Biosolids Low Temperature Pyrolysis
Maximizing Resource Recovery from Sludge

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Juan Josse, Yaniv Scherson; Anaergia Inc.
Anaergia Overview

- Global technology leader in the recovery of resources from organic waste streams
- Complete solutions for resource recovery, specially organics to energy through anaerobic digestion and nutrient recovery
- Proven portfolio of proprietary technological solutions around anaerobic digestion core
- Flexible project delivery options, including DB, BOO, DBO
- Over 20 years of design and operating experience
- Core technologies used in over 1,600 digester plants with over 360 MW of capacity from biogas
Anaergia Global Footprint

1,600 Projects, 380 MW, 12 Facilities, 29 Patents, 20 Years
Anaergia Vision
Zero Organic Waste Future

Integrated Solutions

Wastewater Biosolids
Source Separated Organics
Municipal Solid Waste
Food Processing Waste
Agricultural Waste

Renewable Power
Renewable Gas
Organic Fertilizer
Clean Water
Biosolids Land Application & Landfilling is Increasingly Difficult

797,000 dry tons of Biosolids in 2013
2/3's land applied, 1/3's landfilled

Increasing bans and regulations on land application.
What is Pyrolysis?

**Decomposition of organics using heat**
- Heat feedstock indirectly
- Maintain heated over prescribed time period

**Heat applied in absence of O₂**
- All by-products are usable
- Used for centuries to make charcoal

**By-Products**
- Biochar
- Pyro-Oil
- Pyro Gas

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By-Products:
- Biochar
- Pyro-Oil
- Pyro Gas
# Low Temperature Pyrolysis Increases Resource Recovery

<table>
<thead>
<tr>
<th>Product</th>
<th>Mass Recovery</th>
<th>Composition</th>
<th>Marketability</th>
<th>Additional Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BioChar</strong></td>
<td>55%</td>
<td>&gt;40% Carbon, 7% N, 8% P</td>
<td>Marketable as a fertilizer</td>
<td></td>
</tr>
<tr>
<td><strong>Pyro-Oil</strong></td>
<td>30%</td>
<td>High volatile solids 55%, easily digestible, high biogas yield</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pyro-Gas</strong></td>
<td>15%</td>
<td>Contains H2, CO, CH4 and CO2</td>
<td></td>
<td>H2 and CO convert to methane in anaerobic digester</td>
</tr>
</tbody>
</table>

Oil and gas digestion increase biogas production

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**Anaergia**
Biosolids Pyrolysis
High Nutrient Stable Biochar and More Biogas

Primary Sludge
Thickened WAS

OMNIVORE High Solids AD

Biogas

Recuperative Thickener

Thickened Sludge

Dewatering

Cake

Filtrate to Nutrient Recovery

Filtrate to Nutrient Recovery

Heat from CHP

Pyro Oil and Pyro Gas to Digester

Biochar Dryer

Low Temp Pyrolysis

Filtrate to Nutrient Recovery

Upgrading to Biomethane

Electricity

Heat to digesters and drying

RNG to pipeline or vehicle fuel

Heat to digesters

Heat to digesters and drying

Heat from CHP

Biosolids Dryer

Low Temp Pyrolysis

Biochar Fertilizer

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Biochar Improvements over Dried Biosolids
Less Residual Mass, Higher Value Product, More Biogas

<table>
<thead>
<tr>
<th>Products</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>10%</td>
</tr>
<tr>
<td>Oil</td>
<td>35%</td>
</tr>
<tr>
<td>Solids</td>
<td>55%</td>
</tr>
</tbody>
</table>

ANAEROBIC DIGESTER → Biosolids → PYROLYSIS → Char

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Biosolids Pyrolysis Generates more Energy than it Consumes

NOTE: Typical Flows for 8 MGD Plant
Biosolids Pyrolysis Mass Balance

- Heat product over dwell time in continuous electric pyrolyzer
- Power demand 200 kWh/ton fed at 90% TS
  - 100 kW for water evaporation and solids heating
  - 80 kW for chiller for condenser and char cooler (plant water could also be used)
  - 20 kW for solids/char conveyance, feeder, pump, blower
- Additional biogas generates 350-400 kWel/h per ton of biosolids pyrolyzed
Encina Demonstration Project
First of its Kind Demonstration Facility

- Partnership between Encina Wastewater Authority (EWA) and Anaergia
  - Containerized pyrolyzer utilizing electric screw technology installed and in operation
  - Processes 1,000 lb/hr of dried biosolids pellets (50% of plant production)
  - Produce biochar to commercialize recognizing higher value as a fertilizer / soil amendment
  - Pyro oil and gas directed to Digester #5 for co-digestion with plant sludge. Give sludge a second chance!
Pyrolysis at Encina Wastewater Authority
Pyrolysis at Encina Wastewater Authority
Pilot co-digestion Sludge and Pyrolysis Oil
Pyrolysis Improves Biosolids Quality

- Concentrates nutrients into biochar
- Increases biogas production by >22%
- Reduces biosolids export by >45%
- Improves properties: stability, low dust, low odor
- Sequesters carbon, reducing GHG emissions
- Slow nutrient release, reduced water use as soil amendment
Pyrolysis Oil Generates More Biogas than Sludge

Higher methane generation from Pyrolysis Oil than from Sewage Sludge per gram VS fed to the digester
Co-digestion of Sludge and Pyrolysis Oil Increases Biogas Production

![Graph showing biogas production over time with different conditions.]

- Raw Sludge Only (2.47 g COD/L)
- Raw Sludge (2.47 g COD/L) + Condensate (0.46 g COD/L)
  Total (2.93 g COD/L)
Biochar Concentrates Nutrients

<table>
<thead>
<tr>
<th></th>
<th>Dry Biosolids</th>
<th>Biochar</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>5.0</td>
<td>6.7</td>
</tr>
<tr>
<td>P</td>
<td>4.7</td>
<td>8.3</td>
</tr>
<tr>
<td>K</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Anaergia’s investment in pyrolysis R&D has resulted in know-how, expertise, and broad body of knowledge and IP:

- Various feedstocks
- Range of operational conditions
- Product characterization
- Use of pyrolysis products for increasing biogas generation

- **MORE ENERGY**
  - Increases biogas production by ~25 to 30% through co-digestion of oil & gas

- **LESS SOLIDS TO HANDLE**
  - Reduces mass of dewatered sludge by ~8X through drying and pyrolysis

- **HIGHER VALUE**
  - Solid char has higher fertilizer value, better surface properties, and is easier to store and handle
THANK YOU

www.anaergia.com