Reliable Solar Pumps Boost Gas Production at Upper Midwest Landfill . . . In Winter

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Class D landfill agency installs gas system in 2010
- Production disappoints
- Possible leachate migration
- High costs of expansion, power

Agency engages local Foth engineers to define issues, offer solutions, implement
First Steps

Foth prepares assessment & controlled-measures study

Study postulates:

1. Less liquid in well could mean:
   • More gas production
   • Reduced impact to groundwater

2. Low-flow pumps might do the job
Test Plan

4-month in-well test
- Landfill site #2, NE of city
- 3 wells, deeper than 50 ft.
- 30-acre closed cell

3 pump-power options
- Electric grid: GW-01
- Solar with batteries: GW-02
- Solar panel only: GW-05
3 Apollo™ pumps installed
- Identical motors
- Linear-rod driver, piston action
- Low flow -- <2 gpm (7.6 lpm)
- Intakes at 1-3 feet above bottom
- Test begins Dec. 2011, winter

1 power source for each pump
- Electric 220v AC to 24v DC (GW-01)
- Solar panel with 12v batteries (GW-02)
- Solar panel direct to motor (GW-05)
## Wells Nearly Identical

<table>
<thead>
<tr>
<th>Gas Well</th>
<th>Initial Liquid Elevation (ft amsl)</th>
<th>Pump Intake (ft amsl)</th>
<th>Top of Screen (ft amsl)</th>
<th>Bottom of Screen (ft amsl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW-01</td>
<td>865.55</td>
<td>~850</td>
<td>886.35</td>
<td>840.35</td>
</tr>
<tr>
<td>GW-02</td>
<td>868.56</td>
<td>~849</td>
<td>888.21</td>
<td>843.21</td>
</tr>
<tr>
<td>GW-05</td>
<td>871.67(^{(1)})</td>
<td>~849</td>
<td>890.07</td>
<td>838.07</td>
</tr>
</tbody>
</table>


G. Nauman and B. Harthun, Foth Infrastructure & Environment, LLC, Client memorandum, 2012
Graph 3 - Liquid Elevations in GW-05 (Prior to Pumping)

- **GW-05 Elevation**
- **Top of Screen**
- **Bottom of Screen**
- **Linear (GW-05 Elevation)**

\[ y = -0.0026x + 979.36 \]
Test Methods

Measurements

- Liquid levels Dec. 2011 thru March 2012
- Transducers installed 3/6/12; report every 15 minutes
- Methane & O₂ noted before & during operations
- Lantec GEM™ 2000 gas analyzer records variations
- 42° North latitude (= Toronto)
  • 65-76% cloudy days; 10-11 hrs./day sunlight
Results: All options viable

- All 3 sources, including solar, dewater wells -- reduce liquid to intake
- Low-flow pumping proves effective
- Ave. 24-hr. groundwater levels satisfactorily lowered and maintained; addresses migration
Solar Only Results

- Solar maintains low liquid levels over each 24-hour span
- On-off matches day/night
- 3-4 feet accumulates at night, and . . .
- . . . Morning pumping lowers to intake
- Consistent day to day
- No maintenance

Site installed simple insulation below driver
Graph 4 - Liquid Elevations in GW-01 (During Pumping)
Graph 5 - Liquid Elevations in GW-02 (During Pumping)

- **Pumping Elevation**
- **Previous Elevation**
- **Top of Screen**
- **Bottom of Screen**

Date & Time:

- 3/6/2012 2:2A
- 3/8/2012 2:24
- 3/10/2012 2:24
- 3/12/2012 2:24
- 3/14/2012 2:24
- 3/16/2012 2:24
- 3/18/2012 2:24
- 3/20/2012 2:24
- 3/22/2012 2:24
- 3/24/2012 2:24
- 3/26/2012 2:24
- 3/28/2012 2:24
- 3/30/2012 2:24
- 4/1/2012 2:24
- 4/3/2012 2:24
- 4/5/2012 2:24
- 4/7/2012 2:24
- 4/9/2012 2:24
- 4/11/2012 2:24
- 4/13/2012 2:24
- 4/15/2012 2:24
- 4/17/2012 2:24
- 4/19/2012 2:24
- 4/21/2012 2:24
- 4/23/2012 2:24
- 4/25/2012 2:24
- 4/27/2012 2:24
- 4/29/2012 2:24
- 5/1/2012 2:24
- 5/3/2012 2:24
- 5/5/2012 2:24

