The Value Proposition of Sustainable AJF

CAAFI Biennial General Meeting (CBGM) 2018

Joel Murdock, Managing Director Strategic Projects

4 December 2018

FedEx Express 30x30 Initiative

"Its goal is 30 percent alternative fuel use for aviation by 2030. And we pledge our support for environmentally friendly alternative fuel projects…"

US Chamber of Commerce Aviation Summit – 30 April 2009

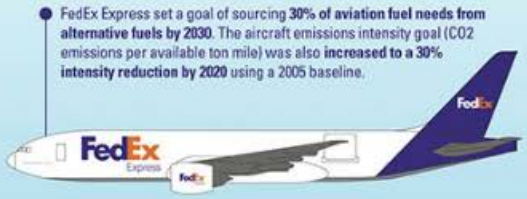
FedEx Global Citizenship Report

csr.fedex.com

FedEx Express

30 x 30

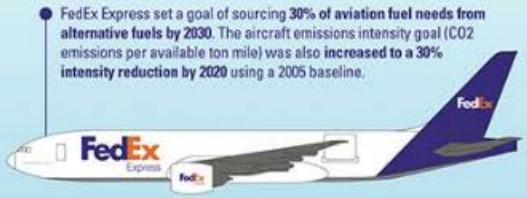
Alternative Jet Fuels
A SUSTAINABLE
FUTURE



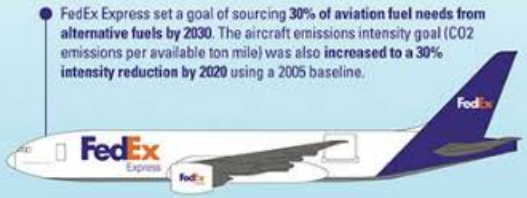
earthsmart
FedEx solutions for a more sustainable world

- Research and Development
- ASTM and Fuel Qualification/Approval
- Commercial Off-Take Contracts
  - Cost competitive with crude oil and jet pricing equivalents
  - 5-10 year contracts with exit mechanisms
  - 5% maximum per location until security of supply established
  - FOB Destination preferred, but will assist with logistics
  - Cannot be a derivative/hedge
  - Must address “Total Cost of Ownership”

FedEx Express



- Total Cost of Ownership includes all cost of getting the jet fuel delivered into the wing of the airplane
  - Index Price (cost of product)
  - Supplier Margin
  - Delivery/Transportation Fees
  - Blending Fees
  - ASTM Fuel Test Fees
  - Miscellaneous Fees
  - Also account for credits and/or benefits
    - Social Impact
    - Economic Impact
    - Environmental Impact



- Logistics include
  - Truck
  - Rail
  - Pipeline
  - Airport Consortium Considerations
  - On/Off Airport Blending
  - Use of Existing Tankage
  - Addition of New Tanks
  - Existing Fuel Supply Logistics

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The National Institute of Food and Agriculture's Role in Facilitating the Development of Regional Systems for the Sustainable Production of Biobased Fuels, Chemicals, and Products: An Introduction to Coordinated Agricultural Projects (CAPs)

Bill Goldner, Ph.D.
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National Institute of Food and Agriculture - USDA

