Landfill GCCS Collection Efficiency - What do the Numbers Really Mean?

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Operating Metrics

• Since we began collecting landfill gas, owners, operators and regulatory agencies have been searching for appropriate metrics to evaluate the relative performance of landfill gas collection and control systems

• This quest has been driven by a number of factors, primarily regulatory and economic
Operating Metrics

• Typical Questions:
  1. Is the GCCS doing what it’s supposed to do?
  2. Is the GCCS complying with regulatory requirements?
  3. Should I be getting more gas out of my landfill?
  4. Should I be getting better gas out of my landfill?
  5. Do I have an “efficient” GCCS?

• These all lead to the “Big Question”...
Big Question

What’s my collection efficiency?
What is “Collection Efficiency”?

• Efficiency
  
  • The ability to do something or produce something without wasting materials, time, or energy
  
  • The quality or degree of being efficient
What is “Collection Efficiency”?

• Collection Efficiency (as applies to GCCS)
  • Traditionally - the rate of gas extraction compared to the rate of gas generation
  • Is that really correct?

• Appears to be a very simple, straightforward approach to evaluating the operations of the GCCS

• USEPA estimates the average CE ~75% (AP-42, 1998)

• SWANA estimates the average CE ~91% (LFG Collection Efficiencies, 2007)
Potential Errors

- Human error
  - Poor meter installation
    - 18” SDR 17 HDPE vs 18” SCH 10 steel (15.88” ID vs 17.5” ID)
    - Incorrect orifice plate
    - Bad location

- Poor or infrequent meter calibration

- Errors in monitoring components
  - Good meter: +/- 1% accuracy
  - Assuming:
    - Dry gas
    - No liquids accumulation
    - No particulate fouling
Potential Errors

• Single meter at flare station
  • Potential physical errors are rather limited
  • Relatively easy to identify and correct

• Multiple meters throughout wellfield
  • Potential for errors increases greatly
  • Using 100 meters on 100 extraction points – potential error at +/- 1% is +/- 100%
  • Should never rely on individual wellhead meters as an aggregate of total flow – *indicators only!*
Potential Errors

• Oxidation
  • Occurs when LFG (i.e. methane) passes through cover soils/organic materials between the anaerobic zone to the atmosphere
  • Acknowledged within the industry but field studies are relatively limited
  • Incorporated into select regulatory models – primarily in California (CALMIN default of 10%)

• $\text{CE}_{\text{REV}} = (\text{Rate of LFG recovery + Rate of oxidation}) / \text{Rate of LFG generation}$
  • 2007 SWANA – Palos Verde CE >99% (including oxidation)
Potential Errors

- Assuming that your flow meters are accurate, you still need to consider the base calculation – LandGEM

- LandGEM was developed by USEPA based on test data from 40 landfills in 1980’s and 1990’s

\[ Q_{CH4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_0 \frac{M_i}{10} e^{-kt_{i,j}} \]

- Assumes uniform waste characteristics
  - Waste types
  - Moisture
  - Compaction
Variability in methane yield rates

- USEPA defaults are $100 \text{ m}^3 \text{ CH}_4/\text{Mg} (L_0)$ and $0.04/\text{yr} (k)$
- 2010 study (De La Cruz and Barlaz), along with other studies, demonstrate variations:

<table>
<thead>
<tr>
<th>Refuse Type</th>
<th>$L_0 (\text{m}^3/\text{Mg})$</th>
<th>$k (\text{yr}^{-1})$</th>
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Operating Metrics

• Back to the original Questions:

1. Is the GCCS doing what it’s supposed to do?
2. Is the GCCS complying with regulatory requirements?
3. Should I be getting more gas out of my landfill?
4. Should I be getting better gas out of my landfill?
5. Do I have an “efficient” GCCS?
1. Is the GCCS doing what it’s supposed to do?

