CAAFI 2014 General Meeting & Expo

Public-Private Partnership Efforts

Moderated by: Nate Brown,

FAA Environment & Energy

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CAAFI 2014 General Meeting & Expo

Bill Goldner,

USDA

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National Institute of Food and Agriculture
www.nifa.usda.gov

National Institute of Food and Agriculture – USDA

Catalyzing Partnerships in Renewable Aviation Fuel Production Systems

CAAFI Biennial General Meeting January 29, 2014

Bill Goldner, Ph.D.

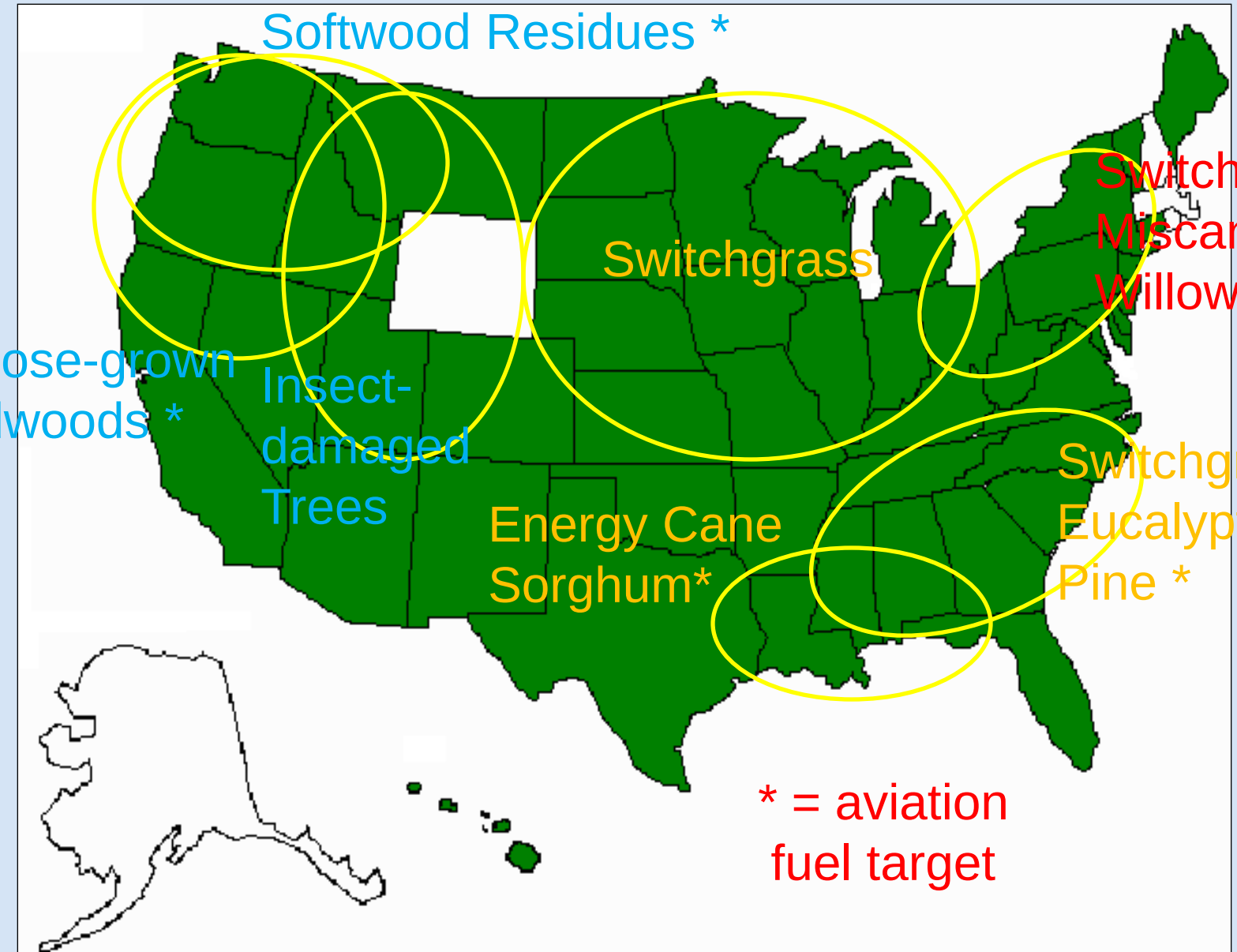
wgoldner@nifa.usda.gov

National Institute of Food and Agriculture Sustainable Bioenergy

- Facilitate system-based approaches for development of sustainable supply chains for the production of biofuels, biopower, and bioproducts.
- >$140 M NIFA current five year investment in renewable aviation fuel supply chains.
  - Agriculture and Food Research Initiative: $112 M (four projects)
  - Biomass Research and Development Initiative: $20 M (three projects)
  - Non-competitive: ~$6 M

Regional Approaches to Bioenergy Systems

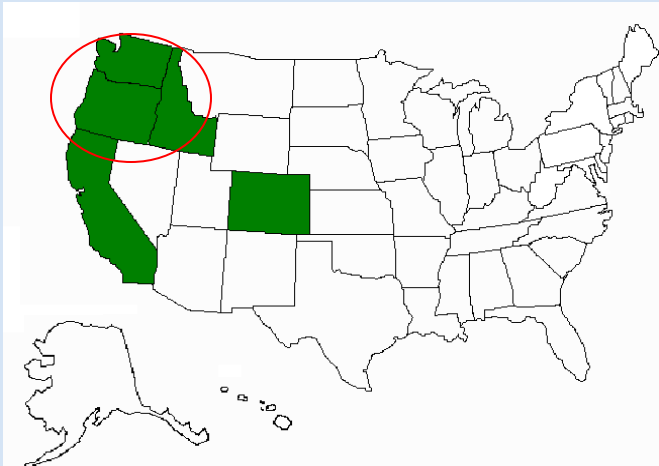
- Coordinated Agricultural Projects (CAP)
  - Regional partnerships
    - Academic, industry, government, non-government,
  - Work back from targets to develop entire supply chains
  - Build on existing infrastructure and previous investments
  - Integrate Research, Education, and Extension/Tech Transfer
  - Robust sustainability analysis: Impacts on …
    - Economics, rural communities, and the environment
  - Targeted Feedstocks (perennial grasses, energy cane, sorghum, woody biomass, oil crops)
  - 2010-2013: 7 AFRI awards totaling ~$156 M over 5 years


Softwood Residues *
Switchgrass
Switchgrass
Miscanthus
Willow
Purpose-grown
Hardwoods *
Insect-
damaged
Trees
Energy Cane
Sorghum*
Switchgrass
Eucalyptus
Pine *
* = aviation
fuel target

