Using Landfill Gas as an Alternative Energy Option

Cliff Haefke
Midwest CHP Application Center
August 9th, 2006

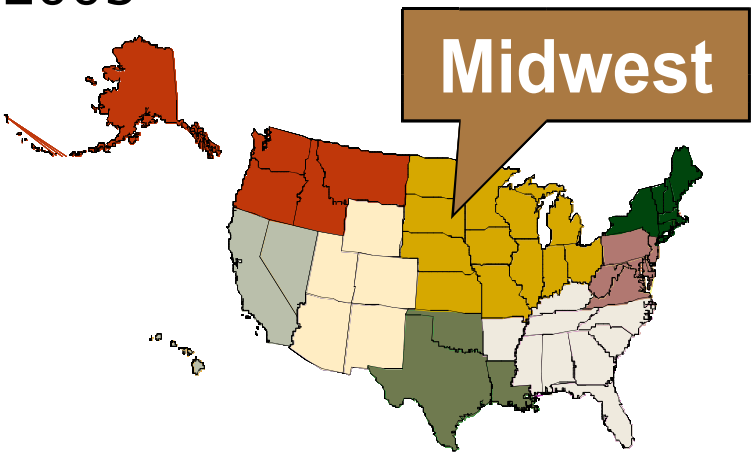
recycling energy™
CHP It's time

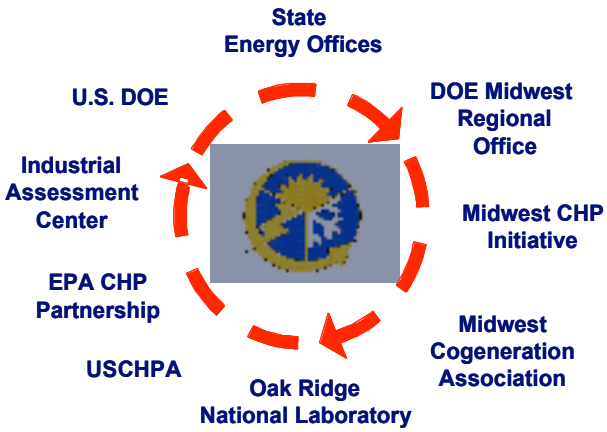
MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Midwest CHP Application Center

Behind the Wheel: Management Focus

- Established in 2001 by U.S. DOE to support U.S. DOE CHP Challenge
- Located at University of Illinois at Chicago
- Provide targeted education, unbiased information, and technical assistance to 12 state Midwest region
- Work closely with state energy offices
- 7 other Regional Application Centers established since 2003





MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Presentation Outline

Behind the Wheel: Management Focus

- Landfill Gas 101
- Applications and Benefits of LFG
- LFGE Potential in Federal Facilities
- LFGE Case Studies

Landfill Gas 101

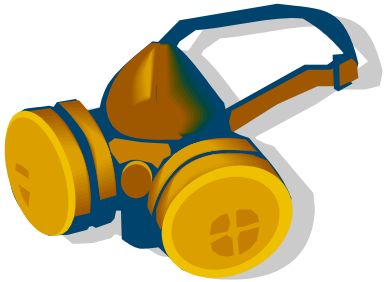
Behind the Wheel: Management Focus

- Waste decomposes and produces landfill gas
- Landfill gas released into air smells bad and contributes to local smog
- Composition of landfill gas
  - 50% methane (CH_4)
  - 50% carbon dioxide (CO_2) & water (H_2O)
  - <1% non-methane organic compounds (NMOC)

Landfill Gas 101 (cont.)

Behind the Wheel: Management Focus

- If left uncontrolled, LFG can be potentially explosive
- Public health, safety, and environmental concerns fall into three categories
  - subsurface migration
  - surface emissions/air pollution
  - odor nuisance



Landfill Gas 101 (cont.)

Behind the Wheel: Management Focus

- Landfills are largest human-made source of methane in the U.S.
- There are many cost-effective options for reducing methane emissions while generating energy
- Projects reduce local air pollution, and create jobs, revenues, and cost savings

Landfill Gas 101 (cont.)

