WNC’s Biofuels Market & Supply Chain

Regional Biofuels Educational Workshop
Western Piedmont Council of Governments-
Hickory, NC
August 22, 2014

Jeremy C Ferrell
Appalachian State University
Ferrelljc@appstate.edu
Why Biofuels?

- Few alternatives to petroleum
- Transportation accounts for over 1/4 of total emissions in US
- Vehicle miles traveled per capita remains constant and CAFÉ standards slowly rise
- National Security
- Develop bio-products economy
- Utilize wastes and side streams
- Carbon sink with forestry and non-food crops
**Biofuels at their best...**

<table>
<thead>
<tr>
<th>Economic Impacts:</th>
<th>Fuel Diversity, investment in manufacturing, job creation, Agricultural development, reduce dependency on petroleum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Impacts:</td>
<td>Green house gas reductions, reduce air pollution, biodegradability, higher combustion efficiency, carbon sequestration</td>
</tr>
<tr>
<td>Energy Security:</td>
<td>Domestic production, supply and ready reliability, domestic distribution, Reduce use of fossil fuels, renewability</td>
</tr>
</tbody>
</table>
Economics of Dependence - US

- GASOLINE CONSUMPTION: 350 MILLION GAL/DAY
- DIESEL CONSUMPTION: 125 MILLION GAL/DAY

- TOTAL: 575 M GAL/DAY – 230 M GAL/DAY (US PRODUCTION) = 345 M GAL/DAY

- EQUALS ~ $1.2 BILLION ECONOMIC LOSS/DAY
North Carolina

Amount of Petroleum Resources:

ZERO

• NC currently consumes approximately 4.2 billion gallons of gasoline and 1.2 billion gallons of petroleum diesel each year. WNC consumes 868MGPY combined.

• Our transportation fuel use represents over $10 billion leaving the state economy annually, >$3B in WNC.
Biodiesel

• Biodiesel made from used cooking oil reduces overall GHG Emissions on a life cycle basis by 80% compared to petroleum diesel.

• Biodiesel made from used cooking oil is a renewable fuel that has a Net Energy Ratio of 6 units returned for each unit invested.

• Biodiesel adds lubricity to increase engine equipment life at even low blend levels such as B2

• Particulates, total hydrocarbons, and carbon monoxide from biodiesel combustion have resulted in a reduction of 48%, 77%, and 48% respectively compared to conventional diesel

• Use of biofuels can help keep air quality high in sensitive areas such as historical nonattainment areas including high mountains, Unifor and Charlotte metro areas.
Biodiesel Feedstocks

Feedstock accounts for nearly 80% of the overall production cost!

• **Traditional**
  - Yellow Grease ($0.29/lb)
  - White Grease ($0.33/lb)
  - Tallow ($0.40/lb)
  - Soybean Oil ($0.33/lb)
  - Palm
  - Other Vegetable Oils (Canola, sunflower)

• **Next Generation**
  - Brown Grease
  - Trap Grease
  - Algae, yeast, bacteria
  - Woody, Cellulosic, Energy grasses
  - MSW

Material flow for biodiesel production process.
WNC Oilseed Feedstock Crops & Rotation:
1 Acre in a 3 year period = 210 gallons oil, 2 tons protein meal, and stover

3 Year Crop Rotation:
1) Soybeans, Rye/Vetch cover
2) Sunflower, Winter Wheat*
3) Corn, Canola*

*harvested in the following year
### Vegetable Oil and Meal Yields by Rotation

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Average Vegetable Oil</th>
<th>Average Oilseed Meal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>liters/hectare/year (gallons/acre/year)</td>
<td>kg/hectare/year (Lbs/acre/year)</td>
</tr>
<tr>
<td><strong>1) Corn-Wheat-Soybeans-Fallow</strong></td>
<td>178 (19)</td>
<td>1067 (950)</td>
</tr>
<tr>
<td><strong>2) Soy-Wheat</strong></td>
<td>355 (38)</td>
<td>2133 (1900)</td>
</tr>
<tr>
<td><strong>3) Corn-Canola-Soy-Fallow</strong></td>
<td>617 (66)</td>
<td>1976 (1760)</td>
</tr>
<tr>
<td><strong>4) Soybeans-Winter Cover Crop-Sunflower-Wheat-Corn-Canola (3-Year Rotation)</strong></td>
<td>580 (62)</td>
<td>1671 (1488)</td>
</tr>
</tbody>
</table>
Net Farming Profit vs. Crop Rotation.

Net Farming Profit per Hectare-Year

<table>
<thead>
<tr>
<th>Profit per Ha/yr</th>
<th>1) Corn-wheat-soy-fallow</th>
<th>2) Soy-wheat</th>
<th>3) Corn-canola-soy-fallow</th>
<th>4) 3-Year Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit per Ha-Year</td>
<td>$99.78</td>
<td>$142.29</td>
<td>$151.05</td>
<td>$95.31</td>
</tr>
</tbody>
</table>
Net Farming Profit vs. Crop Yield.