System for Advanced Biofuels Production from Woody Biomass In the Pacific Northwest

PD: R Gustafson, U Washington, $40,000,000 (5 years)

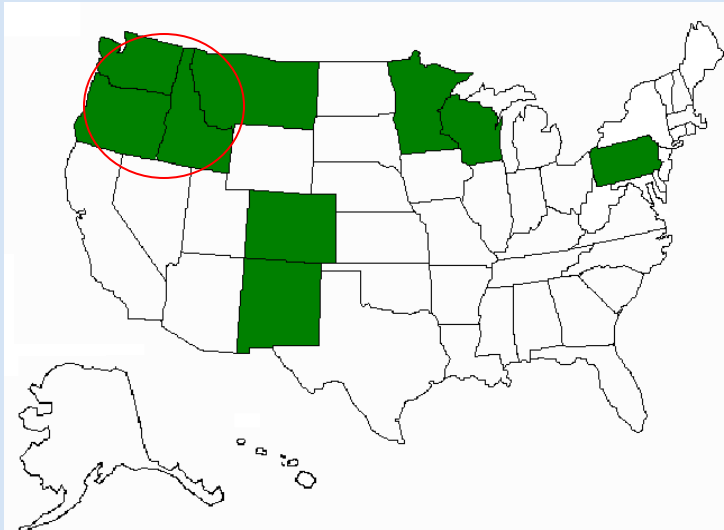
- 27 Key Personnel from 5 Universities, a Community College Consortium, and 2 Industrial Partners from 5 States:
  - Biogasoline, renewable aviation fuel
  - Purpose-grown poplar
    - GreenWood Resources
  - Bioconversion and fuel production
    - ZeaChem



Northwest Advanced Renewables Alliance (NARA): New Vista for Green Fuels, Chemicals, and Products

PD: R Cavalieri, WA St U, $40,000,000 (5 years)

- 41 Key Personnel representing 9 Universities, 3 Federal Partners, and 6 Industrial Partners from 9 States:
  - Renewable aviation fuel, value-added industrial chemicals
  - Woody biomass residues
  - Weyerhaeuser, other land owners
  - Bioconversion and fuel production
    - Gevo, Catchlight
  - Boeing is on advisory board

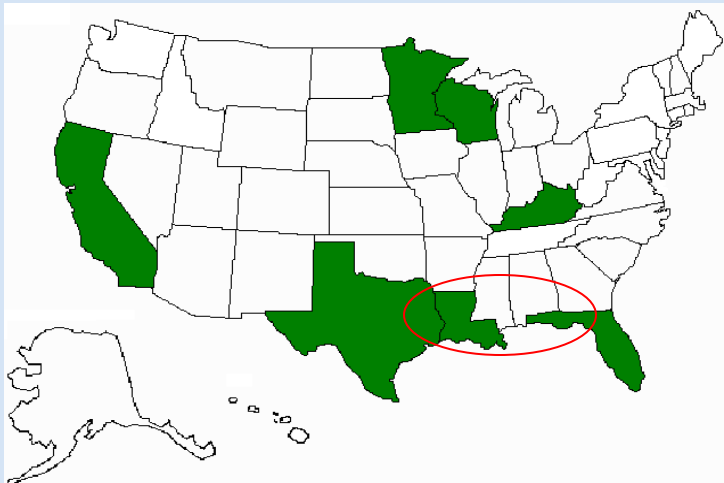


A Regional Program for Production of Multiple Agricultural Feedstocks And Processing to Biofuels and Biobased Chemicals

PD: D Day, LA St U, $17,300,000 (5 years)

- 37 Total Key Personnel from 5 Universities, 1 Federal Partner, and 7 Industry Partners in 7 States:
  - Biobutanol, gasoline, aviation fuel and industrial chemicals
  - Energy cane (ARS, SRU) and sweet sorghum (Ceres)
  - Logistics (John Deere)
  - Bioconversion to sugars,

    fuel and chemical production
    - Virent, DuPont/Genencor, Optinol,
    - MS Processes, Intl.



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Zia Haq,

DOE

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U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Alternative Fuels for Aviation

U.S. Department of Energy
Bioenergy Technologies Office

January 29, 2014

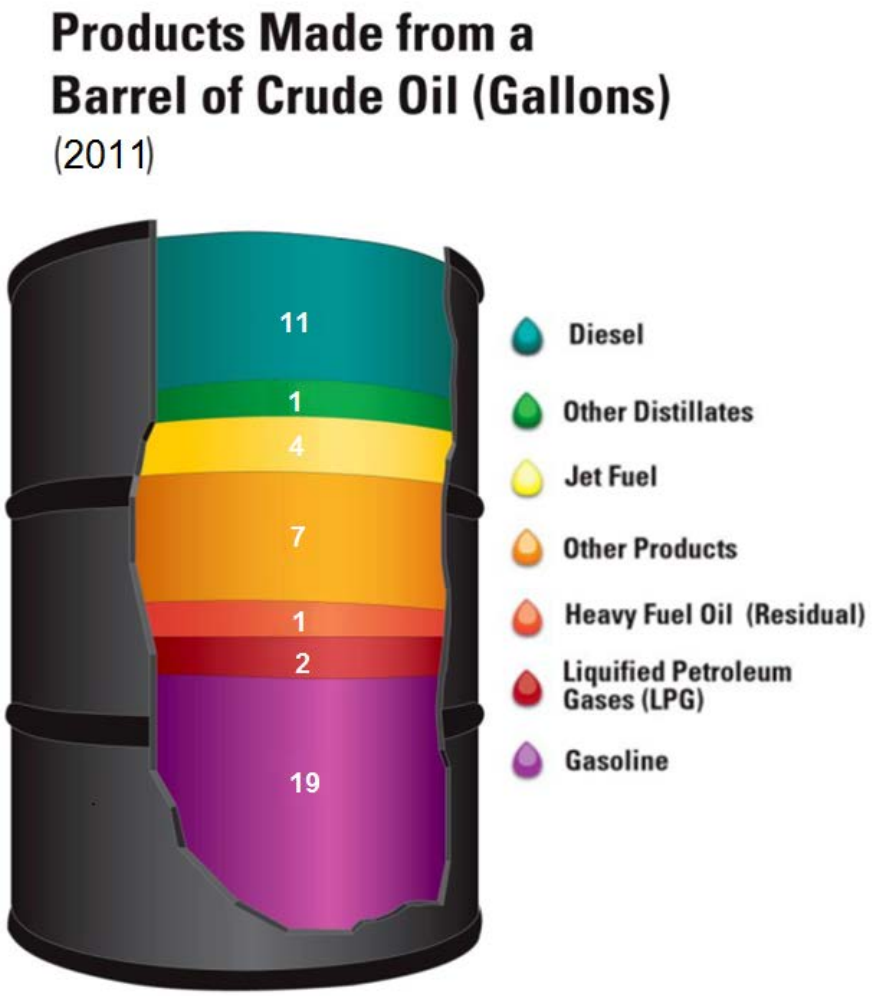
Zia Haq

Program Manager

DPA Coordinator

Bioenergy Technologies Office

Current Strategic Focus: Replacing the Entire Barrel



In 2011 BETO re-examined its focus:

- Cellulosic ethanol only displaces gasoline fraction of a barrel of oil (about 40%).
- Reducing dependence on oil requires replacing diesel, jet, heavy distillates, and a range of other chemicals and products.
- Greater focus needed on RDD&D for a range of technologies to **produce hydrocarbon fuels and displace the entire barrel of petroleum**.

