An Evaluation of the Effectiveness of Organics Recycling & its Impacts on MSW Landfills in NYS

Bryan Szalda | GHD
May 2017
Presentation outline

Introduction

Part 1 – Comparison of Organics Recycling Versus Traditional Landfill

Part 2 – Measuring Cost Effectiveness of Organics Recycling
  • Example 1: Large-scale Digester Plant
  • Example 2: Large-scale Compost Facility

Conclusions / Findings
Introduction

Regulatory agencies have increasingly promoted organics recycling over landfilling
• Reduces greenhouse gas emissions
• Creates soil amendments
• Energy benefits
• Creates jobs
• Reduces reliance on waste disposal

Do benefits of organics recycling outweigh the increased costs?
What effects will MSW landfills experience?
Can we model cost effectiveness of large-scale organics recycling over baseline landfill?
Part 1 Anaerobic Digester Versus MSW Landfill

<table>
<thead>
<tr>
<th>Anaerobic Digesters</th>
<th>MSW Landfills</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Organic waste processed in controlled container (anaerobic).</td>
<td>• Mixed waste (organic &amp; inert waste) buried with daily cover</td>
</tr>
<tr>
<td>• Separation of organic waste</td>
<td>• MSW &amp; Non-hazardous waste</td>
</tr>
<tr>
<td>• Extremely fast kinetics</td>
<td>• Slower kinetics = longer degradation</td>
</tr>
<tr>
<td>• ~100% collection of biogas (60% CH\textsubscript{4}, 40% CO\textsubscript{2})</td>
<td>• Landfill w/ collection system = 75-95% collection of LFG (50% CH\textsubscript{4}, 50% CO\textsubscript{2})</td>
</tr>
<tr>
<td>• Biogas and heat can be processed as renewables</td>
<td>• LFG can be processed as renewable energy source or flared</td>
</tr>
<tr>
<td>• Diegestate can be used as fertilizer, landfill application material</td>
<td>• Waste stays in place, carbon material has long retention time (carbon sink)</td>
</tr>
<tr>
<td>• Much more costly and difficult to implement on a large scale</td>
<td>• Less costly option, more infrastructure in place</td>
</tr>
</tbody>
</table>
Part 1 Anaerobic Digester Projects in New York State

* From NYSDEC website
## Part 1 Compost Facility Versus MSW Landfill

<table>
<thead>
<tr>
<th>Compost Facility</th>
<th>MSW Landfills</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Organic waste processed in controlled vessel (aerobic).</td>
<td>• Mixed waste (organic &amp; inert waste) buried with daily cover (anaerobic)</td>
</tr>
<tr>
<td>• Separation of organic waste</td>
<td>• MSW &amp; Non-hazardous waste</td>
</tr>
<tr>
<td>• Moderately fast kinetics</td>
<td>• Slower kinetics = longer degradation</td>
</tr>
<tr>
<td>• No collection of biogas (90-99% CO₂, low amount of anthropogenic GHG)</td>
<td>• Landfill w/ collection system = 75-95% collection of LFG (50% CH₄, 50% CO₂)</td>
</tr>
<tr>
<td>• Compost is produced and sold, can be used as fertilizer</td>
<td>• LFG can be processed as renewable or flared</td>
</tr>
<tr>
<td>• Much more costly and difficult to implement on a large scale</td>
<td>• Waste stays in place, carbon material has long retention time (carbon sink)</td>
</tr>
<tr>
<td>• Requires large amount of land area as do landfills</td>
<td>• Less costly option, more infrastructure in place</td>
</tr>
</tbody>
</table>
Part 1 Compost Facilities in New York State

* From Cornell Waste Management Institute
Part 1 Effects on MSW Landfills

Short-term effects

- Less waste sent to MSW Landfills = Less revenue
- Waste contains less organic materials = Lower BTU landfill gas
- Decline in recovered LFG / methane (for landfills with collection system)

Are we seeing some effects on NYS landfills already?