CAAFI
December 4, 2018

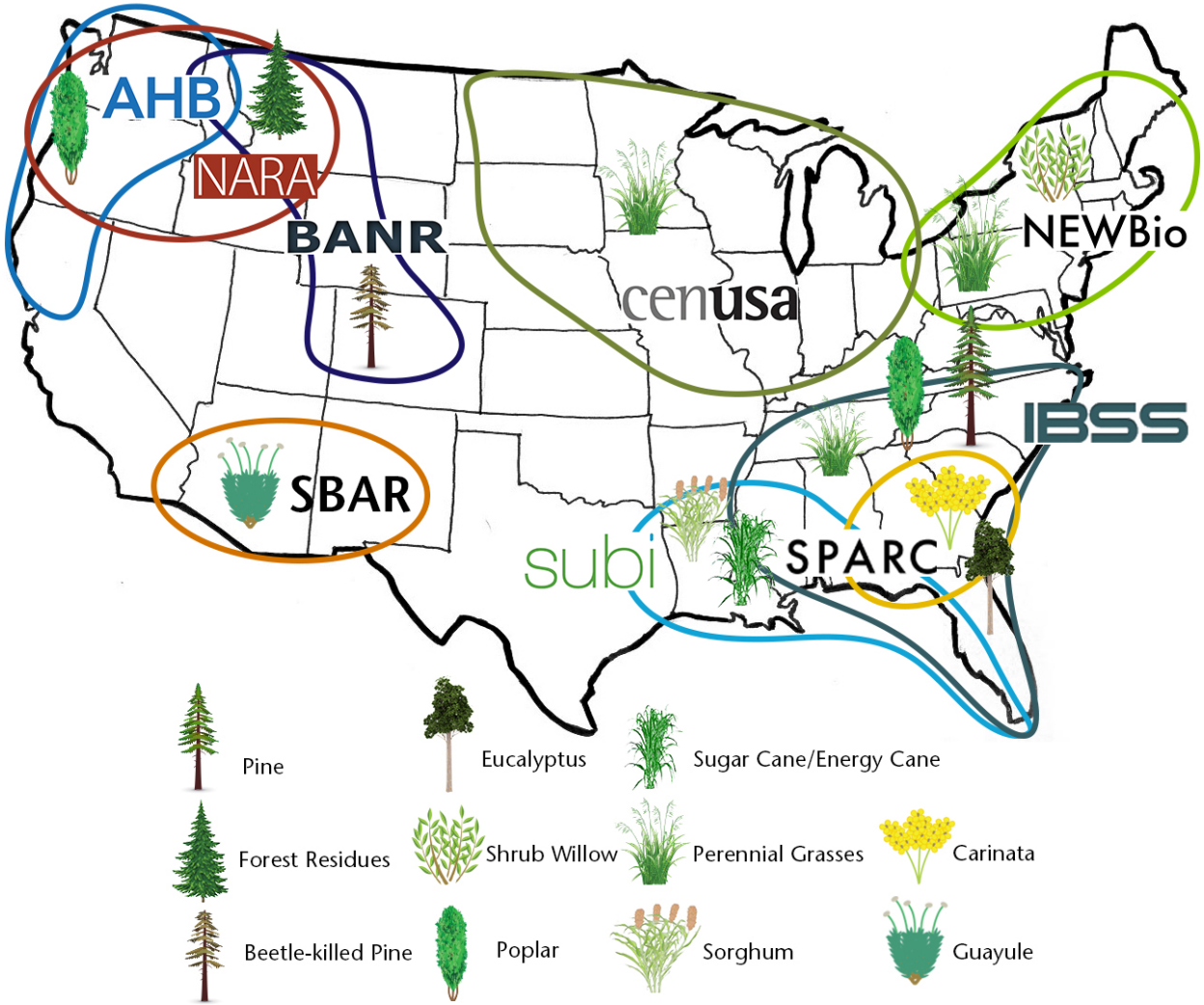
National Institute of Food and Agriculture

- The Bioenergy, Bioproduct Bioeconomy (B3) Portfolio historically provides unique approaches to building supply chains and value propositions through research, education, and Extension
- Supports Bioeconomy through competitive and capacity grant programs

- **AFRI**: Agriculture and Food Research Initiative
  - **Coordinated Agricultural Projects** (CAPs) FOCUS + SCALE = IMPACT
    - Integrate research, development, demonstration, education/workforce development, Extension/outreach/tech transfer to farmers and processors
    - Regional biomass supply chains linked to bioeconomic value propositions (biofuels, biobased chemicals and products)
  - **Foundational Program** grants address bioproducts (e.g. lignin, nano-cellulosics), policy, social and environmental impacts, crop development and evaluation
- **SBIR**: Small Business Innovation Research
- **USDA & DOE Joint Solicitations**
  - Plant Feedstock Genomics Program (with DOE-OS-BER)
  - Biorefinery Optimization (with DOE-BETO)
  - Biomass Research and Development Initiative (with DOE-BETO)

The Bioeconomy

- The Bioeconomy dates back thousands of years
- USDA has been working on the Bioeconomy since 1862
- Modern Bioeconomy = Bioenergy (Biopower, Biofuels), Biobased Industrial Chemicals, and Biobased Products
- CAP project focus: linking emerging biomass supply chains to commercial value propositions and valued ecosystem services
- Understanding and reducing risk across systems
- Public/private transdisciplinary partnerships to demonstrate regional potential and inform and stimulate commercial investment
- NIFA invested $186 M on nine projects