Behind the Wheel: Management Focus

Modern Municipal Solid Waste Landfill

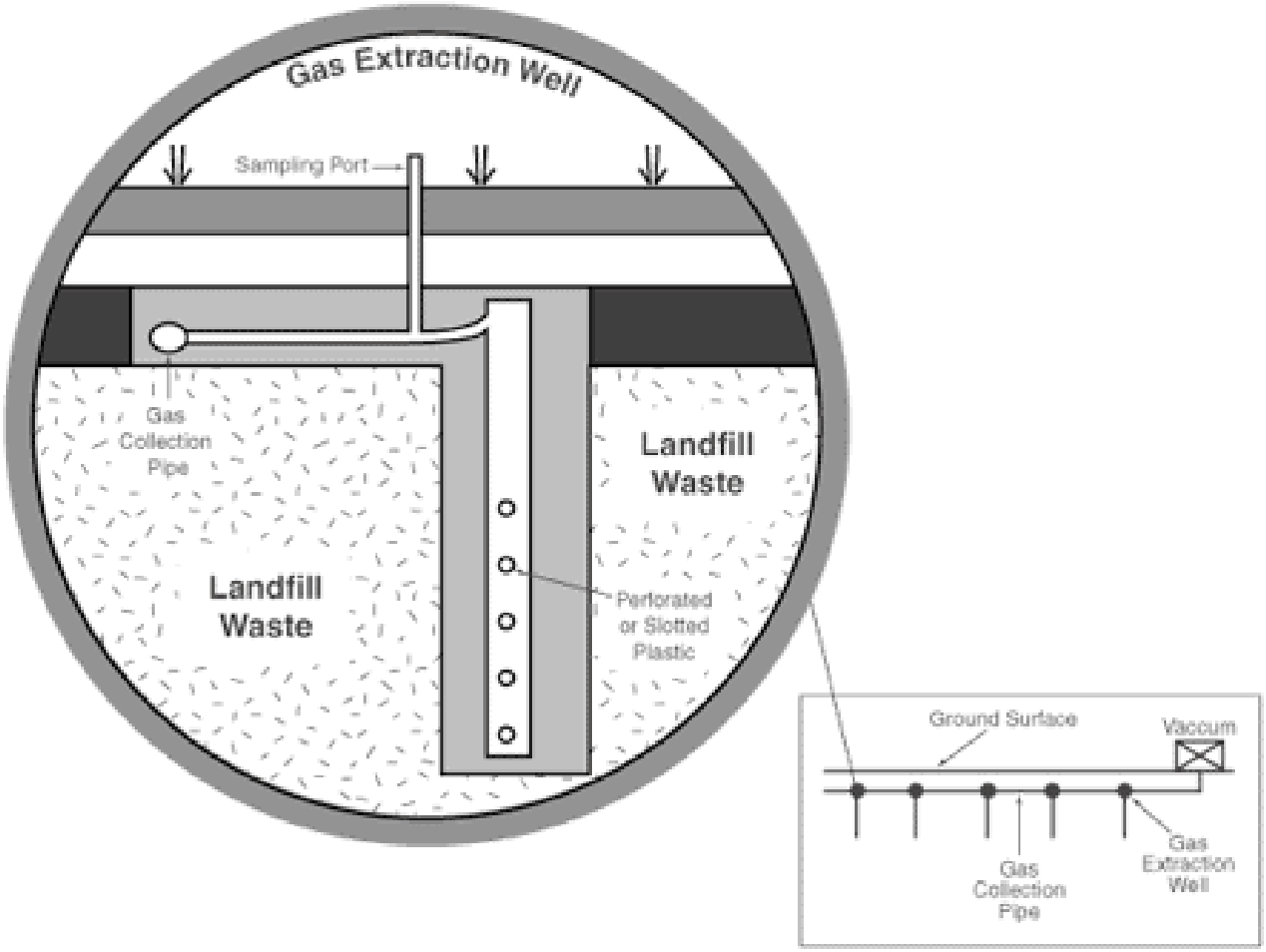
Source: http://www.epa.gov/lmop/

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Landfill Gas 101 (cont.)

Behind the Wheel: Management Focus

Landfill Gas Well



Active Gas Collection System

Source: http://www.epa.gov/lmop/

Landfill Gas 101 (cont.)

Behind the Wheel: Management Focus

- Landfill gas is a readily available, local and renewable energy source
- LFG is the only renewable energy source that, when used, directly prevents atmospheric pollution
- Landfill gas can be converted and used in many ways
- For every 1 million tons of MSW:
  - ~0.8 MW of electricity
  - ~432,000 cubic feet per day of LFG

Applications of Landfill Gas

Behind the Wheel: Management Focus

- On-site use (gas and electricity)
- Nearby direct gas use (sale to industrial end users, such as boilers and kilns)
- Electricity use
- High-Btu upgrade (sales to nearby customers or gas utility)
- Specialty use (greenhouse, vehicle fuel)