- USEPA GHG Reporting Program – 40 CFR 98, Subpart HH
  - MSW landfills began self-reporting in 2010; USEPA provides results to public
  - Monitoring Requirements
    - Continuous monitoring of collected LFG (every 15 minutes)
    - Periodic monitoring of methane concentration
    - Annual waste accepted
  - Reporting Requirements
    - Total LFG Collected (scf), Total methane recovered (metric tons), Average CH$_4$ concentration (% by volume), Total waste accepted (metric tons)
  - Query run for New York landfills: 2010-2015 data
    - Remove closed landfills and landfills that do not have complete 6-year set
Part 1 LFG Collection Rates for Open NYS Landfills
Part 1 CH₄ Recovery Rates for Open NYS Landfills
Part 1 Average CH$_4$ Concentration - Open NYS Landfills
Part 1  Total Waste Landfilled - Open NYS Landfills

<table>
<thead>
<tr>
<th>Year</th>
<th>Waste Accepted (MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>6,800,000</td>
</tr>
<tr>
<td>2011</td>
<td>6,900,000</td>
</tr>
<tr>
<td>2012</td>
<td>6,800,000</td>
</tr>
<tr>
<td>2013</td>
<td>7,000,000</td>
</tr>
<tr>
<td>2014</td>
<td>7,400,000</td>
</tr>
<tr>
<td>2015</td>
<td>7,700,000</td>
</tr>
</tbody>
</table>
Part 1 Effects on MSW Landfills

Long-term effects

• Existing energy projects may have shortened lifespan
• Could see decline in future energy projects at MSW landfills
• Decommissioning of active gas collection systems may occur sooner
Part 2 Measuring Cost Effectiveness of Organics Recycling

Is large-scale organics recycling cost effective in terms of reducing GHG emissions?

Building a Cost Effectiveness Model
• Similar to conducting a BACT Analysis
• Examine net reduction in GHG by implementing technology with landfill as baseline (only anthropogenic GHG is considered)
• Estimate cost difference of organics technology (MSW landfill is baseline)
• Examine environmental, energy and economic costs and benefits
• Only direct effects within facility property boundary were considered

\[
\text{Cost Effectiveness} = \frac{\text{Cost of Technology Compared With Baseline} (\$)}{\text{Net Reduction of Anthropogenic GHG} \ (\text{Ton CO}_2\text{e})}
\]

\[
\text{Cost Effectiveness} = \text{Cost (\$) per Ton CO}_2\text{e reduced}
\]
Part 2 Measuring Cost Effectiveness - Digester Project

Example 1 – Large-scale anaerobic digester project

Assumptions – Digester Plant

• 100,000 TPY food waste; 20-year project life
• Biogas production rate = 150 m³/metric ton food waste
• Biogas composition: 60% CH₄, 40% CO₂
• Energy Project: IC engines generating electricity (99% destruction of methane)

Assumptions – MSW NSPS Landfill

• 100,000 TPY food waste
• 120 year project life for landfill
• LFG Production based on USEPA LandGEM model, version 3.02
  – DOC = 0.15, k = 0.185 yr⁻¹ (referenced from USEPA GHG Reporting Rule)
• LFG composition: 50% CH₄, 50% CO₂
• Collection efficiency = 75%, Cover oxidation factor = 0.10
• Control device destruction efficiency = 99%
Part 2 Biogas Generation – Digester vs. MSW Landfill

![Graph showing biogas generation over time for AD (Anaerobic Digester) and LF (Landfill), with AD generated CH4, AD generated CO2, LF generated CH4, LF generated CO2, AD biogas generated, and total LFG generated.](image)
Part 2 Net GHG Reduction - Digester Project

Total Anthropogenic CH₄ (Digester) = 30,491 tons CO₂e (20 years)
Total Anthropogenic CH₄ (Landfill) = 567,724 tons CO₂e (120 years)
Total GHG Reduction = 537,233 tons CO₂e
Average Reduction (over 20 years) = 26,862 tons CO₂e / year

What happens when a gas collection efficiency of 90% is assumed for NSPS landfill?

Total Anthropogenic CH₄ (Digester) = 30,491 tons CO₂e (20 years)
Total Anthropogenic CH₄ (Landfill) = 227,090 tons CO₂e (120 years)
Total GHG Reduction = 196,598 tons CO₂e
Average Reduction (over 20 years) = 9,830 tons CO₂e / year

* A well operated landfill collection system reduces GHG reduction
Part 2 Approximate Costs – Large Scale Digester Project

Capital Costs: ~ $530 per ton per year
Annual O&M Costs: ~ $60 per ton per year
Total Annual Cost = $10.2 million per year

Annual Cost of Energy Project = $1.6 million per year
Annual Revenue of Energy Project = $1.9 million per year
Annual Revenue of Digestate = $1 million per year

Net Cost = $8.9 million per year
Break-even Tipping Fee (Digester) = $89 per ton
Average Landfill Tipping Fee (2016) = $49 per ton (National Average)
Tipping Fee Differential (Digester) = $40 per ton
Part 2 Cost Effectiveness – Large Scale Digester Project

Additional Consumer Cost = $4 million per year
Net GHG Reduction ranges from 9,830 - 26,862 tons CO$_2$e / year
Cost Effectiveness = $150 - $412 per ton CO$_2$e reduction

What happens when we assume a landfill tipping fee of $70 per ton?

