disadvantages

- More expensive than traditional landfill leachate treatment options
- Generally applicable to larger landfill sites



Costs

- Capital Cost
 - 10,000 gpd facility:
US\$295,000 (702,100 Real)
 - 20,000 gpd facility:
US\$485,000 (1,154,000 Real)
- O & M Cost
 - 10,000 gpd facility:
US\$70,000 (166,600 Real)
 - 20,000 gpd facility:
US\$95,000 (226,100 Real)



Vehicle Fuel



- Com pressed landfill gas (CNG)
- Liquefied landfill gas (LNG) - CryoFuels®
- Early stages of commercial development



Advantages and Disadvantages



● Advantages

- LNG /CNG price lower than diesel fuel cost
- Reduction in use of fossil fuels
- Reduce local ozone pollution

● Disadvantages

- Very small percentage of alternative-fuel vehicles
- Vehicle conversion costs
- Limited track record of performance



Costs

- Retrofit vehicles = \$3,500 to \$4,000 (8,300 to 9500 Real) per vehicle
- Fueling station = \$1,000,000 (2,380,000 Real)
- Fuel price = \$.48 to \$1.26 (1.15 to 3.50 Real) per gallon



Micro Turbines

- A high speed turbo-charged generator that produces stationary power
- Has been used in aviation for some time
- Available in sizes ranging between 25kW to 75 kW



Advantages and Disadvantages



- Advantages

- Low emissions
- Multiple fuel capability
- Lightweight/small size
- Does not require any pretreatment of the fuel
- Lower maintenance costs

- Disadvantages

- Low efficiencies
- Has been tested mostly for natural gas applications
- Limited track record of performance

Costs

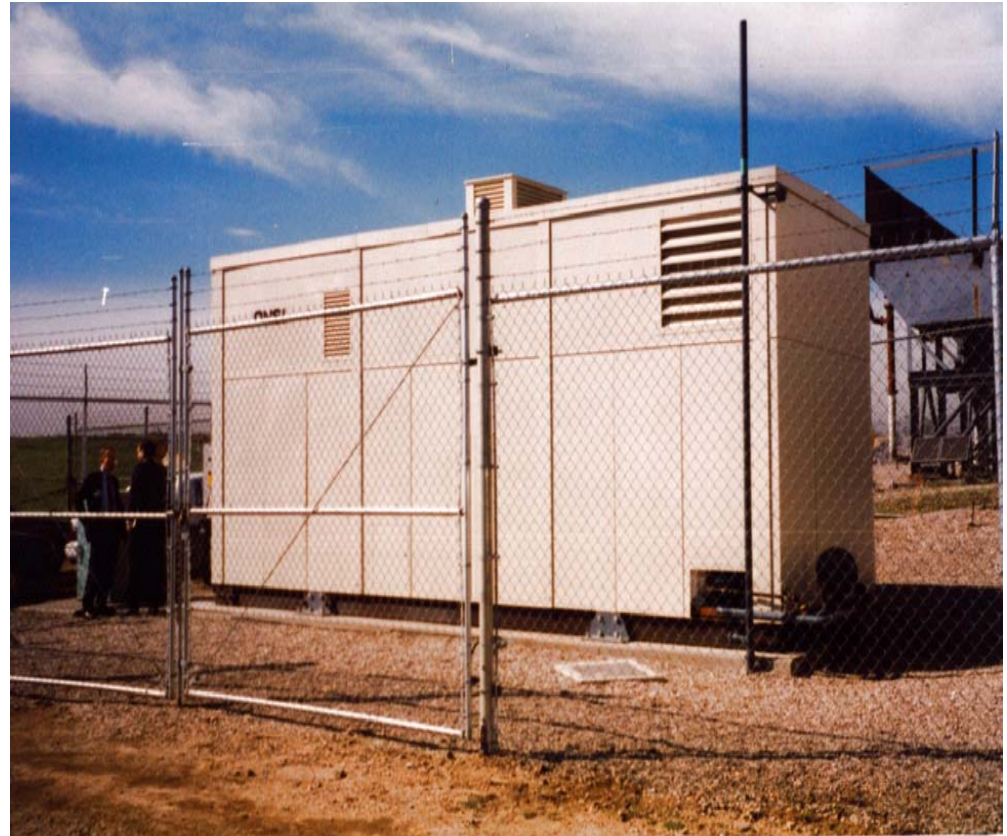


- Capital Cost
 - \$700 to \$1200 (1660 to 3350 Real) per kW
 - Cost is expected to reduce to half in the next five years
- O & M Cost
 - < \$0.01 (0.02 Real) per kW h

Fuel Cells



- Chem ically convert gas to electricity
- Dem onstration phase technology



Advantages



- Advantages
 - Low emissions
 - Reduction in use of fossil fuels
- Disadvantages
 - High cost
 - Limited track record of performance

Costs



- Approximately \$3,000 (7140 Real) per kW
- 200 kW demonstration unit at California landfill = US \$1.5 million (3,500,000 Real)

Greenhouses



- Applicable to smaller landfills
- Produce high purity carbon dioxide



Advantages and Disadvantages



- Advantages

- Meets energy needs of greenhouse
- Increasing competition and shrinking profit margins shifts focus to energy efficiency
- Cost effective production of warm weather crops in otherwise cost-prohibitive growing seasons

- Disadvantages

- Requires locating a greenhouse in close proximity of a landfill
- Seasonal variability

Costs



- A project in the U.S. estimated that it costs US\$4.80 (11.40 Real) per MMBtu
- Limited cost information is available

Technologies of the Future



- Thermal Hybrid Electric (THE) Sun Dish
 - Dual "fuel" Stirling-cycle engine
 - Combines solar and LFG power
 - Research and development scale technology



Advantages and Disadvantages



- Advantages
 - High-efficiency solar system
 - Low emissions
 - Reduction in use of fossil fuels
- Disadvantages
 - High cost
 - Limited track record of performance
 - Only suitable for certain locations
 - Small output capacity

Costs



- Not commercially available at this time



Summary



- Many ways to beneficially utilize LFG
- Available niche technologies range from research and development stage units to commercially available systems
- Technologies exist for low and high volumes of LFG production
- Selection of technology is project specific

Summary, continued...



- Key Selection Considerations Include:
 - Environmental performance
 - Reliability
 - Accuracy of assumptions
 - Permitting issues
 - emissions
 - Cost

