Methane to Markets

Lesson 3b: Economics of Landfill Biogas Technology Applications

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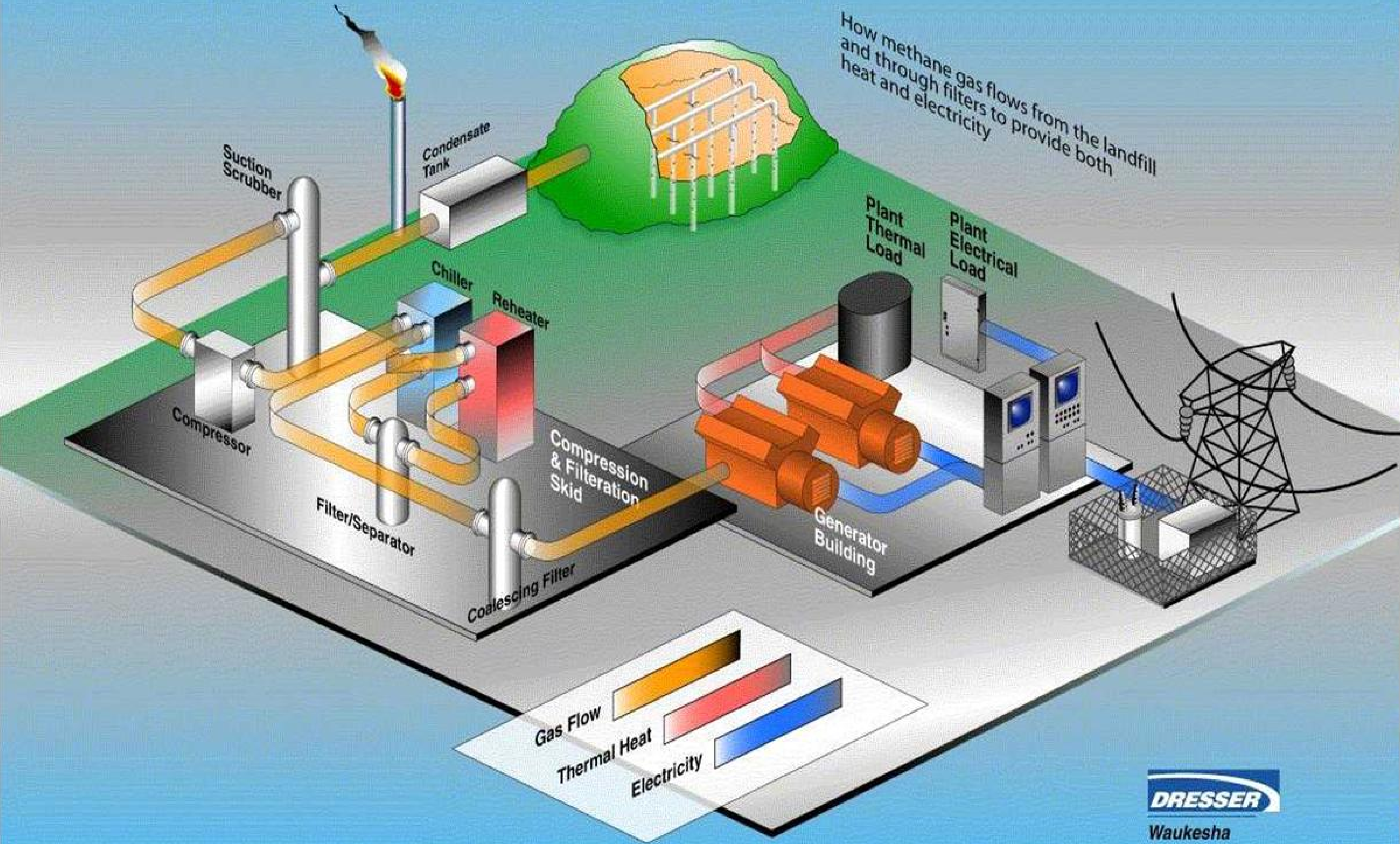
Why Use Biogas (LFG)?

- 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 - >90% up time
- Uses a source of energy that otherwise would have been wasted
- Helps the global environment by reducing uncontrolled emissions.

