Solids Treatment and Management in a Changing Environment

Biosolids and Renewable Energy Specialty Workshop
May 12 - 13, 2015
Biosolids Processing – Drivers for Change

**Traditional Drivers**
- Public Health & Safety
- Environmental
- Public Acceptance
- Economic Impact
- Legislative

**Current/Future Drivers**

**Sustainable Evaluation Framework**
- Solids Minimization
- Resource Recovery
- Sidestream Impacts
- Carbon Footprint
Biosolids Processing Technologies

- Established Technologies
- Emerging Technologies at various stages of development

**Solids Pretreatment**

**Conventional Anaerobic Digestion**

**Solids Dewatering**

**Land-Based Biosolids Management**
- Cake Land Application
- Composting
- Thermal Drying

**Thermal Conversion Technologies**
- Incineration
- Gasification
- Pyrolysis
- Plasma-Assisted Oxidation
- Supercritical Water Oxidation
Technology Options for Solids Minimization/ Energy Recovery

- **Anaerobic Digestion**
  - Conventional - Mesophilic
  - Advanced – Acid/Gas, TPAD etc.

- **Digester Feed Pre-Treatment**
  - Thermal – CAMBI™
  - Lysing Technologies

- **Heat Drying** (Mass & Volume Reduction)
  - Rotary Dryers for Larger Facilities
  - Modular Dryers for Smaller Facilities
Beneficial use of digester gas is an obligation connected with sustainability.
Mass & Energy Balance – Anaerobic Digestion

Based on a 50:50 blend of PS and WAS @ 5% TS

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>PS</strong></td>
<td>25 dtpd 80% VS</td>
</tr>
<tr>
<td><strong>WAS</strong></td>
<td>25 dtpd 80% VS</td>
</tr>
</tbody>
</table>

Conv. Anaerobic Digestion

Total SRT: 15 d
VSR: 45%
16 scf gas/lb VSR
600 Btu/scf gas

Digester Gas

24,000 scfh
14.4 mmBtu/h

Energy Recovery - Boiler

@ 75% efficiency: ~11 mmBtu/h
Process Heat: ~2.8 mmBtu/h

Energy Recovery - CHP

Electricity @ 35% Eff. ~1.5 MW-h
Heat Recovery: ~6.5 mmBtu/h

Dewatering

Digested Solids

32 dtpd @ 23% TS
139 wtpd/164 cy/d

Electricity @ 35% Eff. ~1.5 MW-h
Heat Recovery: ~6.5 mmBtu/h
Mass & Energy Balance – AD w/ Pretreatment

Based on a 50:50 blend of PS and WAS @ 11% TS

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<th>PS</th>
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</table>

Conv. Anaerobic Digestion

Digester Gas
- 29,000 scfh
- 17.6 mmBtu/h

Energy Recovery - CHP
- Electricity @ 35% Eff. ~1.8 MW-h
- Heat Recovery: ~7.9 mmBtu/h

Dewatering

Total SRT: 15 d
VSR: 55%
16 scf gas/lb VSR
600 Btu/scf gas

Digested Solids
- 28 dtpd @ 33% TS
- 85 wtpd/115 cy/d

THP

Steam

Electricity @ 35% Eff. ~1.8 MW-h
Heat Recovery: ~7.9 mmBtu/h
Energy Recovery from Digester Gas

- Can be used to offset purchased energy.
- Several ways to beneficially use digester gas.
- Direct-fired dryers do not require pretreatment for hydrogen sulfide or siloxanes.
**Mass & Energy Balance – AD w/ Thermal Drying**

Based on a 50:50 blend of PS and WAS @ 5% TS

- **PS**
  - 25 dtpd
  - 80% VS

- **WAS**
  - 25 dtpd
  - 80% VS

**Conv. Anaerobic Digestion**

- **Digester Gas**
  - 24,000 scfh
  - 14.4 mmBtu/h

- **Dew. Cake**
  - 32 dtpd
  - 23% TS

**Dried Solids**

- 32 dtpd @ 95% TS
- 34 wtpd/55 cy/d

**Energy Requirement**

- Evap: 13,730 lb H₂O/h
- Energy: 14.0 mmBtu/h

Energy recovery from dryer condensate for process heat
Mass & Energy Balance – AD w/ CHP & Drying

Based on a 50:50 blend of PS and WAS @ 5% TS

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<th>PS</th>
<th>25 dtpd</th>
<th>80% VS</th>
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<tr>
<td>WAS</td>
<td>25 dtpd</td>
<td>80% VS</td>
</tr>
</tbody>
</table>

Digester Gas
- 24,000 scfh
- 14.4 mmBtu/h

Energy Recovery – CHP (Gas Turbines)
- Electricity @ 26% Eff. ~1.1 MW-h
- Heat Recovery: ~6.5 mmBtu/h

