National Institute of Food and Agriculture

The Agriculture and Food Research Initiative Regional Bioenergy Feedstock Systems Coordinated Agricultural Projects (CAPs):

An integrated approach to understanding regional feedstock supply, quality and cost

Presented to the Biomass Research and Development Board Technical Advisory Committee
Washington, DC June 13, 2016
Sustainable Bioenergy and Biobased Product Portfolio Vision

Facilitate the development of sustainable regional production systems for biofuels, biopower, industrial chemicals, and biobased products through partnerships and collaboration, to create and preserve jobs, increase rural economic vitality, enhance food production systems, create ecosystems services, and reduce use of fossil carbon.
Agriculture and Food Research Initiative

- Sustainable Bioenergy Challenge
  - Coordinated Agricultural Projects (CAPs)
  - Bioenergy Education
  - Standard Research Grants
  - Feedstock Genomics (w/DOE Office of Science)
  - Loblolly Pine Genomics

- Foundational Program (2016)
  - Cover Crops for Bioenergy and Biobased Products
  - Socioeconomic and Policy Impacts
Regional Approaches to Bioenergy Systems

– Coordinated Agricultural Projects (CAP)

• Regional partnerships
  – Academic, government, non-government, industry
• Work back from targets to develop entire supply chains
• Build on existing infrastructure and previous investments
• Integrate Research, Education, and Extension/Tech Transfer
• Robust sustainability analysis: Impacts on …
  – Economics, rural communities, and the environment
• Targeted Feedstocks (perennial grasses, energy cane, sorghum, woody biomass, oil crops)
• 2010, 2012-13: 7 awards totaling ~$156 M over 5 years
AFRI - Coordinated Agricultural Projects

- **Transdisciplinary systems approach to reduce risk**
  - Focus on feedstock development, production, and delivery
  - Must partner with feedstock users & well-align with appropriate conversion technologies and industry for bioproduct production
  - Involve communities upfront for their guidance
AFRI Biofuel Feedstocks and Project Locations
Where are the Feedstocks?

They are here. Where’s the value proposition?

Understanding feedstock supply quantity, logistics, quality characteristics, and cost to stand up an integrated value chain
Northwest Advanced Renewables Alliance

A new vista for Green Fuels, Chemicals, & Environmentally Preferred Products

Michael Wolcott
Regents Professor
Project Co-Director

Ralph Cavalieri
Associate Vice-President for Alternative Energy
Project Director

Washington State University
NARA Team

Alaska Airlines
ANDRITZ
Biomass ad Infinitum LLC
Catchlight Energy
CLH
Cosmo Specialty Fibers Inc.
Facing the Future
Forest Business Network LLC
Gevan Marrs LLC
Gevo, Inc.
ICM

Montana State University
National Center for Genome Research
National Renewable Energy Laboratory
Oregon State University
Penn State University
Salish Kootenai College
South Hampton Resources Inc.
Steadfast Management Inc.
Thomas Spink Inc.
University of Idaho
University of Minnesota
University of Montana
University of Utah
University of Washington

University of Wisconsin-Extension
USDA Forest Products Laboratory
USDA Forest Service
Washington State University
Western Washington University
Greenwood Resources
Weyerhaeuser

NW Biofuels + Co-Products
May 3, 2016 in SeaTac, WA
NARA: Feedstock to Fuels

Completing 5 of 5 years
Keys to NARA

- **Innovation and Integration**
  - Robust project management
  - Feedstock Logistics
  - Pre-processing (mild bisulfite, milled wood)
  - Sustainability Analysis (TEA)
  - Novel conversion technologies
    - Isobutanol to AJF, lignosulfonates, activated carbon
  - Workforce development
  - Community and landowner engagement
Why it matters…

- Rural economic development
  - New jobs in rural communities
  - Protected jobs in the pulp industry through diversification
  - Alternative income for landowners
- Products from non-petroleum renewable feedstocks
- Ecosystem services
Biorefinery Approach
Isobutanol to Jet Fuel Demonstration

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

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Sustainability Assessment

Environmental

Sustainable Feedstock
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Weyerhaeuser, OSU, UW, WSU

Life Cycle Assessment
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UW

Economic

Economic Analysis
------------------
TSI, Weyerhaeuser, UW

Social

Social & Market Assessment
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Penn State, WSU, UIdaho
Making Alternative Jet Fuel is Complicated

TAKE HOME LESSONS FROM NARA
NARA ASPEN Process Model

Source: TSI Chemicals & Biomass Products and Processes
Making Alternative Jet Fuel is Complicated
And Its Even More Complicated to Make Money!

