The Boeing Company

Meeting Environmental Requirements for Military Customers

Tim Vinopal
Director – Environment, Health and Safety Engineering
Boeing Defense, Space and Security

Washington Clean Technology Alliance
December 7, 2011

Boeing's Defense Customers Seek Innovative Solutions

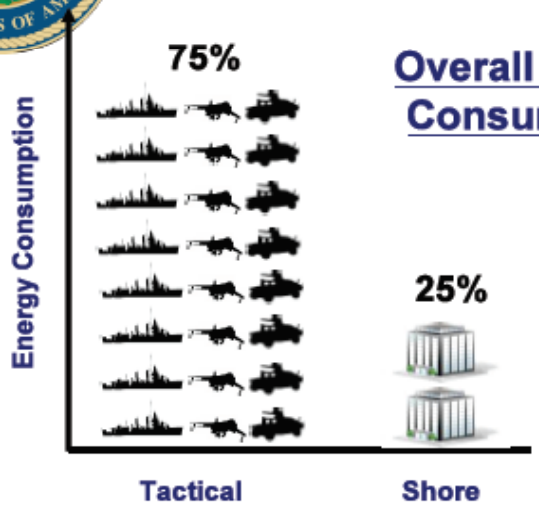
- **Increase energy efficiency and decrease energy demand**
- **Develop and integrate alternative energy generation and storage**
- **Minimize environmental footprint and hazardous chemical use**

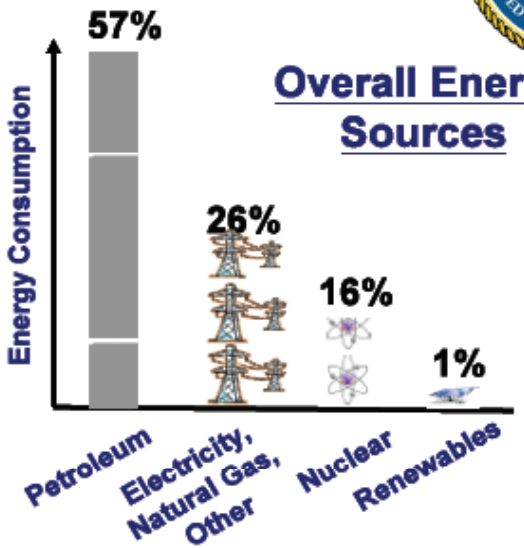
Developing Environmentally Progressive Technologies

- Advanced structures & materials
- Advanced aero & propulsion
- More electric aircraft systems
- Efficient Logistics & Operations
- Platform & Facility Energy Management
- Virtual Live Training
- Distributed/Remote Power Generation
- **Sustainable, renewable fuels**

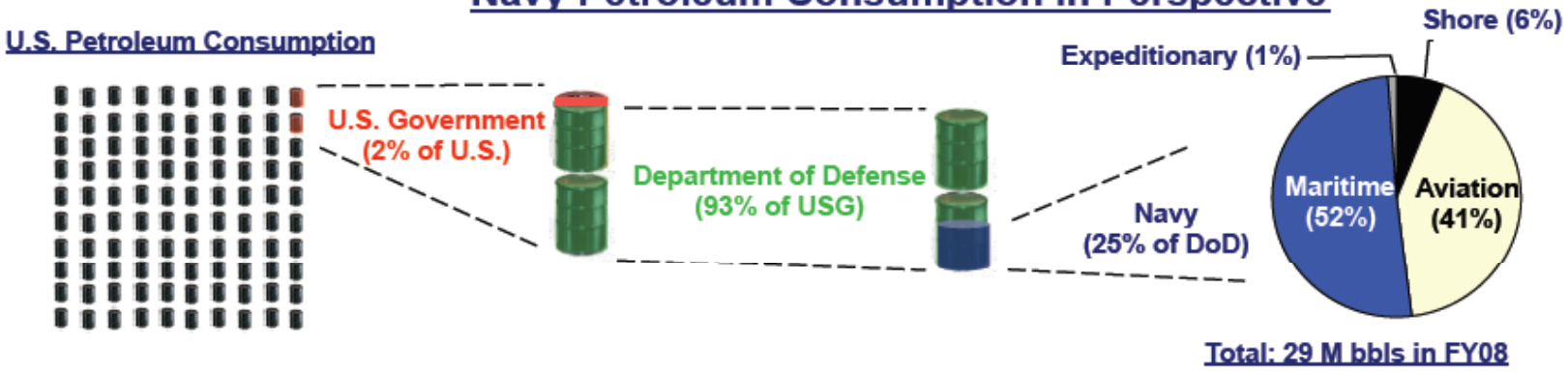
Increasing Platform and Installation Efficiencies

Navy Energy Profile





Navy Petroleum Consumption in Perspective



Total: 29 M bbls in FY08

SECNAV Energy Goals

At the Naval Energy Forum, the Honorable Ray Mabus championed President Obama's goal to reduce consumption of fossil fuels and reduce greenhouse gas emissions. He announced five DON Energy Goals:

New Requirements for Acquisition Processes

- Mandatory evaluation factors used when awarding contracts for platforms, weapon systems, and buildings will include:
  - Lifecycle energy costs
  - Fully-burdened cost of fuel
  - Contractor energy footprint

