Envisioning Alternative Aviation Fuel Supply Chains for the Northwest

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Northwest Advanced Renewables Alliance
The NARA Team
The NARA Team

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

- USDA

Northwest Advanced Renewables Alliance
Sustainable BioJet
Valuable Lignin Co-Products
Rural Economic Development
Pilot Supply Chains
Energy Literacy

NATIONAL MODEL
Our Biomass Source
Isobutanol to Jet Fuel Demonstration

Demonstration unit at South Hampton Resources, Silsbee, TX is fully functional

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NARA: Feedstock to Fuels Pathway

Completed Year 4 of 5

Primary feedstock targets include forest residues from logging and thinning operations. We are also considering mill residues and discarded woody material from construction and demolition, in regions where these materials are under utilized.

FOREST RESIDUES PREPARATION

TRANSPORTATION

PRE-TREATMENT

ENZYMATIC HYDROLYSIS

FERMENTATION

BIOJET & CO-PRODUCTS

Wood chips are treated to make the sugar polymers (polysaccharides) accessible to degrading enzymes. These processes allow the lignin to be available for separation.

Specific enzymes are added to hydrolyze (cleave) the polysaccharides and generate simple sugars (monosaccharides).

Specialized yeast convert the monosaccharides into isobutanol.

Aviation fuels can be generated from the platform molecules derived from wood sugars. Lignin can be used to generate co-products such as epoxies, structural materials and bio-based plastics. As an alternative, lignin can be burned to produce renewable energy.

1000 kg BONE DRY WOODY BIOMASS + DIESEL + HEAT, WATER, & CHEMICALS = ~300 kg LIGNIN AND ~260 LITERS ISOBUTANOL OR ~190 LITERS BIOJET

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An Integrated Approach
Sustainability Assessment

Environmental
- Sustainable Feedstock
  - Weyerhaeuser, OSU, UW, WSU
- Life Cycle Assessment
  - UW

Economic
- Economic Analysis
  - TSI, Weyerhaeuser, UW

Social
- Social & Market Assessment
  - Penn State, WSU, UIdaho

Techno Econ Analysis (TEA)
Life Cycle Analysis (LCA)
Community Impact Analysis (CIA)
Development Sites: Sustainability Criteria

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

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

**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
Refinery to Wing View of NARA Region
View of our Asset Analysis
Focus on our Supply Chain Regions
Comments on Technology Influence
Demonstration Supply Chain

1K IPK (1,000 gallons of biojet)

FOCUS TOPICS TODAY
NARA Region Forest Cover
Aviation Supply Focus

Combined Seattle Market
(656.5 MGY)

Combined Spokane Market
(40.9 MGY)

Combined Portland Market
(316.3 MGY)
Refined Products Production & Distribution
Community Capitals Framework

- Natural Capital
- Physical Capital
- Financial Capital
- Policy Capital
- Civic Capital

Sustainable Development
Applied Community Capital Framework

Biomass Availability

Port Access

Social Capital

Creative Vitality Index

Poverty

Electricity Rates

Four State Region

The weights of each factor are represented by varying layer transparencies.

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Example Hot Spot Analysis
Facility Assets: Pulp, Paper, and Ethanol
Facility Comparisons to NARA IBR

Legend
- Sulfite Mill
- Kraft Mill
- Ethanol Plant
- Partial Module Match

CAAFI SOAP-Jet Webinar
October 9, 2015
Relation of CapEx to Valuation of Retrofit

**Retrofit Option**
Existing Pulp Mill

**Potential Benefits**
- Digester
- Woodyard
- Boiler
- Wastewater

**Considerations**
- Type (sulfite, ctmp, kraft)
- Metallurgy
- Energy Balance

**CapEx**
$500MM - $1B depending on capacity

Pretreatment
- Other
- Woodyard
- Boiler
- Waste H2O
- A2J
- IBA

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Relation of CapEx to Valuation of Retrofit

**CapEx**

$500MM - $1B depending on capacity

**Retrofit Option**

Ethanol Plant

**Potential Benefits**

- Hydrolysis
- Fermentation
- Tank Farms
- Distribution

**Considerations**

- Sugar Compatibility
- Sterility
- Energy Balance
NARA ASPEN Process Model

Source: TSI Chemicals & Biomass Products and Processes
... underpins our Sustainability Analyses

Facility Sizing and Siting
Biomass Sourcing Strategies

Techno Econ Analysis (TEA)
Life Cycle Analysis (LCA)
Community Impact Analysis (CIA)

Source: TSI Chemicals & Biomass Products and Processes
Final Form for Deployment

- Biomass Sourcing Model
- Biorefinery Siting Methodology
- ASPEN Process Model for IBR
- Life Cycle Assessment Model (LCA)
- Community Impact Assessment (CIA)
- Techno Economic Analysis (TEA)
- Environmental Assessment Systems

SUSTAINABILITY ANALYSIS STATUS
READY TO SHARPEN THE PENCIL
Regional Supply Chain Analyses

Pacific Northwest (PNW)
Supply Chain Analysis
This site provides supply chain data and analysis generated by NARA research for the region identified as the Pacific Northwest, which includes Montana, Idaho, Washington, and Oregon.

Mid-Cascades to Pacific (MC2P)
Supply Chain Analysis
This site provides supply chain data and analysis generated by NARA research for the region identified as Mid-Cascades to Pacific, which includes the western sections of Washington and Oregon.

Western Montana Corridor (WMC)
Supply Chain Analysis
This site provides supply chain data and analysis generated by NARA research for the region identified as the Western Montana Corridor, which includes the western section of Montana, Northern Idaho and northeast Washington.

Clearwater Basin
Supply Chain Analysis
This site provides supply chain data and analysis generated by NARA research for the region identified as the Clearwater Basin, located in central Idaho.
Demonstrating a Supply Chain

Feasibility of Integrated Technologies

Supply Chain to Deliver Technologies

Needs of Aviation Partners

Learn, Educate, Connect
1K-IPK – Feedstock Supply Chain

Feedstock Suppliers
- Weyerhaeuser Corp (OR)
- Confederated Salish and Kootenai Tribes (MT)
- Muckleshoot Tribe (WA)

Processing Partners
- Lane Forest Products (OR)
- Kevin Jump (MT)
- Bill Bass (WA)
Weyerhaeuser Corp
Lane Forest Products
1K-IPK – Conversion Supply Chain

Production Partnerships

Pretreatment
Andritz Corp
ZeaChem
Fermentation
ICM
Alcohol to Jet
South Hampton Refining
1K-IPK – Fuel Distribution and Demonstration
**Fuel Certification**
- Alter Jet - ASTM D7566 Blending
- ConvJet – ASTM D1655
- Distribution to Wing
- Commercial Demonstration Flight

**Processing Partners**
- Gevo Corp
- South Hampton Refining
- Blending Partner
- Alaska Airlines
Moving from Invention to Commercial Reality

- Forest Residue Collection and Preparation
- Envisioning Integrated Facilities and Siting
- SPORL / MBS Pretreatment
- Alcohol to Jet
- Demonstrating Feasibility with Supply Chain Implementation Partners
- Educating Citizens, Industry, Policy Makers

Advancing Supply Chain Development

THE ROLE OF NARA
THANK YOU

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