Net Farming Profit/Ha vs. Yield by Crop

Canola
Soy
Sunflower
Wheat
Corn

Net Farming Profit per Hectare

Yield Factor

$225.00
$200.00
$175.00
$150.00
$125.00
$100.00
$75.00
$50.00
$25.00
$0

0.4 0.6 0.8 1 1.2

Yield Factor

$-50.00
$25.00

$-25.00

$-50.00

0.4 0.6 0.8 1 1.2

Yield Factor

Canola
Soy
Sunflower
Wheat
Corn
Small-scale Oilseed Crush and Biodiesel Facilities, Catawba EcoComplex
# Economic Analysis

**Crush Facility Oil Costs by Oilseed**

<table>
<thead>
<tr>
<th>Oilseed</th>
<th>Canola</th>
<th>Sunflower</th>
<th>Soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Area Ha (Ac)</td>
<td>455 (1124)</td>
<td>559 (1382)</td>
<td>298 (736)</td>
</tr>
<tr>
<td>Oil Production liters/year (gal/yr)</td>
<td>395,660 (104,533)</td>
<td>282,615 (74,667)</td>
<td>111,279 (29,400)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Costs</th>
<th>Canola</th>
<th>Sunflower</th>
<th>Soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per liter oil ($/gallon)</td>
<td>$ 1.79 (6.79)</td>
<td>$ 1.95 (7.41)</td>
<td>$ 4.38 (16.59)</td>
</tr>
<tr>
<td>Feedstock (oilseeds)</td>
<td>$ 1.79 (6.79)</td>
<td>$ 1.95 (7.41)</td>
<td>$ 4.38 (16.59)</td>
</tr>
<tr>
<td>Variable</td>
<td>$ 0.05 (0.20)</td>
<td>$ 0.09 (0.37)</td>
<td>$ 0.22 (0.85)</td>
</tr>
<tr>
<td>Fixed</td>
<td>$ 0.21 (0.80)</td>
<td>$ 0.29 (1.11)</td>
<td>$ 0.75 (2.83)</td>
</tr>
<tr>
<td>Total</td>
<td>$ 2.05 (7.78)</td>
<td>$ 2.35 (8.89)</td>
<td>$ 5.36 (20.27)</td>
</tr>
<tr>
<td>Revenue (meal)</td>
<td>$ 0.75 (2.84)</td>
<td>$ 0.86 (3.28)</td>
<td>$ 4.04 (15.29)</td>
</tr>
<tr>
<td>Total Cost</td>
<td>$ 1.31 (4.94)</td>
<td>$ 1.48 (5.61)</td>
<td>$ 1.31 (4.97)</td>
</tr>
<tr>
<td>Oil Cost per kg ($/lb)</td>
<td>$ 1.43 (0.65)</td>
<td>$ 1.63 (0.74)</td>
<td>$ 1.45 (0.66)</td>
</tr>
</tbody>
</table>
Sensitivity of Oil Cost to Crush Capacity.

Oil Cost vs. Crush Capacity

- Canola
- Sunflower
- Soybeans

Capacity (tons/day)

Oil Cost ($/kg)
Sensitivity of Oil Cost to Crush Capacity.

**Oil Cost vs. Crush Capacity**

- **Canola**
- **Sunflower**
- **Soybeans**

RBD Soy: $.99/kg
Sensitivity of Oil Cost to Crush Capacity.

**Oil Cost vs. Crush Capacity**

- Canola
- Sunflower
- Soybeans

**Oil Cost ($/kg)**

- RBD Soy: $.99/kg
- Yellow Grease: $.75/kg

**Capacity (tons/day)**

2 3 4 5 6 7 8 9 10 11 12
## Conversion costs by commodity feedstock, with Subsidies

<table>
<thead>
<tr>
<th>Commodity Feedstock</th>
<th>Yellow Grease/UCO</th>
<th>White Grease</th>
<th>Soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Oil Cost per kg[^PFL, 2013^] ($/lb)</strong></td>
<td>$0.75 (0.34)</td>
<td>$0.86 (0.39)</td>
<td>$0.99 (0.45)</td>
</tr>
<tr>
<td><strong>Conversion Yield</strong></td>
<td>80%</td>
<td>85%</td>
<td>90%</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td><strong>Cost per liter of biodiesel ($/gal)</strong></td>
<td>Feedstock</td>
<td>Variable</td>
</tr>
<tr>
<td>Feedstock</td>
<td>$0.83 (3.16)</td>
<td>$0.91 (3.44)</td>
<td>$0.96 (3.63)</td>
</tr>
<tr>
<td>Variable</td>
<td>$0.28 (1.06)</td>
<td>$0.27 (1.01)</td>
<td>$0.26 (0.97)</td>
</tr>
<tr>
<td>Fixed</td>
<td>$0.34 (1.29)</td>
<td>$0.34 (1.29)</td>
<td>$0.34 (1.29)</td>
</tr>
<tr>
<td>Total</td>
<td>$1.46 (5.51)</td>
<td>$1.52 (5.74)</td>
<td>$1.56 (5.77)</td>
</tr>
<tr>
<td>Revenue (Glycerin)</td>
<td>$0.02 (0.08)</td>
<td>$0.02 (0.10)</td>
<td>$0.03 (0.12)</td>
</tr>
<tr>
<td><strong>Total Conversion Cost</strong></td>
<td>$1.43 (5.43)</td>
<td>$1.49 (5.64)</td>
<td>$1.52 (5.77)</td>
</tr>
</tbody>
</table>

