Challenges with Anaerobic Digestion

Doug Renk
September 18, 2018
Challenges with Anaerobic Digestion

• Anaerobic Digestion Basics

• Waste Management and Energy Creation Across Sectors

• Anaerobic Digestion Feedstock

• Buying a Biogas plant

• Running a successful Biogas Plant
Anaerobic Digestion Basics
Technological Fit with Food Recovery?

Hierarchy For Reducing & Recycling
Food Scraps And Other Organic Discards

- Source Reduction
- Edible Food Rescue
- Residential Backyard Composting
- Small-scale, Decentralized Composting
- Centralized Composting or Anaerobic Digestion
- Mechanical Biological Mixed Waste Treatment
- Landfill & Incinerator

Source: Institute for Local Self-Reliance, 2014
Anaerobic Digestion Basics
What are we really talking about?

Substrate (food)

Complex Organic Carbon

Hydrolysis

Monomers & Oligomers

Acidogenesis

Organic Acids

Acetogenesis

Acetate – H₂ / CO₂

Methanogenesis

CH₄ + CO₂

Biogas = CO₂, H₂S, & CH₄

Effluent
So what do we feed digesters?
What’s Good?

- Undigested fats, proteins, carbohydrates = Gas
- Pre-established bacteria cultures
- Minerals for nutrients and buffering capacity
- Plentiful and consistent
- Fresh = Best
- Delivered = preferred

Feedstock:
Feedstock:

What’s not as good?

- Overly dried or composted manure – loss of VS “Other Stuff” that’s not digestible:
  - Too much water, sand, rocks, rope, etc..
  - Plastic separation requires equipment and labor to manage
  - Dry Manure “Reject” Handling
Anaerobic Digestion Basics
Whose on the market?

**GHD**: meso plug and mix combo in-ground

**Biogas Nord**: continuous meso mix

**Eisenmann**: plug flow

**RCM**
Kompoferm
UTS  Biothane
CH-Four
Ecovation
MT-Energie
Entec biogas

**BIOFerm**: Dry Fermentation, Plug flow, CSTR, Compact
Common Misperceptions in the Industry

- AD reduces waste
- AD reduces phosphorus
- AD has no odor
- Low maintenance
Waste Management and Energy Creation Across Sectors

Municipal Solid Waste

Wastewater

Industrial

Agricultural
Municipal Solid Waste

A typical case...

Cost:
- $28m
- OP-EX estimated $450,000/yr
- Payback (?)

Feedstock:
- 40,000 metric tons/year high-solids organic waste
  - Municipal solid waste
  - Source Separated organics from industrial, commercial, and institutional waste sectors
  - Yard Waste

Average Annual Energy Production:
- 12.5 Million kWh electrical
- 45,300 MMBTU thermal

Biogas Produced:
- 60 Million scf

Emissions Reduced:
- 46,000 metric tons CO₂/year

Where does a project make financial sense?

### Tipping Fees ($/ton)

<table>
<thead>
<tr>
<th>State</th>
<th>High</th>
<th>Low</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington</td>
<td>$142</td>
<td>$28</td>
<td>$70</td>
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<tr>
<td>Maine</td>
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<td>Pennsylvania</td>
<td>$103</td>
<td>$63</td>
<td>$76</td>
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<tr>
<td>New York State</td>
<td>$102</td>
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<tr>
<td>Wyoming</td>
<td>$102</td>
<td>$35</td>
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</tr>
<tr>
<td>Massachusetts</td>
<td>$100</td>
<td>$60</td>
<td>$78</td>
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<tr>
<td><strong>US Average</strong></td>
<td><strong>$50</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based off of BIOFerm’s Project with the City of Edmonton, Alberta Canada
Wastewater Treatment & Industrial

A typical case…

Cost:
- Phase 1 $7 million
- Phase 2 $32 million
- Opex (?)
- Payback (?)

