Dairy Manure Management: Treatment, Handling, and Community Relations

AD Performance Goals: Affect on System Components and Costs

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Waste Treatment System

• Support the overall goals, objectives, and needs for the farm

• These vary from farm to farm
Potential Goals and Objectives

• Removal of manure solids
  ➡ easier pumping to remote storage
  ➡ easier field application
Potential Goals and Objectives

- Removal of bedding sand to:
  - protect subsequent treatment equipment
  - reuse as stall bedding material
  - reduce field compaction
Potential Goals and Objectives

- Odor Reduction
Potential Goals and Objectives

• Electrical generation to:
  ➔ Meet on-farm needs
  ➔ Sell to the utility
Potential Goals and Objectives

- Conservation of manure nutrients
- Reduce pathogens
Integrated Manure Management System
Goals and Objectives of Paper

Present the relationships that exist between manure management goals, treatment equipment, and economics for a treatment system centered around Anaerobic Digestion.
Implementation

• Analyze four manure treatment systems
• Each successive system will build on the previous
• Synthesize the results and form conclusions
Background

• Data obtained from a feasibility study conducted for a NYS producer in 2004
• 800 lactating cows, 100 dry cows, and 400 heifers weighing on ave. 1,000 lbs
• Manure production estimated to be 144, 78, and 53 lbs. per day, respectively
Existing Site Plan

- Existing North Freestall Barn
- Existing South Freestall Barn
- Existing Long-Term Storage No. 1
- Existing Long-Term Storage No. 2
- Existing Dry Cow & Heifer Freestall
- Manure Channel
- Recpt. Pit
- Milking Center
Four Options Analyzed

• Option I. Liquid manure odor reduction

• Option II. Option I + electrical generation

• Option III. Option II + bedding material generation & nutrient exportation

• Option IV. Option III + w/ rotary composting
<table>
<thead>
<tr>
<th>Option</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
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</thead>
<tbody>
<tr>
<td>Digester Type</td>
<td>Plug Flow</td>
<td>Plug Flow</td>
<td>Plug Flow</td>
<td>Plug Flow</td>
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<td>Temperature (F)</td>
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<td>HRT (days)</td>
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<td>Heat Balance</td>
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First Option Analyzed

Option I. Liquid manure odor reduction
Site Plan for Option I

- **Proposed Plug Flow Digester**
- **Manure Channel**
- **Existing Long-Term Storage No. 1**
- **Alternate Feed for Raw Manure**
- **Existing North Freestall Barn**
- **Existing South Freestall Barn**
- **Existing Dry Cow & Heifer Freestall**
- **Recpt. Pit**

Flow Diagram:
- **Radiator**
- **Boiler**
- **Combust all biogas in boiler. Heat energy for digester heating.**
- **Digested Effluent to Storage**
- **Reject excess heat to heat dump radiator.**
- **Digested Effluent to Long Term Storage**
- **Manure Channel**
- **Existing Long-Term Storage No. 2**
- **Heat for Digester**
- **Biogas**
- **Heat for Digester**
### Option I – Est. Capital Costs

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<thead>
<tr>
<th>Facility/Equipment</th>
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<tbody>
<tr>
<td>Digester/Recpt. Pit</td>
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<td>Bldg, reception</td>
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<td>Manure cross channel</td>
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<tr>
<td>Boilers</td>
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<td>Steam gen. &amp; heat exchanger</td>
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<td>Chopper pump</td>
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<td>Plumbing - manure &amp; AD heating</td>
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<td>Valves &amp; meter</td>
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<td>Excavation</td>
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<td><strong>Sub totals</strong></td>
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<tr>
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<tr>
<td><strong>Sub totals</strong></td>
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</table>

**Facility & Equipment Total:** $215,123
Sample Economic Analysis for Waste Treatment

Enter No. Cows Serviced Here: 500
Enter Ave. Electrical Cost Here: 0.1 $/kW-hr.