[^PFL, 2013^]: PFL, 2013

<table>
<thead>
<tr>
<th>Subsidies</th>
<th>$</th>
<th>($/gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RIN</td>
<td>$0.31 (1.20)</td>
<td>$0.31 (1.20)</td>
</tr>
<tr>
<td>Fuel Tax Credit</td>
<td>$0.26 (1.00)</td>
<td>$0.26 (1.00)</td>
</tr>
<tr>
<td>Net Conversion Cost</td>
<td>$0.85 (3.23)</td>
<td>$0.91 (3.44)</td>
</tr>
<tr>
<td>Diesel Bulk Cost</td>
<td>$0.86 (3.25)</td>
<td>$0.86 (3.25)</td>
</tr>
<tr>
<td>Net Profit</td>
<td>$0.005 (0.02)</td>
<td>$-0.05 (-0.19)</td>
</tr>
</tbody>
</table>
Sensitivity of Biodiesel Conversion Costs to Production Metrics.

Conversion Cost vs. Production Metrics for Yellow Grease Feedstock

- Total Conversion Cost /liter vs. Percent Change in Baseline of Production Metrics

Key metrics:
- Yield
- Feedstock Cost (Yellow Grease)
- Labor Cost
- Methanol Cost

Conversion Cost Summary:
- $1.35 to $1.55

Production Metrics Overview:
- -10.0% to 10.0%

Graph Analysis:
- The graph illustrates the relationship between conversion cost and production metrics, highlighting the sensitivity of biodiesel conversion costs to changes in yield, feedstock cost, labor cost, and methanol cost.

Legend:
- Purple line: Yield
- Blue line: Feedstock Cost (Yellow Grease)
- Red line: Labor Cost
- Green line: Methanol Cost
Total Conversion Cost vs. Production Volume

- Yellow Grease
- Choice White Grease
- RBD Soy

Total Conversion Cost/gal vs. Production Volume (Thousands of Gallons per Year)
3 Opportunities related to Inputs & Outputs of Biodiesel Production

Value-Adding:
1) Food-Grade Vegetable Oil

Bioproducts Development:
2) Nutraceuticals: *HPMC for Bio-based gel capsule*
3) Glycerin Soap
1) Food Grade Vegetable Oil
Food Grade Oil

**Technology:** Vegetable Oil Refining

**Status:** Pilot-Project

**Businesses:** Blue Ridge Biofuels, Agstrong, Virgin Oils

**Partner Organizations:** AdvantageWest, Appstate, Catawba County, Biltmore Estate, Blue Ridge Food Ventures

**Raw Materials:** Oilseed crops (canola, soybean, sunflower)

**Supply Chain:** Regional Farmers, Crush and Oil Refining Facilities.
2) Nutraceutical co-products application: *Biobased Gel Capsules*

**Technology:** Biomass fractionation, HPMC development (hydroxypropyl methylcellulose,)

**Status:** R&D

**Organizations:** Bent Creek Institute, Virginia Tech,

**Raw Materials:** glycerol, oilseeds, oilseed meal, brewer spent grains, clean sawdust

**Supply Chain Business:** Biodiesel producers, farmers, crush facilities, breweries, sawmills
3) Glycerin Soap

**Technology:** Saponification of Fats/Oils

**Primary Business:** War Horse Solutions

**Status:** Start-up

**Raw materials:** biodiesel derived glycerin, free fatty acids, essential oils, potassium hydroxide

**Supply Chain Business:** Biodiesel producers, Certified Manufacturing Facility, Packing/Distribution
Biofuels Summary

• Use waste first then dedicated biomass energy crops for biofuel feedstock
• Improve technologies to diversify feedstocks, process low-quality low-cost materials, and produce higher value co-product streams.
• Spin-off businesses are emerging
• Need for Increased Ag Production
  – Oilseed crops (canola, soybean, sunflower) non-gmo, organic
  – Niche oilseed crops
Thank you!

Questions?

Jeremy Ferrell: ferrelljc@appstate.edu