• Control LFG within the waste mass
  • Subsurface methane concentrations less than 5% v/v at the facility boundary and less than 1.25% v/v within an occupied structure
  • Limit surface methane emissions to <500 ppmv above background
  • Minimize off-site nuisance odors

• If your system is doing these things, it is operating effectively

• Approaching 100% efficiency? Getting pretty close!
2. Is the GCCS complying with regulatory requirements?

• Items we just reviewed...plus
  • Vacuum applied to all collectors
  • Oxygen <5% v/v or Nitrogen <20% v/v
  • Temperature <55⁰C (131⁰F)
  • Any applicable variances (NSPS/EG)

• If your system is successfully operating within these parameters, it is complying with regulatory requirements
3. Should I be getting more gas out of my landfill?

• From monitoring data (Items 1 and 2)
  • Do I have vacuum on all of my collectors?
  • Do I have flow from all of my collectors?
  • Do I have subsurface migration?
  • Do I have surface emissions above permissible limits?
  • Do I have off-site odors?
3. Should I be getting more gas out of my landfill?

- Are there areas of the waste mass that need collectors?

- 10 ac, 120 feet ave. thickness, final grade
- 16 ac, >180 feet ave. thickness, operational
- 6.5 ac, 70 feet ave. thickness, interim cover
3. Should I be getting more gas out of my landfill?

- How much solid casing do I have?
3. Should I be getting more gas out of my landfill?

- Are there liquid impacts on my collectors?
  - LFG collectors are “holes” in the waste mass
  - Highest areas of porosity
  - As liquid levels rise – available perforations are reduced
  - Potential limitations to LFG extraction
  - Need to investigate and track liquid levels to determine potential impact
2D/3D Liquid Levels
Liquid Levels Over Time
3. Should I be getting more gas out of my landfill?

- Are my collectors damaged?
  - Are they pinched or crushed?
  - Are they filled with sediment or sludge?
- Are my headers distributing vacuum adequately throughout the wellfield?
- Are the headers sized correctly?
4. Should I be getting better gas out of my landfill?

• How old is the waste mass?
4. Should I be getting better gas out of my landfill?

- What kind of waste am I pulling from?
  - MSW
  - C&D
  - Pulp & Paper Mill or other Industrial Waste
  - Sludge – POTW, industrial, dredgings, solidification

- Do you have other contaminants to deal with?
  - Hydrogen sulfide, Siloxanes, etc.
  - May require additional treatment
  - Segregation of gas extraction
4. Should I be getting better gas out of my landfill?

- Am I over-pulling my wells?
5. Do I have an “efficient” GCCS?

• How do you answer items 1-4?
  1. Is the GCCS doing what it’s supposed to do?
  2. Is the GCCS complying with regulatory requirements?
  3. Should I be getting more gas out of my landfill?
  4. Should I be getting better gas out of my landfill?

• If gas isn’t coming out of the cover or being detected in probes, it’s either being oxidized or collected by the GCCS
So what does it all mean?

- Tough to measure overall operations with a single “collection efficiency” metric
- Truly understanding your GCCS is time-intensive – it is a constantly evolving system
- There are a lot of moving parts
- Use appropriate database tools to manage and analyze the data
Operational Locations

Office Locations

- Arizona
  - Phoenix, AZ
  - Tucson, AZ
- California
  - Dublin, CA
  - San Diego, CA
- Florida
  - Ft. Lauderdale, FL
  - Jacksonville, FL
- Illinois
  - Bolingbrook, IL
  - Springfield, IL
- Kansas
  - Kansas City, KS
- Kentucky
  - Lexington, KY
- Massachusetts
  - Reading, MA
- Michigan
  - Farmington Hills, MI
  - Grand Rapids, MI
- Missouri
  - St. Louis, MO
- New Jersey
  - East Brunswick, NJ
- New York
  - Greenwich, NY
  - Middletown, NY
  - Rochester, NY
- Ohio
  - Cincinnati, OH
  - Logan, OH
- Oregon
  - Portland, OR
- Pennsylvania
  - Pittsburgh, PA
- Washington
  - Spokane, WA
- Wisconsin
  - Plymouth, WI
  - Madison, WI