Total Annual Est. Cost for Ave. No. of Cows Serviced Daily $37,585.22

Initial Investments, Fixed, and Operating Cost Calculation by Component No. 1

20' X 22' Sand Manure Separator

- a. Initial Capital Investment $29,600.00
- b. Installation Cost $400.00
- c. Useful Life, Years 20
- d. Salvage Value $2,960.00
- e. Interest on Investment 0.05

- f. Average Investment (a+b+d)/2 $16,480.00
- g. Annual Interest Charge (e x f) $824.00
- h. Annual Depreciation, linear $1,352.00
- i. Annual Preventative Maintenance $45.00
- j. Annual Repairs Over Useful Life $123.57
- k. Annual Electrical Cost $1,520.83
- l. Annual Labor Hours 2.41
- m. Labor Rate, all costs 16

- n. Annual Labor Costs (l x m) $38.51

Total Annual Cost for Component: $3,903.92
(g+h+l+j+k+n):
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Enter No. Cows Serviced Here: 500
Enter Ave. Electrical Cost Here: 0.1 $/kW-hr.

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l. Annual Labor Hours: 2.41
m. Labor Rate, all costs: 16
n. Annual Labor Costs (l x m): $38.51

Total Annual Cost for Component: $3,903.92 (g+h+I+j+k+n)
## Comparison Summary Costs ($) for the Four Options Analyzed

<table>
<thead>
<tr>
<th></th>
<th>Option I</th>
<th>Option II</th>
<th>Option III</th>
<th>Option IV</th>
</tr>
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<tbody>
<tr>
<td>Total Capital Cost</td>
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</tr>
<tr>
<td>Total Capital Cost Per Cow</td>
<td>269</td>
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<tr>
<td>Total Est. Annual Capital Cost</td>
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<tr>
<td>Total Est. Annual Capital Cost Per Cow</td>
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<tr>
<td>Total Est. Annual Operating Cost</td>
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<tr>
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<td>Total Est. Annual Cost or Benefit Per Cow</td>
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</tbody>
</table>

1. Does not include treatment system electrical use (parasitic power)
2. Negative numbers mean that the farm incurs a net loss from the digester system.

**Represents the annual cost to control liquid manure odor for the farm**
Second Option Analyzed

Option I. Liquid manure odor reduction

Option II. Option I + electrical generation
Site Plan for Option II

Proposed Plug Flow Digester

Existing Long-Term Storage No. 2

Existing North Freestall Barn

Existing South Freestall Barn

Existing Dry Cow & Heifer Freestall

Recpt. Pit

Heat for Digester

Biogas

Digested Effluent to Storage

Digested Effluent to Long Term Storage

Boiler

Radiator

Alternate Feed for Raw Manure

Existing Long-Term Storage No. 1

Manure Channel
Site Plan for Option II

- Proposed Plug Flow Digester
- Manure Channel
- Existing Long-Term Storage No. 1
- Existing Long-Term Storage No. 2
- Existing North Freestall Barn
- Existing South Freestall Barn
- Existing Dry Cow & Heifer Freestall
- Recpt. Pit
- Eng/Gen
  - Biogas
  - Heat for Digester
- Radiator
- Digested Effluent to Storage
- Digested Effluent to Long Term Storage
- Manure Channel
- Alternate Feed for Raw Manure

- Electricity for farm use or sale
- Combust all biogas in engine. Heat energy for digester heating.
- Reject excess heat to heat dump radiator.
- Heat for Digester
- Electricity for farm use or sale

- Eng/Gen
  - Radiator
  - Biogas
  - Heat for Digester

- Existing South Freestall Barn
- Existing North Freestall Barn
- Milking Center
### Comparison Summary Costs ($)
for the Four Options Analyzed

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<thead>
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<th>Option I</th>
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<th>Option IV</th>
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<tbody>
<tr>
<td>Total Capital Cost</td>
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<tr>
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<tr>
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<tr>
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<tr>
<td>Total Est. Annual Revenues Per Cow</td>
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<tr>
<td>Total Est. Annual Cost or Benefit&lt;sup&gt;1,2&lt;/sup&gt;</td>
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<tr>
<td>Total Est. Annual Cost or Benefit Per Cow</td>
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<td>-3.50</td>
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</tbody>
</table>

<sup>1</sup> Does not include treatment system electrical use (parasitic power)

<sup>2</sup> Negative numbers mean that the farm incurs a net loss from the digester system.