Conv. Anaerobic Digestion
- Total SRT: 15 d
- VSR: 45%
- 16 scf gas/lb VSR
- 600 Btu/scf gas

Dew. Cake
- 32 dtpd
- 23% TS

Drying
- 32 dtpd @ 95%TS
- 34 wtpd/55 cy/d

Energy Requirement
- Evap: 13,730 lb H₂O/h
- Energy: 14.0 mmBtu/h

Energy recovery from dryer condensate for process heat
## Technology Comparison – Final Solids Quantities

<table>
<thead>
<tr>
<th>Process</th>
<th>Energy Recovery</th>
<th>Final Product</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Option</td>
<td>Generation MW-h/h</td>
</tr>
<tr>
<td>Conventional AD</td>
<td>Digester Gas to CHP</td>
<td>1.5</td>
</tr>
<tr>
<td>AD with Pretreatment</td>
<td>Digester Gas to CHP</td>
<td>1.8</td>
</tr>
<tr>
<td>AD with Thermal Drying</td>
<td>Digester Gas to CHP/Drying</td>
<td>0 - 1.1</td>
</tr>
</tbody>
</table>
## Technology Selection Criteria

<table>
<thead>
<tr>
<th>Pretreatment + AD</th>
<th>AD + Thermal Drying</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A (cake) for land application.</td>
<td>Class A pelletized product for distribution &amp; marketing.</td>
</tr>
<tr>
<td>Product hauling feasible &amp; short haul distances.</td>
<td>Product hauling to be minimized &amp; long haul distances.</td>
</tr>
<tr>
<td>Capacity to existing digestion process to be increased.</td>
<td>No impact on existing digestion process.</td>
</tr>
<tr>
<td>Sidestream treatment capability available to handle increased N &amp; P loads.</td>
<td>No impact on sidestreams.</td>
</tr>
<tr>
<td>Trained/certified operators available for steam boiler/high pressure operation.</td>
<td>No additional operator certification required.</td>
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Carbon Footprint – Inventory of GHG Emissions

- An important piece of the sustainability puzzle.
- Define scope and system boundary for analysis.

- Direct emissions and indirect emissions.
- GHG emissions (energy use, process emissions)
- GHG credits (renewable energy use, fertilizer offsets)
Components of a Carbon Footprint Assessment

<table>
<thead>
<tr>
<th>Item</th>
<th>Technology Option</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>AD</td>
</tr>
<tr>
<td></td>
<td>Pretreat + AD</td>
</tr>
<tr>
<td></td>
<td>AD + Dry (NG)</td>
</tr>
<tr>
<td></td>
<td>AD + Dry (DG)</td>
</tr>
<tr>
<td>Plant Energy Use</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>Positive</td>
</tr>
<tr>
<td>Fossil Fuel Use</td>
<td>Positive</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>Positive</td>
</tr>
<tr>
<td>Chemicals Consumed</td>
<td>Positive</td>
</tr>
<tr>
<td>Treatment Emissions</td>
<td></td>
</tr>
<tr>
<td>Methane</td>
<td>Negative</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>Positive</td>
</tr>
<tr>
<td>Sludge Management</td>
<td></td>
</tr>
<tr>
<td>Final Use/Disposal</td>
<td>Negative</td>
</tr>
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Legend:
- **Positive**
- **Average**
- **Negative**
Reduction in GHG Emissions through Fuel Blending @ West Palm Beach, FL

- LFG primary fuel – blends NG as required to maintain energy input.
- Ratio of LFG to NG determined by energy content and pressure of LFG.
Materials Recovery from Biosolids – Gaining Interest

PS + WAS → Pre-Treatment → Anaerobic Digestion → Gas Cleaning → CHP

- Dewatering
  - Sidestream Treatment
  - Dewatered Cake
    - Struvite Recovery
    - Thermal Drying
      - Further Processing
        - End Use
          - Dried Product
Bio-P + Digestion = Poor Dewaterability

Ref: Sprouse, G. (2013): Biosolids Dewatering at the Empire WWTP Following Conversion to Bio-P and Influent Wastewater Changes

Lower cake %TS and higher polymer requirements with BPR sludge.
Phosphorus Recovery – WASSTRIPT + Ostara®

- Conventional AS to BPR
  - No significant change in sludge quantities
  - 2-3X phosphorus conc. in biosolids
- Land application at agronomic rates for N – P loading greater than crop needs.
- WASSTRIPT + Ostara®
  - Reduces P recycle to liquid stream
  - Reduces struvite precipitation
  - Recovers P as a marketable product

Pictures Courtesy: Ostara
Summary - Striving for Sustainable Solutions

- Triple Bottom Line Approach


- AD - Primary pathway for energy recovery, but larger solids quantities for beneficial use.

- Resource recovery dictated by market for recovered products and public perception of the technology.
RECYCLE
RENEW
RESTORE

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NEFCO
Recycle, Renew, Restore