
Landfill Gas To Energy
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Agenda

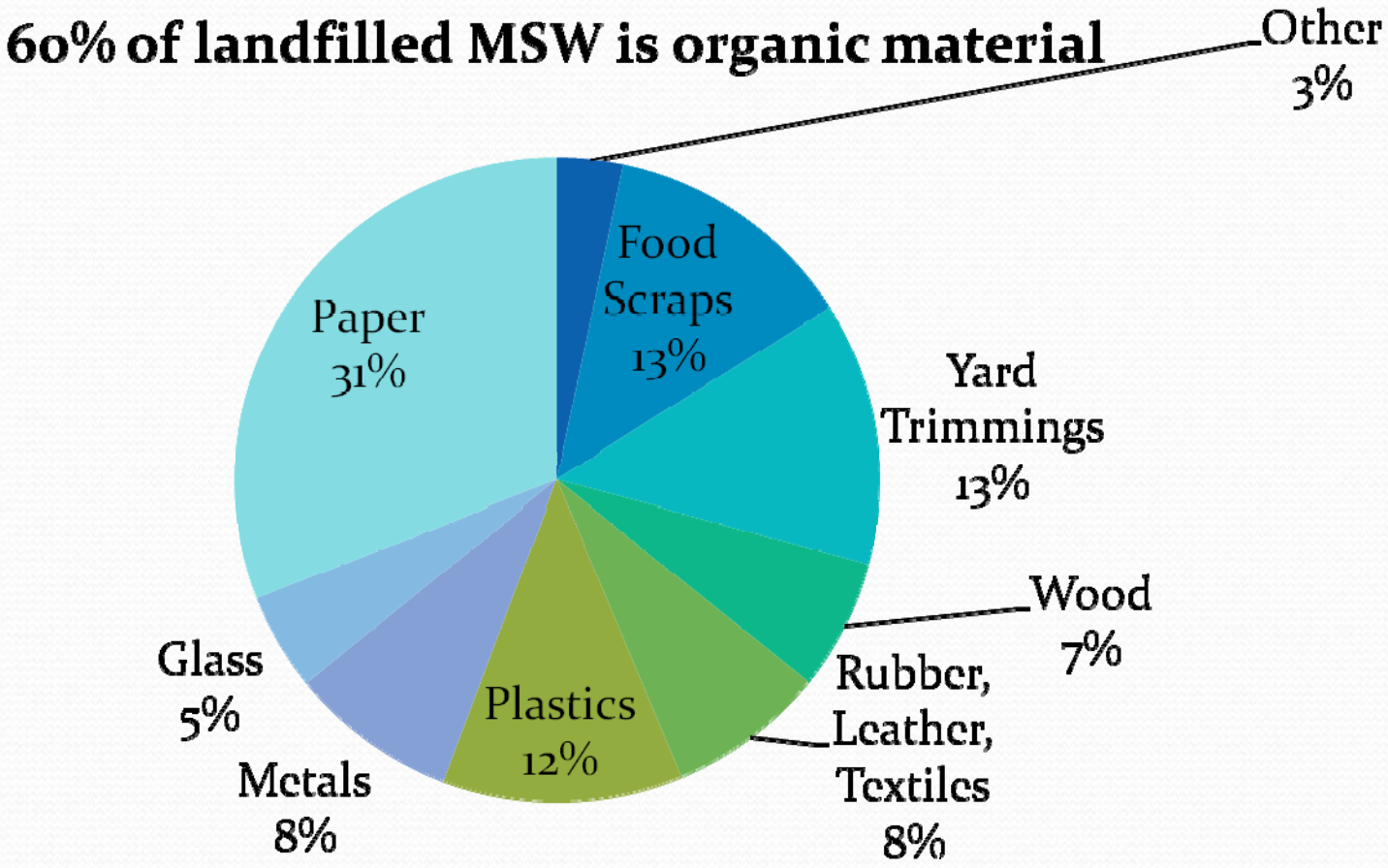
- Provide general overview of landfills in the U.S.
- Define landfill gas and its environmental hazards.
- Describe landfill gas recovery process.
- Explain different landfill gas to energy applications.
- Case study: Coast Guard Landfill Renewable Energy Center, Baltimore, Maryland.

Landfills

- Approximately 2000 operating landfills.
- In 2008, Americans produced 250 million tons of Municipal Solid Waste (MSW).
  - Average of 4.5 lbs of MSW produced per person per day.
  - 166 million tons (or 54%) was deposited into landfills.
    - 2.43 lbs per person per day ended up landfill.
  - Remainder was recycled, composted or incinerated.

