FAA Alternative Jet Fuels R&D and ASCENT Project 01

Presented to: SOAP-Jet Webinar
By: Nate Brown
Date: Feb 23, 2018
Where do we stand?

- Commercial flights on SAJF are expanding
- 1.5 million gallons in 2017 from two commercial producers, many commercial user, multiple U.S. airports

Notes:
1. Includes procurements of fuel by U.S. government, U.S. airlines, manufacturers, and foreign carriers delivered to U.S. airports
FAA Alternative Jet Fuel R&D Investments

• Testing
  ▪ Support certification testing
  ▪ Improve certification process
  ▪ Emissions measurements

• Coordination
  ▪ Public-Private
  ▪ Interagency
  ▪ State & Regional
  ▪ International

• Analysis
  ▪ Environmental sustainability
  ▪ Techno-economic analysis
  ▪ Future scenarios
Analysis: ASCENT 01 Alternative Jet Fuel Supply Chain Project

- Examine barriers to alternative jet fuel production via the full range of pathways being considered for ASTM approval
- WSU, MIT, Purdue, UT Knoxville (UTK), U. of Hawaii, PSU considering the entire supply chain through multiple lenses:
  - Feedstock production
  - Techno-economics of pathways
  - Existing infrastructure
  - Transportation routes and capacity
  - Community assets
- Quantify economic, environmental, and societal opportunities and challenges & identify opportunities for win-win-wins
- Working with CAAFI and USDA
- Links to U.S. DOT Volpe National Transportation Systems Center, DOE Argonne National Lab & National Renewable Energy Lab (NREL)
Analysis: ASCENT Project 01 Priorities 2017/18

1. International Civil Aviation Organization (ICAO) Alternative Fuels Task Force Support
2. Production Analyses
3. Economic Viability Analyses
4. Lipid-focused (oil based) Analyses
5. Regional Tactical Deployment Projects
   - Collaborative projects leverage strengths across A01 team
   - Achieve supply chain development and move toward commercial production
   - Initial projects:
     - **Inland Pacific Northwest** lipid-based alternative jet fuel
     - **Hawaii** C&D waste-based alternative jet fuel
     - **Southeastern U.S.** lipid- and biomass-based alternative jet fuel
### ASCENT P1 Regional Approach

<table>
<thead>
<tr>
<th>Project Groundwork (G)</th>
<th>Regional Deployment Project (D)</th>
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<tbody>
<tr>
<td>G1 - Analysis of feedstock-conversion pathway efficiency, product slate (including co-products), maturation</td>
<td>D1 - Develop detailed supply chain scenarios (feedstock, products/co-products, infrastructure, logistics, conversion method) for analysis/deployment</td>
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<tr>
<td>G2 - Scoping of Techno Economic Analysis (TEA) issues</td>
<td>D2 - Stochastic TEA of pathway</td>
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<td>G3 - Screening level GHG Life Cycle Analysis (LCA)</td>
<td>D3 - Evaluate sustainability and GHG LCA</td>
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<td>G4 - Identification of supply chain participants/partners</td>
<td>D4 - Farmer revenue, rural development, economics</td>
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<td>G5 - Develop appropriate stakeholder engagement plan</td>
<td>D5 - Evaluate social capital/acceptability</td>
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<td>G6 - Identify and engage stakeholders</td>
<td>D6 - Evaluate environmental services revenue options</td>
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<tr>
<td>G7 - Acquire transportation network and other regional data for Freight and fuel Transportation Optimization Tool (FTOT) and other modeling</td>
<td>D7 - Evaluate potential economic benefit of project</td>
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<td>G8 - Evaluate infrastructure availability</td>
<td>D8 - Supply chain risk assessment for business adoption</td>
</tr>
<tr>
<td>G9 - Evaluate feedstock availability</td>
<td>D9 - Incorporate regional data into FTOT for geospatial analysis</td>
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<td>G10 - Develop specific regional proposal</td>
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Alternative Jet Fuel Supply Chain
Tropical Region Analysis
Project 001
Project manager: Nathan Brown, FAA
Lead investigator: Scott Turn, Hawaii Natural Energy Institute, University of Hawaii
February 23, 2018
SOAP-JET Webinar

Opinions, findings, conclusions and recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of ASCENT sponsor organizations.
Kauai
Oahu
Molokai
Maui
Lanai
Hawaii

620 km
385 miles

Nearest Continental Land Mass – 2,400 mi

Land area ~6,250 square mile
Population ~1.4 M
Jet Fuel Use in Hawaii, 2015
Commercial Airports and Military (million gallons)

<table>
<thead>
<tr>
<th>Location</th>
<th>Use (million gallons)</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Honolulu</td>
<td>481.9</td>
<td>71%</td>
</tr>
<tr>
<td>Kauai</td>
<td>22.8</td>
<td>3%</td>
</tr>
<tr>
<td>Maui</td>
<td>71</td>
<td>11%</td>
</tr>
<tr>
<td>Kona</td>
<td>27.6</td>
<td>4%</td>
</tr>
<tr>
<td>Hilo</td>
<td>2.7</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Military</td>
<td>73.3</td>
<td>11%</td>
</tr>
</tbody>
</table>