TAKE HOME LESSONS FROM NARA
Making Alternative Jet Fuel is Complicated
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TAKE HOME LESSONS FROM NARA
Economic Impact
Making Alternative Jet Fuel is Complicated
And Its Even More Complicated to Make Money!
But its Good for the Environment
And Good For Local Economies

Continue the Pathway to Commercial Reality

TAKE HOME LESSONS FROM NARA
Value Chain: Route to Cost Parity for Fuels

Potential Revenues

Fuel Cost Parity with Petroleum
Pathway to Commercial Reality

Current Process Design
• Current Status is FEL-1 to FEL-2
• Needs Optimization of Value Chain
• Refinement of Market and Equipment Costs

Consideration for Comparison to Petroleum
• Petroleum fuel production does not account for greenhouse gas production, only costs
• Petroleum fuel allowed to fully depreciate capital including drilling assets
• Petroleum fuels are lowest in value chain that includes petrochemicals
Making Alternative Jet Fuel is Complicated
And Its Even More Complicated to Make Money!
But its Good for the Environment
And Good For Local Economies
Continue on the Pathway to Commercial Reality

Continue to Focus on Supply Chains

TAKE HOME LESSONS FROM NARA
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.
1K-IPK – Fuel Distribution and Demonstration

**Fuel Certification**
- Alter Jet - ASTM D7566
- Conv Jet – 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
Path to Commercialization?

- Port of Seattle (Sea-Tac) signed MOU with NARA partners Boeing and Alaska Airlines to bring AJF to Sea-Tac in the next 5-10 years.
  - Commissioned infrastructure and engineering study
- Commercialization roadmap preliminary meeting 5/16 at Sea-Tac brought together NARA, potential industrial partners, Port of Seattle.
What’s next?

• Agriculture and Food Research Initiative
  – 2016 RFA is out:
    • Four new regional CAPs
    • Each project $15 M over five years
    • Biofuel, chemical intermediates, biobased products
  – Foundational Research Program
    • Cover Crops for Bioenergy and Biobased Products

• New interagency program with DOE BETO: Feedstock Logistics and Materials Handling

Bill Goldner, Ph.D. wgoldner@nifa.usda.gov
Sustainable Bioproduct Initiative (SUBI) led by Louisiana State University

- In 5<sup>th</sup> year of funding ($17.5 M total)
- Entire supply chain focus
- Integrated Research, Education, and Extension/Outreach
- Successfully developed cold-tolerant energy cane
- Energy cane and sweet sorghum feedstocks for a full range of higher-value co-products to make the entire system economical
- Commercial partners Virent (aviation fuel) and Optinol (butanol)
Keys to SUBI

• **Innovation and Integration**
  – Superior energy cane and sweet sorghum genetics
  – Cold tolerant energy cane to move cane production away from the coast
  – Low input production systems
  – Feedstock logistics
  – TEA and Sustainability Analysis
  – Diverse conversion options
    • Chemicals, bioplastics
    • Fuels (butanol, aviation fuel)
  – Workforce development
  – Community and landowner engagement
Why it matters…

• Rural economic development
  • Jobs in an area that sorely needs them
  • Potential for greater farm income than current cropping systems
• Products from non-petroleum renewable feedstocks and accompanying ecosystem services.
<table>
<thead>
<tr>
<th>Month</th>
<th>Sorghum</th>
<th>E-cane</th>
<th>Commercial sugar</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
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<td>Feb</td>
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<td>Mar</td>
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<td>Apr</td>
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<tr>
<td>Dec</td>
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</tbody>
</table>

Year round feedstock supply
Winnsboro Ho 02-113 1st stubble crop (Sept. 2014).

White PVC pole is 10’ long.