Source: Energy Information Administration, "Oil: Crude Oil and Petroleum Products Explained" and AEO2009, Updated July 2012, Reference Case.
*American Petroleum Institute.

BETO Thermochemical-based IBR projects – Summary

DOE Funded TC IBR projects		
Enerkem	Syngas conversion to methanol-ethanol	Demo/ARRA
INEOS	Syngas fermentation to ethanol	Demo/ARRA
ClearFuels	Syngas to F-T liquids	Pilot/ARRA
Haldor Topsoe	Syngas catalysis to gasoline	Pilot/ARRA
REII	Syngas to F-T Diesel	Pilot/ARRA
UOP	Pyrolysis and hydroconversion to liquid transportation fuels	Pilot/ARRA
GTI	Integrated hydropyrolysis and hydroconversion to gasoline and diesel.	R&D/ARRA
Frontline	Syngas to F-T liquids	iPilot/BETO

Key Accomplishments

- INEOS has completed first commercial production of Cellulosic Ethanol, with more than 90% GHG reduction compared to gasoline
- 1000-hr run for drop-in fuels: Clearfuels
- GTI successfully demonstrated fully integrated, IH2 process, beginning scale up activities for pilot/demo

Key Challenges and Barriers

- Scale up (and down) issues
- Rural power supply reliability
- Operations issues
- Market issues-NG/GTL

FY 2013 TC FOA: CHASE

Goal of program effort: To address R&D challenges that were identified at the "Conversion Technologies for Advanced Biofuels" workshop, specifically in Carbon, Hydrogen, and Separations Efficiencies (CHASE) for Bio-oil Pathways.

Three Technical Barrier Areas were identified:

- **Carbon Efficiency** – Typically only the organic phase is processed in subsequent upgrading steps, leaving behind valuable carbon-containing material in the aqueous phase.
- **Hydrogen Efficiency** – Currently, many systems use steam reforming of non-renewable natural gas to generate hydrogen.
- **Separations Efficiency** - The ability to remove destabilizing components from bio-oils is crucial to achieving improved processes for bio-products production.

Selections include the following:

- Ceramatec
- Oak Ridge National Laboratory
- University of Oklahoma
- Virent, Inc.

DE-FOA-0000812

- Federal Funds: up to $12,000,000
- Starting TRL: 2-3

CERAMATEC TOMORROW'S CERAMIC SYSTEMS

OKLAHOMA

OAK RIDGE National Laboratory

U.S. DEPARTMENT OF ENERGY

VIRENT

Energy Efficiency & Renewable Energy

Natural Gas/Biomass to Liquids Workshop

- The recent development of the increased availability of low cost natural gas has increased opportunities to consider the use of natural gas as a feedstock for conversion into liquid hydrocarbons (GTL).

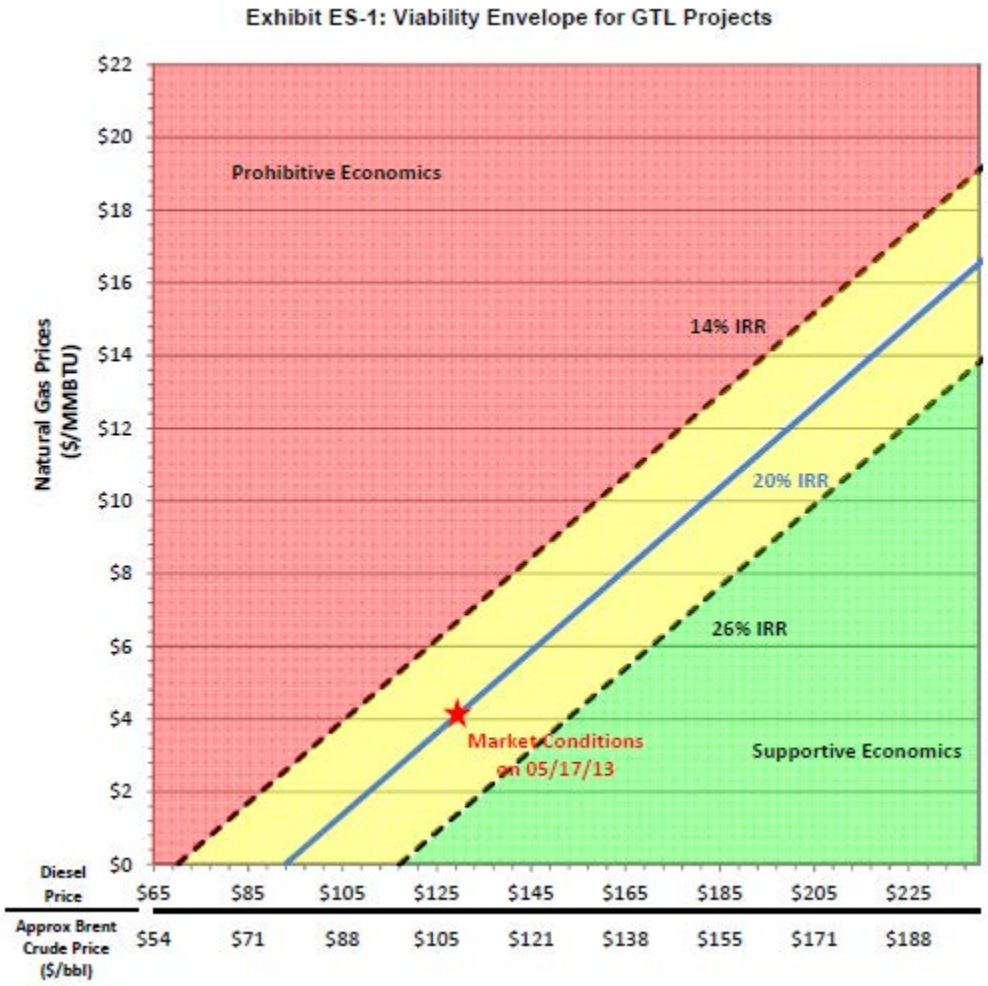
- Co-conversion of natural gas with biomass (GBTL) has the potential of increasing yield of liquid product while also having lower greenhouse gas emissions relative to petroleum.

