Sustainable Alternative Jet Fuels
U.S. Experience

FAA Overview: R&D Activities and Coordination Efforts

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Outline

• U.S. Vision & Approach
• U.S. Activities
• Alt Fuel Developments
• Summary
Aviation Environmental Challenges

• Aviation impacts community noise, air quality, water quality, energy usage, and climate change

• Environmental impacts from aviation emissions could pose a critical constraint on capacity growth

• Alternative jet fuels could reduce the environmental impact of aviation:
  – Carbon neutral growth by 2020 compared to 2005
  – Absolute reduction of significant air quality impacts, notwithstanding aviation growth
  – 1 billion gallons of renewable jet fuel in use by aviation by 2018
U.S. Climate Action Plan for Aviation

The U.S. is pursuing a multipronged approach to address greenhouse gas emissions from aviation

- Aircraft and engine technology improvement
- Operational improvements
- Alternative fuels development and deployment
- Policies, environmental standards, and market based measures
- Scientific understanding through research, modeling and analysis
Alternative Fuels Principles – U.S. Vision

- Alternative Jet Fuels must be drop in, have equivalent safety and better environmental performance than petroleum Jet fuel
- Enable all possible fuels that meet criteria
- Government role to address key barriers
- Work through Public-Private Partnerships
- Address the whole supply chain
- Leverage expertise and resources of other government agencies and other countries
- Aviation should be a lead user of alternative fuels
Challenges for Sustainable Alternative Fuels

• Feedstock availability

• Competitive cost for alternative fuel

• Approved for performance/safety

• Environmentally sustainable

• Commercially produced
U.S. Government Efforts Across the Supply Chain

Agriculture: Biomass Crop Assistance Program & Crop Insurance Program

Energy & Defense: R&D grants

Agriculture & Energy: R&D grants

FAA & Defense: C/Q Fuel testing

FAA, Defense, & NASA: Enviro Analysis

Agriculture, Navy, & Energy: Defense Production Act and Biorefinery Program

Defense & Airlines: fuel purchase

FAA: Guidance for Airports

EPA: Renewable Fuel Standard

Feedstock Production

Feedstock Logistics

Fuel Conversion

Conversion Process Scale-up/Integration

Fuel Testing / Approval

Fuel Performance | Environment Assmt

Enable Production

End User/Buyer

FAA & Defense: C/Q Fuel testing

Agriculture, Navy, & Energy: Defense Production Act and Biorefinery Program

FAA: Guidance for Airports

EPA: Renewable Fuel Standard
FAA Alternative Jet Fuel Activities

• **Testing**
  - Support Cert/Qual testing
  - Improve Cert/Qual process
  - Emissions measurements

• **Analysis**
  - Environmental sustainability
  - Techno-economic analysis
  - Future scenarios

• **Coordination**
  - Interagency
  - Public-Private
  - State & Regional
  - International
FAA Alternative Jet Fuel Activities

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Aviation Fuel Qualification (ASTM D4054 Process)

Specification Properties

Fit-For-Purpose Properties

Component/Rig Testing

Engine/APU Testing

ASTM D7566 Revision

ASTM Balloting Process

ASTM Review & Ballot

Accept

Reject

Re-Eval As Required

ASTM Specification

FAA & OEM Review & Approval

ASTM Research Report

Federal Aviation Administration
Alternative Jet Fuel Pathways & Status

Resource
- Waste Gas
- Natural Gas
- Coal
- Solid Waste
- Lignocellulosic Biomass
- Sugar & Starch Crops
- Terrestrial Oil Crops & Waste FOG

Process
- Advanced thermo-processing
- Bio-processing
- Gasification
- Pyrolysis
- Saccharification

Intermediate
- Syngas
- Alcohols
- Bio-oil

Process
- F-T Synthesis
- Thermo-processing
- Hydro-processing

Product
- Jet Fuel
- FT-SKA
- FT-SPK
- ATJ-SKA
- ATJ-SPK
- HDCJ
- SK, SAK
- SIP
- CH
- HEFA
- GREEN DIESEL

ASTM Status
- Draft – Subject to Revision – July 28, 2014
- Annex A1 Sept 2009
- Annex A2 July 2011
- Annex A3 July 2011
- ASTM TF & Report
- ASTM TF
- ASTM TF & Report
- ASTM TF & Report
- Annex A3 June 2014

Oil extraction
Emissions Measurements

• PARTNER developing relationship for black carbon emissions based on engine thrust and fuel aromatic content\(^1\)

• Intend to further expand alt jet fuels emissions knowledge using measurements from CLEEN Program and NASA tests

• Expanding knowledge to include alt jet fuels that have aromatic content (e.g., HDCJ)
FAA Alternative Jet Fuel Activities

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Environmental Analyses

- Environmental analyses
  - Focus on well-to-wake (WTW) life cycle GHG emissions
  - Results incorporated into ANL GREET model\(^1\) and EPA analysis
  - Examining climate impacts from change in combustion emissions