Source: EPA

Total MSW Generation, 2008



Source: EPA

Landfills and Energy

- Two ways in which landfills can generate usable energy:
  - Waste To Energy (WTE)
    - Burning of non-recyclable waste in order to produce energy.
    - Approximately 107 such facilities operating in the U.S.
    - In 2008, 31.6 millions tons of waste was incinerated in WTE programs.
    - More than 600 worldwide.
  - Landfill Gas to Energy
    - Using landfill gases to generate electricity or heat.

Source: EPA; Photo: Wien Energie

Landfill Gases

- When waste is landfilled, organic matter decomposes and releases landfill gas (LFG).
- LFG is comprised of hundreds of different gases:
  - Methane (CH_4) - 40 - 60%
  - Carbon dioxide (CO_2) - 40 - 60%
  - Nitrogen
  - Oxygen
  - Ammonia
  - Non-methane organic compounds
  - Sulfides
  - Hydrogen

Source: EPA

Environmental Hazards: Methane

- Potent Greenhouse Gas (GHG) – over 20% more potent than CO_2.
- As of 2000, U.S. responsible for 11% of world methane emissions.
- Landfills account for 34% of anthropogenic methane emissions in US.
- If uncontrolled, LFGs cause foul odors, smog, and global warming.
- Uncontrolled methane create explosion risk in landfills.

Source: EPA

Existing Regulations

- Various laws already regulate LFGs:
  - Off-Site Underground Migration (RCRA Subtitle D)
  - Groundwater Contamination (RCRA Subtitle D)
  - Odors (local and state regulations)
  - Methane and NMOC emissions are regulated by the Clean Air Act's New Source Performance Standards and Emissions Guidelines (NSPS/EG).