- DOE is interested in further understanding how the use of natural gas and biomass may be optimized and integrated into a conversion process to produce liquid fuels.
  - Office of Energy Efficiency and Renewable Energy
  - Office of Fossil Energy
  - ARPA-E

GBTL Workshop Results

- Rationale for integrating biomass and natural gas resources to produce liquid transportation fuels is: greenhouse gas reduction and the need for a specific C/H ratio in the fuel
- GBTL processes can produce transportation fuels with 50% lower GHG emissions if substantial amounts of lignocellulosic biomass is co-processed with natural gas
- GBTL processes have significantly higher yields than processes converting only biomass
- Stranded biomass and stranded natural gas offer near-term opportunities to utilize currently unutilized feedstocks
- Research challenges: down-scaling GTL systems, improved catalysts, biochemical conversion processes, feeding biomass into pressurized systems, production of co-products, and many more.

Gas-to-Liquids Cost of Production



Source: NETL, "Analysis of Natural Gas-to Liquid Transportation Fuels via Fischer Tropsch", DOE/NETL-2013/1597, September, 2013.

REMOTE: Reducing Emissions using Methanotrophic Organisms for Transportation Energy

Ramon Gonzalez, Program Director

Chad Haynes, SETA

Anthony Augustine, T2M Advisor

REMOTE Portfolio (16* projects, ~$39M)

CAT 1: High-Efficiency Biological Activation of Methane

Anaerobic

University of Michigan

Arzeda

Aerobic

Berkeley Lab

Northwestern University

CAT 1 & 2

MIT

Penn State

University of Delaware

MOgene — Data Driven. Insight Generating.

CAT 2: High-Efficiency Biological Synthesis of Fuel

coskata

UCLA

UC Davis

University of Washington

CAT 3: Process Intensification Approaches for Biological Methane Conversion

LanzaTech — Spearheading Biofuel Production Technology

CALYSTA Energy™

greenlight BIOSCIENCES

OSU Oregon State University

*Includes 1 OPEN 2012 project and 15 REMOTE projects

CAAFI 2014 General Meeting & Expo

Jim Hileman,

FAA

Produced by

FAA Alternative Jet Fuel Research Update

Event: CAAFI Biennial General Meeting

By: Dr. James I. Hileman
Chief Scientific and Technical Advisor for
Environment and Energy
Federal Aviation Administration

Date: January 29, 2014

FAA E&E Research

Utilizing a priority-driven and goals-focused research program to inform solution development to overcome aviation E&E challenges.

FAA Office of Environment and Energy (AEE) R&D:

- Advances scientific understanding and analytical capability to characterize and assess aviation's impact on environment
- Supports development of mitigation solutions that reduce environmental impacts of aviation and enhance energy efficiency, sustainability and security
- Provides sound scientific data to inform policy making relating to aviation's energy use and environmental impacts

Current FAA Alternative Jet Fuel Activities

- **Testing**
  - Material compatibility
  - Certification / Qualification
  - Emissions measurements
- **Analysis**
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios
- **Coordination**
  - Public-Private
  - State & Regional
  - International

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- **Testing**
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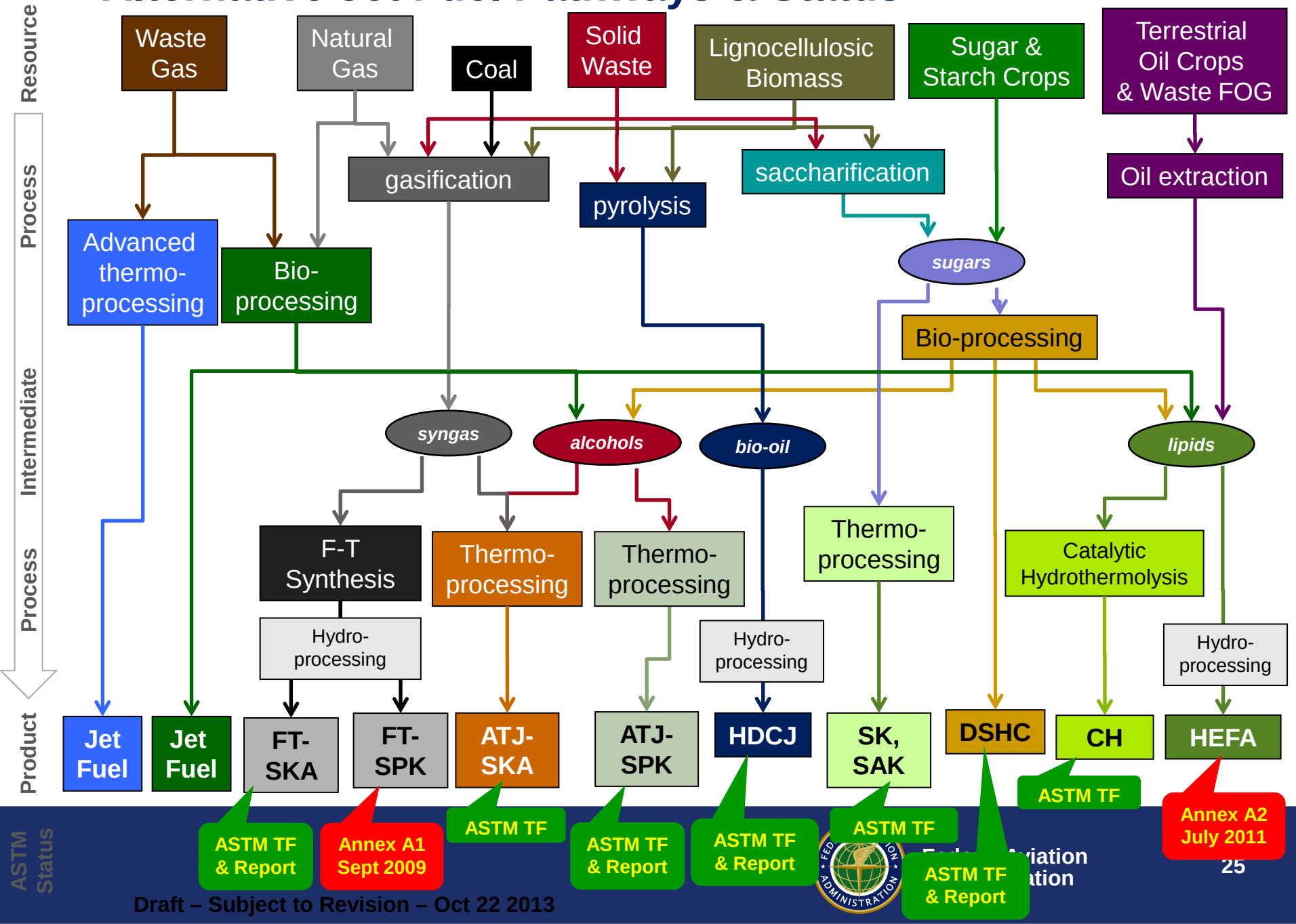
Alternative Jet Fuel Pathways & Status