CAP Feedstocks and Project Regions

USDA NIFA AFRI CAPs

- Northwest Advanced Renewables Alliance
  - Washington State, Weyerhaeuser, Gevo, ICM, Andritz, Oregon St, Alaska Airlines, Boeing, Regional Tribes, FPL, and many others
  - Demonstrated system forest residuals, mill waste → jet fuel
  - 11/2016: World's first commercial cellulosic biofuels flight
  - MOU and infrastructure study Port of Seattle, Boeing, Alaska

USDA NIFA AFRI CAPs

- Biomass Alliance Network of the Rockies (BANR)
- Colorado State, Cool Planet, Confluence Energy, USFS, many others
- Insect damaged conifers
- Developed and tested
  - analysis and decision tools
  - economic, environmental, social
- Planning commercial demo

Two NEW AFRI CAPs Join the Community

SPARC led by University of Florida

- Partnering with Agrisoma and ARA, others
- Targeting alternative jet fuel and animal feed from the oilseed crop Brassica carinata (Carinata)

SBAR led by University of Arizona

- Partnering with Bridgestone America , New Mexico State, others. Targeting natural rubber, industrial chemicals, and alternative jet fuel from the dry land crops guayule (why-oo-ley) and guar.

Contact

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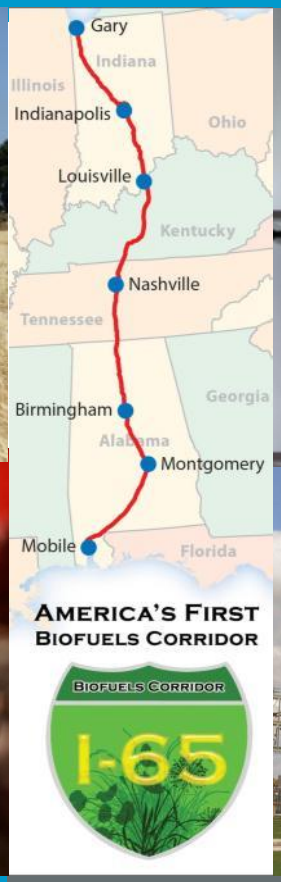
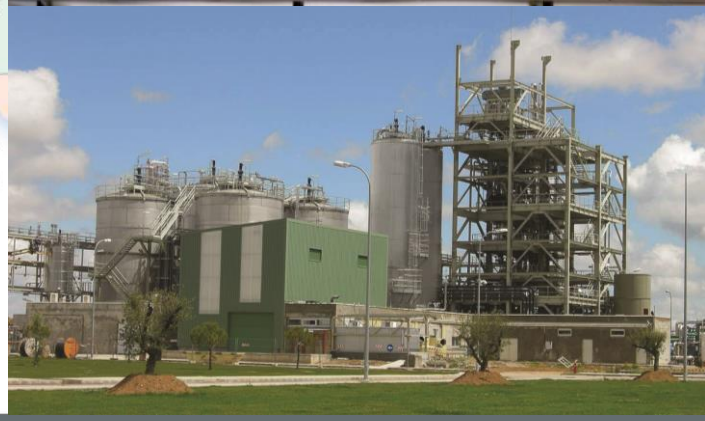




Bioenergy Technologies Office's Efforts on SAJF

December 4, 2018

Jonathan Male

Director

Bioenergy Technologies Office's Critical Program Areas

Production & Harvesting

Feedstock Supply & Logistics
Works to reduce the cost, improve the quality, and increase the volume of sustainable feedstocks available for delivery to a conversion process.

Advanced Algal Systems
Focuses on improving the productivity of algal biomass and enhancing the efficiency of cultivation and harvesting.

Conversion & Refining

Conversion
Develops technologies to convert non-food feedstocks into biofuels, bioproducts, and biopower.

Conducts feedstock blend testing, separations, materials compatibility evaluations, and techno-economic analyses to focus research on highest impacts.

Distribution & End Use

Advanced Development and Optimization
Aims to reduce technology uncertainty in bioenergy by integrating individual technologies into a system/process and provides vital knowledge fed back to research programs.