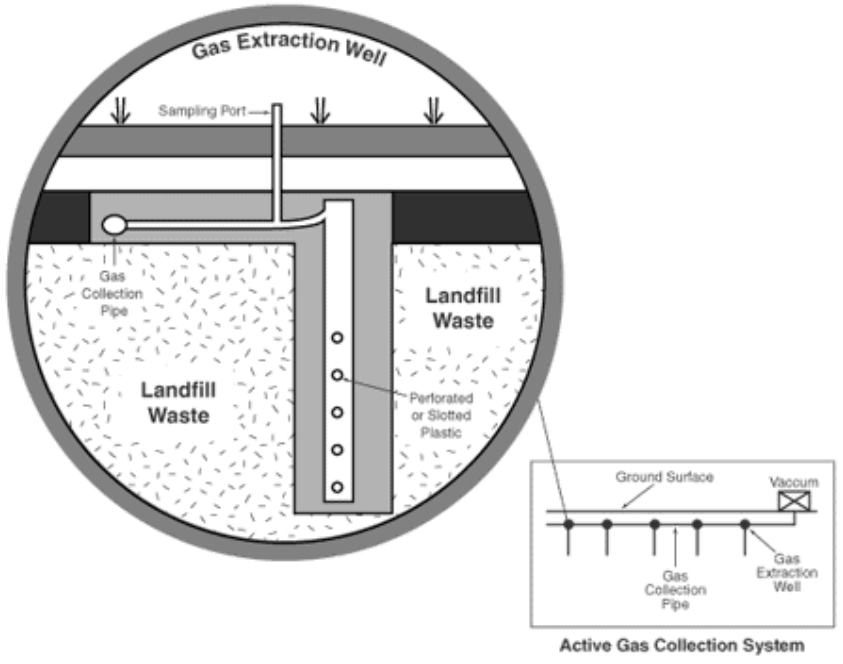
Source: EPA; Waste Management

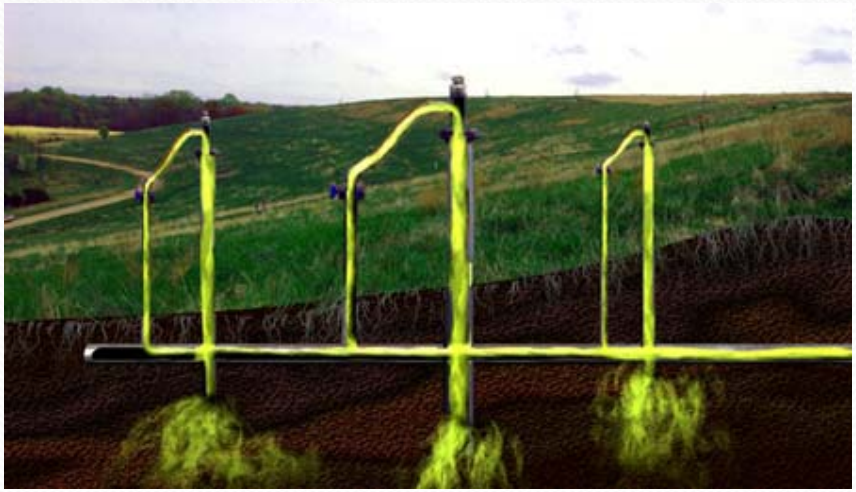
Valuable Energy Resource

- Fuel Equivalents of Landfill Gas (LFG with 50% methane); equivalents per 1,000 cubic feet of LFG:
  - Natural Gas 500 cubic feet
  - Propane 5.5 gallons
  - Butane 4.9 gallons
  - Gasoline 3.9 gallons
  - No. 2 Fuel Oil 3.6 gallons
  - Bituminous Coal 37 pounds
  - Medium-dry Wood 83 pounds

Source: EPA

Gas Recovery





Source: EPA

Landfill Gas Recovery: Passive Systems

- Use existing landfill pressure and gas concentration to vent gas into the atmosphere or collection systems.
- Less efficient than active systems
  - Depends on internal pressure within landfill
- Hazards of external gases migrating into landfill and causing risk of explosion.

Source: EPA

Landfill Gas Recovery: Active Systems

- Active gas collection systems use vacuums or pumps to move gas out of the landfill.
- Allows the operator to better manage the gas collection system by monitoring gas production, composition and pressure.

Source: EPA

Landfill Gas Recovery

Vertical Well

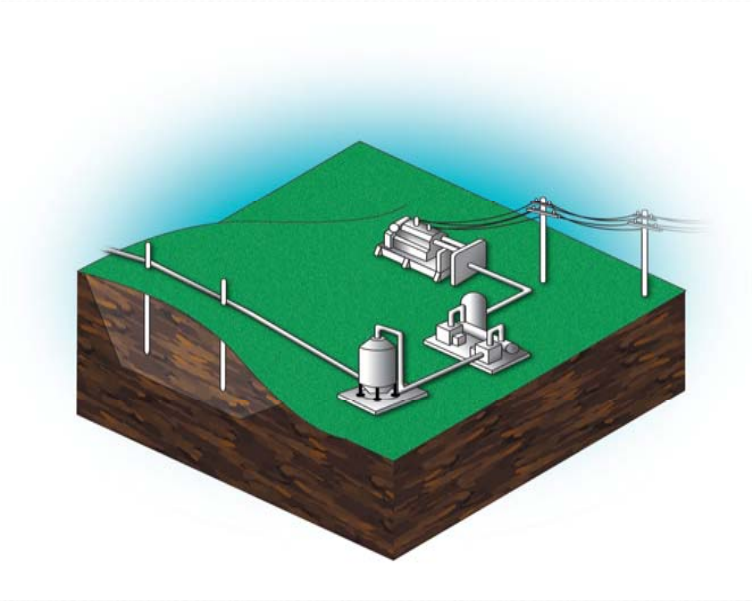
- Better vacuum spread throughout the landfill.
- Can be installed after filling is complete.
- Must Protect wells when placing trash over or around wells.

Horizontal Well

- Less interference with LF operations.
- Early LFG collection.
- Can be installed when landfill is active.
- Well ROI isn't as good vertically as horizontally
- Horizontally bore wells are costly to build.

Source: EPA

Processing and Delivery



- The methane gas is transported first to a gas scrubber, which extracts moisture and filters out particulates, and then to a compression facility.
- Finally, the gas is used to fuel turbines or engines to produce electricity.
- For direct-use applications, landfill gas is delivered offsite to industrial customers and used as an alternative fuel source

Source: EPA

Bioreactors

- Current regulations try to minimize leachate and LFG, which are seen as negative byproducts.
- A bioreactor landfill is a sanitary landfill that uses enhanced microbiological processes to optimize LFG production.
- Methods include:
  - Liquid addition and management
  - Waste shredding
  - PH adjustment
  - Nutrient addition
  - Temperature management
- Increasingly important as operators try to maximize potential credits.