Sail the "Great Green Fleet"

- DON will demonstrate a Green Strike Group in local operations by 2012 and sail it by 2016
  - Nuclear ships
  - Surface combatants using biofuels with hybrid electric power systems
  - Aircraft flying on biofuels

Reduce Petroleum Use in Non-Tactical Vehicles

- By 2015, DON will reduce petroleum use in the commercial fleet by 50 percent
  - Flex fuel vehicles
  - Hybrid electric vehicles
  - Neighborhood electric vehicles

Increase Alternative Energy Ashore

- By 2020, DON will produce at least 50 percent of shore-based energy requirements from alternative sources
  - Solar, Wind, Ocean, Geothermal

Increase Alternative Energy Use Navy-wide

- By 2020, 50 percent of total DON energy consumption will come from alternative sources

Boeing pursuing sustainable biofuel strategy

Enable the industry to achieve market viability – by 2015

Success Criteria

- 600+ million gallons/yr of bio content
- 5-10 feedstock/fuel production projects

Five Focus Areas

Fuels Approval

Specification approach enables viable new fuel types and is not process-specific

Feedstock Viability

Feedstock providers able to support 600M gallons/yr

Airport Infrastructure

Infrastructure to deliver increasing quantities of sustainable biofuels

Commercial Production

Commercial production capacity & business models

Aviation-Prioritized Sustainable Biofuels

Support & advocacy for aviation-prioritized, sustainable biofuels

Technical focus

Strategic & commercial focus

Boeing Acting as a Catalyst to Accelerate Commercialization

Boeing pursuing sustainable biofuel strategy

Enable the industry to achieve market viability – by 2015

Five Focus Areas

Fuels Approval

Specification approach enables viable new fuel types and is not process-specific

Progress to date:

1. Detailed testing regime & reporting established
2. ASTM approval of 1st pathway (HRJ)
3. DefStan 91-91 HRJ approval

Next Steps:

1. All USN & USAF aircraft 'HRJ-certified'
2. ID & testing next pathways (ATJ)

Feedstock Viability

Feedstock providers able to support 600M gallons/yr

Progress to date:

1. Feedstock trade groups formed (Algal Biomass)
2. Sustainability Stds (RSB, EPFL)
3. Regional initiatives: SAFRM; SAFN; Mexico; EU
4. Masdar; Brazil; Hawaii projects launched

Next Steps:

1. Lanzatech/VAA
2. Others in ME, EU, Asia

Airport Infrastructure

Infrastructure to deliver increasing quantities of sustainable biofuels

Progress to date:

1. Certified "drop-in fuel"
2. Alaska/Horizon airline daily flights - SEA
3. KLM & DLH flights – AMS & FRA

Next Steps:

1. Others in EU, ME, Asia, N & S America
2. Support for USN air stations, USAF bases

Commercial Production

Commercial production capacity & business models

Progress to date:

1. UOP pilot plant in TX
2. Dynamic Fuels 75 Mgal/yr in LA
3. Neste 50 Mgal/yr in Finland

Next Steps:

1. AltAir 75 Mgal/yr in CA
2. Neste in SG & NL (250 Mgal/yr ea)
3. DoE/USDA/DoD prod incentives

Aviation-Prioritized Sustainable Biofuels

Support & advocacy for aviation-prioritized, sustainable biofuels

Progress to date:

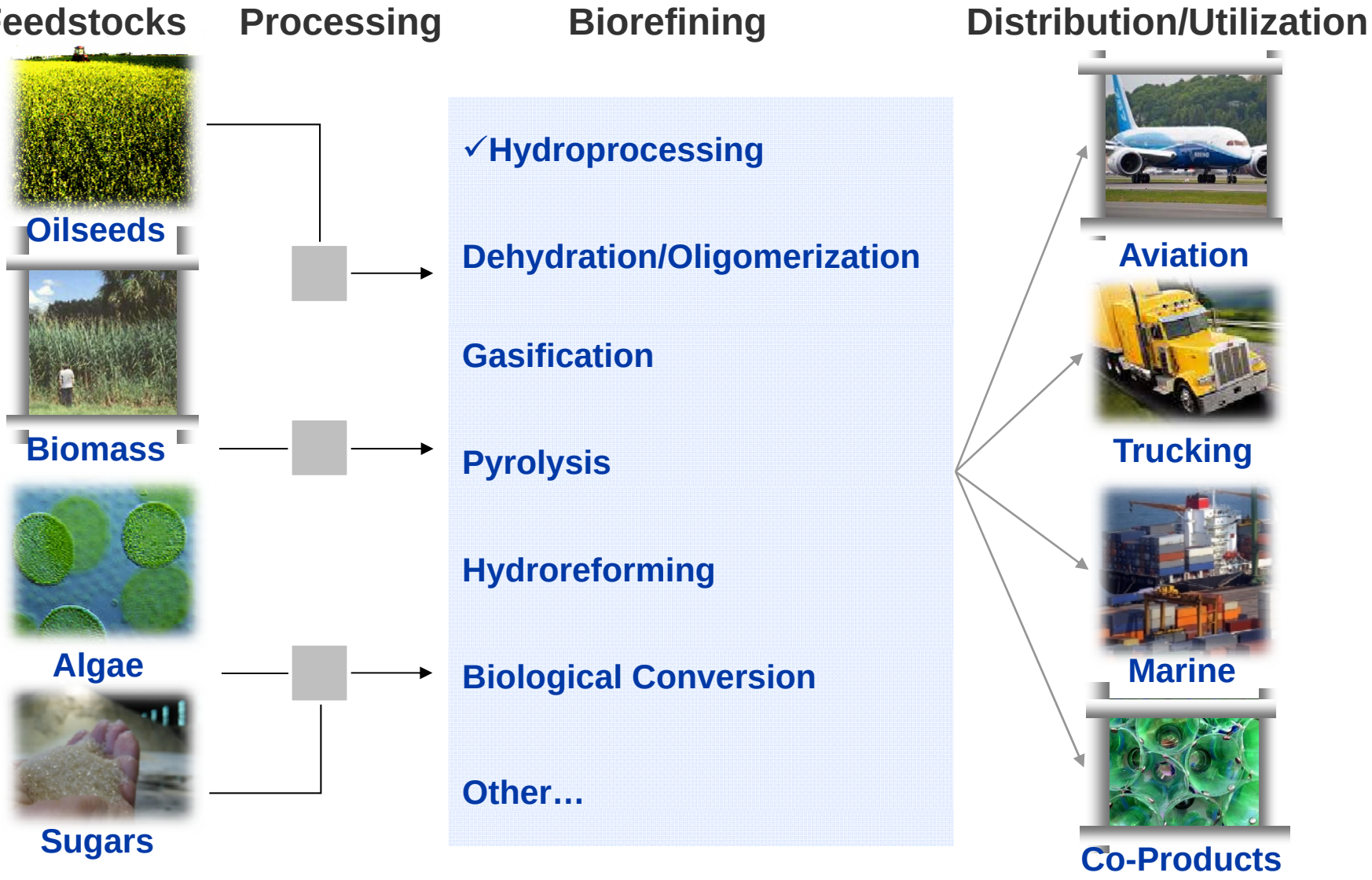
1. Airlines form SAFUG
2. IACO Global Sectoral approach for emissions
3. USDA-ATA Farm To Fly
4. DPA/ $510 mil.+ funding, grants

Next Steps:

1. RINS jet pathways
2. Long term contracting, biojet price collar (HR 6343)
3. Algae parity (HR 4168)

Boeing Acting as a Catalyst to Accelerate Commercialization

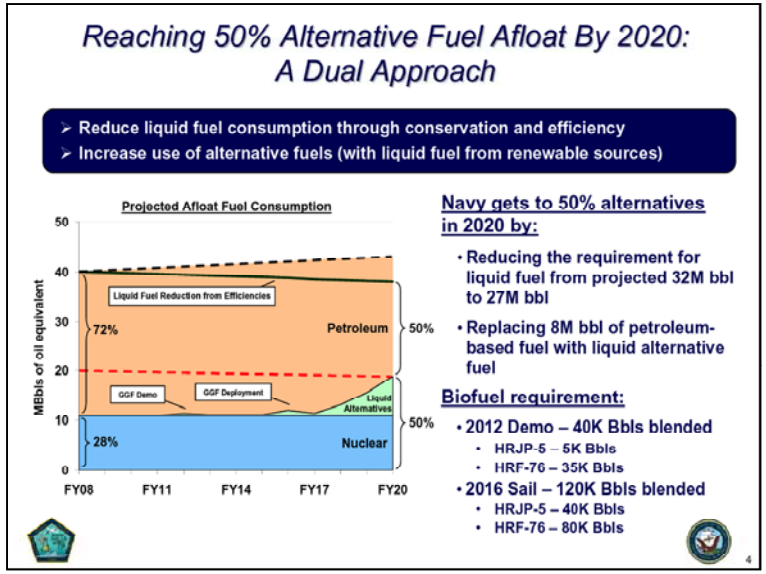
Advanced Biofuel Production



Cost and quantity goals require diverse feedstocks

Military customers supporting initial biofuel market & research

- **US Navy**
  - **Certifying ship and aircraft fleet**
  - **Great Green Fleet Strike Group:**
    - **Local demo 2012 – need 40k Bbls JP-5 + F-76 (purchased 450 k gal Nov 2011)**
    - **Intl deployment 2016 – 120k Bbls JP-5 + F76**
  - **Long term market – 8M Bbls**
- **US Air Force**
  - **Certifying aircraft fleet**
  - **Qualify new pathways**
    - **Certification office request for 1st 6,000 gallons of Alcohol-to-jet on 6/15/11**
    - **Willing to support other pathways as they become viable**
    - **Ongoing procurements**



Sustainable Biofuels – Progress Report




Progress

- Flight tests – fuel met / exceeded expectations
- Excellent fuel – ASTM & Def Stan approved 2011
- Comprehensive regional assessments underway
- USDA – Boeing – ATA “Farm to Fly”
- White House USDA-DoE-DoD producer support
- Commercial revenue flights beginning – KLM, DLH, Alaska, Aeromexico, Finnair, etc. only 3 months after approval

Action Required

- Continued emphasis on sustainability
- Research & certification of expanded feedstock and processing pathways
- Long term contract authority
- Commercial production scale-up
- Stretch goal: market quantities by 2015

