LMOP Workshop: LFG Collection & LFG Energy Technologies

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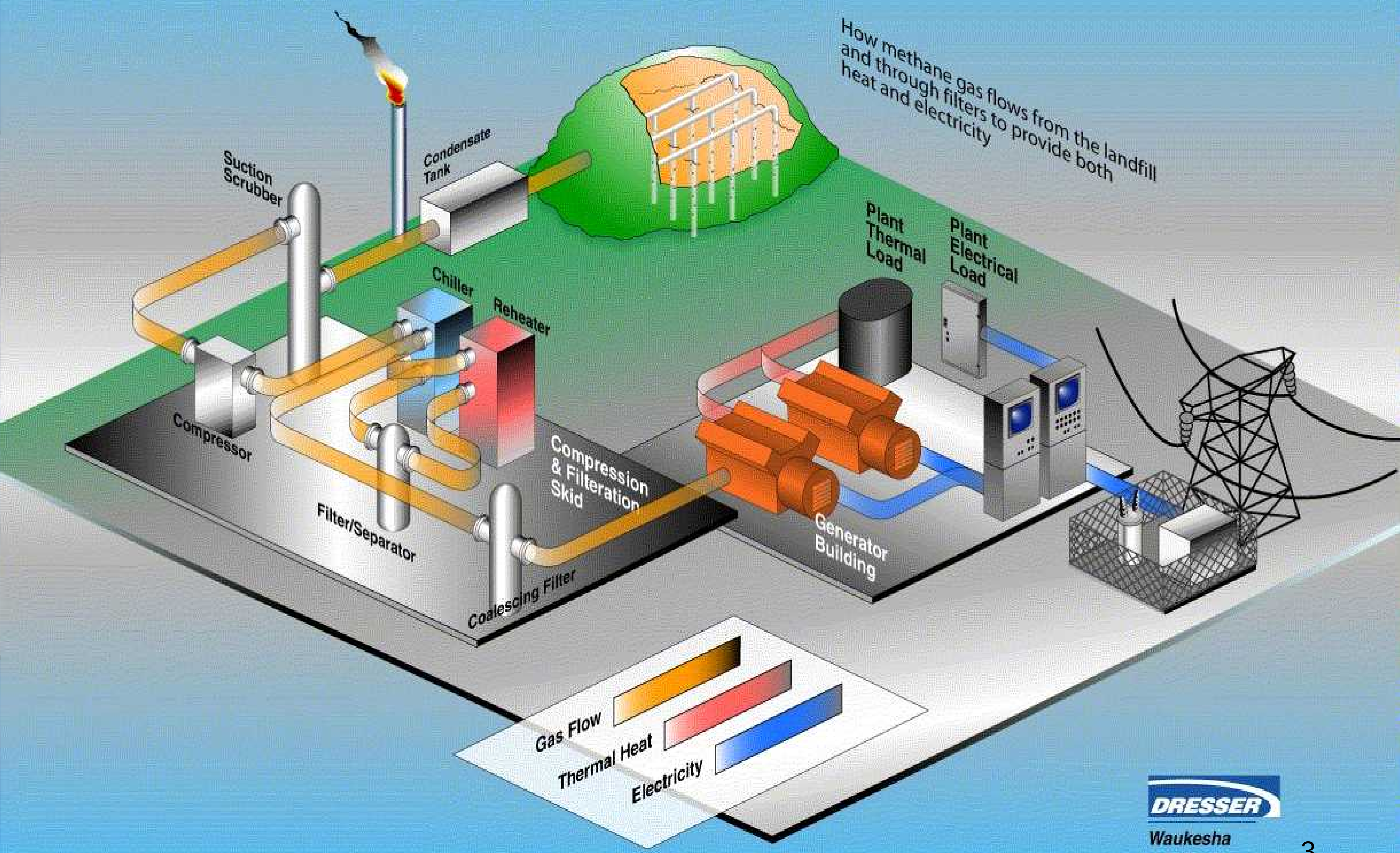
Introduction

- Goal – convert LFG into a useful energy form
- Technologies include:
  - Power production/cogeneration
  - Direct use of medium-Btu gas
  - Production of high-Btu gas
- Three components of all LFG systems:
  - Gas collection system and flare
  - Gas treatment system
  - Energy recovery system
- The type of technology selected for a project depends local conditions

Landfill Gas to Energy



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Technologies for Electricity Generation