Heat Recovery Applications

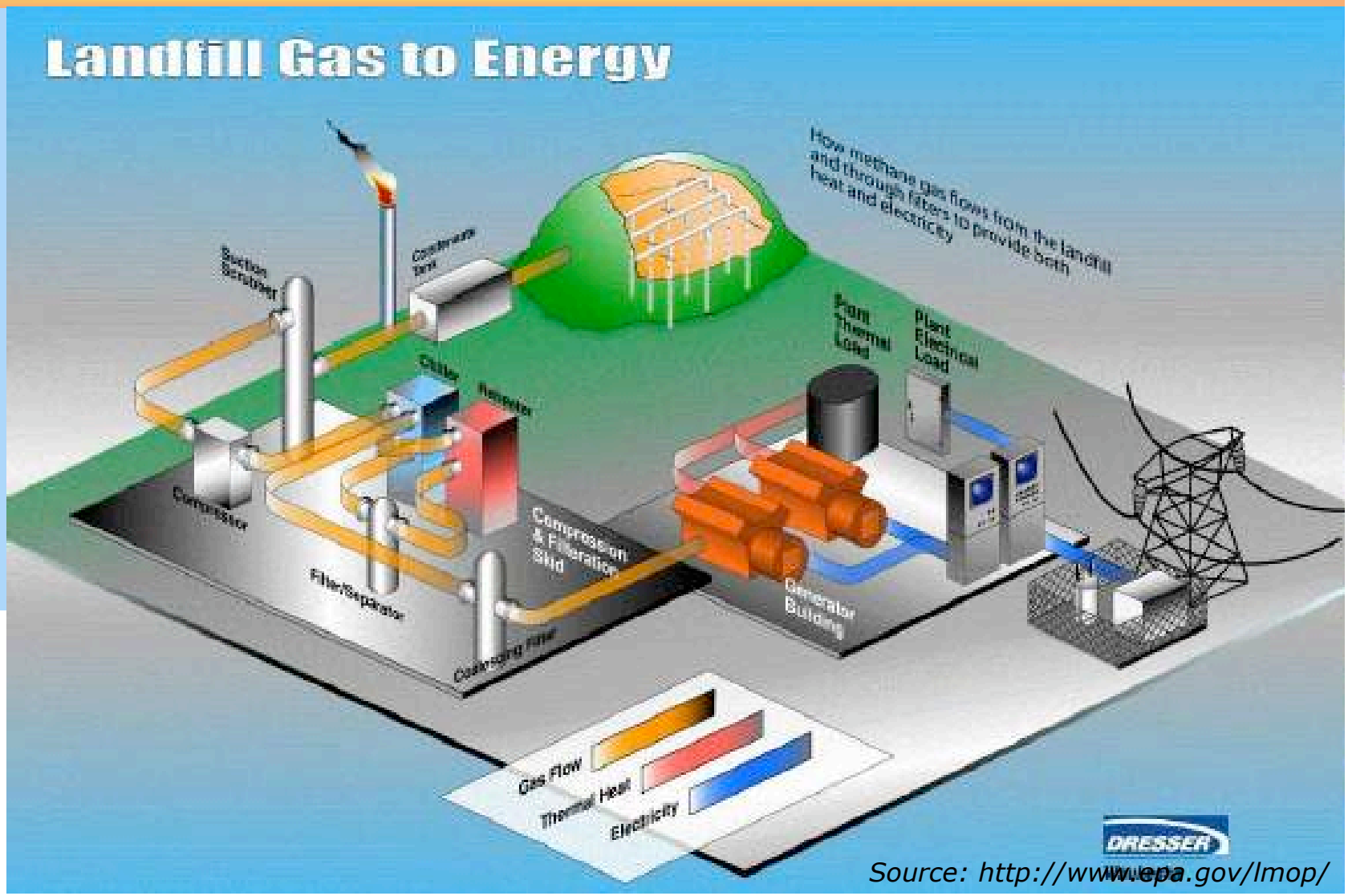
Behind the Wheel: Management Focus

- A landfill's on-site heat uses are generally minor and largely limited to space heating
- Can send hot water or steam off-site by pipe
- Locate electric generation at end user's location and recover heat for building's loads

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Methane – to - Energy

Behind the Wheel: Management Focus



Source: http://www.epa.gov/lmop/

LFG has been used to help produce…

Behind the Wheel: Management Focus

Aquaculture (e.g., Tilapia)
Biodiesel
Biosolids (drying)
Bricks and concrete
Carpet
Cars and trucks
Chemicals
Chocolate
Consumer goods and containers
Denim
Electronics
Fiberglass, nylon and paper
Furthering space exploration
Garden plants
Green power
Infrared heat
LNG/CNG vehicle fuel
Orange and apple juice
Pharmaceuticals
Pierogies and snack food
Pottery and glass
Soy-based products
Steel
Tomatoes (hydroponic)
Taxpayer savings and increased sustainability!

Landfill Gas and Green Power
A Winning Combination

Behind the Wheel: Management Focus

- Dual benefit – destroys methane and other organic compounds in LFG
- Offsets use of nonrenewable resources (coal, oil, gas) reducing emissions
  - SO2, NOx, PM, and CO2
- LFG projects help curtail global climate change by reducing CH4 emissions (a greenhouse gas more potent than CO2)
- LFGE is generated 24/7 and projects have online reliability over 90%
- LFG can act as a long-term price and volatility hedge against fossil fuels

Economic Benefits

Behind the Wheel: Management Focus

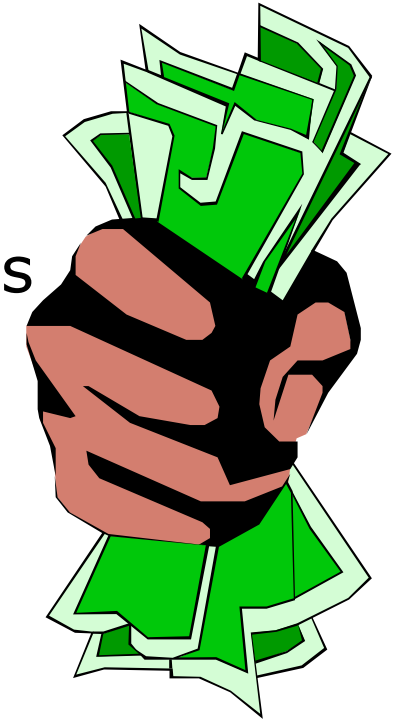
- LFG projects are a win-win opportunity for all parties involved by producing a related benefit for the community:
  - jobs - engineers, construction firms, equipment vendors, and utilities or end-users of the power produced.
  - cost is spent locally for drilling, piping, construction, and operational personnel
  - captured gas can be sold for use as heat or fuel
  - converted and sold on the energy market as a renewable "green" power

The community can turn a financial liability into an asset.

Jobs and Revenue Creation

Behind the Wheel: Management Focus

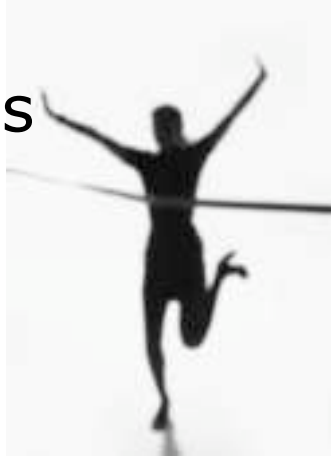
- A typical 3 MW LFG electricity project is estimated to have the following national benefits (direct, indirect, and induced) during the construction year:
  - Increase the output of the U.S. economy by more than $10M
  - Increase U.S. employee earnings by more than $3.0M (wages, salaries, etc.)
  - Employ more than 70 people (expressed in full-time equivalents per year)



Community Benefits

Behind the Wheel: Management Focus

- Community is innovative and responsible with local resources
- Enhances community's image as an environmental leader
  - Reduces local ozone levels and smog formation
  - Diminishes explosion threats and unpleasant odors
  - Improves overall landfill management
- Makes the area surrounding the landfill a better place to live
- Leader in ensuring the well-being of its citizens



Environmental Impacts

Behind the Wheel: Management Focus

Specifically, for each 1 million tons of waste or 1.1 MW or 60,000 mmBtu, the greenhouse gas environmental benefits is equivalent to one of the following:

Landfill Gas to Electricity	Versus	Landfill Gas to Pipeline Quality Natural Gas
9,600 cars taken off the road	vs	18,600 cars taken off the road
13,000 acres of forests planted	vs	27,000 acres of forest planted
210 rail cars of coal not required	vs	420 rail cars of coal not required
100,000 barrels of oil not required	vs	197,000 barrel of oil not required
660 additional homes are powered a year	vs	5,500 additional homes are heated per year

