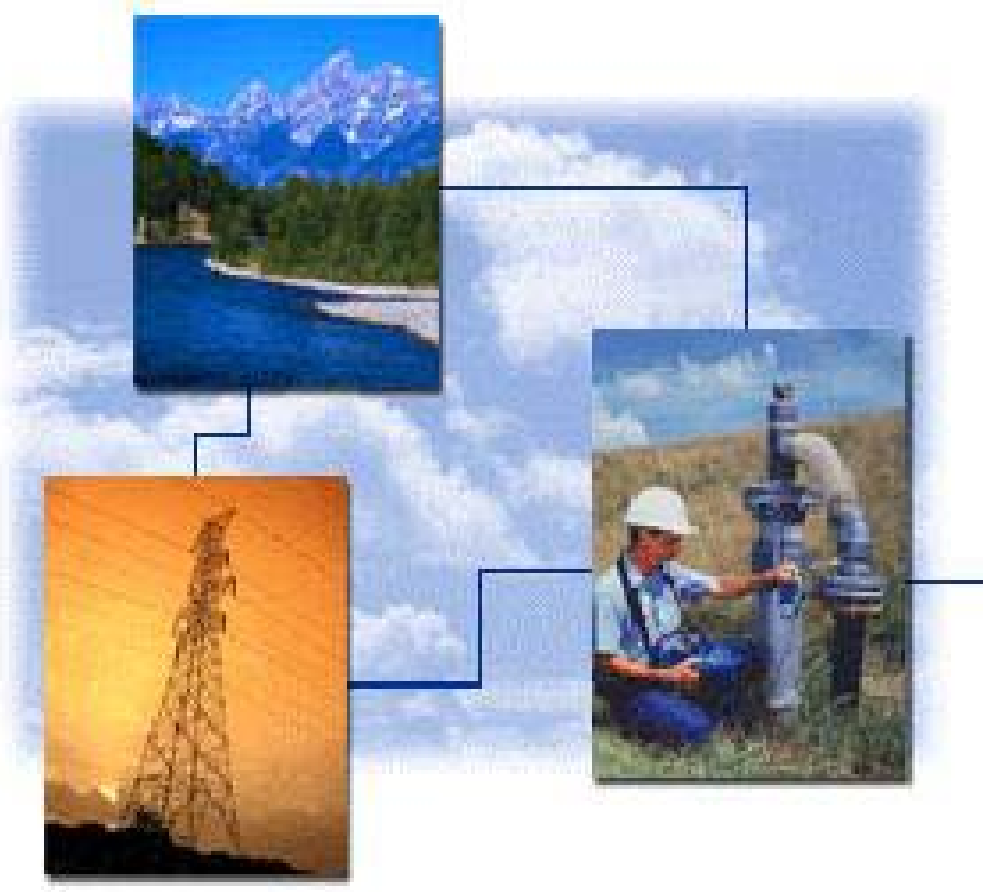
June 2003

Landfill Gas GHG Emission Offset Opportunities



Background

- Landfill gas (LFG) results from the natural decomposition of municipal solid waste in landfills
- LFG composition:
  - ~ 50% methane (CH_4)
  - ~ 50% carbon dioxide (CO_2)
  - small amounts of non-methane organic compounds
- CH_4 is a potent GHG, 21 times the GWP of CO2
- Recovering & combusting LFG offers significant opportunities for cost-effective emission reductions

