Issues and Options for the Forest Biorefinery

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Biomass Composition

Lignin: 15-25%
- Complex aromatic structure
- Very high energy content
- Resists biochemical conversion

Hemicelluloses: 23-32%
- Xylose is the 2nd most abundant sugar in biosphere
- Polymer of 5- and 6-carbon sugars, marginal biochemical feed

Cellulose: 38-50%
- Most abundant form of carbon in biosphere
- Polymer of glucose, good biochemical feedstock

Biomass is 40-45% Oxygen, or 20-30% lignin!
LCA and process models are needed to make sound economic and policy decisions.

![Graph showing energy production (mil/ac*yr) for FAME, EtOH, FTD, and DME]
Cost of Feedstocks? (what is the real question?)

Effective Cost of Biomass

Dollars per Ton

Ag Residues

Current Woody Biomass

Future Woody Biomass

1 10

Months

achieve NC STATE
Innovation in Action
Effect of Fresh Corn Composition on EtOH Selling Price (NREL)

Histogram of MESPs for 735 Stover Compositions

Min. EtOH Selling Price ($/gal)

Number of Occurrences

Mean = $1.14
Stdev = $0.06
Range = $0.30
Variation of Woody Biomass Composition

![Graph showing the variation of components in woody biomass. The x-axis represents the percent of the component, ranging from 20 to 80%. The y-axis represents frequency, ranging from 0 to 25.0%. The graph includes two bars for each percent value, one for total sugars and one for lignin. The bars show the distribution of the components across the percentage range.](image-url)
Stand Alone Woody Biomass to Ethanol
Variation of Woody Biomass

<table>
<thead>
<tr>
<th>Park Market</th>
<th>Option 1</th>
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<tbody>
<tr>
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Revenue Schedule:
- $15,000 per year
- 10% growth rate per year
- 5% salvage value at end of 10 years

Cash Flow:
- Initial investment: $15,000
- Annual revenue: $15,000
- Salvage value: $1,500

After Taxes:
- $13,500 per year
- 15% tax rate

Free Cash Flow:
- $12,000 per year
- 10% discount rate

Discount Rate: 10.5%
Woody Biomass Processing

Fuel Production Connected to Current Plants
  • Value Prior to Pulping
  • Value Prior to Combustion
  • co-production of ethanol

Standalone Fuel Production
  • ethanol from wood in a pulp mill
  • ethanol from wood with pulp technology
  • wood gasification, w/ and w/o “heat sink”

Stand alone power production
  • torrefaction, (pellets), combustion
  • cofiring
Ethanol Production as Function of Carbohydrate Content
(~ 15 Million Gallons per Year difference in production volume)

![Graph showing the relationship between Gallons of Ethanol per Year and % Glucan / % Total Carbohydrate.]

- R² = 0.8632
- R² = 0.9976

- Gallons of Ethanol per Year, Millions
- % Glucan / % Total Carbohydrate
- Glucan
- Total Carb
NPV as Function of Carbohydrate Content
(~$93 Million difference in NPV over range of sugar content)