Source: http://www.greengasenergy.com

Status of the LFGE Industry

Behind the Wheel: Management Focus

- At least 400 operational projects in 40 states supplying:
  - 9 billion kilowatt hours of electricity and 74 billion cubic feet of LFG to direct-use applications in 2005
- Estimated Annual Environmental Benefits:
  - Planting nearly 19,000,000 acres of forest, or
  - Preventing the use of over 160,000,000 barrels of oil, or
  - Removing emissions equivalent to over 13,000,000 vehicles, and
  - Powering over 725,000 homes and heating nearly 1,200,000 homes

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Status of Landfill Gas Energy Project Development and Candidate Landfills by State

the US DOE

Source: http://www.epa.gov/lmop/

Landfill Site Candidate Criterion

Behind the Wheel: Management Focus

- Desired landfill characteristics
  - Landfill contains municipal solid waste (MSW)
  - Landfill has 1+ million tons of MSW in place
  - Landfill is 30+ feet deep
  - Site receives 25+ inches of annual rainfall

Rules-of-Thumb

Behind the Wheel: Management Focus

- Landfills begin producing methane as soon as 6 months after they begin operation
- The typical lifetime of an LFG-to-energy project is 10-20 years
- One million tons of MSW can yield 300 scfm of recoverable LFG – enough to deliver about 800 kW
- A LFG project that uses 300 scfm yields the same reduction in greenhouse gases as removing ~6,000 cars from the road for one year or planting ~8,000 acres of forest annually