Landfill Gas to Energy



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LFGE Project Benefits

- Destroys methane and other organic compounds in LFG
- Offsets use of non-renewable resources
- Each 1 MW of generation capacity:
  - Annual environmental equivalent to planting 4,900 hectare of trees or removing the CO2 emissions of 9,000 cars, or powering more than 650 homes.

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Possible Uses

- Direct Use
- Combined Heat and Power
- Electricity Production
- Alternate Fuels

Landfill Gas has been used to help produce…?

- Flowers and tomatoes
- Pottery and glass
- Cars and trucks
- Pharmaceuticals
- Bricks and concrete
- Steel
- Orange and apple juice
- Snack food
- Biodiesel and ethanol
- Consumer goods and containers
- Fiberglass, nylon and paper
- Denim
- Electronics
- Chemicals
- Chocolate
- Dried wastewater sludge
- Soy-based products
- Carpet
- Infrared heat
- Green power
- Cost savings
- Increased sustainability

Direct Gas Utilization

- **Boilers**
- **Direct thermal applications – kilns, furnaces**
- **Innovative applications**
  - Greenhouses
  - Infrared heaters
  - Pottery kilns
  - Leachate evaporation
  - Medical waste Incinerators and autoclave

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Direct Gas Utilization

- Gas piped to a nearby customer for use in boiler, kiln or other process
- 100 projects in the US
- Around 20 projects in the EU
- Pipeline length range from .6 to 15 kilometers
  - less than 5 kilometers is most feasible
- Gas used at off-site end user

Direct Use Applications

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Greenhouses

- Use both electricity and heat.
- Carbon dioxide can be used to grow greenhouse plants.
- 6 operational greenhouse projects in the U.S.

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Electricity Generation

- **Most prevalent type of project in the US**
  - In US, 1100 MW of capacity from over 250 operational projects
  - In UK, nearly 1000MW, over 450 projects, 1/3rd of UK's renewable energy
- **Electricity sold to utility, cooperative or nearby customer**
- **Typical project size: 4 MW**

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Electricity Generation

- **Internal Combustion Engines**
- **Turbines**
- **Microturbines**

Internal Combustion Engine

- **Sizing**
  - 300kW to 3 MWs
  - Typically 1MW Units
- Proven and reliable

Simeprodeso, Monterrey, Mexico

- Jenbacher Engines
- 7.4MW initially and expanded to 12MW
- 6 Gas Pumps
- More than 500 gas wells

Simeprodeso, Monterrey, Mexico

Current generation capacity of 12 MW.

Third phase under development to increase capacity to 17 MW.

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Economics

- Economic Evaluation Process
  - Quantifying Revenues
  - Quantifying Costs
- Comparison of Technologies
- U.S. EPA Cost Model
- Typical Project Costs
- Jobs and Revenue Creation
- Summary

Evaluating Project Economics

- The Economics of a Landfill Biogas Project Depends on a Number of Factors:
  - Landfill biogas quantity
  - Local energy prices
  - Equipment technology
  - Other revenue sources

Economic Evaluation Process

1. Estimate Energy Sales Revenues

   - Includes cash that flows to the project from sales of electricity, steam, gas, or other derived products.
   - Potential markets include: utilities, industrial plants, commercial or public facilities and fuel companies.

Economic Evaluation Process

2. Quantify Capital and O&M Costs

- Capital costs include the initial cost of the equipment, installation costs, debt service, owner's costs and returns on equity.
- O&M costs are the annual costs associated with the operation and maintenance of the field equipment, including gas wells, pipelines, blower, etc.

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Economic Evaluation Process

3. Research other Revenue Sources

   - Grants or low interest loans.
   - Carbon credits.
   - Renewable Energy Credits.
   - Premium Renewable Energy Pricing.
   - Others.

Economic Evaluation Process

4. Compare Project Expenses and Revenue

   – Check to see if the first year expenses and revenues are roughly equivalent.
   – If they are comparable, then further economic evaluation is warranted.

Economic Evaluation Process

5. Create a Model of Cash Flows

   – The expenses and revenues should be calculated and compared on a year by year basis over the expected life of the project.
   – Calculations to include: project performance over time, escalation in project expenses and energy prices, financing costs, and tax considerations.