Clean Energy AND Energy Security

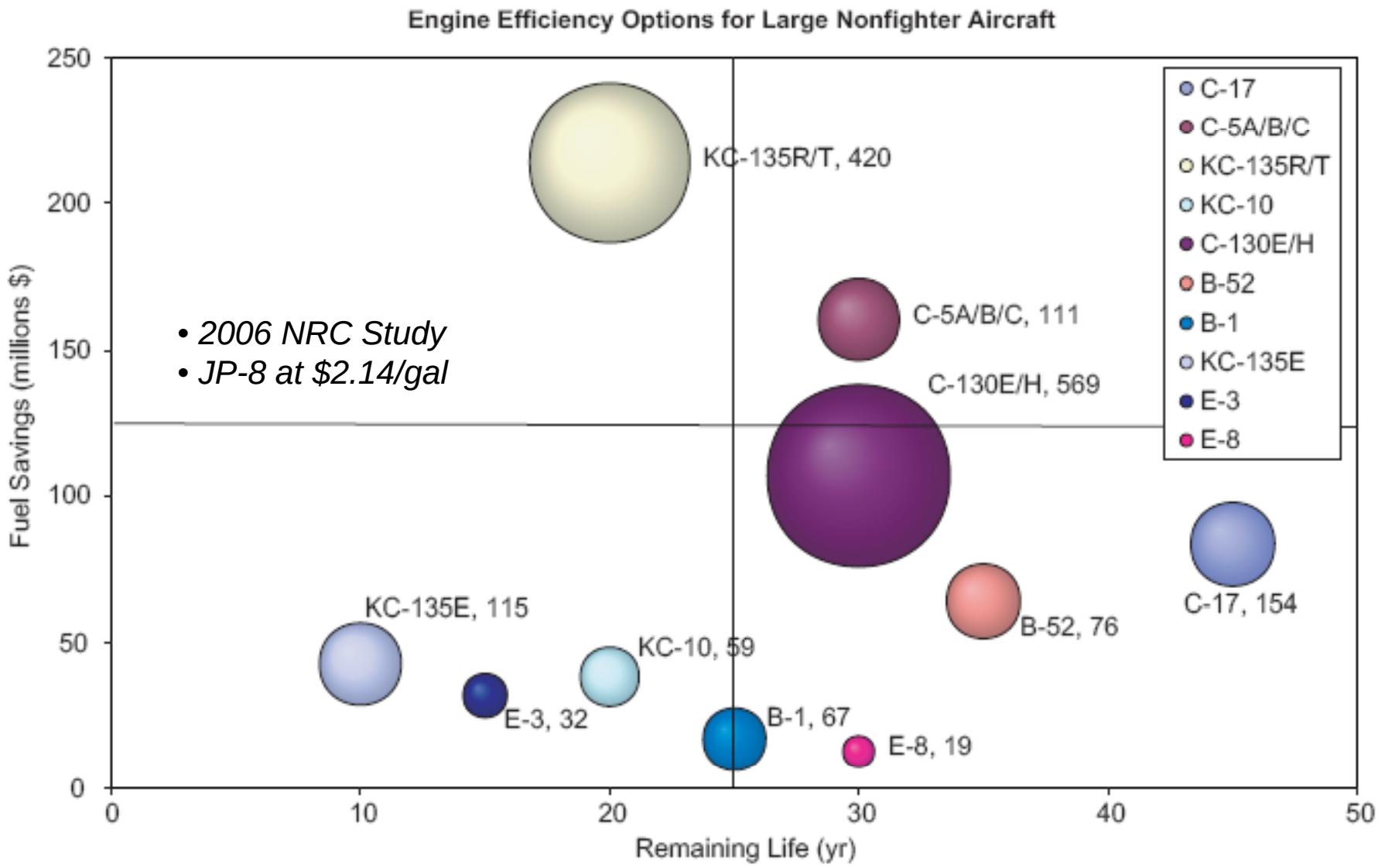

BOEING

Our Challenge and Opportunity

"Just as employees mastered 'impossible' challenges like supersonic flight, stealth, space exploration and super-efficient composite airplanes, now we must focus our spirit of innovation and our resources on reducing greenhouse-gas emissions in our products and operations."

W. J. McNerney
Chairman, President and CEO
The Boeing Company

Re-Engine Opportunities Help DoD Save Fuel



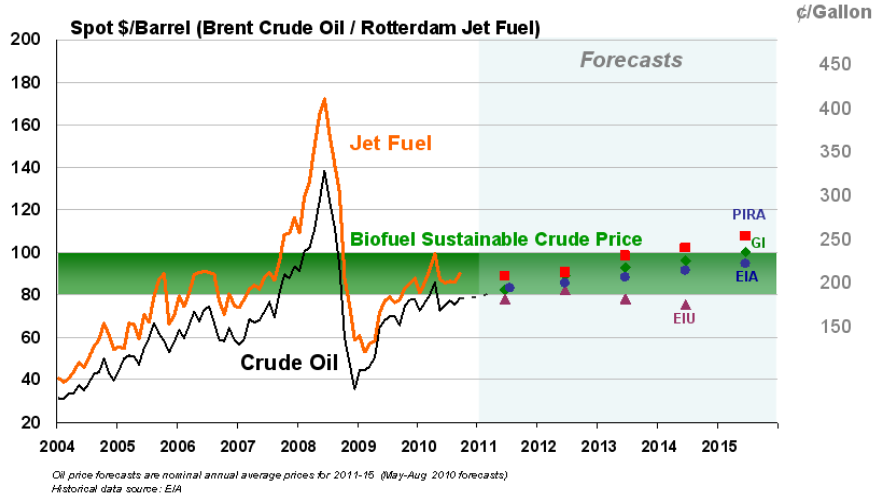
Why Sustainable Biofuels?