Project Technology	Number of Projects
Internal Combustion Engines	370
Gas Turbine	36
Cogeneration	41
Steam Turbine	15
Microturbine	15
Combined Cycle	10
Stirling Cycle Engine	2

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Technologies for Direct Use

Project Technology	Number of Projects
Boiler	61
Direct Thermal	49
High-Btu	30
Leachate Evaporation	12
Greenhouse	5
Alternative Fuel	5

State of LFG Energy in Texas

- 33 Operational LFG Energy Projects
  - 101 megawatts (MW) of electrical generation from 24 LFG energy projects in Texas
  - 35 million standard cubic feet per day of LFG is utilized in 9 direct use projects
- 2 projects under construction:
  - Ft. Bend Regional Landfill (highBTU)
  - Nelson Gardens LF (electricity)
- Over 50 Candidate Landfills in Texas

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Gas Collection System and Flare

- Major components:
  - Collection wells and trenches
  - Condensate collection and management system
  - Blower
  - Flare

Collection Wells and Trenches

- Two collection configurations:
  - Vertical wells
  - Horizontal trenches
- System design depends on:
  - Site-specific conditions
  - Timing of installation
- LFG from each well is transported via lateral pipes to a main collection header

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Collection Wells and Trenches (cont.)

- Condensate collection
  - Forms when warm gas cools in a pipeline
  - Can impede flow of LFG
- Blower
  - Pulls gas from landfill
  - Size and type depends on system
- Flare
  - Controls emissions during project start-up or downtime

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Collection Wells and Trenches (cont.)

- System costs depend on site-specific conditions
- Example:
  - 40 acre site designed for 600 cfm gas flow
  - $25,000/acre or $1,000,000 total
  - $2,350 annual O&M costs/well
  - $4,700 annual O&M costs/flare*

* Based on 2012 cost estimates

LFG Treatment Systems

- Treatment requirements depend on end-use of the LFG:
  - Direct use – minimal treatment
  - Electricity – treatment to remove contaminants that might damage engines/turbines
  - High-Btu – extensive treatment required

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LFG Treatment Systems (cont.)

- Primary treatment
  - Dewatering and filtration to remove moisture and particulates
  - More common - compression and cooling to remove water vapor and humidity
- Secondary treatment
  - Provide much greater gas cleaning
  - Two common contaminants removed include siloxanes and sulfur

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Energy Recovery Systems

- Power production/cogeneration
- Direct use of medium-Btu gas
- Production of high-Btu gas


Electricity Generation

- 75% of all LFG energy projects produce electricity
- Common technologies include:
  - Internal combustion engines
  - Gas turbines
  - Microturbines


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Internal Combustion Engines

- Most common type of technology
- Advantages
  - Relatively low cost
  - High efficiency (25-35%)
  - Good size match for many landfills
    - Typical output 800 kW to 3 MW

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Internal Combustion Engines (cont.)

Examples of available internal combustion engine sizes and corresponding gas flows:

Engine Size	Gas Flow (cfm at 50% methane
540 kW	204
633 kW	234
800 kW	350
1.2 MW	500

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Gas Turbines

- More suitable for larger projects
  - Typically larger than 5 MW
- Advantages:
  - Significant economics of scale
  - Resistant to corrosion
  - Lower nitrogen oxide emission rates
  - Relatively compact with low O&M costs
- Disadvantages:
  - Less efficient than IC engines
  - Siloxane Removal

Microturbines

- Reasons to select technology:
  - Reduced LFG availability (<300 scfm)
  - Lower LFG methane content (<35%)
  - Lower nitrogen oxide emissions
  - Add and remove units as gas quantities change
  - Ease of interconnection

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Microturbines (cont.)

- Treatment typically required:
  - Moisture removal
  - Siloxanes
  - Sulfur

- Sizes include 30, 70 and 250 kW units
  - Larger capacity units should be used if LFG quantities exist
- More expensive on a dollar-per-kW installed capacity basis

Sample Electricity Generation Costs

Technology	Typical Capital Costs ($/kW)*	Typical Annual O&M Costs ($/kW)*
Internal Combustion Engine (>800 kW)	$1,700	$180
Small Internal Combustion Engine (<1MW)	$2,300	$210
Gas Turbine (>3MW)	$1,400	$130
Microturbine (<1MW)	$5,500	$380

* 2010 dollars

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Direct Use

- 25% of all LFG energy projects are direct use applications
- LFG is piped to nearby end-user and used in boiler or other industrial process
- Limited treatment is required
- Ideal gas end-user will have a steady gas flow compatible with landfill’s gas flow

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Direct Use (cont.)

