Alternative Feedstocks and Biodiesel Production

Presented at the Practical Biodiesel Blueprint Conference in Kuala Lumpur, Malaysia January 23 & 24, 2007 by Rudy Pruszko
Center for Industrial Research and Service Iowa State University Extension
Transesterification

\[
\text{Triglyceride} + 3 \text{CH}_3\text{OH} \xrightarrow{\text{(NaOH)}} \text{Mixture of Fatty Esters} + \text{Glycerin}
\]
Standard Recipe

100 lb + 21.71 lb →
Oil + Methanol

100.45 lb + 10.40 lb + 10.86 lb
Biodiesel + Glycerol + Excess Methanol

Plus 1 lb of NaOH catalyst
Biodiesel Production Schematic

- **Reactor**: Oil, Methanol, Catalyst
- **Separator**: Methyl Ester, Glycerin (50%)
- **Acidulation and Separation**: Acid, Free Fatty Acids
- **Methanol Removal**: Crude Glycerin (85%)
- **Neutralization and Methanol Removal**: Wet Methanol
- **Methanol/Water Rectification**: Water, Methanol Storage
- **Water Washing**: Water, Gray Water
- **Dryer**: Water, Finished Biodiesel
Feedstock Supply

- Supply and demand principle
- Meal constraint on additional crush
  - Ethanol industry
  - Export markets
- Competition with food industry
  - Cost differential with food grade
  - Oil is a small part of the cost in food production
- Oil imports (competition and biodiesel)
Why Feedstock Price is Important
5 mm gpy Biodiesel Production Cost

Biodiesel Production Cost Summary

Customer: CIRAS Iowa State University
Case: Product cost with $0.22/lb Soybean Oil feed (5 mm gpy plant size)

<table>
<thead>
<tr>
<th>Biodiesel Production Cost</th>
<th>Cost/gal ($)</th>
<th>Cost/liter ($)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Feedstock</td>
<td>1.672</td>
<td>0.442</td>
<td>72.1%</td>
</tr>
<tr>
<td>Cost of Feedstock Transport</td>
<td>0.076</td>
<td>0.020</td>
<td>3.3%</td>
</tr>
<tr>
<td>Cost of Acid</td>
<td>0.011</td>
<td>0.003</td>
<td>0.5%</td>
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<tr>
<td>Cost of Base Catalyst</td>
<td>0.108</td>
<td>0.029</td>
<td>4.7%</td>
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<tr>
<td>Cost of Sodium Hydroxide</td>
<td>0.001</td>
<td>0.000</td>
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<tr>
<td>Cost of Methanol</td>
<td>0.122</td>
<td>0.032</td>
<td>5.3%</td>
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<tr>
<td>Cost of Heat Energy</td>
<td>0.022</td>
<td>0.006</td>
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<td>Cost of Electricity</td>
<td>0.004</td>
<td>0.001</td>
<td>0.2%</td>
</tr>
<tr>
<td>Cost of Labor</td>
<td>0.079</td>
<td>0.021</td>
<td>3.4%</td>
</tr>
<tr>
<td>Depreciation</td>
<td>0.128</td>
<td>0.034</td>
<td>5.5%</td>
</tr>
<tr>
<td>Cost of Maintenance</td>
<td>0.040</td>
<td>0.011</td>
<td>1.7%</td>
</tr>
<tr>
<td>Cost of Admin and Overhead</td>
<td>0.025</td>
<td>0.007</td>
<td>1.1%</td>
</tr>
<tr>
<td>Cost of Marketing</td>
<td>0.030</td>
<td>0.008</td>
<td>1.3%</td>
</tr>
<tr>
<td>Total</td>
<td>2.320</td>
<td>0.613</td>
<td>100.0%</td>
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Distribution of Biodiesel Production Cost (%)

- Feedstock: 75.4%
- Chemical: 4.1%
- Energy: 5.5%
- Labor: 1.1%
- Depreciation: 3.4%
- Overhead and Maintenance: 10.5%
Where you find solutions

Why Feedstock Price is Important
30 mm gpy Biodiesel Production Cost

Biodiesel Production Cost Summary

Customer: CIRAS Iowa State University
Case: Product cost with $0.22/lb Soybean Oil feed (30 mm gpy plant size)

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<td>Cost of Base Catalyst</td>
<td>0.103</td>
<td>0.027</td>
<td>4.8%</td>
</tr>
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<td>Cost of Sodium Hydroxide</td>
<td>0.001</td>
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</tr>
<tr>
<td>Cost of Methanol</td>
<td>0.122</td>
<td>0.032</td>
<td>5.6%</td>
</tr>
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<td>0.030</td>
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<td>1.4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2.168</strong></td>
<td><strong>0.573</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

Distribution of Biodiesel Production Cost (%)

- Feedstock: 80.6%
- Chemical: 11.0%
- Energy: 1.2%
- Labor: 1.2%
- Depreciation: 2.9%
- Overhead and Maintenance: 3.0%
Where you find solutions