Background

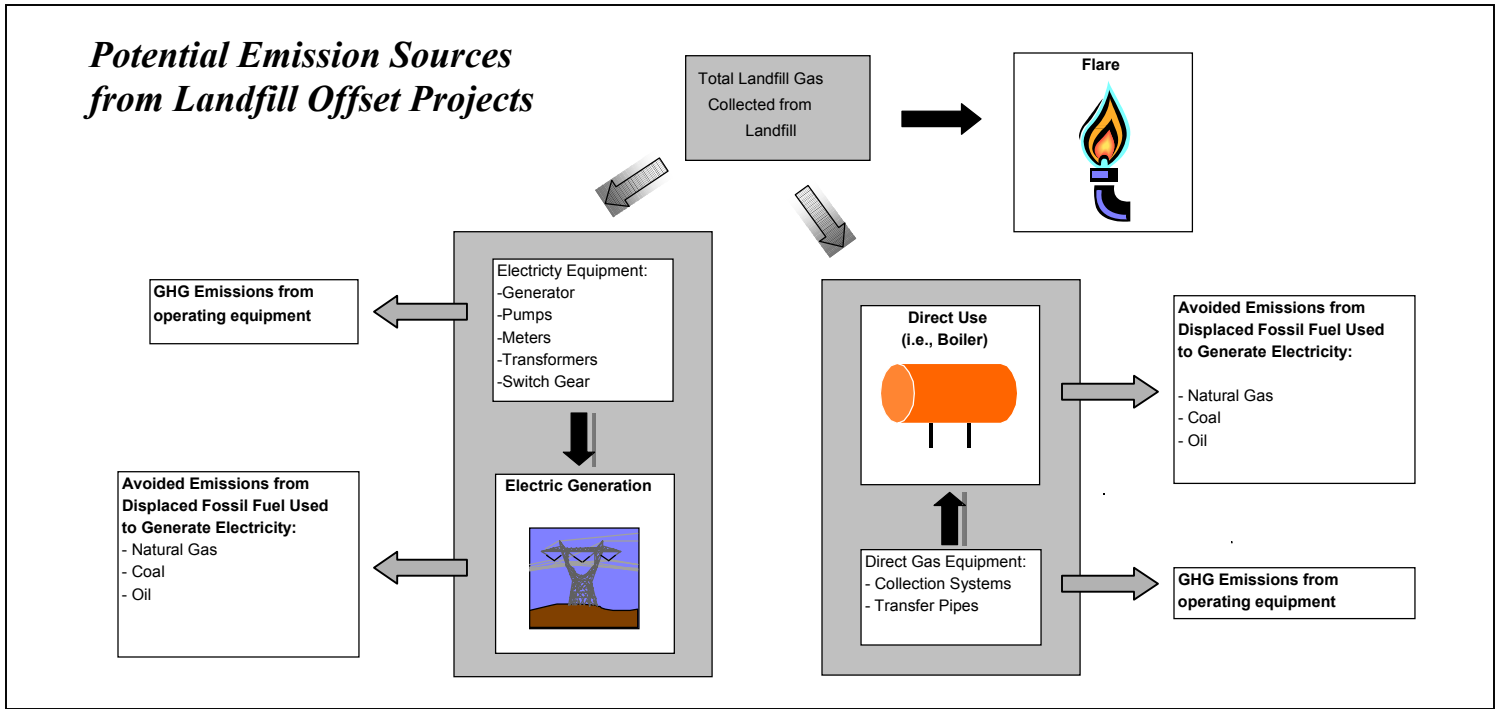
- Project definition: types of LFG projects
  - *Electricity generation*: LFG is collected & used as fuel to produce electricity (using engines, turbines, etc.)
  - *Direct use as fuel*: LFG is collected and transported for use as fuel for various applications (boilers, industrial processes, vehicle fuel, greenhouses)
  - *Flaring*: LFG is collected and combusted in a flare (without recovering its energy value)
- Project benefits
  - Reduce GHG emissions
  - Improve local air quality, and reduce odors & explosion hazards associated with gas migration from landfill
  - Improve economic development near landfill
  - Provide revenue