Draft – Subject to Revision – Oct 22 2013

Current FAA Alternative Jet Fuel Activities

- Testing
  - Material compatibility
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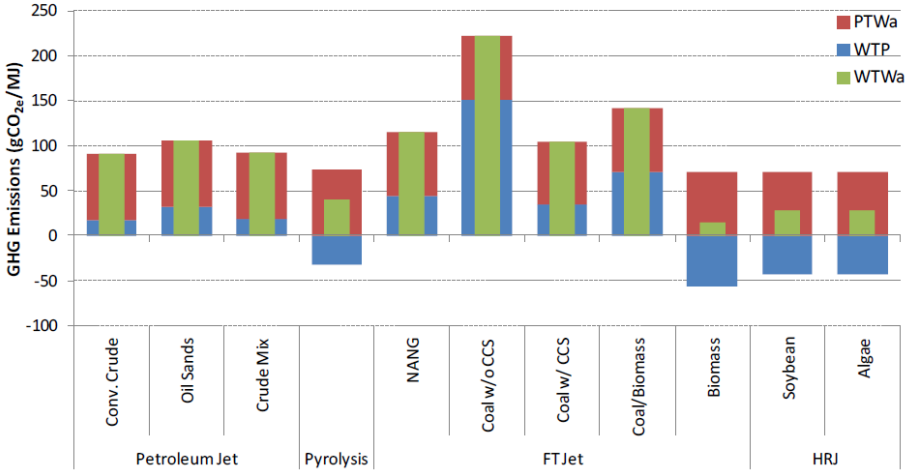
- **Analysis**
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios
- Coordination
  - Public-Private
  - State & Regional
  - International

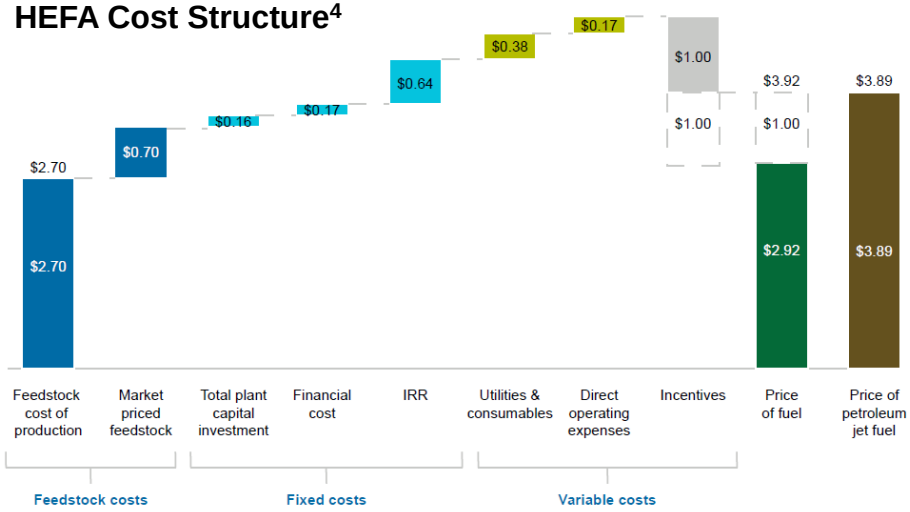
Environmental and Economic Analyses

- Environmental analyses
  - Focus on well-to-wake GHG, including climate impacts of combustion emissions
  - Results incorporated into ANL GREET model and EPA analysis
- Economic analyses
  - Techno economic analysis that are coordinated with DoE efforts
  - Identifying opportunities for cost reduction
- Future production scenarios
- Research being conducted by PARTNER[1] and ASCENT[2] COE and Volpe Center

Life Cycle GHG Emissions[3]



HEFA Cost Structure[4]



1. http://partner.mit.edu/projects/environmental-cost-benefit-analysis-alternative-jet-fuels
2. http://ascent.aero
3. http://greet.es.anl.gov/files/aviation-lca
4. http://www.masbi.org/content/assets/MASBI_Report.pdf

Federal Aviation Administration

Current FAA Alternative Jet Fuel Activities

- Testing
  - Material compatibility
  - Certification / Qualification
  - Emissions measurements
- Analysis
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios
- **Coordination**
  - Public-Private
  - State & Regional
  - International

New FAA Programs

Aviation Sustainability Center (ASCENT)

- New Center of Excellence for Alternative Jet Fuel and Environment

Continuous Lower Energy, Emissions and Noise (CLEEN) II

- Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels

Sustainability and Environmental Management Research Support (SEMRS)

- Supporting FAA with Sustainability, Environmental Management, Research, and Additional Support activities
- Open solicitation that closes Feb 11: https://faaco.faa.gov/index.cfm/announcement/view/15569

ASCENT Overview

- Partnership among universities, commercial firms, and government laboratories to conduct research and education
- Expands environment and energy research carried out by PARTNER to address alternative jet fuel research request in 2012 FAA Modernization and Reform Act
- COE brings together expertise of PARTNER COE with USDA AFRI Regional Bioenergy Coordinated Agriculture Projects (CAPS) and SunGrant Initiative
- Award announcement: September 13, 2013
- Duration: five years; renewable once (ten year total)
- Funding: at least $4 million annually from FAA plus 100% cost share requirement
- Sponsor engagement: U.S. government agencies (FAA, USDA, DoE, DoD, EPA, NASA) and Transport Canada