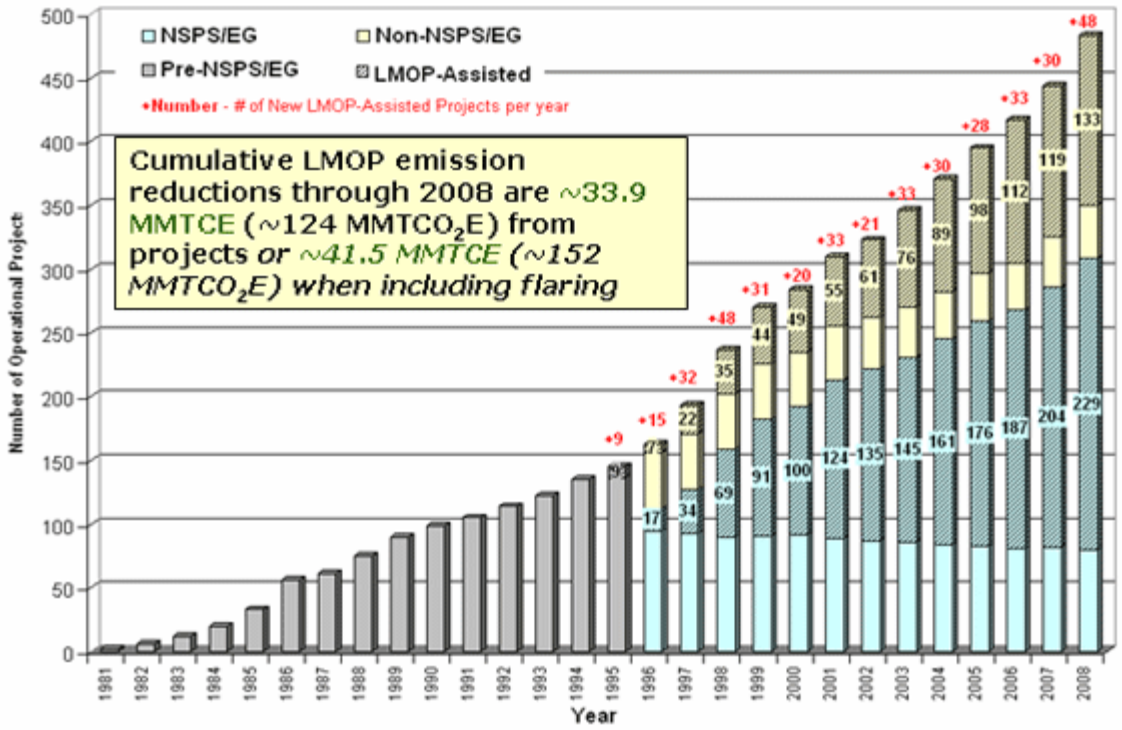
Source: EPA

Current Use

- First came on scene in mid to late-1970s.
- Notable increase in mid-1990s as efficiency and dependability increased.
- Currently, more than 496 LFG energy projects operating in more than 40 states.
  - 2/3 generate electricity
  - 1/3 direct-use projects
- Likely to see large increase due to:
  - Possible cap and trade regulation.
  - State emission portfolio standards.

Source: EPA

Growth in Landfill Gas Utilization Project Development



Source: EPA

Gas to Energy

- Flaring
  - Methane is converted to carbon dioxide, resulting in large GHG impact reduction.
  - No energy recovery; wasted energy source.
- Direct Use
  - Pipeline Quality Gas Production
- Electricity Generation
- Alternative Fuels

Source: EPA

Direct Use: Medium Btu Gas

- Minimal processing of gas.
- Used to completely or partially displaces fossil fuels.
- Cost efficient when facility that can use LFG is less than 5 miles away.
- Most common applications include:
  - Boilers
  - Direct thermal applications
    - Brick kilns; asphalt plants
    - Nurseries
    - Commercial heating
  - Furnaces

Source: EPA; CA Energy Commission

Pipeline Quality Gas Production: High Btu Gas

- Requires large degree of processing.
- Direct injection of cleaned LFG into natural gas pipelines.
  - LFG is 40-60% methane; pipeline natural gas contains about 90% methane.
  - LFG contains ½ Btu of natural gas.