Challenge:

Fuel price and source diversity / security

Opportunity:

- Secure advantaged position
- Mitigate price volatility
- Military – address energy security issues
- Mitigate risk from heavy crudes



Challenge:

Greenhouse gas emissions

Opportunity:

- Reduce emissions cost-effectively
- Position with stakeholders, customers
- Mitigate exposure to regulation

Sustainable Aviation Biofuel Projects by Region

Fuel approval

DefStan 91-91

Commercial Flights

Working Together MOUs with PetroChina

Inaugural Chinese biofuel flight

Life Cycle Analysis

VA / LanzaTech collaboration

SAFUG-Europe Member Projects

Sustainable Aviation Fuels Northwest

ASTM INTERNATIONAL

Fuel approval

•RINs petition
•$500M grants

Brazil R&D Cente with Embraer

MOU Hawaii Bioenergy

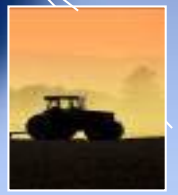
Project Flight Path

SAFUG growth

Masdar Research Project

Aviation Biofuel Road Map

North America commercial flights



Aviation Biofuel Assessment Project

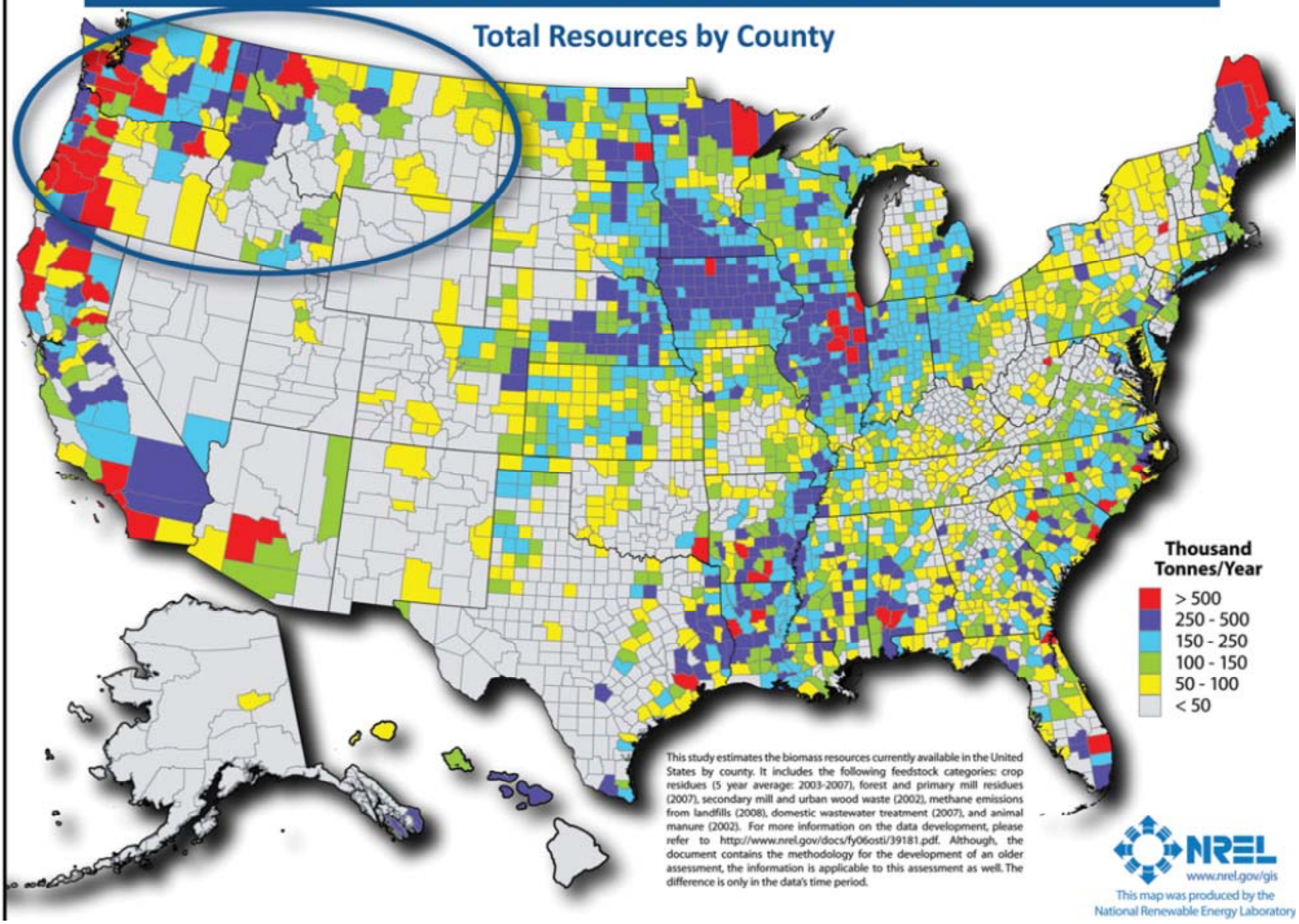
SAFN (Sustainable Aviation Fuels Northwest) Objectives

