Distributed Ammonia Production from Biomass

Minnesota Renewable Energy Roundtable
July 24, 2012
West Central Renewable Ammonia Development LLC

• Public/private collaboration to develop biomass to anhydrous ammonia project in west central Minnesota

• Project milestones and objectives:
  – Develop biomass supply of 100,000 tons per year
  – Engineer unified conversion process using commercially available technologies
  – Estimate capital & operating costs of proposed plant
  – Prepare financing plan for construction & operations
Project History

• 2009 - Ag sub-committee of the Kandiyohi County/Willmar Economic Development Commission identified ammonia opportunity

• 2010 preliminary feasibility study conducted
  – Wind to ammonia not economic
  – Biomass to ammonia has potential

• 2011 Next Gen grant opened and WCRAD was formed to pool public/private resources

• 2012 WCRAD awarded grant
Acknowledgements

• The effort for local ammonia production has benefited from the efforts of a number of people among them:
  – West Central Research & Outreach Center
    • Mike Reese
  – S.L. Simon Engineering PA
    • Stan Simon
  – Swift County EDC
    • Jennifer Gruis
  – Kandiyohi County/Willmar EDC
    • Steve Renquist and Cathy Keuseman
Strategic Issue

• Achieving Minnesota’s goal of 25 x 25 depends heavily on crop and crop residue for biomass supply.

• Crop productivity depends on a reliable source of nitrogen fertilizer

• Dependency transfers from foreign oil to foreign ammonia
Economic Significance

• All nitrogen fertilizers used in Minnesota are produced out of state and most are out of country.

• Fertilizer producers have changed their pricing strategy to “value added” basis as opposed to “cost to produce” based

• The result is a significant burden on MN agriculture – about $500 million for corn alone
The Price of Ammonia is Tied to Corn
Farmgate Prices at Record Highs

Source: USDA, Farm Futures
## Sources & Uses of Funds

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debt Financing</td>
<td>$29,000,000</td>
</tr>
<tr>
<td>Seed Equity</td>
<td>1,500,000</td>
</tr>
<tr>
<td>Member Equity</td>
<td>27,500,000</td>
</tr>
<tr>
<td><strong>Total Sources of Funds</strong></td>
<td><strong>$58,000,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Use</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings &amp; Equipment</td>
<td>$52,000,000</td>
</tr>
<tr>
<td>Soft Costs</td>
<td>2,800,000</td>
</tr>
<tr>
<td>Pre-Production Expenses</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Working Capital</td>
<td>2,200,000</td>
</tr>
<tr>
<td><strong>Total Uses of Funds</strong></td>
<td><strong>$58,000,000</strong></td>
</tr>
</tbody>
</table>
## Breakeven Prices

### Net Income Analysis

<table>
<thead>
<tr>
<th>Biomass $/Ton</th>
<th>NH₃ $/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ 0.00</td>
<td>$252.45</td>
</tr>
<tr>
<td>$ 25.00</td>
<td>$299.20</td>
</tr>
<tr>
<td>$ 50.00</td>
<td>$352.95</td>
</tr>
<tr>
<td>$ 75.00</td>
<td>$406.70</td>
</tr>
<tr>
<td>$100.00</td>
<td>$460.45</td>
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</tbody>
</table>

### EBITDA Analysis

<table>
<thead>
<tr>
<th>Biomass $/Ton</th>
<th>NH₃ $/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>$ 0.00</td>
<td>$109.82</td>
</tr>
<tr>
<td>$ 25.00</td>
<td>$163.57</td>
</tr>
<tr>
<td>$ 50.00</td>
<td>$217.32</td>
</tr>
<tr>
<td>$ 75.00</td>
<td>$271.07</td>
</tr>
<tr>
<td>$100.00</td>
<td>$324.82</td>
</tr>
</tbody>
</table>
Project Questions

• Establish biomass supply chain
  – Is pelleting a cost savings?
  – What role for natural gas?

• Process design
  – Is the gasification technology ready?
  – Can we produce 99.999% hydrogen?
  – What ammonia reactor design will we use?

• What form of nitrogen fertilizer will we produce?
## Biomass Supply

<table>
<thead>
<tr>
<th>Biomass Source</th>
<th>Annual Acres</th>
<th>Available biomass tons per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRP lands – 1/3 per year</td>
<td>1/3 of 185,299</td>
<td>123,486</td>
</tr>
<tr>
<td>Spoiled hay – 3% of acres</td>
<td>3% of 139,500</td>
<td>15,000</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>73,100</td>
<td>73,100</td>
</tr>
<tr>
<td>Corn for Grain</td>
<td>1,086,300</td>
<td>2,172,600</td>
</tr>
<tr>
<td>Corn to Sugar Beets</td>
<td>94,800</td>
<td>189,600</td>
</tr>
<tr>
<td>Sweet Corn Stover</td>
<td>100,000</td>
<td>200,000</td>
</tr>
<tr>
<td>7 County totals</td>
<td></td>
<td>2,773,786</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We need</td>
<td></td>
<td>95,000 tons per year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3% of the available</td>
</tr>
</tbody>
</table>
Biomass Supply Second Phase

• Sort the biomass supply by harvest window
  • Maximize utilization of the harvest equipment
  • Widen the harvest window to protect against weather
  • Corn stover is not expected to be the largest contributor

• Identify specific farmers and land for contracting
  • Moving from aggregate to specific for biomass sources
Local Feedstock Options

Wood Chips or Pellets

Sources of Woody Biomass:
- Logging residue
- “Primary” mill residue
- “Secondary” mill residue
- Dedicated energy crops
- Land clearing projects
- Brush from brush lands
- Pre-commercial thinning

The project’s prime back-up & 6-month reserve supply

Assumption: 30,000 tons or 4% of available tons

Minnesota’s Forest Biomass Value Chain Page 24...

...“There are 800,000 green tons available the next four years”....

Source: BioBusiness Alliance of Minnesota
Natural Gas

• Natural gas prices are low - $4 per million Btu or less

• Up to 1/3 of biomass can be replaced with natural gas with no process change.

• What role should natural gas play in the process design?
  – As start up fuel?
  – As operating fuel?
  – As feedstock?
Biomass to Ammonia Process

Biomass Source

- Pyrolysis Steam Reforming Gasifier
- Combustion Gases

Gas Conditioning

- Syn Gas Burner

Water Gas Shift

- Steam

Carbon Dioxide

PSA Hydrogen Recovery

- Nitrogen

Ammonia Rx

Ammonia

West Central Renewable Ammonia Development LLC
Process Issues

• Gasification
  – Feedstock flexibility
  – Yield
  – Syn gas quality

• Hydrogen production
  – Water gas shift performance
  – Hydrogen separation

• Ammonia Reactor
  – Conventional Haber Bosch
  – Urea reactor
Nitrogen Forms

• Nitrogen fertilizer can be applied in several forms
  – Anhydrous ammonia
  – Urea
  – Aqueous Ammonia
  – UAN solution

• It is dangerous to assume you can change customer preference but the cost effects are substantial
In Summary

• There is strong incentive for Minnesota to become its own nitrogen fertilizer supplier.

• The current pricing strategy is creating a price umbrella which invites competition.

• At issue:
  – Is the technology available to execute the process?
  – Will the business withstand predatory response?