Source: EPA; CA Energy Commission

Electricity Generation

- More than 70% of LFG energy projects generate electricity through combustion of LFG in internal combustion engines.
- Other uses include:
  - Gas turbines
  - Microturbines
  - Boiler/steam turbine applications
  - Combined cycle applications
  - Fuel Cells
- Cogeneration
  - Heat and Electricity

Source: EPA

Alternative Fuels

- Vehicle Fuels
  - Compressed Natural Gas and Liquified Natural Gas
  - 2007 – 12,000 vehicles worldwide; 2010 – 70,000
- Methanol
  - Removal of CO_2 and vapor.
- Ammonia
- Urea

Source: EPA; US Dept of Energy

Landfill Gas Energy Projects and Candidate Landfills

LANDFILL METHANE OUTREACH PROGRAM

Source: EPA

Environmental Benefits

- Prevents direct release of methane into environment.
- Direct GHG reductions:
  - LFG energy project will capture estimated 60 – 90% of methane generated by landfill. When burned as a gas for heating or electricity methane is turned into water and CO_2.
    - This type of CO_2 is not considered to contribute to global climate change because the carbon that was contained in the biomass would be released in equal amounts were the matter to decompose naturally. Further, CO_2 is less damaging than methane is terms of global warming.
- Indirect GHG reductions:
  - Use of LFG displaces the use of non-renewable resources that would be needed to produce same energy.

Source: EPA

Environmental Benefits

- In 2009, the 485 operation projects supplied:
  - 12 billion kilowatt-hours of electricity and 85 billion cubic feet of LFG to direct-use applications annually
- Estimated '09 Annual Environmental Benefits
  - Carbon sequestered annually by ~19,500,000 acres of pine or fir forests, or
  - CO_2 emissions from ~199,000,000 barrels of oil consumed, or
  - Annual greenhouse gas emissions from ~15,700,000 passenger vehicles.

Source: EPA

Economic Benefits

- Landfill Owners:
  - Revenue stream from selling LFG to direct end user or pipeline, or from sale of electricity generated to local power grid.
  - Reduced environmental compliance costs.
  - Renewable Energy Certificates (RECs)
  - Tax credits
  - Renewable Energy Bonds
  - Public relations

Source: EPA

Economic Benefit: Available Financial Assistance

- Federal
  - Dept of Treasury
    - Renewable Electricity Production Tax Credit
    - Business Energy Investment Tax Credit
  - Dept of Energy
    - Renewable Energy Production Incentive
    - Energy Efficiency and Conservation Block Grant
  - Dept of Agriculture
    - High Energy Cost Grant
- States
  - Alabama Renewable Energy Grants
    - $75,000 construction of landfill gas projects
  - South Carolina Biomass Energy Tax Credit