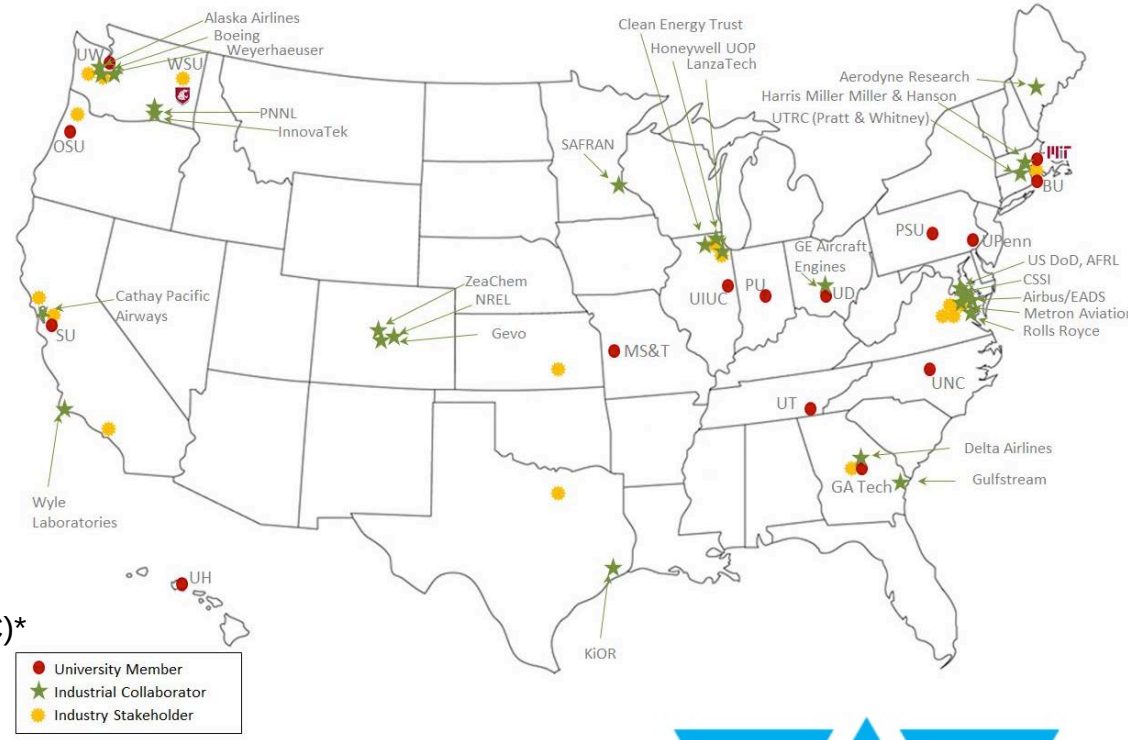
FAA CENTER OF EXCELLENCE FOR ALTERNATIVE JET FUELS & ENVIRONMENT

Lead Universities:

- Washington State University (WSU)*
- Massachusetts Institute of Technology (MIT)

Core Universities:

- Boston University (BU)
- Georgia Institute of Technology (Ga Tech)
- Missouri University of Science and Technology (MS&T)
- Oregon State University (OSU)*
- Pennsylvania State University (PSU)*
- Purdue University (PU)*
- Stanford University (SU)
- University of Dayton (UD)
- University of Hawaii (UH)
- University of Illinois at Urbana-Champaign (UIUC)*
- University of North Carolina at Chapel Hill (UNC)
- University of Pennsylvania (UPenn)
- University of Tennessee (UT)*
- University of Washington (UW)*



ASCENT
AVIATION SUSTAINABILITY CENTER

*** Denotes USDA NIFA AFRI-CAP Leads and Participants**

Continuous Lower Energy, Emissions and Noise (CLEEN) Phase II

- **FAA R&D Program:**
  - Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels
  - 1:1 minimum cost share requirement
- **CLEEN I: 2010-2015 ($125M FAA Funding)**
  - Alternative Jet Fuel Projects with Boeing, Rolls Royce, Pratt & Whitney, and Honeywell
- **CLEEN II: 2015-2020 ($100M FAA Funding)**
  - Industry Day - December 3, 2013 in Washington DC
  - Solicitation expected in mid-2014
  - More information available at: http://www.faa.gov/about/office_org/headquarters_offices/apl/research/aircraft_technology/cleen/

Summary

- Alternative jet fuels are a key component of FAA strategy in meeting environmental goals
- FAA efforts are directed to overcoming key challenges via testing, analysis and coordination
- Multiple programs and activities:
  - Commercial Aviation Alternative Fuels Initiative (CAAFI)
  - Continuous Lower Energy, Emissions and Noise (CLEEN) Program
  - Aviation Sustainability Center (ASCENT)
  - National Alternative Jet Fuel Strategy development

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Dan Friend,

DOC

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Department of Commerce and Alternative Aviation Fuels

Daniel G. Friend
Special Assistant to the Director (Energy Research)
National Institute of Standards and Technology
Office of Special Programs
Boulder, CO

Panel on *Public-Private Partnership Efforts*
CAAFI General Meeting
Washington, DC
29 January 2014

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Daniel.friend@nist.gov

DOC "... promotes job creation, economic growth, sustainable development and improved standards of living for all Americans by working in partnership with businesses, universities, communities and our nation's workers. ... a wide range of responsibilities in the areas of trade, economic development, technology, entrepreneurship and business development, environmental stewardship, and statistical research and analysis."

Bureau of Economic Analysis (BEA)
Bureau of Industry and Security (BIS)
U.S. Census Bureau
Economic Development Administration (EDA)
Economics and Statistics Administration (ESA)
International Trade Administration (ITA)
Minority Business Development Agency (MBDA)
National Oceanic and Atmospheric Administration (NOAA)
National Telecommunications and Information Administration (NTIA)
National Institute of Standards and Technology (NIST)
National Technical Information Service (NTIS)
U.S. Patent and Trademark Office (USPTO

Promoting foreign direct investment and export opportunities for U.S. companies; technologies and atmospheric measurements in support of decision making related to global climate change; Advancing measurements and standards; resolving issues preventing innovation and trade.	Organizing events to assist foreign investment in the U.S.; assisting in selling and licensing of relevant products and technologies to overseas clients; promoting harmonization of international standards and practices. Developing atmospheric chemistry, transport, and climate models; developing atmospheric measurement techniques and instruments; conducting atmospheric measurements from a variety of platforms; evaluating the role of aircraft emission sources in the troposphere and stratosphere; evaluating the potential impacts on ecosystems. Developing measurement methods and performing measurements; providing calibrations; developing reference materials and reference data; supporting development of standards.	To facilitate successful commercial deployment and trade in fuels. To assess the role of emissions from the use of alternative jet fuels in the climate system and ecosystems. To eliminate measurement and standards barriers that inhibit innovation and trade in alternative jet fuels.

Minimize the barriers--associated with technical uncertainties, incompatibility of standards, and trade impediments--for adoption of drop-in alternative jet fuels.