- Convene regional stakeholders with expertise across the aviation biofuel supply chain
- Assess the opportunities and challenges across multiple biomass feedstock supply chains
- Identify sustainability principles and practices
- Produce collaborative & consensus-driven action plan

Sustainable Aviation Fuels Northwest Stakeholders

BIOMASS RESOURCES OF THE UNITED STATES

Total Resources by County



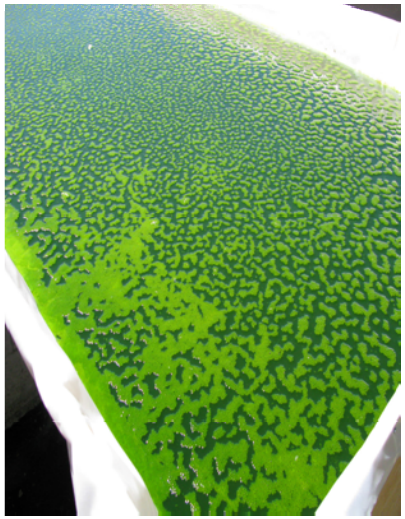
This study estimates the biomass resources currently available in the United States by county. It includes the following feedstock categories: crop residues (5 year average: 2003-2007), forest and primary mill residues (2007), secondary mill and urban wood waste (2002), methane emissions from landfills (2008), domestic wastewater treatment (2007), and animal manure (2002). For more information on the data development, please refer to http://www.nrel.gov/docs/fy06osti/39181.pdf. Although, the document contains the methodology for the development of an older assessment, the information is applicable to this assessment as well. The difference is only in the data's time period.

NREL
www.nrel.gov/gis

This map was produced by the National Renewable Energy Laboratory

Key Feedstock Pathways

- Oilseeds
- Algae
- Forest Residuals/Thinnings
- Municipal Solid Waste

Top Six SAFN Recommendations

1. Strategic focus on sustainable fuels for aviation
2. Stable, long-term policy to attract investment
3. Support for aviation fuels under RFS2
4. State and local support of infrastructure and training
5. Target regional R&D
6. Incorporate sustainability criteria

Mabus: DLA Purchased 450,000 Gallons Of 'Drop-In' Biofuels

Posted on InsideDefense.com: December 5, 2011

The Defense Logistics Agency purchased 450,000 gallons of biofuels last week which will be used in upcoming exercises, Navy Secretary Ray Mabus and Agriculture Secretary Tom Vilsack told reporters via teleconference today.

The purchase is the largest of drop-in biofuels in government history and "we think the largest single purchase in U.S. history," Mabus said. The Navy will use the fuel for the "Great Green Fleet" demonstration next summer during the biennial Rim of the Pacific Exercise, "so it's a very small percentage of the fuel we use on an annual basis," he said.

DLA will pay $12 million to Dynamic Fuels, LLC in Geismar, LA, and Solazyme in San Francisco, CA, for the fuel, which comes out to about $27 per gallon. However, Mabus argued that because the fuel is a 50-50 blend of regular fuel and biofuel, it's like paying $15 per gallon for biofuel. "It's half of what we were paying last year," he said.

Mabus told reporters, "It met all our criteria that it be a drop-in biofuel: that it come from non-food sources and that it not increase the carbon footprint."

Solazyme's blend is composed of algae based fuels and Dynamic Fuels' blend is made from used cooking oils. -- *Lee Hudson*

Near Term HEFA Potential Production

UOP A Honeywell Company

- Pilot Plant in Houston, TX
- Feedstock Flexible
- Producing Diesel and Jet

- Joint Venture between Syntroleum Corporation and Tyson Foods
- Location Geismar, Louisiana
- Plant Commissioned Fall 2010
- Capacity 75 Million Gallons per year
- Feedstock Flexible
- Producing Diesel and Jet

NESTE OIL

- Commercial plants in operation: Finland, Rotterdam and Singapore
- Capacity 50M Gal/yr (Finland), 250 Mgal/yr Singapore, 250 Mgal/yr Rotterdam
- Feedstock Flexible
- Producing Diesel (Rotterdam and Singapore)
- Producing Diesel and Jet in Finland

AltAir Fuels

- ATA organized an MOU with AltAir for an off take agreement for HEFA
- Fifteen (15) airlines signed the agreement.
- 75M gallon per year plant under construction in Bakersfield, CA. Completion data 2nd quarter 2012
- Producing Diesel and Jet

Other producers are emerging with ASTM & DefStan spec approval

Fuels Approval Process – ASTM D 4054

Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuels Additives

Test Program

- **Fuel Specification Properties**
- **Fit-for-Purpose Properties**
- **Component or Rig Tests**
- **Engine Endurance Test**

Research Report (Boeing lead author on HEFA Report)