Crosscutting

Sustainability and Strategic Analysis
Supports program decision-making and develops science-based strategies to understand and enhance the economic and environmental benefits of advanced bioenergy.

BETO's Unique Position to Enable an Impact

- **Market:**
  - **SIZE:** The 26 B gallon jet fuel market is expected to double in size over the next two decades a market requiring nearly a billion tons of biomass.
  - **PULL:** Cost competitive Sustainable Alternative Jet Fuel (SAJF) and High-Performance Fuels (HPFs) are needed to decouple carbon growth from market growth.
- **Capabilities:**
  - Sugar, lignin, waste materials, waste gases each provide unique value
  - BETO's collaborators have the technical capabilities to convert these to SAJF and HPF fuels
  - Set priorities using TEA informed approach
- **Three Opportunities:**
  i. Diluting aromatics with iso-alkanes,
  ii. Examine replacing the aromatics with iso-alkanes and cycloalkanes, and
  iii. Control distributions of existing molecules that provides mission-based value to jet fuel consumers.
- **Bring down cost:**
  - Source carbon from sustainable inexpensive resources
  - Use process intensification
  - Solve another societal problem
- Must have the end use in mind as jet fuel properties differ from gasoline and diesel properties.

FY2018 Funding Opportunity Announcement

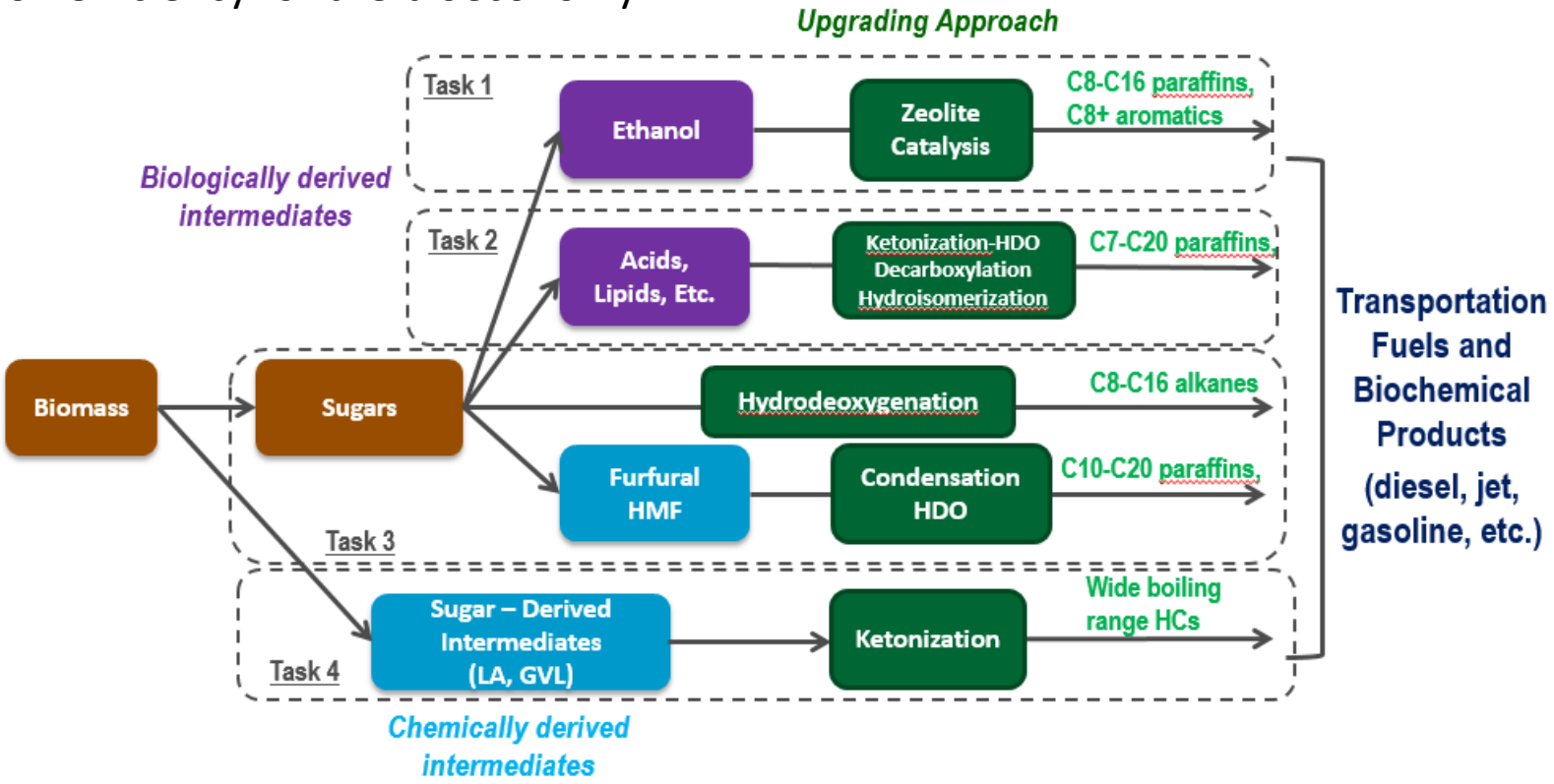
Process Development for Advanced Biofuels and Biopower (PDABB)