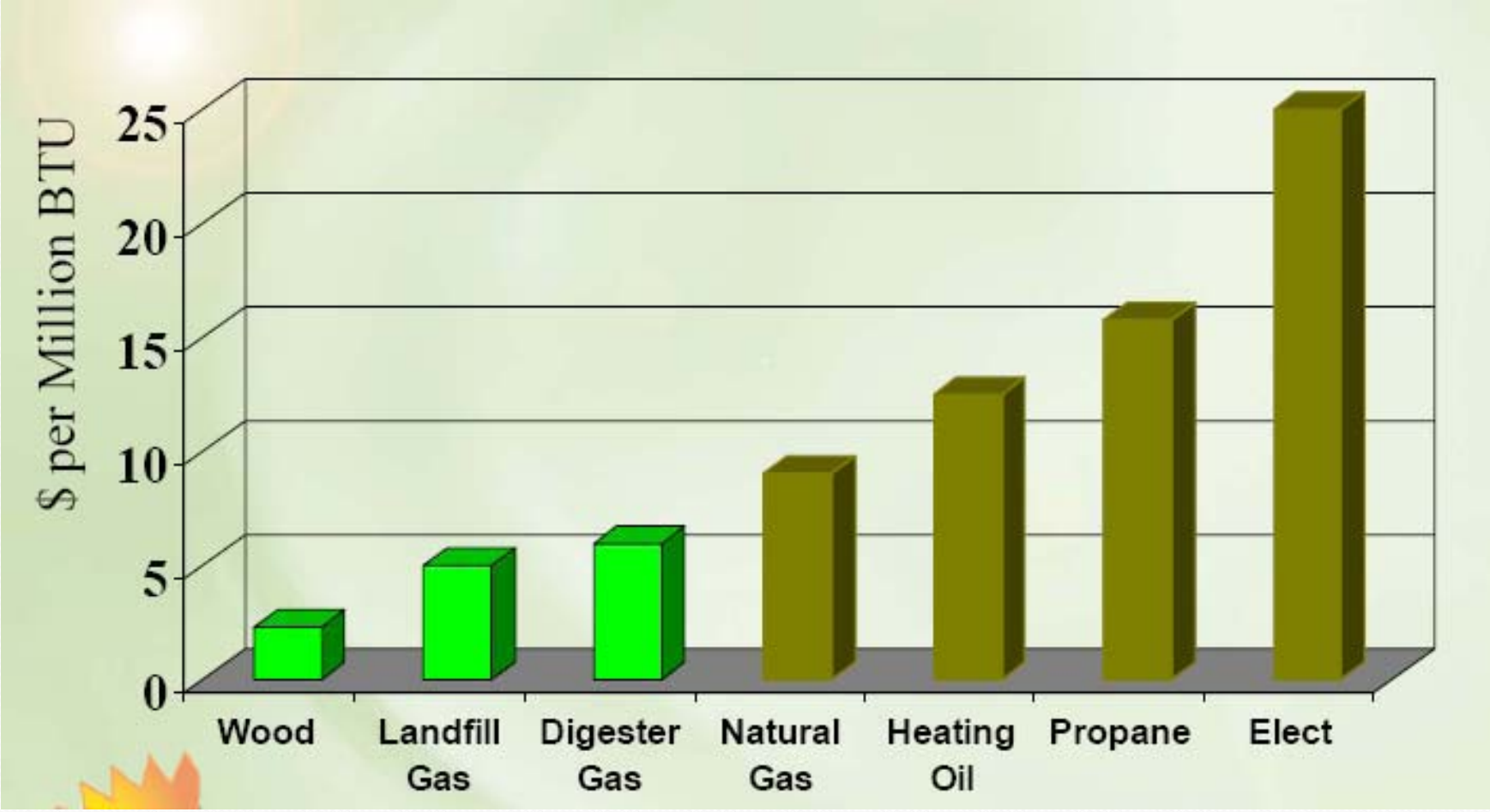
Source: EPA; US Dept of Energy

Economic Benefit

- End User
  - Significant savings for businesses and organizations that choose LFG as a direct fuel source.
    - However, infrastructure is expensive.
  - More economically stable energy source.
  - Positive publicity.
- Community
  - Job creation – construction, design and operation.
  - Attract businesses.

Source: EPA

Economic Benefits



Source: EPA

Challenges

- To be economically viable, landfill must be located near transmission lines or direct-use facility.
- Should landfills that make direct sales of methane to third-party customers be regulated as a public utility?
  - CT, FL, and WI exempt small LFG to electricity projects.
- Landfills must create enough gas to be cost effective.
- Possible release of dioxins.

Source: EPA

Landfill Methane Outreach Program

- Created in 1994
- Voluntary program created by EPA to provide assistance to organization interest in LFG recovery projects and educate the public as to lasted LFG advances and opportunities.
  - Matches landfills and end users.
  - Assists with preliminary technical and economic feasibility assessments.
  - Generates positive publicity for energy projects.