Determining Offset GHG Potential

- Step 1: Identify project type
  - Electricity generation - Direct use project - Flare
- Step 2: Determine eligibility
  - Some landfills are required to collect & combust LFG by Federal, State or Local regulations:
    - Federal regulations require larger landfills to collect & combust LFG (NSPS & NESHAPS); gas migration control is regulated under RCRA
    - Some States regulate LFG emissions - requirements are either the same as the Federal regulations or more stringent
    - Local codes may require landfills to control LFG migration/odors
  - Regulatory status at a particular landfill can change over time - consider future status
  - Projects involving regulated landfills would not be eligible for CH_4 offsets only carbon benefits from avoided CO_2 (i.e., from avoided electricity use or fossil fuel use)

Determining Offset GHG Potential

- Step 3: Define project boundary
  - Boundary will include the landfill and may include emission sources outside of the landfill site depending on the project (i.e., direct use -boiler)
  - All project related emission sources should be identified
    - Fugitive CH_4 from waste decomposition
    - CO_2 from energy generation and gas collection and cleaning equipment
    - CO_2 from energy use for auxiliary processes
    - CO_2 emissions from combusting LFG do not have to be accounted for (biogenic)



Determining Offset GHG Potential

- Step 4: Establish baseline
  - Regulated landfills - offset opportunities are only from carbon benefit of avoided fossil fuel use at these sites
  - Non-regulated landfills - offset opportunities include methane mitigation in addition to displacement of fossil fuels
  - Establish timeline of baseline - LFG project lifetime is ~ 15 years
  - Baseline should be dynamic - periodically reviewed and adjusted - due to changing variables
    - LFG generation, regulatory status, emission factors - fuel use
- Step 5: Pre-installation estimation of project emissions and savings
  - Emissions attributable to the proposed landfill project should be estimated and subtracted from baseline emissions in order to estimate total emissions reductions due to the project.
    - If the project includes energy recovery for direct use or electricity generation, these project emissions also should be estimated.

Determining Offset GHG Potential

- Step 6: Monitoring
  - The quantity of LFG collected & combusted can be readily measured using a metering system;
  - Data (e.g., emission factors) needed for estimating the carbon benefit of avoided fossil fuel use (for electricity generation or direct use projects) should be obtained;
  - Accounting should be made for GHG emissions that result from the project (e.g., gas processing, treatment)

- Step 7: Post-installation calculation of project GHG savings
  - Measure quantity of methane combusted in flare, electricity generation equipment or direct use technology & convert to CO_2 equivalents (exclude if LFG combustion required by regulation)
  - Calculate carbon benefit of avoided fossil fuel use using emission factors
  - Calculate or estimate GHG impacts of project-related emission sources and deduct from carbon savings

Example Project 1: Electricity Generation, Unregulated Landfill

- Landfill & project description
  - Landfill receives 2 million tons of waste between 1993 and 2013
  - LF isn't subject to a regulatory requirement to combust LFG
  - LFG combusted on-site in IC engines to produce electricity for sale to grid; 15 year project lifetime; will deliver ~ 7500 MWh per year
- Capital cost ~ $2 million
- Annual O & M cost for initial year ~ $260,000
- 11 percent return on investment @ $0.075/kwh
- Emission reductions ~ 0.06 MMTCO$_2$ per year
  - Includes landfill methane combusted + carbon benefit from avoided fossil fuel use

Example Project 2: Direct Use Project, Regulated Landfill

- Landfill & project description:
  - LF receives 8 million tons of waste between 1983 and 2013
  - Required by Federal regulation to collect & combust LFG
  - LFG to be piped to a facility where it will replace natural gas in boilers to produce steam for heating; 15 year project lifetime beginning in 2004; will deliver ~1400 scfm LFG
- Capital costs ~ $0.7 million (Excludes cost of gas collection system, since already collecting gas per regulation)
- Annual O & M cost for initial year ~ $200,000
- 147 percent return on investment @ $2/MMBTU
- Emission reductions ~ 0.02 $MMTCO_2$ per year
  - Includes ONLY the carbon benefit from avoided fossil fuel use, because LFG combustion is required at this site