OEM Internal Review

OEM Internal Review

AIRBUS · Honeywell · BOEING · Rolls-Royce

Reject or Additional Data as Required

FAA Review

OEM Approval

Incorporate into Fuel Specification with FAA Consensus

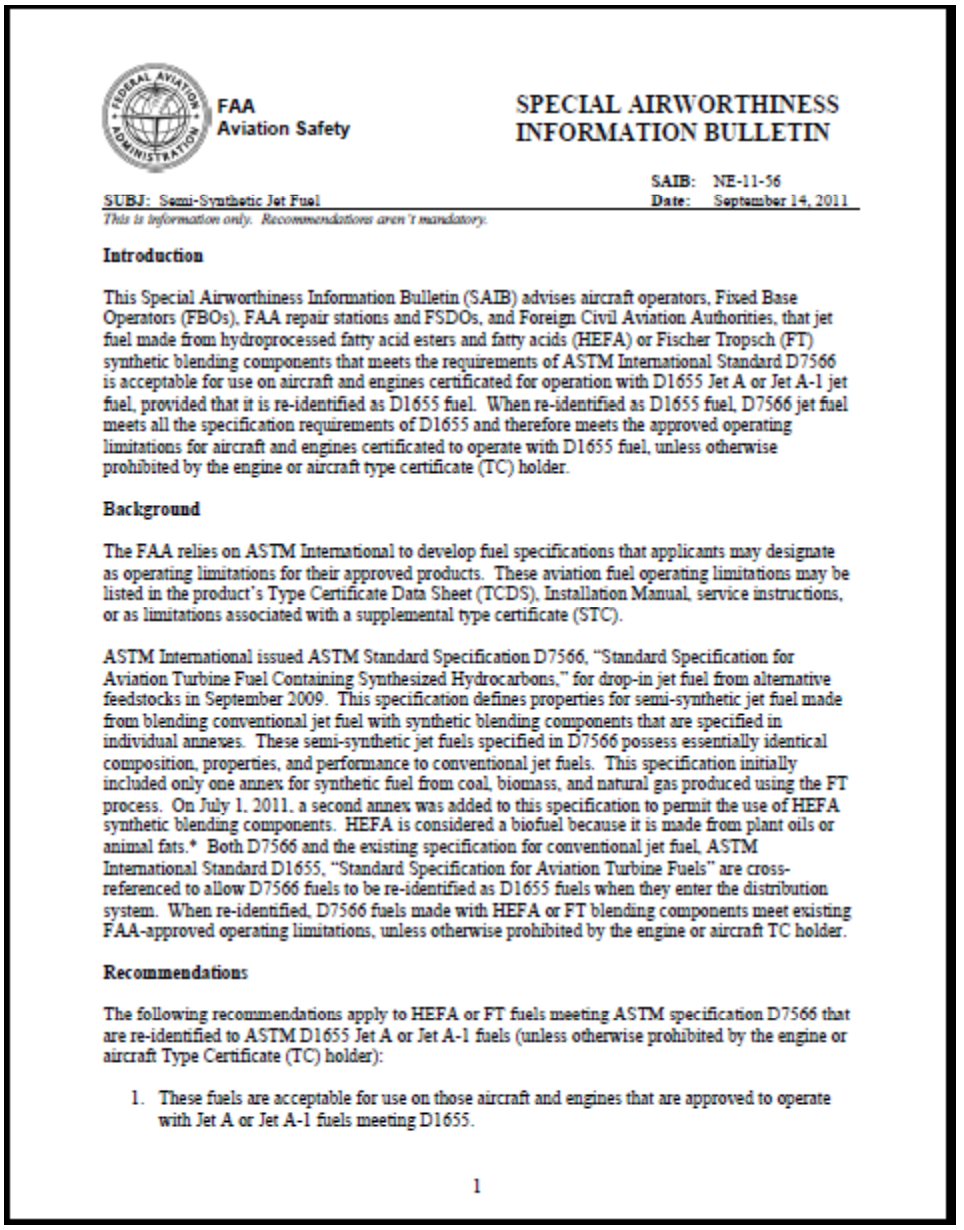
ASTM Review & Ballot

Reject or Additional Data as Required

ASTM Specification

First Authorized Biofuel Pathway Bulletin Issued 9/14/11

- **Meets fuel performance requirements**
- **Requires NO change to airplanes or engines**
- **Requires NO change to infrastructure**
- **Can be mixed or alternated with today's Jet-A fuel**



FAA
Aviation Safety

SPECIAL AIRWORTHINESS
INFORMATION BULLETIN

SAIB: NE-11-56
Date: September 14, 2011

SUBJ: Semi-Synthetic Jet Fuel

This is information only. Recommendations aren't mandatory.

Introduction

This Special Airworthiness Information Bulletin (SAIB) advises aircraft operators, Fixed Base Operators (FBOs), FAA repair stations and FSDOs, and Foreign Civil Aviation Authorities, that jet fuel made from hydroprocessed fatty acid esters and fatty acids (HEFA) or Fischer Tropsch (FT) synthetic blending components that meets the requirements of ASTM International Standard D7566 is acceptable for use on aircraft and engines certificated for operation with D1655 Jet A or Jet A-1 jet fuel, provided that it is re-identified as D1655 fuel. When re-identified as D1655 fuel, D7566 jet fuel meets all the specification requirements of D1655 and therefore meets the approved operating limitations for aircraft and engines certificated to operate with D1655 fuel, unless otherwise prohibited by the engine or aircraft type certificate (TC) holder.

