CNG Fueling Developments and Renewable Conversion to RNG – Technology and Update on a RNG Fleet

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Agenda

• Section
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  • 2  • Why Digest Grease and Food Processing Residuals?
  • 3  • Examples of Dedicated Co-digestion Projects
  • 4  • The Anaergia Municipal Solution “The Omnivore”
  • 5  • Fleet Update: Manure and Food Residuals to Vehicle Fuel
  • 6  • Overview of Anaergia
  • 7  • Questions
2.0 — Why Digest Grease and Food Residuals

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Food Residuals and Grease = Energy

- Grease on a “volatile solids” basis will generate 2.5 times more gas than typical manures or WAS.
- Food Processing Residuals can be 1.5 to 2 times more than typical manures or WAS.
- The higher solids concentration is where food and grease residual become much more valuable.
- Pre-consumer is obviously the easiest to manage.
- Grease trapping residuals provides a excellent opportunity for co-digestion as long as the trapper is not skimming.
- Digestion and Composting are NOT mutually exclusive: the residual from digestion of food residuals are identical to that left after composting, fiber is conserved.
- That is, digestion first recovers the energy and leaves the ability for composting non digestible fiber.
Typical Food Waste Reception
Typical Pumped Reception
## Typical Contents of AD and Landfill Biogas

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Landfill gas</th>
<th>Biogas from AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower calorific value, MJ/Nm³</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>kWh/Nm³</td>
<td>4.4</td>
<td>6.5</td>
</tr>
<tr>
<td>MJ/kg</td>
<td>12.3</td>
<td>20.2</td>
</tr>
<tr>
<td>Density, kg/Nm³</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Wobbe index, upper, MJ/Nm³</td>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td>Methane number</td>
<td>&gt; 130</td>
<td>&gt; 135</td>
</tr>
<tr>
<td>Methane, vol-%</td>
<td>45</td>
<td>65</td>
</tr>
<tr>
<td>Methane, range, vol-%</td>
<td>35-65</td>
<td>60-70</td>
</tr>
<tr>
<td>Long-chain hydrocarbons, vol-%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hydrogen, vol-%</td>
<td>0-3</td>
<td>0</td>
</tr>
<tr>
<td>Carbon monoxide, vol-%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carbon dioxide, vol-%</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Carbon dioxide, range, vol-%</td>
<td>15-50</td>
<td>30-40</td>
</tr>
<tr>
<td>Nitrogen, vol-%</td>
<td>15</td>
<td>0.2</td>
</tr>
<tr>
<td>Nitrogen, range, vol-%</td>
<td>5-40</td>
<td>–</td>
</tr>
<tr>
<td>Oxygen, vol-%</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Oxygen, range, vol-%</td>
<td>0-5</td>
<td>–</td>
</tr>
<tr>
<td>Hydrogen sulphide, ppm</td>
<td>&lt; 100</td>
<td>&lt; 500</td>
</tr>
<tr>
<td>Hydrogen sulphide, range, ppm</td>
<td>0–100</td>
<td>0–4000</td>
</tr>
<tr>
<td>Ammonia, ppm</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Total chlorine as Cl⁻, mg/Nm³</td>
<td>20–200</td>
<td>0–5</td>
</tr>
</tbody>
</table>

Source: Energigaser och miljö (Energy gases and the environment) Swedish Gas Centre, 2005; Gaskvalitet årsgevvensnitt (Gas quality, annual averages) 2005, www.energinet.dk
3.0 - Dedicated Co-digestion Examples

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Unique Design Considerations for Co-Digestion

- Manage inherent and seasonal variability:
  - Volume
  - Volatile Solids Content
  - Contamination
Helios™ Based Food Digestion

• **Michigan State University, East Lansing, USA**
• **Substrate:** Food Waste, Biosolids, Manure
• **Capacity:** 16,800 TPY
• **Energy Output:** 0.5 MWe, 1.0 MW Total
Construction Layout – MSU Digester
Helios™ Based Co-Digestion

- **Szarvas, Hungary**
- **Substrates:** Food Processing Waste, Grease, Biosolids, Manure
- **Capacity:** 122,000 TPY
Helios™ Based Food Waste Digestion

- **Glenfarg, Scotland**
- **Substrate**: Food Waste
- **Capacity**: 19,800 TPY
- **Energy Output**: 800 kWe, 1.6 MW Total
Helios™ Based Food Waste Co-Digestion

- **Kloh, Germany**
- **Substrate**: Source Separated Organics, Grease, Potatoes, Swine Manure
- **Capacity**: 18,000 TPY
Future: Source Separated Organics

