Maximizing Greenhouse Gas Emissions Reductions at the Vancouver Landfill

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Presentation Outline

- City of Vancouver / Greenest City Action Plan
- Vancouver Landfill Background
- Landfill Gas Capital Improvements
- LFG Modeling
- Optimizations and Innovations
- Summary
- Discussion/Questions
Vancouver’s Context

- A city of 578,000 residents and 378,000 jobs, in a region of over 2.2 million people and 1.1 million jobs
- Compact community (59% apartments and 41% homes)
- Annual community GHG emissions of 2.7 million tonnes
The Challenge

GREENEST CITY IN THE WORLD BY 2020

In early 2009, the City’s Mayor formed the Greenest City Action Team (GCAT) with a mandate to make recommendations on how Vancouver can become the greenest city in the world by 2020.
There are ten Greenest City goals, each with their own 2020 target(s)

Two of the goals, ‘Climate Leadership’ and ‘Zero Waste’ helped drive our local efforts for methane abatement at the Vancouver landfill
Solid Waste Management Facilities in MV
Vancouver Landfill Background Information

- **Opened**: 1966
- **Population Served**: ~ 1,000,000
- **Authorized Waste**: 750,000 tonnes/year
- **Property**: 420 hectares
- **Landfill footprint**: 225 hectares
- **Remaining Life**: 2037
Vancouver Landfill Fill Plan
Landfill Gas Control

- Collection since 1991; utilization since 2003
- Control of odours and GHG emissions
- Local source for power production & heat recovery
Landfill Gas Utilization

- 20 year Agreement with Maxim
- 4 CAT 3532 reciprocating engines produce 7.4 MW, electricity for 6000 homes
- LFG fired boilers & waste heat utilization for greenhouses
Vancouver Landfill & Village Farms
Vancouver Landfill
Gas Collection System 2011

Total Landfill Gas Wells 227
14 Horizontal Wells
213 Vertical Wells

Western 40 Ha
Phase 2
Phase 3 WEST EAST
Area 2W
Area 2E
Area 3
Phase 1

- 3 Horizontal wells
- 70 Vertical wells
- 45 Vertical wells
- 52 Vertical wells
- 11 Horizontal wells
- 46 Vertical wells

Flare station
 Conditioning facility
2.9 km Pipeline across HWY 99

Co-Generation facility
Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses
## Capital Costs for LFG and Closure Works

<table>
<thead>
<tr>
<th>Description</th>
<th>Capital Cost</th>
<th>Commissioning Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>New LFG Wells</td>
<td>$3M</td>
<td>2012</td>
</tr>
<tr>
<td>Phase 2 Closure/101 wells</td>
<td>$19M</td>
<td>2012/2013</td>
</tr>
<tr>
<td>Phase 3W Closure/34 wells</td>
<td>$13M</td>
<td>2013</td>
</tr>
<tr>
<td>W40 Ha Closure Design/Construction</td>
<td>$27M</td>
<td>2014/2015</td>
</tr>
<tr>
<td>Additional wells/improvements</td>
<td>$5M</td>
<td>2014/2015</td>
</tr>
</tbody>
</table>
Vancouver Landfill
Gas Collection System 2012

Total Landfill Gas Wells 263
17 Horizontal Wells
246 Vertical Wells

Western 40 Ha
Phase 2
- 3 Horizontal wells
- 32 Vertical wells
West
- Active Fill Area
Phase 3
- EAST
Area 2W
- 70 Vertical wells
Area 2E
- 45 Vertical wells
Area 3
- 52 Vertical wells
Phase 1
- 11 Horizontal wells
- 49 Vertical wells

Flare station
 Conditioning facility
- 2.9 km Pipeline across HWY 99

Co-Generation facility
- Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses
Vancouver Landfill
Gas Collection System 2013

Total Landfill Gas Wells 359
29 Horizontal Wells
330 Vertical Wells

Western 40 Ha
- 15 Vertical Test wells
- 15 Vertical wells
- 3 Horizontal wells

Phase 2
- 3 Horizontal wells
- 24 Vertical wells
- 39 Vertical wells

Phase 3
- 3 Horizontal wells
- 12 Vertical wells
- 16 Vertical wells

Area 2W
- 70 Vertical wells

Area 2E
- 45 Vertical wells

Area 3
- 52 Vertical wells

Phase 1
- 11 Horizontal wells
- 69 Vertical Wells

Co-Generation facility
- Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses

Flare station
Conditioning facility
- 2.9 km Pipeline across HWY 99
Vancouver Landfill
Gas Collection System 2016