Additional Consumer Cost = $2 million per year
Net GHG Reduction ranges from 15,507 - 26,862 tons CO$_2$e / year
Cost Effectiveness = $73 - $199 per ton CO$_2$e reduction

* Areas with higher landfill tipping fees provide more cost-effective options for anaerobic digester projects
Part 2 Measuring Cost Effectiveness – Compost Facility

Example 2 – Large-scale Compost Facility

Assumptions – Compost Facility (In-Vessel)
- 50,000 TPY food waste, 50,000 TPY yard waste; 20-year project life
- GHG emissions = ~100% biogenic (No CH₄ production)
- Compost Revenue Rate: $25 per cubic yard (bulk)
- Volume Reduction Rate = 50%

Assumptions – MSW NSPS Landfill
- 50,000 TPY food waste, 50,000 TPY yard waste
- 120 year project life for landfill
- LFG Production based on USEPA LandGEM model, version 3.02
  - Food waste Parameters: DOC = 0.15, k = 0.185 yr⁻¹
  - Yard waste Parameters: DOC = 0.20, k = 0.10 yr⁻¹
- LFG composition: 50% CH₄, 50% CO₂
- Collection efficiency = 75%, Cover oxidation factor = 0.10
- Control device destruction efficiency = 99%
Part 2 GHG Generation – Composting vs. MSW Landfill

![Graph showing GHG generation comparison between composting and MSW landfill over years.](image)

- **Compost Generated CO2**
- **Compost GHG Generated**
- **LF Generated CH4**
- **LF Generated CO2**
- **Total LFG Generated**
Part 2 Net GHG Reduction – Compost Facility

Total Anthropogenic CH₄ (Composting) = ~ 0 tons CO₂e (20 years)
Total Anthropogenic CH₄ (Landfill) = 682,761 tons CO₂e (120 years)
Total GHG Reduction = 682,761 tons CO₂e
Average Reduction (over 20 years) = 34,138 tons CO₂e / year

What happens when a gas collection efficiency of 90% is assumed for NSPS landfill?

Total Anthropogenic CH₄ (Composting) = ~ 0 tons CO₂e (20 years)
Total Anthropogenic CH₄ (Landfill) = 290,724 tons CO₂e (120 years)
Total GHG Reduction = 290,724 CO₂e
Average Reduction (over 20 years) = 14,536 tons CO₂e / year

* A well operated landfill collection system reduces GHG reduction
Part 2 Approximate Costs – Large Scale Compost Project

Capital Costs: ~ $662 per ton per year
Annual O&M Costs: ~ $53 per ton per year
Total Annual Cost = $10.6 million per year

Compost Volume Reduction Rate = 0.50
Annual Revenue Rate = $25 per cubic yard
Annual Revenue of Compost = $1.9 million per year

Net Cost = $8.7 million per year
Break-even Tipping Fee (Compost Facility) = $87 per ton
Average Landfill Tipping Fee (2016) = $49 per ton (National Average)
Tipping Fee Differential (Compost Facility) = $38 per ton
**Part 2** Cost Effectiveness – Large Scale Compost Project

Additional Consumer Cost = $3.8 million per year
Net GHG Reduction ranges from 14,536 to 34,138 tons CO$_2$e / year
Cost Effectiveness = $111 - $261 per ton CO$_2$e reduction

*What happens when we assume a landfill tipping fee of $70 per ton?*

Additional Consumer Cost = $1.7 million per year
Net GHG Reduction ranges from 14,536 to 34,138 tons CO$_2$e / year
Cost Effectiveness = $50 - $116 per ton CO$_2$e reduction

*Areas with higher landfill tipping fees provide more cost-effective options for compost facilities*
Findings/Conclusions

Small-scale organics recycling projects have increased in recent years
• Recent drop in methane production observed in NYS Landfills
• Could have a number of short-term and long-term effects if trends continue

Cost effectiveness model can estimate whether large-scale project benefits outweigh higher costs
• Net Reduction in GHG very sensitive to collection efficiency assumed for MSW Landfills

Further improvements to cost effectiveness model could include
• Incorporate indirect off-site effects of large-scale AD / compost projects
• Measure and incorporate impacts on MSW landfills
QUESTIONS

Bryan Szalda
+1 716 297 6150
bryan.szalda@ghd.com