Major World Vegetable Oil Supply
Foreign Agriculture Service USDA 10/06-9/07 Projections

- Palm: 31%
- Soybean: 29%
- Rapeseed: 14%
- Sunflowerseed: 9%
- Olive: 2%
- Peanut: 4%
- Cottonseed: 4%
- Coconut: 3%
- Palm Kernel: 4%
## Major World Vegetable Oil Pricing

**10/06 – 9/07 Projections**

($/metric ton)

<table>
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<tr>
<th>Vegetable</th>
<th>Price ($)</th>
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<tr>
<td>Coconut</td>
<td>$616</td>
<td>Peanut</td>
<td>$996</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>$587</td>
<td>Rapeseed</td>
<td>$679</td>
</tr>
<tr>
<td>Palm</td>
<td>$465</td>
<td>Soybean</td>
<td>$469</td>
</tr>
<tr>
<td>Palm Kernel</td>
<td>$629</td>
<td>Sunflower</td>
<td>$638</td>
</tr>
</tbody>
</table>

*Source: Food and Agricultural Policy Research Institute (FAPRI)*
Animal Feedstocks

- Tallow
- Yellow Grease (Recycled Waste Vegetable Oil)
- Poultry Fat
- Brown Grease
- Pork Fat - White Grease
- Lard
- Fish Oil
<table>
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<th>Feedstock Type Comparison</th>
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<tbody>
<tr>
<td><strong>Animal fats</strong></td>
</tr>
<tr>
<td>• Less expensive</td>
</tr>
<tr>
<td>$0.14/lb average</td>
</tr>
<tr>
<td>• Higher sulfur</td>
</tr>
<tr>
<td>• FFA 5-50%</td>
</tr>
<tr>
<td>• Less available</td>
</tr>
<tr>
<td>• Higher gel temp.</td>
</tr>
<tr>
<td>• More stable</td>
</tr>
</tbody>
</table>
Alternative Feedstocks

Seed Oil Crops

- Soybean (375 Kg oil/ha)
- Mustard (481 Kg oil/ha)
- Camelina (490 Kg oil/ha)
- Jatropha (1590 Kg oil/ha)
- Nuts (Brazil, Pecan...) (405-2010 Kg oil/ha)
- Chinese Tallow/Popcorn Tree (4000 Kg oil/ha)
- Oil Palm (5000 Kg oil/ha)
- Algae (up to 8000 Kg oil/ha)
Alternative Feedstocks

Seed Oil Crops Derivatives
- Crude Palm Oil
- RBD Palm Oil
- RBD Palm Olean
- RBD Palm Stearin
- Palm Fatty Acid Distillate (PFAD)

- Crude Kernel Palm Oil
- RBD Kernel Palm Oil
- RBD Kernel Palm Olean
- RBD Kernel Palm Stearin
- Palm Kernel Expeller
Alternative Feedstocks

Concerns

• Free Fatty Acid (FFA) content
• Waxes (Corn, Sunflower, Chinese Tallow)
• Moisture/Water content
• Insoluble, Unsaponifiable, Impurity content
• Color bodies
Alternative Feedstocks

Desirable Characteristics

• Low cost
• High purity level
• Low Moisture/Water content
• Steady and reliable supply
• Can be processed with current plant equipment
• Edible or Inedible
Alternative Feedstocks

Biodiesel Production Strategy

• Pretreatment of the Feedstock
  – Feedstock supplier's plant
  – Biodiesel plant

• Post treatment of Biodiesel

• Combination strategy

• Feedstock Cost vs. Production Cost
Innovations in Feedstocks

• Plant genetics - Biotechnology
• Designer Biodiesel
  – Pick feedstocks to determine biodiesel properties or characteristics desired
• Separation of fatty acids
• Chemically modifying fatty acid chains
• Utilizing waste streams
Innovations in Technology

Pretreatment Technologies

• Chemical Treatment
  – Caustic to remove FFA
  – Acid catalysis/esterification
  – Solid catalyst
  – Glycerolysis
  – Enzymatic
  – De-gumming
Innovations in Technology

Pretreatment or Post Treatment Technologies

- Separation
  - Centrifuges
  - Absorbents
  - Resins
  - Molecular sieves
  - Chilling/cryogenics
  - Carbon treatment
  - Distillation
  - Flash evaporation
  - Gravity settling
  - Filtration
  - Water Washing
Summary

• Cost of the Feedstock determines your profits
• Alternative feedstocks are available
• Understand the cost and technology associated with processing alternative feedstocks
• Pretreatment is preferred to Post treatment
Summary

• Be aware of the properties of the biodiesel made from alternative feedstocks
• Install the equipment needed to process alternative feedstocks
• Test the new feedstock in the lab first
Resources

- Biodiesel Workshop, material from the Biodiesel Production, Analytical, and Business workshops, Iowa and Idaho, 2005, http://www.me.iastate.edu/biodiesel
- USDA
- CIRAS and Iowa State University
Where you find solutions

Resources


Available from

http://www.biodieselbasics.com
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