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Economic Evaluation Process

6. Assess Economic Feasibility

   – Can be assessed by calculating annual net cash flows, the net present value of future cash flows and/or the owner's rate of return.
   – These measures are calculated over the life of the project and are most reliable for evaluation of economic performance.

Comparison of Technologies

- After completing the initial economic analysis for each technology option, a comparison should be made to determine the best option.

Comparison of Technologies

- Head-to-Head Comparison:
  - Comparing annual cash flows, net present value, debt coverage, and rate of return independently.

Comparison of Technologies

- Consideration of Non-Price Factors:
  - Environmental performance
  - Reliability
  - Accuracy of assumptions

Comparison of Technologies

- US EPA Cost Model:
  - Excel spreadsheet developed to assist with comparison
  - Based on average capital and O&M costs for each technology (US $)

Cost Model-Required Inputs

- Landfill open year
- Landfill close year
- Landfill biogas wellfield area
- Waste acceptance rate
- Project type
  - Engine
  - Turbine
  - Direct Use
- Collection and flaring costs
- Project start date and duration

Cost Model–Optional Inputs

- Gas flow
- Methane generation rate
- Methane content
- Waste depth
- Collection efficiency
- End user distance
- Interest, inflation, discount and tax rates
- Tax credits
- Direct credits
  - Greenhouse gas
  - Renewable energy
- Product price
- Electricity rates

Cost Model Outputs

- Average project sizes
  - Direct Use
  - Electricity
- Initial capital cost
- Annual operation costs
- Internal rate of return
- Net present value
- Payback
- Breakeven price
- Environmental benefits

Initial Capital Cost Estimates ($USD)

- 20-acre landfill
- Wellfield (20 wells and header piping)
  - **$340,000-$460,000**
- Blower/Flare station (assume 300 standard cubic feet per minute of flow)
  - **$200,000**
- Treatment system
  - **$500,000**
- Engine (0.5 MW capacity)
  - **$800,000**
- Pipeline (1 mile)
  - **$105,000-$448,000**

Electricity Generation / Cogeneration

- Factors for a Economically Feasible Project:
  - Local electricity prices
  - Access to electricity purchasers
  - Landfill biogas volume
  - And available technology

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Typical Electric Project Components & Costs

- 3 MW engine project for 15 years:
  - Installed engine and gas treatment skids
    - Installed capital cost = ~$5,100,000
  - Interconnect
    - ~$250,000 (approximate – many variables at play)
  - Annual operation & maintenance
    - Cost = ~$570,000/year
- Total capital cost = ~$5.35 million
- Total annual cost = ~$570,000

Direct Use

- Generally the most economic recovery option. Considerations:
  - The buyers proximity to a landfill
  - The buyers gas requirements

Typical Direct-Use Project Components & Costs

- 800 scfm project for 15 years:
  - Gas compression & treatment
    - Installed capital cost = ~$1,040,000
  - Pipeline
    - Installed capital cost = ~$330,000/mile
  - Annual operation & maintenance
    - Cost = ~$50,000/year
  - End-of-pipe combustion equipment retrofits, if needed
- Total capital cost (5-mile) = ~$2.69 million
- Total O&M cost = ~$750,000

Jobs and Revenue Creation

- A typical 3 MW LFG electricity project is estimated to have the following benefits (direct, indirect, and induced) during the construction year:
  - Increase the output of the national economy by ~$14 million ($3 million of which is a local benefit and mostly employee earnings)
  - Employ nearly 70 people nationally (expressed in full-time equivalents [FTE] per year)

Jobs and Revenue Creation (cont.)

- A typical 1,040 scfm LFG direct-use project is estimated to have the following benefits (direct, indirect, and induced) during the construction year:

	5-mile pipeline	10-mile pipeline
Increase output of national economy	$6 million	$12 million
Portion of national benefit at local level	$2 million	$4 million
People employed nationally (FTE)	43	80

Summary

- Compare results of economic feasibility analysis for landfill biogas use.
- Rank options based on financial as well as non-price factors.
- Select best option for use of the gas.