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Diversity of Project Types

Behind the Wheel: Management Focus

Electricity Generation

Internal Combustion Engine

Gas Turbine

Emerging Technologies

Microturbine

Organic Rankine Cycle Engine

Stirling "External Combustion" Engine

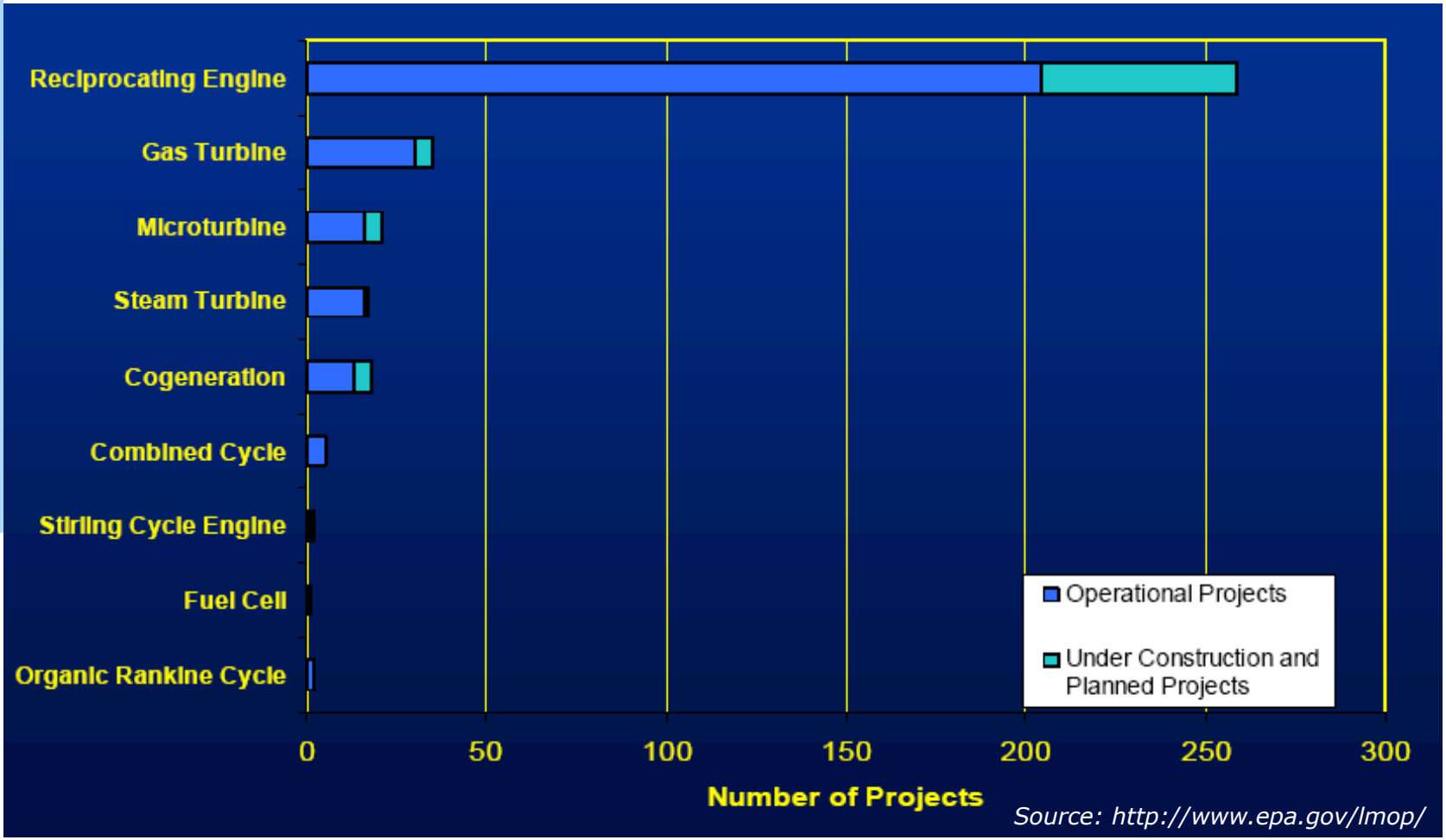
MIDWEST CHP APPLICATION CENTER

In Partnership with the US DOE

Technology Trends

Behind the Wheel: Management Focus

Electricity Projects

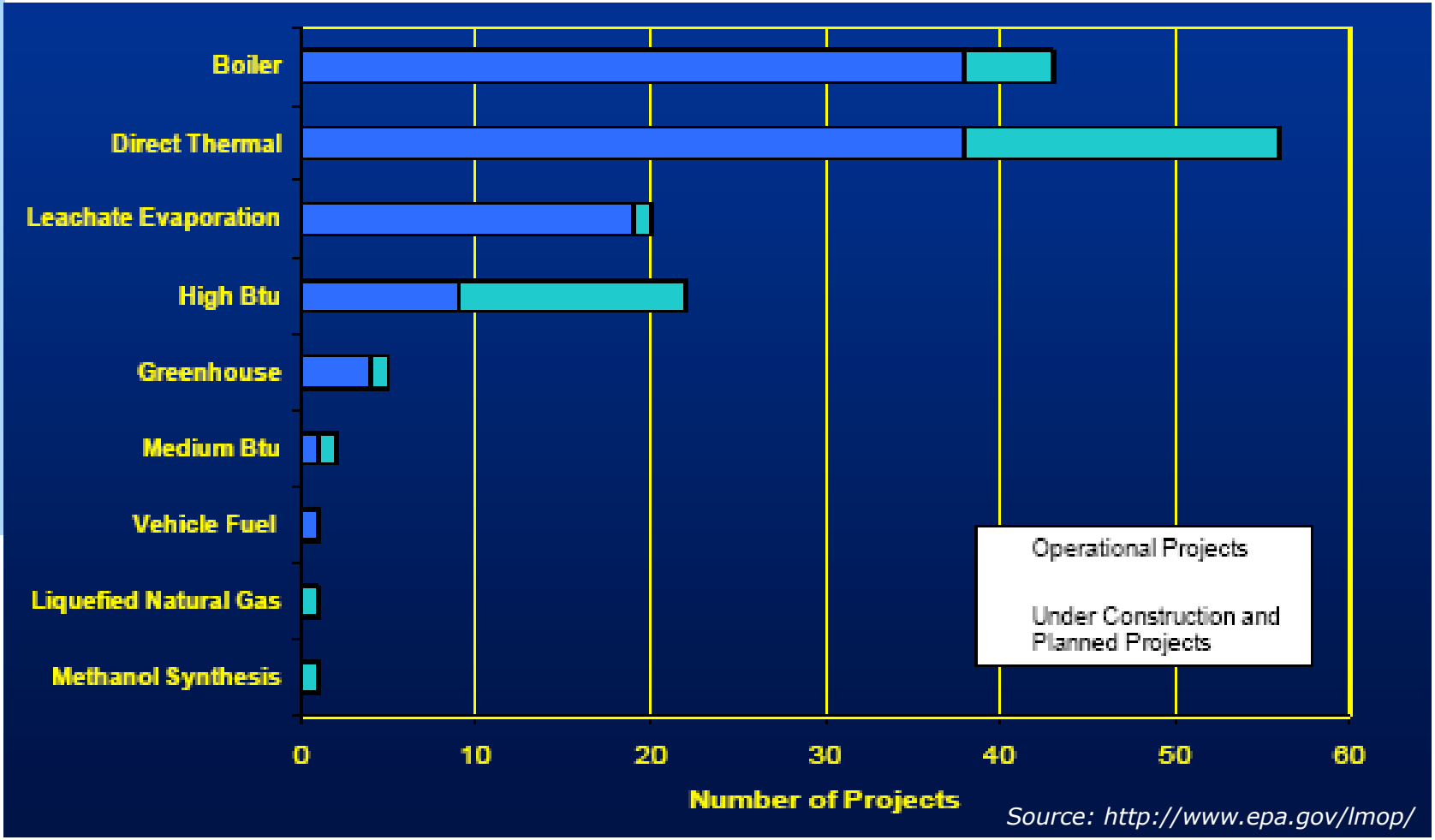


Source: http://www.epa.gov/lmop/

Technology Trends

Behind the Wheel: Management Focus

Direct-Use Projects

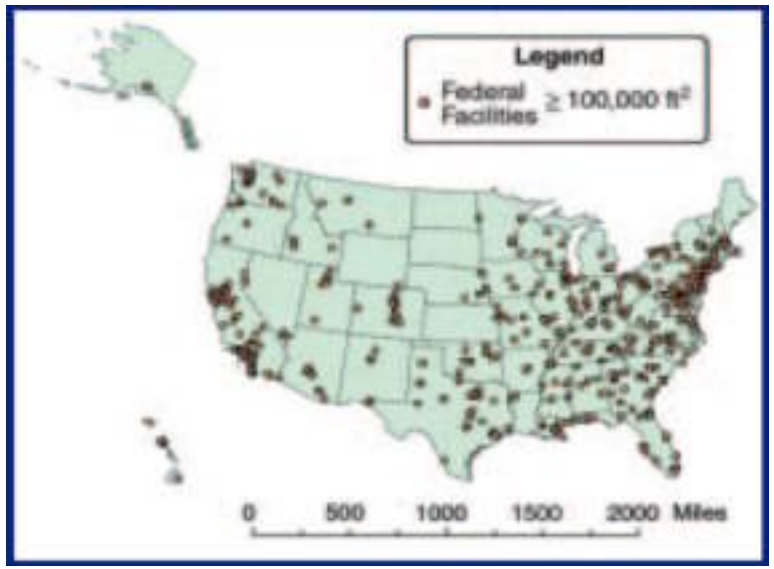


Source: http://www.epa.gov/lmop/

Potential for Federal Buildings

Behind the Wheel: Management Focus

- More than 1,200 large federal facilities are within 15 miles of at least one candidate landfill
- Nearly 500 of these facilities are within 5 miles of a candidate landfill – well within the limits for economic feasibility



Federal facilities within 15 miles of a candidate landfill

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Benefits to Federal Buildings