- Advance technologies to produce price-competitive drop-in renewable jet fuels
- Process R&D to develop integrated production processes
- High specific energy (> 4% relative to comparable jet fuels)
- Produce minimum 100 gallons
- Test combustion operability (Tier 1 & Tier 2)

Selections	Approach/Objective	DOE ($M)
Technology Holding LLC (UT)	Fermentation of cellulosic sugars to isoprene and catalytic upgrading to a high energy density jet fuel	$2.5
Washington State University (WA)	A hybrid process to upgrade bio-crude (from pyrolysis and hydrothermal liquefaction) to jet fuel	$2.8
Applied Research Associates (FL)	Hydrothermal cleanup of waste brown grease to make free fatty acids; then catalytically transform to hydrocarbons	$2.4
Gas Technology Institute (IL)	Reforming of CO/CO_2-rich biogas to syngas; fluidized bed Fischer-Tröpsch conversion to jet fuel	$3.0

ChemCat Bio Catalytic Upgrading of Biochemical Intermediates

Chemical Catalysis for Bioenergy Consortium (ChemCatBio) is leveraging unique DOE capabilities for accelerating development of catalysts and related technologies to enhance conversion efficiency for the bioeconomy



Task 5 – Project coordination; hydrolysate/fermentation broth supply; TEA

ChemCatBio

DPA Advanced Drop-in Biofuels Production Projects

Fulcrum Sierra Biofuels

- Under Phase 1, Fulcrum Sierra BioFuels successfully completed their scope of work and was able to raise all of the required private-sector financing to construct the Biorefinery in Phase 2
  - ✓ Completion of Front-end Engineering Design (FEED) package
  - ✓ Successful contract negotiations for long-term feedstock supply and fuel off-take agreements
  - ✓ Achievement of National Environmental Policy Act (NEPA) Compliance – Finding of No Significant Impact
  - ✓ Secured project site and permitting
  - ✓ Successful fundraising from bond and private equity markets for the total contractor cost share for Phase 2
- Fulcrum successfully constructed and commissioned their Municipal Solid Waste (MSW) Feedstock Processing Facility (FPF)
- During Phase 2, Fulcrum Will:
  - ➢ Complete detailed design of Biorefinery
  - ➢ Construct Biorefinery
  - ➢ Operate Biorefinery and demonstrate MILSPEC fuel production

Red Rock Biofuels

- Under Phase 1, Red Rock Biofuels successfully completed their scope of work and was able to raise all of the required private-sector financing to construct the Biorefinery in Phase 2
  - ✓ Completion of Front-end Engineering Design (FEED) package
  - ✓ Successful contract negotiations for long-term feedstock supply and fuel off-take agreements
  - ✓ Achievement of National Environmental Policy Act (NEPA) Compliance – Finding of No Significant Impact / Finding of No Practical Alternative
    - ✓ Project site contained cultural resources that necessitated extensive consultation with Tribes and other stakeholders
  - ✓ Secured project site and permitting
  - ✓ Successful fundraising from bond market for the total contractor cost share for Phase 2
- During Phase 2 Red Rock will:
  - ➢ Complete detailed design of Biorefinery
  - ➢ Construct Biorefinery
  - ➢ Operate Biorefinery and demonstrate MILSPEC fuel production