Background

The FAA relies on ASTM International to develop fuel specifications that applicants may designate as operating limitations for their approved products. These aviation fuel operating limitations may be listed in the product's Type Certificate Data Sheet (TCDS), Installation Manual, service instructions, or as limitations associated with a supplemental type certificate (STC).

ASTM International issued ASTM Standard Specification D7566, "Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons," for drop-in jet fuel from alternative feedstocks in September 2009. This specification defines properties for semi-synthetic jet fuel made from blending conventional jet fuel with synthetic blending components that are specified in individual annexes. These semi-synthetic jet fuels specified in D7566 possess essentially identical composition, properties, and performance to conventional jet fuels. This specification initially included only one annex for synthetic fuel from coal, biomass, and natural gas produced using the FT process. On July 1, 2011, a second annex was added to this specification to permit the use of HEFA synthetic blending components. HEFA is considered a biofuel because it is made from plant oils or animal fats.* Both D7566 and the existing specification for conventional jet fuel, ASTM International Standard D1655, "Standard Specification for Aviation Turbine Fuels" are cross-referenced to allow D7566 fuels to be re-identified as D1655 fuels when they enter the distribution system. When re-identified, D7566 fuels made with HEFA or FT blending components meet existing FAA-approved operating limitations, unless otherwise prohibited by the engine or aircraft TC holder.

Recommendations

The following recommendations apply to HEFA or FT fuels meeting ASTM specification D7566 that are re-identified to ASTM D1655 Jet A or Jet A-1 fuels (unless otherwise prohibited by the engine or aircraft Type Certificate (TC) holder):

1. These fuels are acceptable for use on those aircraft and engines that are approved to operate with Jet A or Jet A-1 fuels meeting D1655.

1

ASTM Research Report

Fuel Producers

Bio-SPK: UOP, Syntroleum, Energy & Environmental Research Center (EERC), ENEOS, Neste Oil

FT-SPK: Sasol, Shell, Syntroleum

Feedstocks

Jatropha, Camelina, Tallow, Algae, Halophytes, Canola, Palm

Extensive Tests Performed

Fit-For-Purpose, Materials, Engine/APU, Flight and other Ground & Toxicity testing

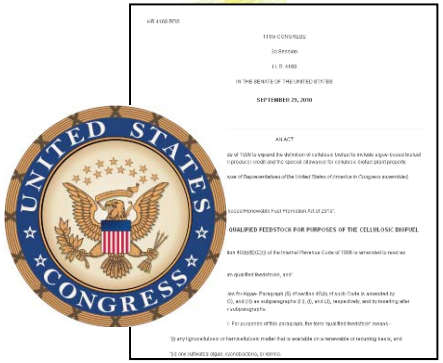
Fit-For-Purpose & Materials tests were run on 100 %Bio-SPK, 100% FT-SPK and 50% jet fuel blends of Bio-SPK and FT-SPK blends

Research Report Prepared by Boeing, UOP and the US Air Force

BOEING

UOP
A Honeywell Company

Boeing Supporting Sustainable Biofuel Policy



- **Advocacy for "global sectoral approach" for aviation emissions at ICAO/UN – measure once, pay once**
- **Farm to Fly – USDA/ATA initiative**
  - Advocate policies that benefit growers, processors, end users
  - Create parity with other energy sources to stimulate development and investment
- **Other national policy efforts to support sustainable biofuel development**
  - Long term contracting (SB 3807 & NDAA 2011 DoD Gen Counsel inputs)
  - Biojet "price collar" bill (HR 6343)
  - Algae parity bill (HR 4168)

Looking to level the policy playing field for aviation biofuels

"Farm to Fly"

- **What: An initiative between aviation industry and USDA, led by ATA and Boeing, to accelerate biofuels commercialization**
  - **Sustainable rural economic development and jobs**
  - **Increased energy security, improved environmental outcome**
- **How: Address challenges of cost, feedstock availability**
  - **Identify and advocate policy initiatives that benefit growers, processors, end users**
  - **Create parity with other energy sources to stimulate development and investment**
- **Examples:**
  - **Ensure loan regulations, grants, crop insurance programs support sustainable biofuel feedstocks**
  - **Incorporate candidate feedstocks into existing programs**
- **Early Success:**
  - **USDA has already changed two rules to broaden qualification for advanced biorefinery payments- non-rural and foreign ownership**

Airlines / ATA / Boeing: Partnering for Future Fuels

RINs Petition

- **RINs (Renewable Identification Numbers) are the “currency” created by the EPA to enforce minimum amounts of biofuel use in gasoline and diesel**
- **Jet fuel does not have to be blended with biofuels, but if the EPA approves, biojet fuel can receive a RIN for doing so**
- **This RIN can be sold to a refiner / fuel importer for ~$1.20/gallon. If 1% of all jet fuel in 2015 is renewable, this yields ~$200M/yr for renewable jet fuel producers**

Renewable jet fuel industry can benefit significantly with EPA approval