Source: EPA

Case Study: Coast Guard Landfill Renewable Energy Center, Baltimore, Maryland

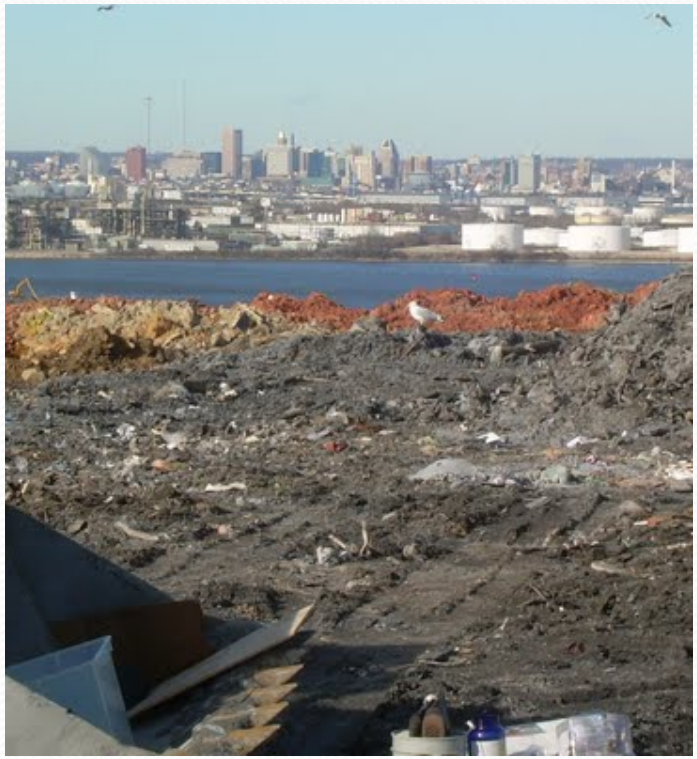
Source: USCG

Energy Policy Act of 2005

- Energy Policy Act of 2005
  - Requires the President, through the Secretary of Energy, to ensure that federal agencies meet the below renewable energy consumption requirements:
    - NLT 3% in FYs 2007-2009
    - NLT 5% in FYS 2010-2012
    - NLT 7.5% in FY 2013 and the years following
- Executive Order 13423 mandated that ½ of statutorily required renewable energy must come from solar, wind, geothermal, biomass fuel projects constructed after 1999.

Source: USCG

Quarantine Road Landfill



- Under pressure by EPA to make changes because it was not meeting its air quality obligations.
- Initially requested bids from private parties; however, ended in litigation.
- Because the landfill was city owned, it could contract with state and federal agencies under different procurement rules.

Source: USCG


USCG Yard Bioenergy Project Location
Quarantine Road Landfill
Inner Loop
Outer Loop
695
Baltimore Beltway
Hawkins Point Rd
Bldg 15
Ross Ave
Wagaziha Ave
Hamlet Ave
Curtis Creek
Arundel Cove
CSX Railroad
Legend
USCG Yard
Curtis Bay, Baltimore
Baltimore City
Quarantine Road Landfill
Baltimore City LFG Collection System
Offsite Pipeline (Ameresco Owned)
Onsite Pipeline (USCG)
Blower/Flare Station
Compressor/Dehydration Station
Renewable Energy Center (REC)
Map Area
Baltimore City
Anne Arundel County

Source: USCG

Overview

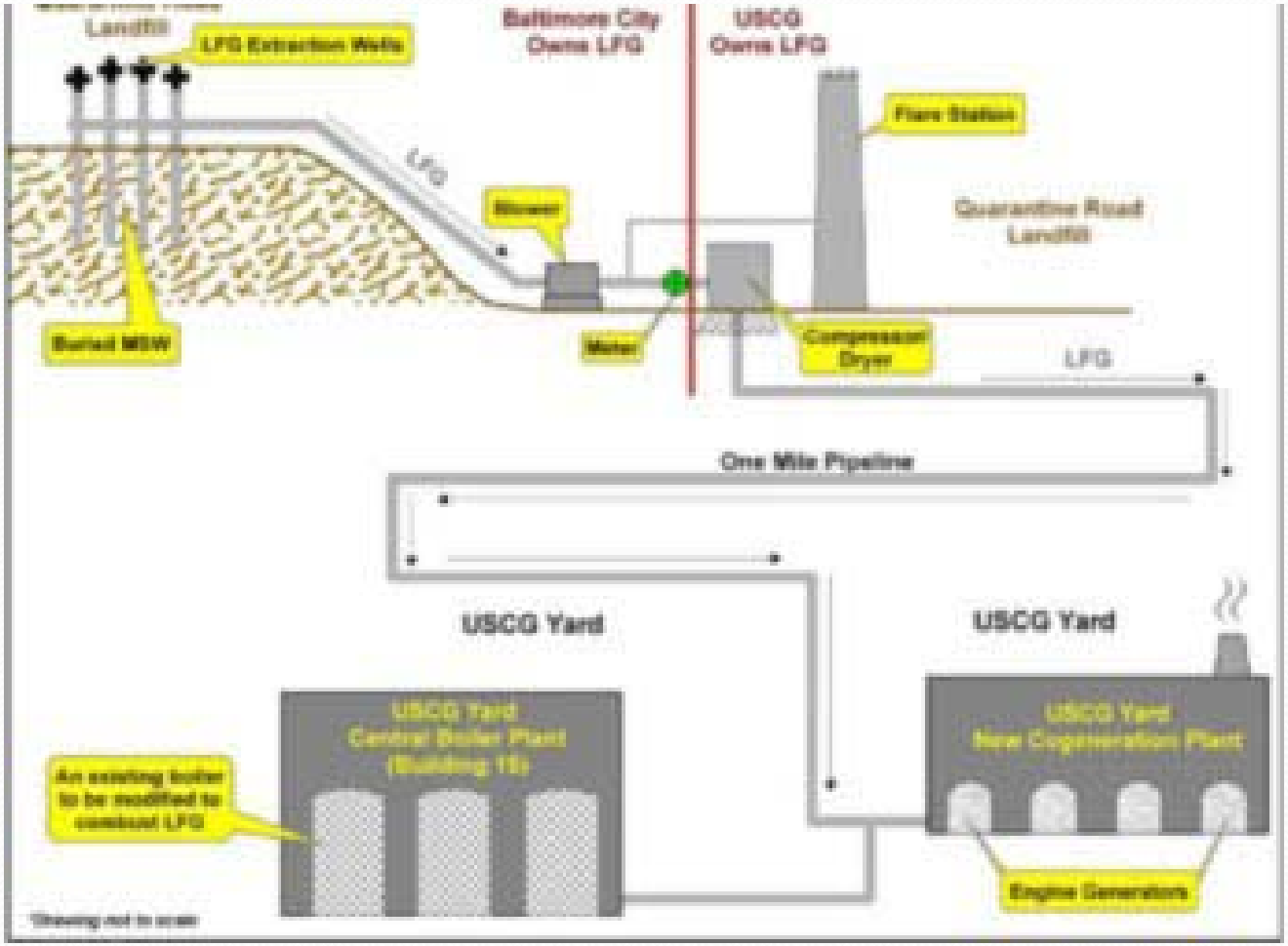
- Start-up on April 22, 2009
- Baltimore City owned Quarantine Road Landfill; site contains approx. 10m tons of waste.
- Project highlights:
  - Largest renewable energy project in Coast Guard history.
    - Also invested in solar and wind projects.
  - First co-generation plant in the State of Maryland.
  - Meets the renewable energy requirements of the entire Department of Homeland Security through the year 2012.