Activities:

- Lead efforts to resolve barriers to international trade
- Evaluate and assess climate change and ecosystem implications
- Conduct measurements and develop measurement methods
- Work with standards developing organizations
- Support economic development & tech needs of small/mid-size manufacturing enterprises
- Protect intellectual property

International Trade Administration
Partnering with CAAFI

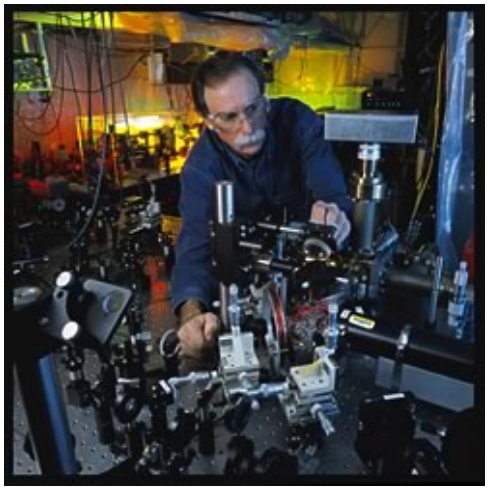
- Global network of industry & international business experts—help U.S. companies compete
- SelectUSA program to promote opportunities and investment (http://selectusa.commerce.gov)
- 150 industry experts in DC; offices in 70 countries, 100 U.S. cities—trade data and analysis
- Hosted first CAAFI Business Team Mtg in 2008
- Worked with CAAFI and Kallman to promote business opportunities and foreign direct investment—airshows
- Works with CAAFI to connect alt fuels companies with DOC resources (local, global)

Alexis Haakensen alexis.haakensen@trade.gov

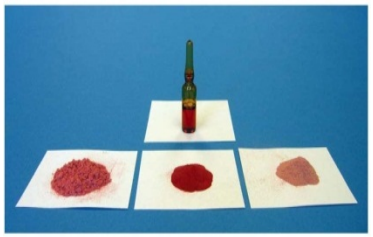
Cora Dickson cora.dickson@trade.gov

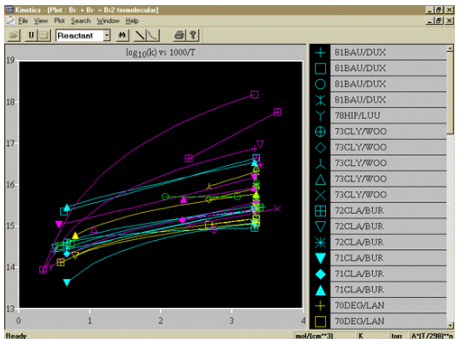
NIST Metrology, Standards, and Technology

- Fundamental Research
- Measurement Services
- Standards Support
  - U.S. Inquiry Point WTO TBT
  - www.nist.gov/sco



- Standard Reference Materials
  - Physical artifacts with certified physical and/or chemical properties
- Standard Reference Data
  - Evaluated numeric data on physical or chemical properties
  - Scientific algorithms on behavior of systems
- Calibrations



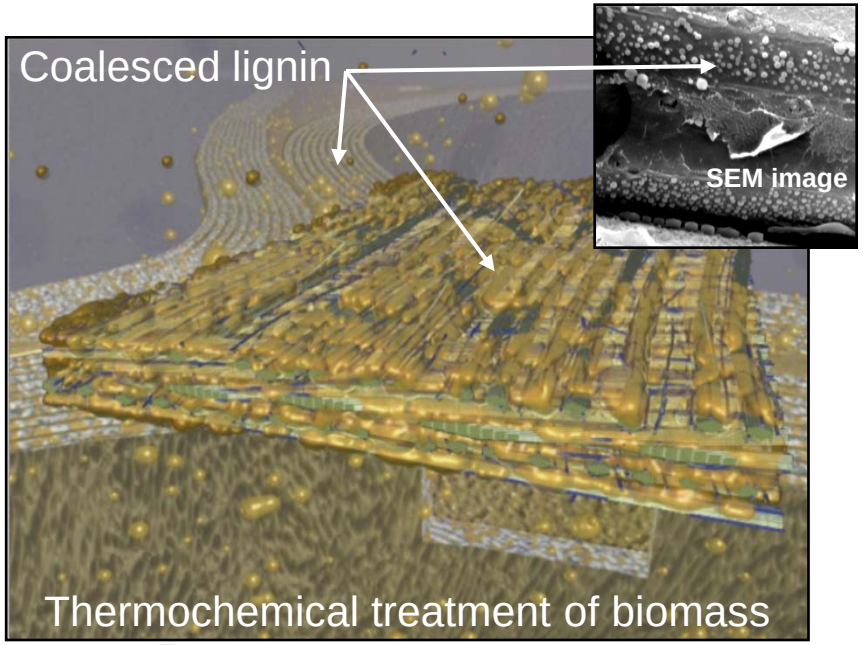


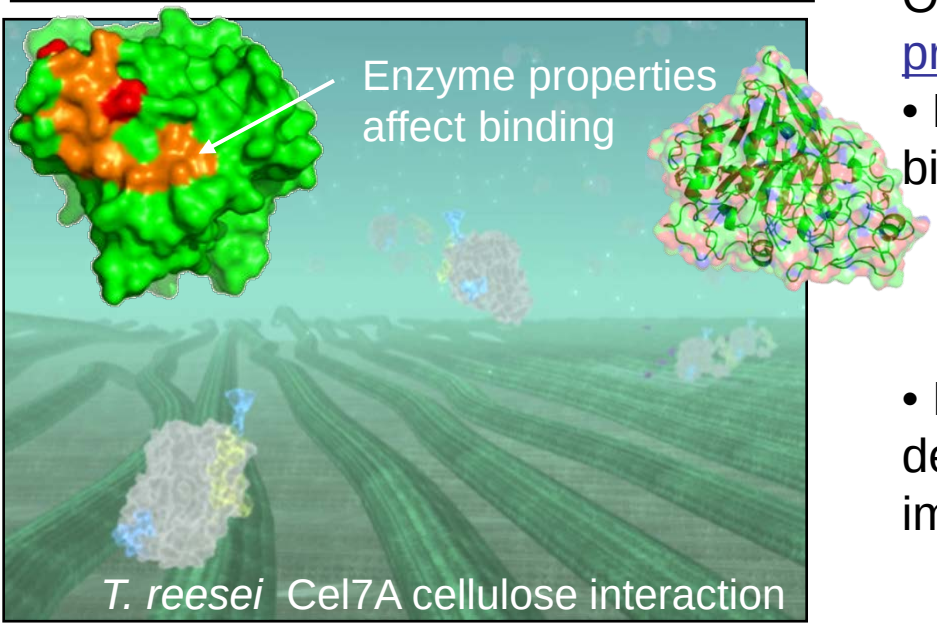
NIST Partnership Opportunities

- User Facilities
  - Center for Nanoscale Science and Technology (CNST)
  - NIST Center for Neutron Research (NCNR)
- Manufacturing Extension Partnership (MEP)
  - 1200 technical experts; centers in every state
  - Make it in America; E3—Economy, Energy, Environment
  - www.nist.gov/mep
- Laboratory Programs
  - Collaborations, CRADAs, …
- Contacts: Dan Friend (Office of Special Programs) daniel.friend@nist.gov

  Nick Barbosa (Material Measurement Laboratory) nicholas.barbosa@nist.gov

Next Generation Biofuels:
Enzyme/thermochemical processing





Interaction of T. Reesei cellulases with lignin from thermochemical treatment using quartz-crystal micro-balance

Background: Fungal secretome has many glycoside hydrolases that depolymerize cellulose and hemi-cellulose.