- **Dagenham, UK (Under Construction)**
- **Substrate:** Municipal Source Separated Organic Waste
- **Capacity:** 49,000 TPY
- **Energy Output:** 1.4 MWe, 2.8 MW Total
Proprietary Organics Recovery & Pre-Treatment

- Recover 95% of organics
- Separates wet & dry fractions
- Wet fraction is digested
- Dry fraction to recovery recyclables and/or RDF
- Proven installation base
Wet & Dry Fractions From Organics Recovery

Wet Fraction
- Easily digested & high energy density
- 30-35% Total Solids
- 20-40% of MSW Feed
- Conveyed to slurry cleaning

Dry Fraction
- Conveyed for recyclable extraction
- 60-80 tons per ton of MSW
- 3%-5% putrescible content
- 13,000-15,000 MJ/T
Cleaning Wet Organic Fraction using a Dynamic Cyclone

- Two step cleaning process
- Small Plastics Removal
- Grit settling
- Protects digester performance
- Provides highest quality digestate for compost
Organic Wet Fraction Cleaning - Process

Step 1: Dynamic Cyclone
- Centrifugal force & vertical screen
- Removes small plastics

Step 2: Settling Tank
- Downward agitator settles glass & grit
- Bottom auger removes materials
Proprietary Anaerobic Digestion Designs

Proprietary Anaerobic Systems
• High efficiency 2 stage digesters
• Recuperative thickening
• Hydraulic Mixing & Service Box

Benefits
• Improved heating & mixing efficiency
• Reduced footprint and piping
• Increased biogas output
• 30% more MWh/ft²
Recovery of Recyclables

- Recover plastics, papers and metals from waste stream
- Well established technologies
- Proven recovery rates
Anaergia Core AD Technology Differentiation

Triton Dual Stage Digesters
- 30% less footprint
- 30% less energy
- Lower costs for large plants
- 34 patents/filings

Hydraulic Mixers
- Designed for high solids
- Safer: no ignition source
- >30% Power Savings
- 6 patents/filings

Substrate Handling
- Designed for high solids
- High efficiency
- Unparalled reliability
- 10 patents/filings

Service Box
- No biogas release
- No process downtime
- No confined space entry
- 6 patents/filings
Exclusive Drying Technology Partnership

- Patented Holo-scru design to maximize heat transfer surface area
- Temperature control along entire process
- Self Cleaning Mechanism for uninterrupted service
- North American Made & experience with Sludge
- Reduces footprint by 50%
- Reduces Energy per tonne processed by 60% (using waste heat from CHP)
Recovery of Recyclables - Preparation

**Bag Opening**
- Opens garbage bags
- Facilitates material separation
- Upstream of organics extraction press

**Coarse Lamella Screen**
- Diverts large items from the press
- Increases throughput of the press
SSO Residuals Diversion - Fertilizer

- Fertilizer and Water production from source separated organics
- Compost of digestate
Organic Extraction from MSW
Anaergia’s Proprietary Process

Anaergia Press designed to produce
- Organic Wet Fraction - Clean organics for Bio-digestion,
- Dry Fraction - Easily Recyclable fraction as metals, Paper, Plastics, and high quality fuel (RDF)

Press capacities <15, <20, <35 tph MSW.

Heart of process is high pressure extruder press (600 bar)
MSW is squeezed in extrusion chambers with 12 mm holes

Wet organic fraction further diluted and cleaned for digestion with Dynamic Cyclone Separator
Pre-Treatment
Organics Extraction Process – Off Plate Food
Biogas Upgrading to RNG & CNG

- **Fair Oaks, Indiana**
- **Project:** Biogas upgrading to CNG & RNG
- **Energy Output:** 1,500 SCFM or 7,700 GPD of diesel equivalent
Background on Fair Oaks Dairy

- Operates 11,000 Milking Cattle Operation in Fair Oaks Indiana
- Currently operates a fleet of roughly 55 milk trucks
- Sand bedded Dairy
- Food and Food Processing Residuals available
Reasons for RNG Project

• Higher financial return than electricity generation
• Location Close to Fueling Station
• Dedicated Routes & Fleets
• RIN’s
• Tax Credits and Incentives
• Industry Commitment to Sustainability
Benefit of Anaergia Solution for Fair Oaks

- 7,700 gpd of diesel
- Fueling 55 trucks
- Wheeling & public sales
- $10,000/day cost savings
- Reduced carbon emissions by 100% when using RNG
Biogas Upgrading Process Overview

- **Biogas generation**
- **Compression and Humidity Control**
- **Biogas Cleaning**