Source: USCG

Overview

- Recovery & Processing System at landfill
  - 1 mile 16 inch pipeline from landfill to USCG
- Co-Generation
  - USCG receives both steam and electricty.
- Four generators located in Bldg. 48
  - 4.6 MW output
    - 33,000 vehicles or 3,000 homes
  - 13,000 lb/hr of 85 psig steam
- Interconnected w/ utility
- Designed for 98% up-time

Source: EPA


Landfill
LFG Extraction Wells
Baltimore City
Owns LFG
USCG
Owns LFG
Flare Station
LFG
Blower
Quarantine Road
Landfill
Buried MSW
Meter
Compression
Dryer
LFG
One Mile Pipeline
USCG Yard
USCG Yard
USCG Yard
Central Boiler Plant
(Building 15)
An existing boiler
to be modified to
combust LFG
USCG Yard
New Cogeneration Plant
Engine Generators

Source: USCG

Finances / Contract Overview

- Energy Saving Performance Contracts
  - Allows Coast Guard to secure third-party financing as long as financing can be paid back with energy-cost savings.
  - At the time of contract, Coast Guard was spending approximately $2 million dollars a year on electricty.
- Ameresco built pipeline and processing facility at no cost to USCG.
- $41 million dollar 15 year contract
  - Includes $200,000 paid to City of Baltomore for gas.
  - $15 million in capital costs.
  - Continuing maintenance and operation.
- At end of 15 years, USCG own processing plant and pipeline.
  - How long will landfill supply gas?

Source: USCG

Anticipated Benefits

- Reduced vulnerability to off-site power interruptions with improved energy security, constant reliable fuel source (LFG) and on-site power & steam production.
- Long term price stability
- Annual avoided utility cost of over $2M
- City revenue increase annually through the term.
- Reduced boiler plant emissions and avoidance of methane gas into the environment

Source: USCG

So Far. . .

- Growing pains
  - Contractor initially was sucking out too much methane from the landfill, which ended up killing some of the microorganisms responsible for creating methane.
  - Result: 50% of anticipated energy

Source: USCG

Conclusion: Future

- EPA has identified 570 candidate landfills with the potential to generate 421 – 613 billion cubic feet of methane each year.
  - Could produce 4000 megawatts of electricity.
    - Power 3 millions homes.
    - Remove 35.2 million cars from roads.
    - Eliminate need for 372 million barrels of oil.
- 500 landfills have a gas collection system but no energy project.
- 95 landfills have an energy project and excess LFG available,
- 970 landfills do not have a gas collection system

Source: EPA

Conclusions: Future

- Trash powered street lights
  - Gaon Street Light – Street light with a trash can base.
  - Methane from composted trash is used provide power to street light