Feedstock:
- 7,000 dry tons biosolids/year
- 15,000 dry tons biosolids/ year

Average annual energy production:
- 3 Million kWh electrical
- 11,796 MMBTU thermal
- 47,733,850 ft$^3$ biogas at 55% CH$_4$

Based off of BIOFerm’s Project with the City of Akron, OH and KB BioEnergy
Agricultural

A typical case...

Cost:
- $7 million
- $864,000/year
- Payback (?)

Herd Size:
- 9,000 dairy cows

Processing Capacity:
- 350 tons of manure/day

Average annual energy production:
- 11-12.5 Million kWh electrical
- 45,300 MMBTU thermal
- 165,000,000 ft³ of biogas

Emissions Reduced:
- 44,602 metric tons CO₂/year

Based off of BIOFerm’s Project with the University of Wisconsin Oshkosh and Rosendale Farm
A closer look into Municipalities: Waste-to-Energy
PFD of Municipal Process

Pre Processing
- Equipment
- $Capex$
- $Opex$

Anaerobic Digestion
- $Capex$
- $Opex$

Post Processing
- Liquid or Solid?
- $Capex$
- $Opex$

Final Use
- $Capex$
- $Opex$

Quality
- Quantity
- Collection
- Moisture

Food Waste
- $Capex$
- $Opex$

Equipment

Collection
MSW Collection Considerations

- Collection
  - Single-Stream
  - Residential Separation
  - Frequency

- Residence Times

- Hauling Distances

Images courtesy of Google
Typical MSW Generation (Before Recycling/Diversion)

- Paper 27.4%
- Food Waste 14.5%
- Yard Waste 13.5%
- Plastics 12.7%
- Metals 8.9%
- Rubber/Textiles 8.7%
- Wood 6.3%
- Glass 4.6%
- Other 3.4%

Photo courtesy of BioCycle.net, information courtesy of 2012 EPA Estimates
Waste Characterization

- Waste Constituents
  - Contamination
  - Physical properties

- Laboratory Testing
  - Total & Volatile Solids
  - Biogas & Methane Potential
Pre-Processing Considerations

- **Equipment**
  - Debaggers
  - Shredders
  - Magnets
  - Trommels
Pre-Processing Considerations

- **Equipment**
  - De-packager
Digestor Considerations

- Dry Fermentation
- CTSR
- Plug Flow
Post processing Considerations

- Digestate end use- adding value
- Handling Solid vs. Liquid waste
- Capturing nutrients
High-Solids AD- Non-Pumpable Materials
Anaerobic Digestion - Non-Pumpable Materials
What to consider when interested in buying a Biogas Plant
Is bigger always better?
A Comparison of European to US AD Application

- A Tale of Two Policy-driven Markets
Buying a Biogas Plant: Feedstock

Germany:
- Majority of feedstock is energy crops (e.g. corn and grass) and manure
- Well known and highly consistent substrates
- About 20% of plants run on municipal organic waste

USA:
- Growing biomass not widely accepted (food vs. fuel debate)
- Use waste streams, e.g. manure, source separated organics
- Potential lies with source separated organics (34 million tons of food waste per year, only 2.5% is currently recycled)
Buying a Biogas Plant: Economics

Germany:
- Electricity prices are higher compared to US
- Renewable energy is subsidized
- Biogas market competition is high, keeping technology prices competitive
- Time to payback, even for a small farm based system, is relatively short

USA:
- Electricity prices are low
- Renewable energy incentives: 30% tax grant/credit, other incentives vary from state to state
- Payback times are longer
- Collecting tip fee for organic waste will positively influence economics

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Kosten der Haushaltsstrompreise 2005-2011

<table>
<thead>
<tr>
<th>Jahr</th>
<th>Förderung Erneuerbarer Energien (REG-Umlage)</th>
<th>sonstige Stromkosten (z. B. Netzgeld, MWSt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>18,2</td>
<td>17,5</td>
</tr>
<tr>
<td>2006</td>
<td>16,7</td>
<td>18,0</td>
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<tr>
<td>2007</td>
<td>16,9</td>
<td>19,2</td>
</tr>
<tr>
<td>2008</td>
<td>20,2</td>
<td>20,3</td>
</tr>
<tr>
<td>2009</td>
<td>21,4</td>
<td>21,4</td>
</tr>
<tr>
<td>2010*</td>
<td>22,7</td>
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<tr>
<td>2011*</td>
<td>24,1</td>
<td>24,1</td>
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<tr>
<td>2012*</td>
<td>25,8</td>
<td>25,8</td>
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</table>