Total Landfill Gas Wells 403
40 Horizontal Wells
363 Vertical Wells

Western 40 Ha
15 Vertical Test wells
3 Vertical wells
.39 Vertical wells

Phase 2
3 Horizontal wells
3 Vertical wells

Phase 3
WEST
3 Horizontal wells
23 Vertical wells

EAST
38 Vertical wells
35 Vertical wells

Area 2W
70 Vertical wells

Area 2E
45 Vertical wells

Area 3
52 Vertical wells

Phase 1
11 Horizontal wells
69 Vertical wells

Flare station
Conditioning facility
2.9 km Pipeline across HWY 99

Co-Generation facility
Electrical generators (engines) to supply power to BC Hydro and heat utilized in greenhouses
LFG Modeling - Empirical Approach

• LFG generation and recovery forecasting tool - LFG model
• LFG model should explain historical data
  - Annual waste disposal by area and type
  - Actual LFG recovery and methane % (total)
  - Estimated collection efficiency - based on assessment of wellfield design/operations

• Challenges:
  - 7 landfill areas with different collection efficiencies
  - 3 waste categories (MSW, demo, demo-hog) with different LFG generating characteristics

• Solution:
  - Model with separate “modules” for each landfill area
  - Each module has separate “sub-modules” by waste category
  - Total of 7 modules x 5 sub-modules = 35 sets of calculations
Historical Data - Actual LFG Recovery

Monthly Average Flow (scfm@50% CH4)  Annual Average Flows (scfm@50% CH4)
## Model Calibration by Landfill Area (2012)

<table>
<thead>
<tr>
<th></th>
<th>Western 40</th>
<th>Cell B&amp;C</th>
<th>Cell D</th>
<th>Cell E</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Total Site</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LFG Generation</strong> (m³/hr)</td>
<td>532</td>
<td>442</td>
<td>255</td>
<td>463</td>
<td>2,883</td>
<td>3,074</td>
<td>2,521</td>
<td>10,170</td>
</tr>
<tr>
<td><strong>Percent of Total %</strong></td>
<td>5.2</td>
<td>4.4</td>
<td>2.5</td>
<td>4.6</td>
<td>28.3</td>
<td>30.2</td>
<td>24.8</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Collection Efficiency (%)</strong></td>
<td>0%</td>
<td>64%</td>
<td>70%</td>
<td>55%</td>
<td>70%</td>
<td>75%</td>
<td>47%</td>
<td>61%</td>
</tr>
<tr>
<td><strong>LFG Recovery</strong> (m³/hr)</td>
<td>0</td>
<td>281</td>
<td>179</td>
<td>255</td>
<td>2,014</td>
<td>2,310</td>
<td>1,173</td>
<td>6,212</td>
</tr>
</tbody>
</table>
Total Site LFG Generation and Recovery

- LFG Generation
- Recovery with Existing/Planned System
  - Actual Recovery (2004-2011)
  - Actual Recovery March-May 2012
Projected LFG Generation by Area
# Comparison of Model Input Assumptions for MSW

<table>
<thead>
<tr>
<th>Waste Types</th>
<th>Fast-Decay Organics</th>
<th>Medium-Decay Organics</th>
<th>Slow-Decay Organics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>k (1/yr)</td>
<td>L₀ (m³/Mg)</td>
<td></td>
</tr>
<tr>
<td>SCS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food, 50% of garden</td>
<td>0.3</td>
<td>69-70¹</td>
<td>Paper, textiles, 50% of garden</td>
</tr>
<tr>
<td>Paper, textiles, 50% of garden</td>
<td>0.12</td>
<td>156-162¹</td>
<td></td>
</tr>
<tr>
<td>IPCC²</td>
<td>Food³</td>
<td>0.185</td>
<td>0.06</td>
</tr>
<tr>
<td>Garden³</td>
<td>0.10</td>
<td>70</td>
<td>93</td>
</tr>
<tr>
<td>IPCC³</td>
<td>Paper textiles</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>IPCC³</td>
<td>186</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>IPCC³</td>
<td>All other waste with organics</td>
<td>0.06</td>
<td>120</td>
</tr>
<tr>
<td>BC MOE⁴</td>
<td>Food, yard, landscape, “other”</td>
<td>0.11</td>
<td>160</td>
</tr>
<tr>
<td>IPCC³</td>
<td>Inorganic waste</td>
<td>0.02</td>
<td>20</td>
</tr>
</tbody>
</table>

1. SCS assigned different L₀ values for waste disposed before and after 1/1/2007 based on variations in the composition of wastes disposed.
2. IPCC (Intergovernmental Panel on Climate Change) values for wet, temperate climate.
3. IPCC model has 4 organic waste categories, including separate categories for food and garden waste shown under “fast-decay organics.”
4. BC MOE uses categories “decomposable”, “moderately decomposable”, and “relatively inert” which are compared here to fast-decay, medium-decay, and slow decay organic wastes.
Comparison of LFG Generation Estimates