Elevation (ft. amsl):

- 835
- 845
- 855
- 865
- 875
- 885
- 895
Results – Solar Only

At 42º North latitude/winter

- Maintains liquid levels over 24 hours
- On-off matches day/night
- 3-4 feet liquid accumulate at night
- Day pumping lowers liquid to intake
- Operation consistent day to day
- No periods of pump-in

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Graph 6 - Liquid Elevations in GW-05 (During Pumping)

- Pumping Elevation
- Previous Elevation
- Top of Screen
- Bottom of Screen
More screen = More gas

- All power sources dewatered 75-90%+ screen (15-18+ ft.) in each well
- Methane production increased 15%+ in electric & solar-battery wells . . .
- And 20%+ in solar-only
- Positive correlation: More screen exposure and higher methane flow
## Screen Exposure to Methane Flow

<table>
<thead>
<tr>
<th>Gas Well</th>
<th>Initial Liquid Elevation (ft amsl)</th>
<th>Average Liquid Elevation During Pumping (ft amsl)</th>
<th>Initial Length of Screen Exposed (feet)</th>
<th>Length of Screen Exposed During Pumping (feet)</th>
<th>Percent Of Additional Screen Exposed During Pumping</th>
<th>Percent Increase in Methane Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>GW-01</td>
<td>865.55</td>
<td>850.96</td>
<td>20.80</td>
<td>36.42</td>
<td>75.0</td>
<td>15.9</td>
</tr>
<tr>
<td>GW-02</td>
<td>868.56</td>
<td>850.15</td>
<td>19.65</td>
<td>38.06</td>
<td>93.6</td>
<td>17.3</td>
</tr>
<tr>
<td>GW-05</td>
<td>871.67</td>
<td>853.65</td>
<td>18.40</td>
<td>35.39</td>
<td>92.3</td>
<td>20.2</td>
</tr>
</tbody>
</table>

G. Nauman and B. Harthun, Foth Infrastructure & Environment, LLC, Client memorandum, 2012
Graph 7 - Gas Concentrations at GW-01

- Orange line: Methane
- Gray line: Oxygen
- Black line: Pump On

Date & Time

Concentration (%)
Graph 9 - Gas Concentrations at GW-05

- Methane
- Oxygen
- Pump On

Date & Time: 8/23/2011 12:00, 9/2/2011 12:00, 9/9/2011 12:00, 9/12/2011 12:00, 9/19/2011 12:00, 9/23/2011 12:00, 9/30/2011 12:00, 10/1/2011 12:00, 10/7/2011 12:00, 10/10/2011 12:00, 10/19/2011 12:00, 10/20/2011 12:00, 10/26/2011 12:00, 11/2/2011 12:00, 11/8/2011 12:00, 11/15/2011 12:00, 11/19/2011 12:00, 11/29/2011 12:00, 12/5/2011 12:00, 12/9/2011 12:00, 12/13/2011 12:00, 12/19/2011 12:00, 12/26/2011 12:00, 1/1/2012 12:00, 1/7/2012 12:00, 1/13/2012 12:00, 1/14/2012 12:00, 1/21/2012 12:00, 1/23/2012 12:00, 1/30/2012 12:00, 2/9/2012 12:00, 2/17/2012 12:00, 2/23/2012 12:00, 3/1/2012 12:00, 3/7/2012 12:00, 3/9/2012 12:00, 4/9/2012 12:00, 4/19/2012 12:00
More solar pumps installed

- Foth specs solar-only low-flow pumps for all site gas wells
- System expands: No costs for compressors, grid, batteries or new lines
- Pumps continue to operate satisfactorily: 2+ years, no or minimal maintenance
How Solar Pumps Work
Pneumatic and Electric Pumps

- Atlas Pneumatic Ext., Winter
- Apollo Solar - Field Array
- V-2 Pneumatic, Side Slope
- Edge Pneumatic, Brownfield
- Anchor Electric, with Controller
Accessories

Solar Panel
Pop-Out Seal Cartridge
Rod Oiler
Flow Meter
Solar Charge Controller
Power Supply Converter
On-Off Timer
Pneumatic Timer