Behind the Wheel: Management Focus

- Energy cost savings
- Security from power grid interruptions
- Lowest-cost system for both accommodating a steady base load and providing back-up generation capacity
- Progress toward federal goals for use of renewable energy
- Hedge against fluctuations in fuel and power costs
- Significant environmental benefit from reduced greenhouse gas emissions

Resources and Tools

Behind the Wheel: Management Focus

- U.S. EPA's Landfill Methane Outreach Program (LMOP)
  - Established in 1994
  - Voluntary program that creates alliances among states, energy users/providers, the landfill gas industry, and communities
  - http://www.epa.gov/lmop/

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

Federal Financial Incentives

Behind the Wheel: Management Focus

- Section 45 Tax Credit
  - Electricity generation – 0.9 cents/kwh
  - Placed in service by 12/31/07
  - 5 or 10 year window for credits depending on placed-in-service date
- Section 29 Tax Credit (re-designated as Section 45K)
  - Both direct-use and electricity generation
  - Effective for taxable years ending after 12/31/05
- Renewable Energy Production Incentive (REPI)
  - Local/state government or non-profit electric co-op facilities
  - Online by 10/11/06
  - Payment for first 10 years of operation

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Case Study – Space Center

Behind the Wheel: Management Focus

- NASA's Goddard Space Flight Center, Maryland
- 1st federal building to burn LFG on federal property
  - Gas is piped 5 miles from Prince George's County Sandy Hill Landfill
  - 2 of 5 existing boilers were modified to burn LFG and use NG and fuel oil as backup
- NASA expects to
  - Save taxpayers ~$3.5 million in fuel costs over 10 years
  - Reduce greenhouse gas emissions by more than 1.6M metric tons of CO_2 (equivalent to removing emissions of >35,000 cars)

Case Study – Sherriff Station

Behind the Wheel: Management Focus

- Winnebago County owns and operates a 3 MW LFGE facility in Oshkosh, Wisconsin
  - Experienced increase in production of landfill gas
  - Decision made to pipe LFG to newly built Sheriff's station
- (1) MW Jenbacher CHP unit was installed to utilize heat from the engine to create hot water for the building's heating system
- Electricity being used for the building with excess being sent to the grid for WPS
- Total efficiency of the power plant improves from 38% to over 87% utilizing CHP

Case Study – High School

Behind the Wheel: Management Focus

- Antioch Community High School
- HOD Landfill
  - History of Project
  - Description of Gas-to-Energy System

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

HOD Landfill History

Behind the Wheel: Management Focus

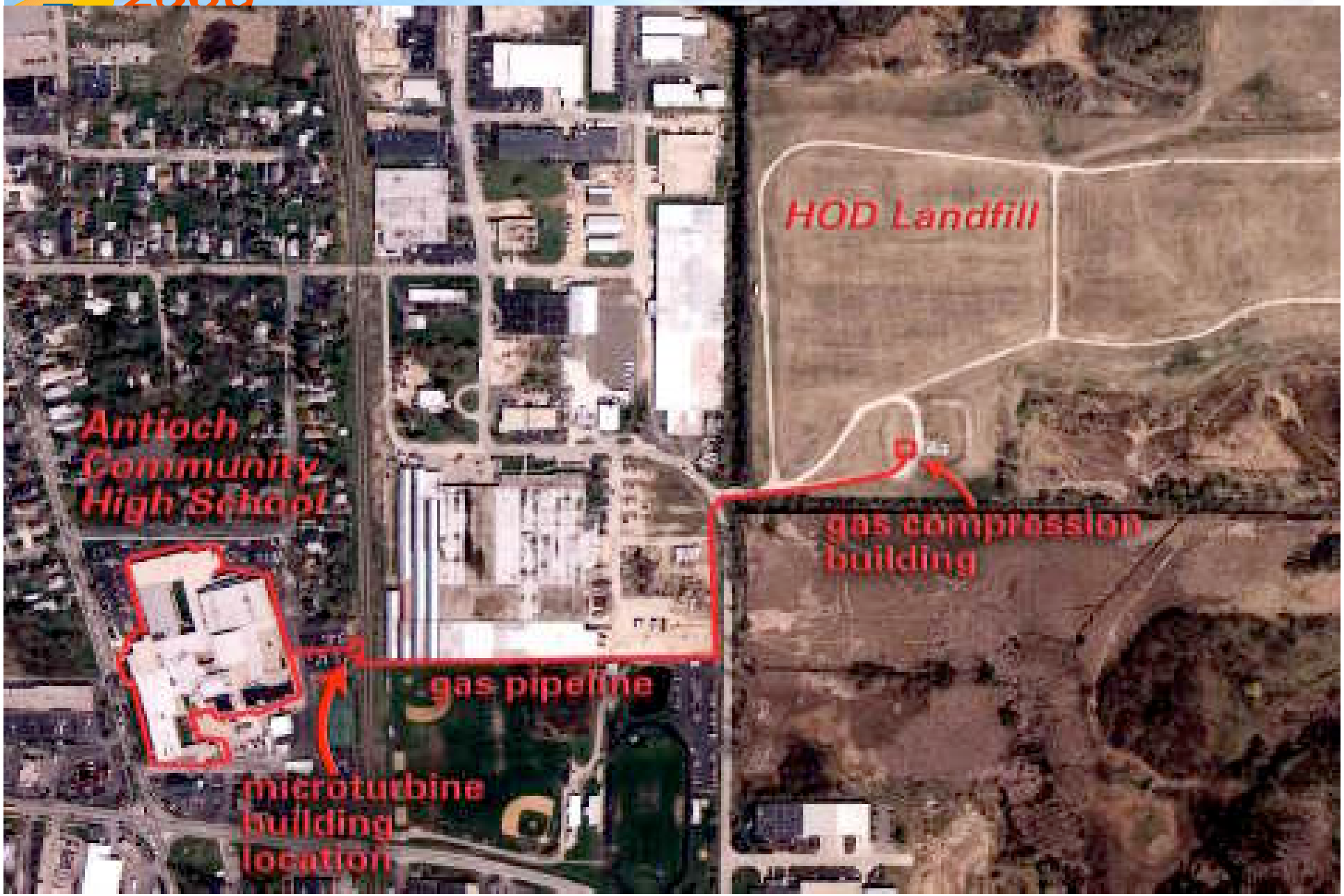
- 51-acre municipal and industrial solid waste landfill
- Active from 1963 to 1984
- 35 gas extraction wells
- Current gas production is ~300 cubic feet per minute at 47% methane
- Projections showed >150 CFM for the next 10-20 years
- Declared by USEPA ready for use as athletic fields