**Steps:**
1. **Fueling Stations**
2. **Biomethane Compression**
3. **Biomethane PSA/TSA Polishing**
Carbon dioxide and other polar molecules have a higher solubility in water than methane, so water can be used to remove contaminants from biogas. If the contaminants are removed or ‘scrubbed’ at high pressure (~130 psig), the water can be continuously regenerated of ‘stripped’ in a separate low pressure vessel (~3 psig). High quality biogas (renewable natural gas) exits.
Biogas Scrubbing

- Methane recovery on left
- Flash towers
- Stripping tower
Anaergia Provided a Fully Integrated Solution

- Central Facility
- Pipeline
- Secondary Compression
- Fueling Station
CNG/RNG Fueling Station

- Dual lane fueling
- Credit card operation for commercial sales
- Operation since fall of 2011 on CNG. RNG since October 2012
Fuel Quality

Major Component Gas Analysis By Gas Chromatography (ASTM D1945)

Report Date: 24-Oct-12
Client Name: Fair Oaks Dairy Farm, LLC
GTI Sample Number: 121726-001
Sample Description: RNG Flare Line 10/24/2012 09:32
Date Analyzed: 24-Oct-12 Analyst: DJ

<table>
<thead>
<tr>
<th>Component</th>
<th>Mol %</th>
<th>Det. Limit</th>
<th>Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen/Argon</td>
<td>0.45%</td>
<td>0.03%</td>
<td>0.89%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1.24%</td>
<td>0.03%</td>
<td>2.14%</td>
</tr>
<tr>
<td>Methane</td>
<td>98.3%</td>
<td>0.002%</td>
<td>97.0%</td>
</tr>
</tbody>
</table>

Calculated Real Gas Properties per ASTM D3588-98(03)

- Temp. (°F) = 60.0
- Press. (psia) = 14.696
- Compressibility Factor [z] (Dry) = 0.99806
- Compressibility Factor [z] (Sat.) = 0.99775
- Relative Density (Dry) = 0.5625
- Gross HV (Dry) (Btu/ft³) = 994.8
- Gross HV (Sat.) (Btu/ft³) = 977.8
- Wobbe Index = 1326.5
- Net HV (Dry) (Btu/ft³) = 895.7
- Net HV (Sat.) (Btu/ft³) = 880.4
Fuel Dispensed

The RDF fleet has run a total of 5,768,541 miles and offset the use of 980,761 gallons of diesel fuel during its first year of operation.
RNG in Fleet Operations

- 53 daily loads from Fair Oaks, IN and Hartford, MI to:
  - Indianapolis, IN (17)
  - Murfreesboro, TN (17)
  - Winchester, KY (19)
- 42 CNG tractors leased by Fair Oaks and 50 tanks provided by Ruan
- 110 drivers domiciled at Fair Oaks and Sellersburg Relay
- Fueling on RNG began 7:30 AM October 24, 2012
Anaergia’s Vision: Zero Organic Waste Future

Integrated AD Solutions

Municipal Solid Waste
Source Separated Organics
Food Processing Waste
Wastewater Biosolids

Renewable Gas
Renewable Power
Organic Fertilizer
Clean Water
A Global Leader from a North American Base
Expertise Built on Unmatched Collective Experience

- Est. 1982
- Core AD Capability
- Proprietary Technology
- Installation base

- North American DBOO Capability
- Plant Operations
- Power Purchase Agreements

- Global Engineering and Client Support
- New Technology Commercialization
- R&D Programs

Proprietary Technology, Project Engineering and Operations Expertise

Confidential – not for distribution
Total Solution In House Capabilities

Anaergia

- Process Engineering
- Equipment Fabrication
- Project Execution
- Operations & Maintenance

1,600 Projects 355 MW 26 Patents 20 Years
Overview of Anaergia’s Anaerobic Capabilities

Waste Preparation & Pre-Treatment
- Organics Pre-treatment
- Hydrolysis – Biological and Thermal
- Chopping and Homogenizing

Waste to Resource Conversion
- Anaerobic Digestion System

Reuse & Value Creation
- Electrical & Thermal Energy Production
- Biogas Upgrading to Vehicle Fuel or Pipeline Injection
- Fertilizer Production
Total Systems Integration Provider

- Complete Integrated System
- Turnkey Delivery
- Performance Guarantees
- Operations & Maintenance
- Financing
- Bonding
Anaergia’s Plant Operations Division

- Over 20 years experience
- 50 staff
  - Engineers
  - Operations Managers:
  - Plant Operators
Operation and Maintenance Services

Operations Services Contd...:

• Training
• Operations Troubleshooting
• Plant Start-up Assistance
• Scheduled & Unscheduled Maintenance
In the end there must be a reason, just beyond money, to do this. It is a simple fact that we must have clean water and energy to subsist.