- Increased HRT
- 125 KW engine/gen set
- Gas processing bldg.
- Plumbing and electrical
<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option I</td>
<td>Liquid manure odor reduction</td>
</tr>
<tr>
<td>Option II</td>
<td>Option I + electrical generation</td>
</tr>
<tr>
<td>Option III</td>
<td>Option II + bedding material generation &amp; nutrient exportation</td>
</tr>
</tbody>
</table>
Site Plan for Option III

- **Proposed Plug Flow Digester**
- **Manure Channel**
- **Existing Long-Term Storage No. 2**
- **Alternate Feed for Raw Manure**
- **Existing Dry Cow & Heifer Freestall Barn**
- **Existing North Freestall Barn**
- **Existing South Freestall Barn**
- **Recpt. Pit**
- **Eng/Gen**
- **Solid-Liquid Separator**
- **Digested Effluent to Long Term Storage**
- **Digested Effluent to Storage**
- **Heat for Digester**
- **Electricity for farm Use or sale**
- **Combust all biogas in engine. Heat energy for digester heating.**
- **Biogas**
- **Radiator**
- **DMS for bedding and export**
- **Existing Long-Term Storage No. 1**

Additional notes:
- **Eng/Gen:** Electricity for farm use or sale. Heat energy for digester heating.
- **Solid-Liquid Separator:** DMS for bedding and export.
- **Eng/Gen:** Combust all biogas in engine. Heat energy for digester heating.
Site Plan for Option III

- **Existing Long-Term Storage No. 1**
- **Alternate Feed for Raw Manure**
- **Existing North Freestall Barn**
- **Existing South Freestall Barn**
- **Existing Dry Cow & Heifer Freestall Barn**
- **Recpt. Pit**
- **Eng/Gen**
- **Solid-Liquid Separator**
- **Bedding and Export DMS**
- **Manure Channel**
- **Digested Effluent to Storage**
- **Proposed Plug Flow Digester**
- **Heat for Digester**
- **Biogas**
- **Radiator**
- **Combust all biogas in engine. Heat energy for digester heating.**
- **Reject residual heat to heat dump radiator.**
- **Digested Effluent to Long-Term Storage**
- **Electricity for farm Use or sale.**
- **Heat for Digester**
- **Electricity for farm Use or sale.**
## Comparison Summary Costs ($)

for the Four Options Analyzed

<table>
<thead>
<tr>
<th></th>
<th>Option I</th>
<th>Option II</th>
<th>Option III</th>
<th>Option IV</th>
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<tr>
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<td>-3.50</td>
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</tbody>
</table>

---

1. Does not include treatment system electrical use (parasitic power)

2. Negative numbers mean that the farm incurs a net loss from the digester system.
<table>
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<tbody>
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<td>Option II + bedding material generation &amp; nutrient exportation</td>
</tr>
<tr>
<td>Option IV.</td>
<td>Option III + w/ rotary composting</td>
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</tbody>
</table>
Site Plan for Option III

- Proposed Plug Flow Digester
- Manure Channel
- Existing Long-Term Storage No. 2
- Alternate Feed for Raw Manure
- Existing Dry Cow & Heifer Freestall Barn
- Existing North Freestall Barn
- Existing South Freestall Barn

Flows:
- Digested Effluent to Storage
- Eng/Gen
- Biogas
- Radiator
- Proposed Plug Flow Digester
- Manure Channel
- Rotary Composter
- Solid-Liquid Separator
- Recpt. Pit
- Existing North Freestall Barn

Notations:
- Electricity for farm use or sale
- Heat for Digester
- Heat for Eng/Gen
- Reject residual heat to heat dump radiator
- Combust all biogas in engine. Heat energy for digester heating
- Heat for Eng/Gen

Other Notations:
- Electric energy for farm use or sale
- Rotary Composter
- Eng/Gen
## Comparison Summary Costs ($)
for the Four Options Analyzed

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<th>Option IV</th>
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<tbody>
<tr>
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<tr>
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1. Does not include treatment system electrical use (parasitic power)
2. Negative numbers mean that the farm incurs a net loss from the digester system.

- Rotary drum composter
- Processing bldg.
- Solids conveyors
- Compost dryer
- Austere equipment
Comparisons

- On-farm electrical generation is not profitable but reduces the cost for odor control to $2,800 annually.

- Option III provides the greatest economical benefit ($35,200 annually) if post-digested reclaimed manure solids (not composted) can be used as freestall bedding material without compromising the farm’s udder health and milk quality goals.
Comparisons

• If reclaimed manure solids cannot be used as bedding, then the annual cost for Option III becomes $4,400, a difference of $39,600.

• The economic benefit of aerobically composting post-digested separated solids does not exceed the cost. Option IV is only viable if use of post-digested separated solids as bedding is not permissible.