Biogás Nicaraagua

MADMEC
Summer, 2007
MISSION

Combining Chemical Engineering Principles, Architectural Design, and Material Science, Biogas Kits develops alternative Biogas energy solutions for rural and urban populations in developing countries. By taking into consideration and integrating several important facets of life: cooking and lighting requirements, housing location, waste management, sanitation, agricultural production, and concern for the environment, Biogas Kits is able to offer each individual client or community a unique and affordable solution to accommodate their energy needs in an eco-friendly way.

Our ideal digester is affordable, durable, and mass reproducible while sensitive to the social needs of Nicaraguans.
Why Biogas? Why Nicaragua?
Hambre Cero

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Existing Technology

Single Phase Digester

Phase 1 Acid & Methane Phase 1 & 2
Biomass $\rightarrow$ $\text{CH}_3\text{COOH} + \text{H}_2 + \text{CO}_2$
$\text{CH}_3\text{COOH} \rightarrow \text{CH}_4 + \text{CO}_2$
$\text{CH}_3\text{COOH} \rightarrow \text{CH}_4 + \text{CO}_2$
$\text{CO}_2 + 4\text{H}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O}$

1. Animal manure is biomass input
2. Biodigester (Acid Phase, Methane Phase 1 & 2)
3. Biogas stream
4. Output waste stream (fertilizer)

Current biogas technologies use a single low density plastic liner (such as a low grade polyethylene) as the container for a plug flow digester system. The system is inexpensive, but vastly inefficient and problematic. Various problems including frequent breaks and leaks (as seen in the image to the left), and a high residence time (defined as the time it takes to yield biogas output from a biomass input), consistently retard production of biogas.
Proposed Technology

Tri Phase Digester

1. Animal manure is biomass input
2. Biodigester (Acid Phase)
3. Acidified material from the Acid Phase Digester is input to the Methane Phase 1 Digester
4. Carbon Dioxide gas is recycled from the Acid Phase Digester to the Methane Phase 2 Digester
5. Methane Phase 1 Digester

Phase 1 Acid Phase
Biomass $\rightarrow$ $\text{CH}_3\text{COOH} + \text{H}_2 + \text{CO}_2$

Phase 2 Methane Phase 1
$\text{CH}_3\text{COOH} \rightarrow \text{CH}_4 + \text{CO}_2$

Phase 3 Methane Phase 2
$\text{CH}_3\text{COOH} \rightarrow \text{CH}_4 + \text{CO}_2$
$\text{CO}_2 + 4\text{H}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O}$

6. Biogas produced from Methane Phase 1 Digester
7. Material proceeds from the Methane Phase 1 Digester to the Methane Phase II Digester
8. Methane Phase 2 Digester uses carbon dioxide from the Acid Phase and biomass material from Methane 1
9. Biogas stream from Methane Phase 2 Digester
10. Output waste stream (fertilizer)

Methane Forming Bacteria
Mc. mazaei
Mb. Sohngenii
Ms. methanica
Mb. formicicum
Methanosarcina barkerii

Smaller & Faster
Cheaper & Integrated
### Operating Conditions and Parameters

#### Biogas Digester Alpha (actual)

<table>
<thead>
<tr>
<th></th>
<th>Unit of Measurement</th>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>inches</td>
<td>10</td>
<td>14.25</td>
<td>10</td>
</tr>
<tr>
<td>Length</td>
<td>inches</td>
<td>73.88</td>
<td>236.5</td>
<td>138.3</td>
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<tr>
<td>Volume</td>
<td>inches³</td>
<td>5802.51673</td>
<td>37718.15043</td>
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<tr>
<td>Working Volume</td>
<td>inches³</td>
<td>4642.013384</td>
<td>30174.52</td>
<td>350.32 (0.203)</td>
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<td>Mode of Operation</td>
<td>mode</td>
<td>Continuous Daily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retention Time</td>
<td>days</td>
<td>1</td>
<td>6.5</td>
<td>7</td>
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<tr>
<td>Loading Rate</td>
<td>lbs/day</td>
<td>43.55</td>
<td>43.55</td>
<td>**.029 ft³/day</td>
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<tr>
<td>Temperature</td>
<td>degrees Celsius</td>
<td>Ambient (but the hotter the better)</td>
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<td></td>
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<tr>
<td>pH</td>
<td>no units</td>
<td>5.5-5.8</td>
<td>7.0-7.2</td>
<td>6.5-8.5</td>
</tr>
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</table>
Future of Biogas Nicaragua
Potential Buyers

Name: Don Jose Dans
Occupation: Restaurant Owner in the City of Diriamba
Statement of Interest: “I am a retired electrical engineer. I would love to have this system for my restaurant and I am very interested in automating it with 12V solenoid valves so that it can be completely automated
Social Status: Upper Middle Class

Name: Richard Stephens
Occupation: Farmer and Horse Owner in Diriamba
Statement of Interest: “I have to buy gas every single month from Tropigas. I have plenty of Horses and cows to supply a biodigester with and am also very interested in eco-friendly energy solutions.”
Social Status: Upper Middle Class

Name: Jose Medrano
Occupation: Pig Farmer and land owner north of Managua
Statement of Interest: “I saw your article in the newspaper and I am definitely interested in buying your biodigester. I am particularly interested in it to make fertilizer which I use and sell. I will pay $2,000 for the device.”
Social Status: Upper Middle Class
Material Objectives

• **Durability**
  — Direct sunlight (UV exposure)
  — Animal interactions
  — General abuse

• **Economy**
  — Inexpensive
  — Easy Scalability
  — Availability of standard components
LDPE—Plastic Bags

Pros

• **Extremely Inexpensive**
• **Universally Available**

Cons

• **Very Fragile**
• **Not UV resistant**
• **Difficult connections**
• **Needs external protection**
PVC Tubing

Pros

• Resilient material
• Widely available
• Some standard Components

Cons

• Poor UV resistance
• Much more expensive than LDPE
• MFG’d end caps unavailable
HDPE Tubing

**Pros**
- Resilient material
- Widely available
- Many standard Components
- UV Resistant

**Cons**
- Much more expensive than LDPE
Caupolican Tarps

Pros
• Resilient material
• Custom Fabricated
• UV Resistant

Cons
• More expensive than LDPE
• Possible difficulty in meeting large demands
• Requires more robust structural support
• Time Required for manufacture
# Materials Matrix

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<tr>
<th></th>
<th>Poor</th>
<th>Average</th>
<th>Good</th>
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<tbody>
<tr>
<td>UV Exposure</td>
<td>LDPE, PVC</td>
<td></td>
<td>HPDE, Tarp</td>
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<tr>
<td>Animals</td>
<td>LDPE</td>
<td></td>
<td>HDPE, Tarp</td>
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<tr>
<td>Anticipated Abuse</td>
<td>LDPE</td>
<td>PVC</td>
<td>HDPE, Tarp</td>
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<tr>
<td>Price</td>
<td>PVC, HDPE, Tarp</td>
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<td>LDPE</td>
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<tr>
<td>Scalable</td>
<td>Tarp</td>
<td></td>
<td>LDPE, HDPE, PVC</td>
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<tr>
<td>Standard Components</td>
<td>LDPE</td>
<td>PVC, Tarp</td>
<td>HDPE</td>
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</tbody>
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QUESTIONS?
EC.715 D-Lab: Disseminating Innovations for the Common Good
Spring 2007

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