- Enzymes work synergistically
- Productivity is lost in the presence of lignin

Objective: Investigate interaction of enzymes in presence of lignin using QCMD

- Elucidate the mechanism(s) of non-productive binding of enzymes to lignin
  - specific/non-specific binding
  - protein denaturation
  - steric interference
- Identify which enzymes are affected and develop strategies to overcome this process impact

NREL NATIONAL RENEWABLE ENERGY LABORATORY

NIST National Institute of Standards and Technology U.S. Department of Commerce

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Mohan Gupta,

FAA

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Development of National Alternative Jet Fuels R&D Strategy

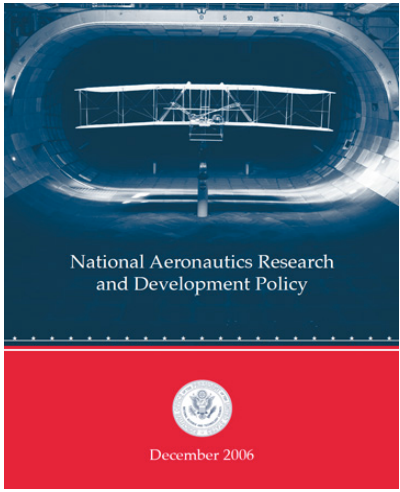
Research, Development, Demonstration, and Deployment (RD3) Challenges, Opportunities, and Strategic Way Forward

Mohan Gupta, FAA
Co-Chair of the Federal Interagency Coordination Group
Tri-Chair of the NSTC/ASTS Energy & Environment Working Group

January 29, 2014

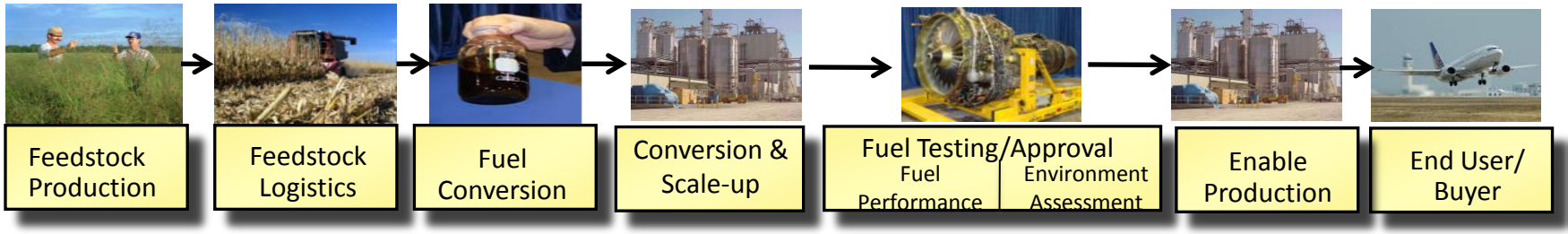
Background: National Aeronautics Research & Development Plan

Developed under sponsorship of the National Science & Technology Council, Aeronautics S&T Subcommittee (ASTS)



Plan focuses on 17 aeronautics goals in four areas –

- Mobility, Security, Safety and Environment and Energy
- Energy Availability, Efficiency & Environmental Protection
  - Goal 1: "Enable new aviation fuels derived from diverse & domestic resources to improve fuel supply security & price stability"



USDA	✓	✓	✓	✓	---	✓	✓	✓
DOC	✓	---	✓	✓	✓	✓	---	✓
DOD	---	---	---	---	✓	✓	✓	✓
DOE	✓	✓	✓	✓	---	✓	✓	---
EPA	---	---	---	---	---	✓	✓	---
FAA	---	✓	---	✓	✓	✓	---	✓
NASA	---	---	---	---	✓	✓	---	---
NSF	✓	✓	✓	---	---	---	---	---

Development of National Alternative Jet Fuels R&D Strategy

Overarching R&D Challenges

- Development of types and geographical diversity of feedstocks
- Production and yield efficiency of feedstock
- Sustainable and dependable supply
- Conversion efficiency and commercial scale production
- Jet specificity and demand for byproducts
- Cost-competitiveness
- ASTM approval for performance, safety and operability
- Environmental sustainability and resource demand

Currently - no common guiding path that defines an actionable R&D strategy to help meet these challenges.

Development of National Alternative Jet Fuels R&D Strategy

Intended Purpose

Identify opportunities and strategically address challenges associated with Research Development Demonstration and Deployment (RD3) along the supply-chain of alternative jet fuels.

National AJF R&D Strategy – A mechanism to

- **Articulate** *Achievable* Objectives, *Measurable* Performance Metrics and Timeline to achieve the goal
- **Mobilize** the federal and non-federal stakeholders community towards achieving the common goal and objectives
- Understand industry needs and target federal strategic R&D efforts to address **RD3 challenges** along the alternative jet fuels supply-chain
- **Integrate**, align and coordinate interagency activities
- **Promote** increased collaboration
- **Enhance** technology transfer

DRAFT Goal Statement

Enable the development, production, and use of environmentally sustainable, cost-competitive and socially responsible alternative jet fuel with stable supply to significantly meet the needs of U.S. jet aviation

Development of National Alternative Jet Fuels R&D Strategy

Stakeholders' input is integral to inform the development of this Strategy

- STPI surveyed stakeholders to identify R&D challenges along the supply-chain
- STPI organized stakeholders workshop on Jan 7, 2014 to discuss these challenges

Interagency Coordination Group (ICG) continues to draft the Strategy

ICG recognizes the value in follow-up efforts after the release of the Strategy

Implement a process for a periodic assessment of the federal and community-wide progress made towards meeting the Strategy goal and identify R&D adaptations to meet evolving challenges, as needed.