Decision Support Modeling for Anaerobic Digesters

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Michigan Public Service Commission

Acknowledgements: State of Michigan Energy Office, Michigan State University Dept. of Biosystems and Agricultural Engineering, Project GREEN, Consumers Energy

Peer Reviewers: Sali Group, Quantalux, Consumers Energy
Decision Support Modeling for Digesters

• Helps determine whether the project should move forward to a professional study

• Allows for the testing of different scenarios to identify potential problems or “deal breakers”

• Can isolate the effects of a change in a particular variable or evaluate scenarios
Considerations for Digesters

- Design varies from one facility to the next

- Co-digestion has the potential to boost biogas production, but can cause output variability and increase capital costs

- Achieving positive returns on investment can be a challenge without advance planning
Anaerobic Digestion Development Iterative Tool (ADDIT)

- Developed to work alongside the MSU Biomass Inventory
  - Encourage new AD development
  - Inventory used to identify feedstock sources with energy potential/ ADDIT allows site specific data
  - System optimization for current ADs

- Preliminary test of technical and economic feasibility of AD systems
- Ability to optimize a variety of system parameters including:
  - Electricity cost
  - Feedstock mixture (i.e., co-digestion )
  - Financial combination
  - Revenues
Anaerobic Digestion Development Iterative Tool (ADDIT)

ADDIT Flowchart

Step 1 Preliminary Evaluation

Step 2 Model Inputs

Step 3 Theoretical Energy Potential Assessment (Output)

Step 4 Economic Assessment (Outputs)

Step 5 Verification of Theoretical Biogas Potential

Anaerobic Digester Research and Education Center

MI Waste Biomass Energy Inventory to Support Renewable Energy Development

Calculation Worksheets

Calculation Worksheet Flowchart

Biogas Production

System Performance

Biogas to Genset Calculations

Electricity Production

Thermal Energy and Prices

Carbon Credits

Pro Forma

ROI Analysis

*Requires User Input

Electricity Bills

Investment Costs
- Dairy/Community
- Municipal
- Food Processor

Financing

Property Taxes

O&M Costs

Depreciation
Identify “Deal Breakers”

Identify “deal breakers” that could make the system either technically or economically infeasible

- Electric Infrastructure - 3-Phase Line Proximity
- Feedstock Characteristics
  - Consistency
  - Cleanliness
  - Availability
  - Transportation
- Environmental permitting limitations
# Analyze Feedstock

## Why Important?
Determines energy production potential and affects system design

## Key Points to Consider
- Carbon to Nitrogen Ratio (verifiable through testing)
- Relative Contribution of Each Feedstock
- Digestable?
- Adequate supply?

## Inputs

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Type of Biomass</td>
<td>Fruit &amp; vegetable processing</td>
<td>Fruit &amp; vegetable processing</td>
<td>BOD Water</td>
<td>WWTP biosolids</td>
<td>WWTP biosolids</td>
<td>Cafeteria Waste</td>
</tr>
<tr>
<td>Biomass as Collected (wet ton/yr)</td>
<td>2,600</td>
<td>5,000</td>
<td>1,400,000</td>
<td>23,500</td>
<td>39,900</td>
<td>15</td>
</tr>
<tr>
<td>Biogas Production Potential ($ft^3$ biogas/lb VS)</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

## Outputs

| Type of Biomass | Generator Size including Efficiencies and Heat Loss (kW) | Total Net Energy accounting for all Operational Needs including Transportation, Biomass Availability, Influent Heat, Digester Heat, Digester Operation, Digester Operational Time, Generator Efficiency, and Generator Operational Time (kWh/yr) | Generator Size including Efficiencies and Heat Loss (MMBtu/yr) |
|----------------|--------------------------------------------------------|------------------------------------------------------------------|
| Fruit & vegetable processing | 25 | 190,200 | 450 |
| Fruit & vegetable processing | 45 | 365,900 | |
| BOD Water | 155 | 1,338,600 | |
| WWTP biosolids | 140 | 1,188,800 | |
| WWTP biosolids | 235 | 2,018,500 | |
| Cafeteria Waste | 5 | 1,100 | |
Examine Seasonal Production

**Why Important?**
Higher heat requirements can reduce production during winter months

**Key Points to Consider**
- Energy Produced vs. Moisture Content
- Heat Loss through Tank Walls
- Biogas Usage
  - Electricity vs. Natural Gas Offset
  - Flared

Higher heat requirements can reduce production during winter months.

**Type of Biomass**
- Fruit & vegetable processing
- Fruit & vegetable processing
- BOD Water
- WWTP biosolids
- WWTP biosolids
- Cafeteria Waste

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<td>39,900</td>
<td>15</td>
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<tr>
<td>Moisture (%)</td>
<td>90</td>
<td>90</td>
<td>99</td>
<td>90</td>
<td>90</td>
<td>90</td>
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<tr>
<td>Feedstock Density (lb/ft³)</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
<td>62</td>
</tr>
<tr>
<td>VS/TS (% of TS)</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>86</td>
<td>86</td>
<td>85</td>
</tr>
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<tr>
<td>CH4 Content (%)</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>55</td>
<td>55</td>
<td>60</td>
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<tr>
<td>Energy for Heating Influent (MMBtu/yr)</td>
<td>264</td>
<td>396</td>
<td>110,762</td>
<td>2,384</td>
<td>4,047</td>
<td>1</td>
</tr>
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</table>
## Economic Analysis

### Why Important?
 Revenue sources include: electricity production, natural gas offsets, reduction in waste treatment costs or tipping fees (food processors)

### Key Points to Consider
- Level of Proposed Revenues
- Minimize Cost and Achieve Performance Targets
- Reducing Financing Costs (i.e., interest) Increases the ROI

### Outputs

<table>
<thead>
<tr>
<th>Description</th>
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</tr>
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<tbody>
<tr>
<td>Anaerobic Digester Total System Cost</td>
<td>$3,687,300</td>
</tr>
<tr>
<td>Anaerobic Digester Total Cost per KW</td>
<td>$8,300</td>
</tr>
<tr>
<td>Loans</td>
<td>80%</td>
</tr>
<tr>
<td>Grants</td>
<td>10%</td>
</tr>
<tr>
<td>Cash</td>
<td>10%</td>
</tr>
<tr>
<td>Required Return to Total Capital (Before Taxes)</td>
<td>8%</td>
</tr>
<tr>
<td>Anaerobic Digester Capital Cost</td>
<td>$2,728,000</td>
</tr>
<tr>
<td>Net Present Value*</td>
<td>($3,684,564)</td>
</tr>
</tbody>
</table>

*Assumes 8.6 cents/kWh

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<tbody>
<tr>
<td>Required Electric Price</td>
<td>22.9¢/kWh</td>
</tr>
</tbody>
</table>
Next Steps

- **Verification of feedstock energy potential**
  Recommended Testing Laboratory: Anaerobic Digestion Research and Education Center
  Dana Kirk
  Assistant Professor
  Michigan State University
  Anaerobic Digestion Research and Education Center (ADREC)
  Contact: Dana Kirk (kirkdana@msu.edu)
  [http://researchgroups.msu.edu/adrec/](http://researchgroups.msu.edu/adrec/)

- **ADDIT Available for Download**

- Other modeling methods are also available (i.e., objective optimization)

- Get professional assistance/engineering study
Questions?

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