- Provide LFG to multiple end-users if one ideal end-user is not available
- Using LFG may require equipment modifications
- LFG quality might be improved to avoid equipment modifications
- LFG typically treated to remove siloxanes

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Direct Use (cont.)

Boiler

- Most common type of direct use project (over 60 projects operating)
- Minimal LFG treatment required
- Usually requires some modifications to run on LFG

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Direct Use (cont.)

Typical LFG Flows Based on Landfill Size

Landfill Size (metric tons WIP)	LFG Output (MMBtu/yr)	Steam Flow Potential (lbs/hr)
1,000,000	100,000	10,000
5,000,000	450,000	45,000
10,000,000	850,000	85,000

Direct Use (cont.)

Leachate Evaporation

- 12 operational projects
- Good option if leachate disposal is unavailable or expensive
- Typical evaporator size 10,000 to 30,000 gallons per day
- Costs:
  - Capital $300,000 - $500,000
  - Annual O&M $70,000 - $95,000

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Direct Use (cont.)

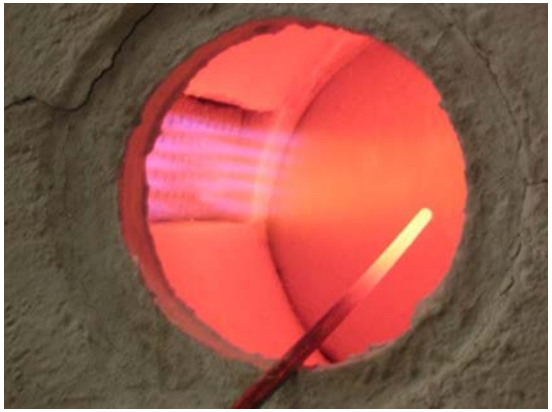
Greenhouses

- 5 projects in operation
- LFG used for heating and hot water production in hydroponic plant culture
- Costs will vary

Direct Use (cont.)

Artisan Studios

- Used in energy-intensive activities:
  - Glass-blowing
  - Metalworking
  - Pottery kilns



- Can be very successful if community backs project
- Small LFG flows and relatively inexpensive

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High-Btu Gas Production

- Refers to increasing the CH_4 content of the gas and decreasing CO_2
- Common uses of high-Btu gas:
  - Injection into natural gas pipeline
  - Creation of vehicle fuel (CNG, LNG)
- Typically more expensive
- Process may achieve economies of scale for larger projects

High-Btu Gas Production (cont.)

- Three common methods for producing high-Btu gas:
  - Amine scrubbing
  - Molecular sieve (or PSA)
  - Membrane separation
- Methods focus on removing CO_2
- O_2 and N are best controlled by proper collection system operation

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Amine Scrubbing

- Selexol is the most common amine used
- Process includes:
  - LFG compression
  - Moisture removal using refrigeration
  - H_2S removal in solid media bed
  - NMOC removal via Selexol absorber
  - CO_2 removal via secondary Selexol absorber


Molecular Sieve

- Employs compression, moisture removal and H_2S removal similar to amine scrubbing
- Utilizes activated carbon and molecular sieve for NMOC and CO_2 removal

Membrane Separation

- Employs compression, moisture removal and H_2S removal similar to amine scrubbing
- Utilizes activated carbon to remove NMOCs
- Uses membranes to remove CO_2

CNG Production

- Membrane separation and molecular sieve technology used to produce CNG
- 100 cfm of LFG = 440 diesel gallons


LNG Production

- LNG is produced using conventional natural gas liquefaction technology
- Conditions:
  - Little to no CO_2 present
  - Systems are customized and generally on larger scales
- O_2 and N removal are essential

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Selection of Technology

- Primary consideration: projected expense vs. potential revenue
- Sale of medium-Btu gas is often the simplest and most cost-effective
- Electricity projects may make more sense if:
  - No near-by energy user
  - Additional revenue sources are available (RECs, carbon credits)
- High-Btu may be best if enough gas

Selection of Technology (cont.)

- Considerations in selecting the right technology for electricity generation:
  - Gas recoverability for at least 10 years
  - Gas quality
  - Need for heat or steam – might consider a CHP project
  - State and local air quality regulations
- Remember each project is site-specific and there are other factors to consider.

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Thank you!

Questions?