Courtesy of Chris Adams.
Sweet Sorghum

- Annual crop
- Contains a sugar containing juice, starch containing seed heads and fiber
- 90-120 day crop cycle, can be grown across target region
- Gross structure similar to sugarcane
- Can be widely grown across Southern US
- About 6,000 acres required to sustain processing plant for 3 months
## Crop Comparison

<table>
<thead>
<tr>
<th>Energycane</th>
<th>Sweet sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Harvest time (months)</strong></td>
<td><strong>Harvest time (months)</strong></td>
</tr>
<tr>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td><strong>Ag Inputs</strong></td>
<td><strong>Ag Inputs</strong></td>
</tr>
<tr>
<td>none</td>
<td>None*</td>
</tr>
<tr>
<td><strong>Planting</strong></td>
<td><strong>Planting</strong></td>
</tr>
<tr>
<td>perennia</td>
<td>annual</td>
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<tr>
<td><strong>Acres/1000t/day factory</strong></td>
<td><strong>Acres/1000t/day factory</strong></td>
</tr>
<tr>
<td>8,000</td>
<td>6,000</td>
</tr>
<tr>
<td><strong>Growth in non-traditional regions</strong></td>
<td><strong>Growth in non-traditional regions</strong></td>
</tr>
<tr>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Dry ton/acre</strong></td>
<td><strong>Dry ton/acre</strong></td>
</tr>
<tr>
<td>10-18</td>
<td>1-9</td>
</tr>
</tbody>
</table>

*fallow with clover
# Biofuel Feedstock Production Costs - Louisiana

<table>
<thead>
<tr>
<th>Feedstock Production Cost</th>
<th>Energy Cane ($/dry ton)</th>
<th>Sweet Sorghum ($/dry ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Production Costs</td>
<td>$70 - $74</td>
<td>$74 - $90</td>
</tr>
<tr>
<td>Land Rent(^1)</td>
<td>$14 - $15</td>
<td>$15 - $18</td>
</tr>
<tr>
<td>Transportation(^2)</td>
<td>$12 - $24</td>
<td>$13 - $27</td>
</tr>
</tbody>
</table>

\(^1\) Rent charged at 1/6 crop share.

\(^2\) Hauling cost example range = $3 to $6 per wet ton.

\(^3\) Costs per dry ton estimated using average dry matter content of 24.3% for energy cane and 22.4% for sweet sorghum.
SUBI Pilot Plant at Audubon Sugar Research Center
Process Outline

Sustainable Production
Feedstock development
Sustainability

Conversion to Fuel
Value to Consumer

Harvest
analyze
Deliver

Technology development

Intermediate Product

Process
Economic feasibility

Biomass

Feedstock development

Technology development
Place Based Opportunities for Sustainable Outcomes and High Hopes (POSOH)

• 5 Co-PIs
• 2 states (Michigan, Wisconsin)
• 3 Land Grant Universities, including 1994 (College of Menominee Nation)
• Funding exclusively for education activities
Place Based Opportunities for Sustainable Outcomes and High Hopes (POSOH)

• Goals
  – Strengthen the regional K-16 education system by encouraging teachers to incorporate both traditional (native) and scientific (Western culture) ways of understanding the natural world
  – Develop teaching approaches that facilitate student-led research
  – Increase the number and diversity of students from rural and Tribal communities to work creatively in teams, participate in internships in industry or university research programs, and ultimately enter science programs at universities
Northeast Bioenergy and BioProducts Educational Program

• 7 Co-PIs
• 5 states (DE, MD, OH, NY, WV)
• 5 Land Grant Universities, including 1890 (University of Maryland – Eastern Shore, West Virginia State, and Delaware State)
• 2 Research Centers (Ohio Bioproducts Innovation Center, Pace Law School)
• Funding exclusively for education activities
Northeast Bioenergy and BioProducts Educational Program

- Goals
  - Provide teachers a strong footing in multi-disciplinary content and research based training materials and activities linked to the Northeast’s projected bioenergy feedstock systems
  - Develop information for teachers about the range of technical, educational, socio-economic and scientific competencies required in the emerging bio-economy
  - Create summer research/industry internship positions and teacher training positions at the USDA NRCS and Rochester Institute of Technology