- Recent life cycle GHG work\(^2\)
  - Tallow and waste oils for HEFA
  - Advanced fermentation of sugars, starches, and switchgrass

- Water footprint analysis\(^3\)
  - Examined water footprint of all fuels considered for LC GHG emissions
  - Fuel use on same order of magnitude as conventional jet fuel unless irrigation is used

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3. PARTNER Project 47 (partner.aero): Staples et al. 2013
Economic Analyses

• Techno-Economic Analysis
  – Computing minimum selling price (MSP) for \( n^{th} \) plant
  – Using discounted cash flow rate of return method

• Effort is focused on identifying ways to reduce production costs

• Lower feedstock costs
  – HEFA production from rotation crop such as pennycress\(^1\)
  – Advanced fermentation using sugar cane\(^2\)

• Modify product slate
  – For HEFA, maximizing jet fuel production requires $0.25 to $0.30 per gallon more than maximizing diesel fuel to break even\(^3\)
  – Maximizing biochemicals makes certain jet fuel production pathways economical\(^4\)

• Utilizing brownfield facilities reduces production costs\(^2,\(^3\)

Research results can be found at http://partner.aero/:
1. Project 31 – Winchester et al. 2013
2. Project 47 – Staples et al. 2014
3. Project 28 – Pearlson et al. 2013
4. Project 47 – Bond et al. 2014
FAA Alternative Jet Fuel Activities

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  - State & Regional
  - International
Commercial Aviation Alternative Fuels Initiative (CAAFI)

- Public-Private coalition for commercial aviation to engage the emerging alternative fuels industry
- Enable development of alt jet fuels:
  - Equivalent safety/performance (drop-in)
  - Comparable cost
  - Environmental improvement
  - Security of Energy supply
- Four teams for key issues:
  - Environment Team
  - Certification-Qualification Team
  - R&D Team
  - Business Team
- State and Regional Support
- International Cooperation
Coordinate USG Efforts Across the Supply Chain

- **Feedstock Production**
  - Agriculture: Biomass Crop Assistance Program & Crop Insurance Program
  - Agriculture: Feedstock Development Center Grants
  - Energy: R&D

- **Feedstock Logistics**
  - Energy & Defense: R&D grants

- **Fuel Conversion**
  - Agriculture & Energy: R&D grants

- **Conversion Process Scale-up/Integration**
  - FAA & Defense: C/Q Fuel testing
  - FAA, Defense, & NASA: Enviro Analysis

- **Fuel Testing / Approval**
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- **Enable Production**
  - Agriculture, Navy, & Energy: Fuel Performance | Environment Assessment

- **End User/Buyer**
  - Defense & Airlines: Fuel purchase
  - FAA: Guidance for Airports

**Agencies and Programs:***
- USDA
- EPA
- NASA
- NSF
Farm to Fly 2.0

… “THEREFORE, AS OUR GOAL, we the undersigned, jointly signify our intent to continue working together over the next five years in an expanded collaboration entitled “Farm to Fly 2.0”, to enable commercially viable, sustainable bio-Jet Fuel supply chains in the U.S. that are able to support the goal of one billion gallons of bio-Jet Fuel production capacity and use for the Aviation Enterprise by 2018”
CAAFI State & Regional Deployment

- Working with local lead organizations/POCs
- Provide context, advice, strategy, benchmarking
- Facilitate networks & links between stakeholders
- Link to Farm to Fly 2.0

*Does not include Dept. of Energy Pilot Projects, Defense Production Act Projects, map credit to diymaps.net.
International Engagement

• Bilateral Cooperation Agreements
• Informal coordination with counterpart organizations
• International Civil Aviation Organization
New FAA Programs

Aviation Sustainability Center (ASCENT)
• New Center of Excellence for Alternative Jet Fuels and Environment

Continuous Lower Energy, Emissions and Noise (CLEEN) II
• Reduce aircraft fuel burn, emissions and noise through technology & advance alternative jet fuels
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)*

* Denotes USDA NIFA AFRI-CAP Leads and Participants & Sun Grant Schools

ASCENT Website: http://ascent.aero
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 open now until January 23, 2015
  – More information available at: https://faaco.faa.gov/index.cfm/announcement/view/18077
Alt Fuels Development Progress 2014

- ASTM approval of SIP fuels (June 2014), additional ballots under preparation
- Engine tests of novel fuels continue
- ASCENT analysis projects established
- Continued domestic and international engagement
Alt Fuels Progress Anticipated in 2015

- Continue support to ASTM approval of additional fuel pathways

- Continue Certification / Qualification testing of fuels with current methods (D4054) to support ASTM approval

- Continue work to improve testing methods to reduce cost and time of Certification / Qualification over longer term

- Continue analysis in support of deployment

- Continue domestic and international engagement
Summary

- Alternative jet fuels are a key component of U.S. strategy for meeting aviation environmental goals
- FAA efforts are directed to overcoming key challenges via testing, analysis and coordination
- Multiple programs and activities focus on different aspects of the challenge
- Partnerships across technical areas are a key focus
- Strong domestic and international coordination necessary for success
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