Project Timeline

Behind the Wheel: Management Focus

- 1963 – Landfill began operation
- 1984 – Landfill closed
- 1998 – EPA issued an ROD
- 1999 – Public notice posted
- 2000 – RD was approved by EPA
- 2001 – RMT contacted ACHS
- 2002 – ACHS received grant (Apr.)
- 2002 – Construction began (Dec.)
- 2003 – System Operating (Sep.)

2006


HOD Landfill
Antioch Community High School
gas compression building
gas pipeline
microturbine building location

Cleaning and Compression

Behind the Wheel: Management Focus

- Piping Characteristics
  - High-density polyethylene (HDPE SDR 9) pipe 4” dia
  - 1/2 mile long pipe
  - Installed 4 to 12 feet below ground
  - Piped from HOD Landfill to microturbines at school
- Horizontal drilling techniques allowed pipe to cross beneath a stream, a road, public utilities, athletic fields, and a railroad
  - Minimal disturbance of the ground surface.
  - Extremely important for the community and the school's athletic programs

HOD Landfill Gas Collection System Tie-in

Behind the Wheel: Management Focus

- Collection system at HOD landfill includes 35 LFG extraction wells, a blower, and a flare
- Construction of the new CHP system required connection to the existing system to allow excess LFG to be combusted in the flare.
- Additional pipes and control valves were included in the system
  - Route gas to conditioning and compression building
  - Allow existing blower and flare to remain operational, while providing correct volume of LFG to microturbines

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

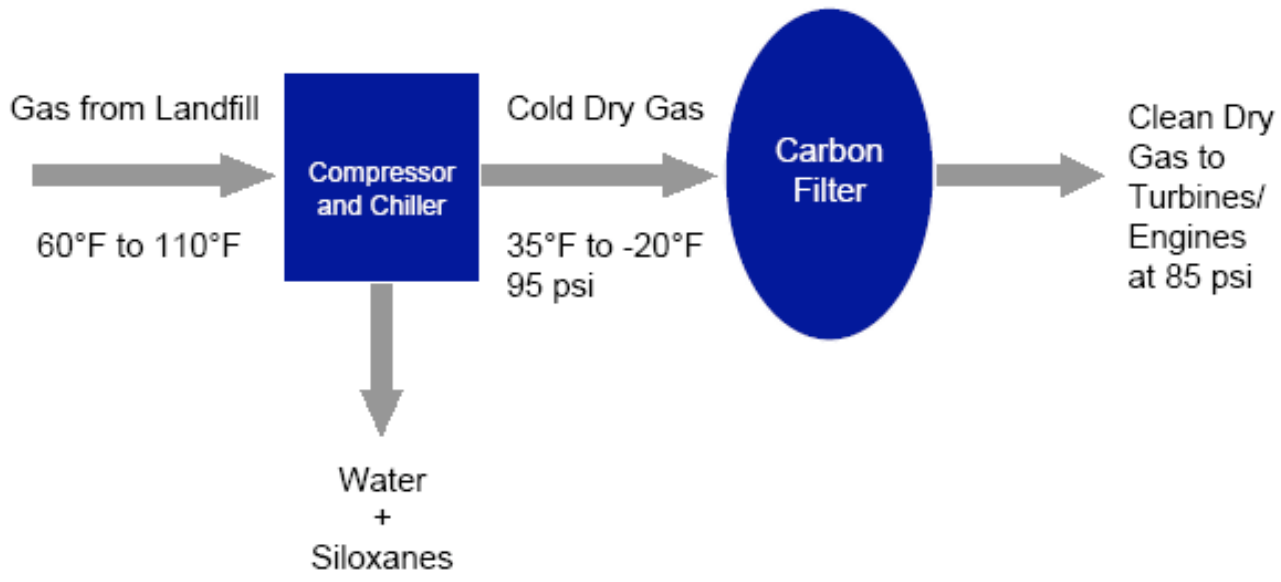
Landfill Gas Conditioning System

Behind the Wheel: Management Focus

Collected LFG is conditioned through a series of chillers that drop gas temperature to -10°F to remove moisture and siloxane compounds.

