Wood to Wing
Envisioning an Aviation Biofuels Industry from Forest Residuals

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NW Wood-Based Biofuels + Coproducts
April 28, 2014 in Seattle, WA

Catchlight Energy
CLH
Cosmo Specialty Fiber
Facing the Future
Gevo, Inc
Montana State University
Oregon State University
Pennsylvania State Univ
Salish Kootenai College
Steadfast Management
TSInc
University of Idaho
University of Minnesota
University of Montana
University of Washington
University of Wisconsin
USFS – Forest Products Lab
USFS – PNW Research Sta.
Utah State University
Washington State University
Western Washington Univ
Weyerhaeuser

Feedstock  Conversion  Sustainability  Stakeholders  Education
Sustainable BioJet
Valuable Lignin Co-Products
Rural Economic Development
Supply Chain Coalitions
Energy Literacy

NATIONAL MODEL
Regional Commercial Aviation Fuel Consumption

Regional Commercial Aviation Fuel Consumption - 2010
Pacific Northwest - 743 million gallons

WASHINGTON
525 million gal

MONTANA
29 million gal

IDAHO
33 million gal

OREGON
156 million gal
Western Montana Corridor (WMC)

Western Montana Corridor 2012 - 2013
Stakeholder survey shows broad support for the emerging industry
Mid Cascade to Pacific (MC2P)

Mid Cascades to Pacific Region (MC2P)
2013 - 2014
Findings and locations are being developed and should be available by late spring 2014

Western Montana Corridor
2012 - 2013
Stakeholder survey shows broad support for the emerging industry
Overall Impact in WMC

$110 million Economic impact*
736 new jobs created
60% Reduction in global warming potential

*Economic impact and jobs directly and indirectly generated from annual forest residue feedstock purchases by a hypothetical biojet fuel refinery in the WMC.

Western Montana Corridor 2012 - 2013
Stakeholder survey shows broad support for the emerging industry

Recommended Conversion Site
Recommended Depot Site
Major Fuel Consumption Site

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Our INDUSTRIAL CROP – Forest Residues
Our Target Feedstock

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Price ($/BDT)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hog Fuel</td>
<td>30,000</td>
<td>50%</td>
</tr>
<tr>
<td>Forest Residuals</td>
<td>60,000</td>
<td>15%</td>
</tr>
<tr>
<td>Pulp Chips</td>
<td>111,000</td>
<td>1%</td>
</tr>
</tbody>
</table>
IMPROVE: Step-by-Step Efficiencies

IMPROVEMENTS THROUGHOUT THE SUPPLY CHAIN
TEA Approach
Based on NREL
TEA of Biochem Cellulosic Ethanol
NREL/TP-5100-47764

Significant Changes to Inputs
- Revised CapEx
- Revised OpEx
- Four Production Scenarios
- Multiple “initial” versions

Contributors
- Catchlight Energy
- Gevo
- TSI (Tom Spink, Inc)
- Weyerhaeuser

Download: http://goo.gl/6CYDB
TEA Approach

Based on NREL
TEA of Biochem Cellulosic Ethanol
NREL/TP-5100-47764

Base Case
- Feedstock Preparation (sorting, storage)
- Calcium Bisulfite Pretreatment
- On-Site Enzyme Production
- Standard IBA/IPK Production
- Multi-Fuel Boiler - Burn Lignin

Contributors
- WY Engineering Design Woodyard
- TSI - Pretreatment
- Gevo IBA/IPK

Download: http://goo.gl/6CYDB
Current Status

NARA A2J IPK = 2-3x Petroleum Jet Prices depending on RIN value

Case 3.4 - Assumptions
Integrated Biorefinery - 770M BDT/yr
Feedstock - ground slash piles - NARA FS-10
Greenfield CapEx Entire Facility
Commercial Feedstock Costs
Burn Lignin + Rejects
Today’s NG Prices
Major Contributions to Fuel Costs

- Operating Costs
- Return on Capital
- Fixed Costs
CapEx

$500MM - $1B

depending on capacity
**DEVELOPMENT SITES:** Suitability Criteria

**GRAYFIELDS**
- Existing industrial sites
- No assumed contamination
- Community blight

**GREENFIELDS**
- Non-industrial sites
- Wildlife habitats
- Agricultural land
- Resource land
- Ecological value

**BROWNFIELDs**
- Existing industrial sites
- Real or perceived contamination
- Community blight
- Human health hazard
- Owner liability
DEVELOPMENT SITES: Existing Assets

SITE
Location, Infrastructure
Environmental permitting

EQUIPMENT
Operating Companies
Infrastructure

COMMUNITY
Workforce housing
Cultural and public buildings
OpEx

~ 0.45 Total
+ iso-octane co-product
PROJECTED BIOMASS SUPPLY EXAMPLES

MULTIPLE TREATMENT (DELIVERY) POINTS

$ per BDT

0.00 1.00 2.00 3.00

Million BDT per year

$ per BDT

0.00 1.00 2.00 3.00

ILLUSTRATION – DRAFT – SUBJECT TO REVISION

SOFTWOOD BIOMASS DELIVERED TO EUGENE + GRANTS PASS AT VARIOUS PRICES

ALL LANDS
ONE Potential Co-Products Scenario

Potential Revenues

Fuel Cost Parity with Petroleum

Lignin Co-Product 1
Lignin Co-Product 2
RIN
Byproduct
BioJet

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2014 - Lessons Learned

1. Reduce Capital Costs –
   Existing Facilities
   Shuttered Mills

2. Diversify Markets –
   Value Chain with Non-Fuel

3. Build Value Chain –
   Economic
   Environmental
1. Refine Technical Pathway –
   Yield-Yield-Yield
   Reduce CapEx
   High Vol and High Value Co-Products

2. Optimize Logistical Pathway –
   Forest Operations and Transportation

3. Commercialization –
   Stakeholder Involvement
   Education Programs
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Dwight Anderson – CLE

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**Supply Chain**
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**Co-Products**
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