- SCS LFG Generation Projection
- BCMOE LFG Generation Projection
- BCMOE LFG Generation - 2011 Report
## Landfill Gas Generation, Recovery and Collection Efficiency

<table>
<thead>
<tr>
<th>Year</th>
<th>Collection System Efficiency (%)</th>
<th>Modeled LFG Generation</th>
<th>Modeled LFG Recovery from Existing &amp; Planned System</th>
<th>Actual LFG Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>m³/hr scfm</td>
<td>m³/hr scfm</td>
<td>m³/hr scfm</td>
</tr>
<tr>
<td>2011</td>
<td>37%</td>
<td>10,317 6,072</td>
<td>3,777 2,223</td>
<td>3,777 2,223</td>
</tr>
<tr>
<td>2012</td>
<td>61%</td>
<td>10,170 5,986</td>
<td>6,212 3,656</td>
<td>6,212 4,159</td>
</tr>
<tr>
<td>2013</td>
<td>74%</td>
<td>10,075 5,930</td>
<td>7,471 4,397</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>74%</td>
<td>10,039 5,909</td>
<td>7,435 4,376</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>75%</td>
<td>10,033 5,905</td>
<td>7,510 4,420</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>76%</td>
<td>10,060 5,921</td>
<td>7,647 4,501</td>
<td></td>
</tr>
</tbody>
</table>
1. Boring Diameter, 900 mm
2. Pipe Material, PVC
3. Pipe Dia./Wall, 200 mm/13 mm (Sch 80)
4. Pipe Openings, Slotted
5. Pipe Joint, Bell End
6. Filter Pack, 19 to 50 mm Stone
7. Seal Thk. & Qty, 900 mm at 3 locations
8. Centralizer(s), every 9 m
Optimizing Gas Extraction - Larger Boring Diameter

900 mm
## Optimizing Gas Extraction - Larger Boring Diameter

### Table: Exposed Area of Waste for Various Boring Diameters

<table>
<thead>
<tr>
<th>Boring Diameter (mm)</th>
<th>Exposed Area of Waste for Select Length of Slotted/Perforated Pipe</th>
<th>Increase from 300 mm Boring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>per 1 m (m²)</td>
<td>per 10 m (m²)</td>
</tr>
<tr>
<td>230</td>
<td>0.7</td>
<td>7.2</td>
</tr>
<tr>
<td>300</td>
<td>0.9</td>
<td>9.4</td>
</tr>
<tr>
<td>450</td>
<td>1.4</td>
<td>14.1</td>
</tr>
<tr>
<td>600</td>
<td>1.9</td>
<td>18.8</td>
</tr>
<tr>
<td>750</td>
<td>2.4</td>
<td>23.6</td>
</tr>
<tr>
<td>900</td>
<td>2.8</td>
<td>28.3</td>
</tr>
</tbody>
</table>

- Yellow: size for conventional water well drilling rig
- Yellow-green: size for caisson type drilling rig
- A: size installed prior to 2006
- B: size installed prior to 2010
- C: size installed in 2011 and 2012
Optimizing Gas Extraction - Greater Open Area per Metre of Pipe
Optimizing Gas Extraction - Centralizers
Optimizing Gas Extraction - Well Seals to Prevent Air Intrusion
Optimizing Gas Extraction - Well Seals to Prevent Air Intrusion
Optimizing Gas Extraction - CQA for Gas Wells
Optimizing Gas Extraction - Accurate Flow Meters for Each Landfill Subarea for Enhanced Metering and Model Calibration and Vacuum Control

The Most Accurate and Reliable Technology for Measuring Gas, Liquid and Steam

Developed from aerospace technology, the Verabar averaging pitot flow sensor provides unsurpassed accuracy and reliability. With its solid one piece construction and bullet shape, the Verabar makes flow measurement clog-free and precise.

The unique sensor shape reduces drag and flow induced vibration. And the location of the low pressure ports eliminates the potential for clogging and improves signal stability.

\[ K = \frac{1}{\sqrt{1 - C_b \cdot f}} \]

Courtesy of Veris
Innovations - Infrastructure for Dewatering Gas Wells where Needed
Innovations - Well Head Adapter for Mounting Pumps, Monitoring Devices and Bubblers

Courtesy of ATZ
Innovations - Non-Intrusive/Disruptive Water Level Measurements
Innovations - Remote Monitoring for Separate Areas

Courtesy of ATZ
Summary

- Vancouver is showing leadership in green initiatives through accelerated gas works construction
- Potential reduction of 800,000 tonnes CO₂ (2012 - 2016)
- Reduced odours in the community
- Implementing innovative technology
- Spent $16M to date, committed to an additional $63M to 2016
Discussion/Questions

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