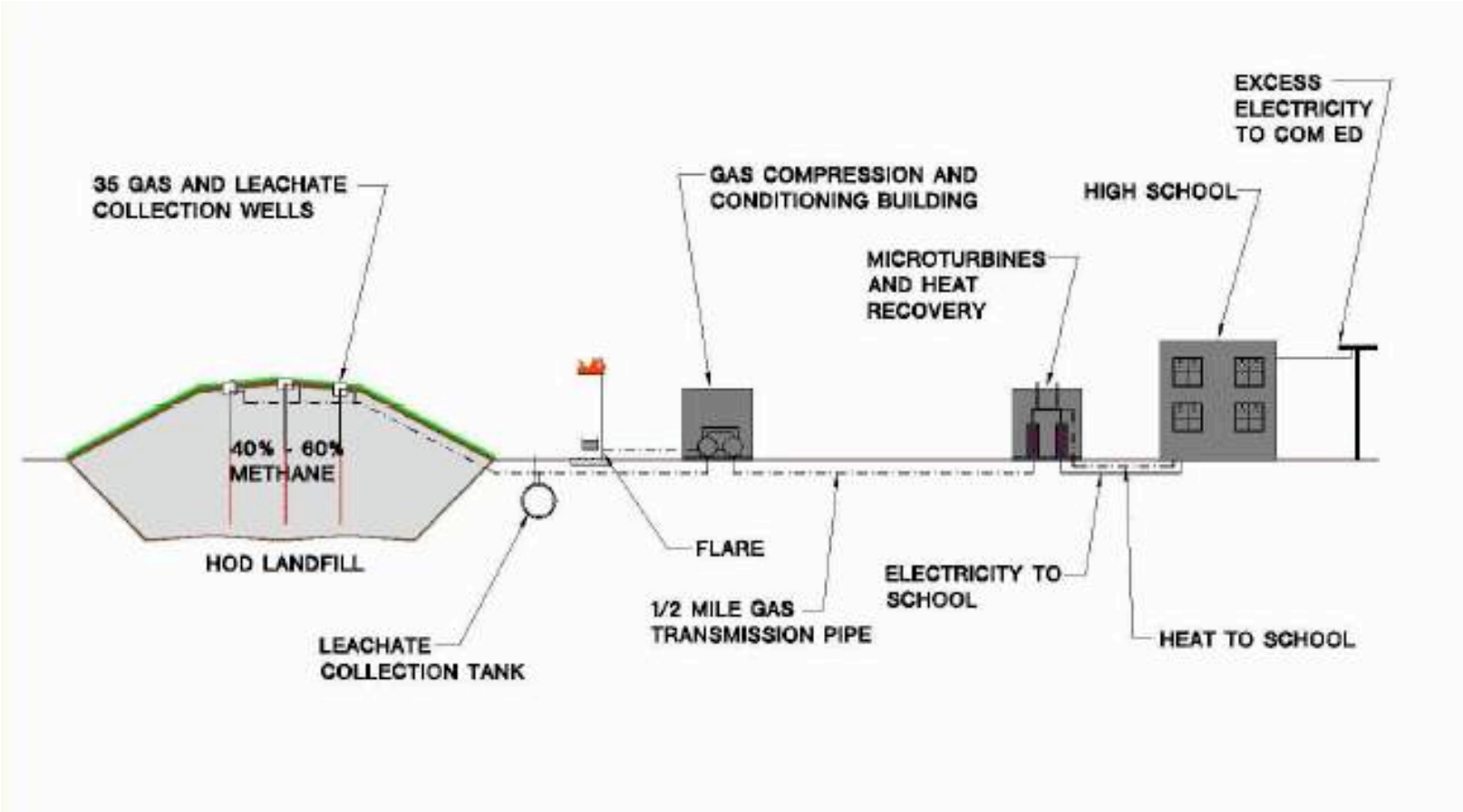
- Activated carbon unit included to remove additional impurities
- The LFG is compressed to 95 pounds per square inch to meet the input fuel requirements of the Capstone MicroTurbines.

Gas cleaning and conditioning system is located at HOD Landfill in a building adjacent to the blower and flare. ($200,000)



Landfill Gas-to-Energy Project

Behind the Wheel: Management Focus



MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Electric Generation

Behind the Wheel: Management Focus

- 12-turbine system selected to provide a system that remains functional as LFG production decreases
- Built-in relay protection automatically trips off the microturbines in the event of a utility system outage or a power-quality disturbance
- Excess electricity sold to local utility ComEd

Heat Generation

- Each Capstone Microturbine produces exhaust energy of around 290,000 Btu/hr at 550°F.
- Exhaust from the Microturbines is used to preheat water in high school heating system
- When waste heat recovery is not required, microturbine exhaust is automatically diverted around the exchanger, allowing for continued electrical output.
- During extremely cold weather, the school boiler system automatically uses natural gas to supplement the heat output of the microturbines.

Project Economics

Behind the Wheel: Management Focus

- Total Installed Costs - $1,900,000
- Grant from IL DECCA's PERP - $500,000
- Remaining cost secured through revenue bonds to paid off through energy savings
- Projected Annual Savings in 2002 >$100,000
- Greater savings today with higher natural prices

Project Benefits

Behind the Wheel: Management Focus

Win-win situation for all involved, including HOD Landfill, ACHS, the Village of Antioch, the State of Illinois, Commonwealth Edison, and EPA

- Low energy costs for the high school
- Use of waste heat for internal use in the high school
- Clean, complete combustion of waste gas
- Decreased emissions to the environment through reduced need for traditional electrical generation sources
- Reduction in greenhouse gas emissions

Project Benefits (continued)

Behind the Wheel: Management Focus

- Public relations opportunities for ACHS and the community as the first school district in the United States to get electricity and heat from LFG
- Educational opportunities in physics, chemistry, economics, and environmental management for ACHS students as a result of this on-campus, state-of-the-art gas-to-energy system

Summary

Behind the Wheel: Management Focus

- At most landfills, the gas collection equipment is already in place since they are required to flare the waste gas.
- Applications of LFG need to be identified and evaluated.
- Only some pipes need to be built and a genset installed to create an electric generating DG or CHP landfill gas project.
- State and Federal incentives available.
- More info
  - http://www.epa.gov/lmop/
  - http://www.chpcentermw.org

MIDWEST CHP APPLICATION CENTER
In Partnership with the US DOE

Thank you

Behind the Wheel: Management Focus

- For Questions, please contact:
  - **Cliff Haefke**
  - **Research Engineer**
  - **Midwest CHP Application Center**
  - **(312) 355-3476**
  - **chaefk1@uic.edu**

  - **John Cuttica**
  - **Director**
  - **Midwest CHP Application Center**
  - **(312) 996-4382**
  - **cuttica@uic.edu**

For more information, please visit **www.CHPCenterMW.org**

MIDWEST CHP APPLICATION CENTER

In Partnership with the US DOE