*Schätzung

U.S. Residential Electricity Price

Source: Short-Term Energy Outlook, March 2011
Buying a Biogas Plant:
Product Sales

Germany:
- Erneubare Energien Gesetz (EEG), Renewable Energy Law, revised in 2009 regulates feed-in tariffs for all renewable energy technologies, guaranteed for 15 – 20 years

Example Biogas:

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEG Biomass</td>
<td>0.1167 €</td>
</tr>
<tr>
<td>Renewable Biomass Bonus</td>
<td>0.07 €</td>
</tr>
<tr>
<td>Manure Bonus</td>
<td>0.04 €</td>
</tr>
<tr>
<td>Technology Bonus</td>
<td>0.02 €</td>
</tr>
</tbody>
</table>

- Total: 0.2467 €
- Retail Cost: Around 0.25 €/kWh

USA:
- Has no country wide feed-in tariff
- Few states (e.g. Hawaii) have adopted them, but don’t necessarily include biomass/biogas
- Each biogas client has to negotiate their own Power Purchase Agreement with their utility
## Buying a Biogas Plant: Financing

<table>
<thead>
<tr>
<th>Germany:</th>
<th>USA:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial instruments exist to finance biogas plants:</td>
<td>No defined financial instruments exist to finance biogas plants:</td>
</tr>
<tr>
<td>▪ Project economics clearly defined</td>
<td>▪ Project economics do not follow a set model</td>
</tr>
<tr>
<td>▪ Proven application of technology</td>
<td>▪ Unproven technical track record in the US</td>
</tr>
<tr>
<td>▪ Standard safety certification of plant technology (TÜV)</td>
<td>▪ Standard safety certification does not exist</td>
</tr>
<tr>
<td>▪ Risk assessment is quantified by DIN standards</td>
<td>▪ Risk assessments based on foreign data</td>
</tr>
</tbody>
</table>
## Buying a Biogas Plant: Permitting

### Germany:
- **Federal standards:**
  - BImSchG: Federal Emission Control Law
  - EG-Hygiene VO: European Hygiene Regulation for animal products
  - TA Luft: Technical Instructions for Emission Control
  - TA Lärm: Technical Instructions for Noise Control
  - DMG: Fertilizer Law
  - BioAbfVO: Municipal Organic Waste Regulation
- Safety and expert reports available (TÜV)
- Permitted per component unit, e.g. digester tank, biofilter
- Over 5000 plants permitted

### USA:
- No federal standards
- No standard safety certifications
- State standards for emissions (CHP emissions), differ from state to state
- Building codes vary from one state to another
Challenges with Anaerobic Digestion
Decision Checklist

- Who is designing your biogas plant? What is their experience in the local market?

- What is the financial strength of the company that is selling you a system? How committed are they to the market in your country?

- How many engineers, support staff etc. are located in your market?

- Who is guaranteeing that the system will work through the initial warranty and long term operation?
Challenges with Anaerobic Digestion
Decision Checklist

- Who is guaranteeing that your feedstock will produce the stated amount of biogas?

- Who provides ongoing biological support for your biogas plant? Are long term service contracts available?

- Who provides ongoing technical support and service locally?

- What kind of lead time can you expect and tolerate for replacement parts?
Challenges with Anaerobic Digestion

Conclusions

– Careful selection of technology provider. Must have a good track record
– AD is a complex biological system, and adequate training of operational personnel is required
– There is no “one size fits all” because feedstocks will differ on a case by case basis, and this has to be taken into account during the design and operation of the system
At BIOFerm™ we see our role as “re-definers” of waste across a variety of sectors. We hope to provide the tools for industries to make the most of the resources within their reach—

because nothing is waste until you waste it.

Thank You!