Total Use in 2015 -- 679 M Gallons
Value Chain for AJF Production

Feedstock Production
Feedstock Logistics
Conversion
Distribution
End Use

Agriculture ---- Industry ---- Investors ---- Government ---- Community
Tropical Bioresources and Pathways to AJF

Bioresource

Intermediate Products & Conversion Technologies

Alternative Jet Fuel

Blue – Commercial elsewhere
Pink – Commercial in Hawaii
Orange – Under Development

Synthesized Kerosene & Aromatic Kerosene
Synthesized Iso-Paraffins
Synthesized Paraffinic Kerosene
Synthesized Paraffinic Kerosene w/ Aromatics
Hydro-processed Depolymerized Cellulosic Jet
Catalytic Hydro-thermolysis
Hydrotreated Esters & Fatty Acids

Sugarcane
Fiber Sorghum
Sesbania
Glyricidia
Energycane
Banagrass
Eucalyptus
Leucaena
Rice Residues
Jatropha
Kamani
Pongamia
Croton megalocarpus

Extraction → Sugars

Bioprocessing → Hydro-processing

Hydrolysis

Gasification & Gas Clean Up

Fiber

Pretreatment

Urban Solid Waste

Extraction → Oil

Pyrolysis

Catalytic Hydrothermolysis

Hydro-processing

Synthesis Gas

Fischer Tropsch Synthesis

Bio-Oil

Synthesized Paraffinic Kerosene

Synthesized Paraffinic Kerosene w/ Aromatics

Hydro-processing

Synthesized Kerosene & Aromatic Kerosene

Synthesized Iso-Paraffins

Synthesized Paraffinic Kerosene

Hydro-processed Depolymerized Cellulosic Jet

Catalytic Hydro-thermolysis

Hydrotreated Esters & Fatty Acids

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Hydro-processing

Synthesized Kerosene & Aromatic Kerosene

Synthesized Iso-Paraffins

Synthesized Paraffinic Kerosene

Hydro-processed Depolymerized Cellulosic Jet

Catalytic Hydro-thermolysis

Hydrotreated Esters & Fatty Acids
Island of Oahu
City & County of Honolulu
~600 sq miles (~25 mi x 25 mi)
Population ~1 million

Map data ©2017 Google
PVT Land Company
Nānākuli, Hawaii
http://www.pvtland.com

- PVT is the only construction & demolition landfill on Oahu
- Current intake 1,775 tons C&D waste per day
- ~50% of intake converted to feedstock, up to 900 tpd
- Waste-in-place also “mined” for additional “feedstock”
- Feedstock: wood, plastic, cloth, paper, and other organics
- Recycling system to generate feedstock was dedicated in 2014, currently processing and stockpiling material
- Tipping fee $50 per ton, or $54 per ton for LEED certified
PVT Feedstock Processing Facility
PVT Site Characteristics

Rainfall – 525 to 800 mm per yr
20 to 30 inch per yr

Prevailing Winds

Map data ©2017 Google
PVT Feedstock Characterization

• Characterization of feedstock properties needed to inform conversion process design
  – Ultimate analysis for major elements: C, H, O, N, S
  – Proximate analysis: volatile matter, fixed carbon and ash
  – Major ash species: K, Cl, Na, P, Mg, Si, Fe, Ti, Al, and Ca
  – Minor ash species: Mn, Fe, Cu, Zn, Rb, and Sr
  – Moisture content
  – Energy content or heating value

• Characterization of feedstock properties needed for logistics particle size of materials, bulk densities, etc.

• Time series data to assess variability in supply
Value Chain for AJF Production

Feedstock Production
Feedstock Logistics
Conversion
Distribution
End Use

Agriculture ---- Industry ---- Investors ---- Government ---- Community
Possible Locations of Value Chain Participants

- PVT Land Company
- Joint Base Pearl Harbor-Hickam
- Island Energy Refinery
- Campbell Industrial Park
- Par Hawaii Refinery
- Kalaeloa Airport
- Daniel K. Inouye Airport

~10 miles between PVT and CIP
Hawaii Petroleum Supply Schematic

* Currently Par Hawaii and Island Energy refineries

Questions?
Alternative Jet Fuel Supply Chain Analysis

ASCENT 1

Regional Supply Chain Approaches

Development of a Supply Chain for the Production of Jet Fuel from Oilseeds Grown in the Pacific Northwest

Project Manager: Nathan Brown, FAA
Lead Investigators: M. Wolcott, K. Brandt, N. Martinkus
Graduate Student: Dane Camenzind, WSU

[January 22, 2018]

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SIMPLE SUPPLY CHAIN MODEL

KEY

- Inputs
- Operations
- Outputs

Inputs
- OILSEEDS (HARVEST)
- OILSEED STORAGE
- OILSEED CRUSHER
- HEFA REFINERY
- GREEN JET FUEL

Operations
- FATS, OILS & GREASES

Outputs
- BIODEisel & GREEN DIESEL
- OIL

- GREEN JET FUEL
COMPLEX SUPPLY CHAIN MODEL

KEY

- Inputs
- Operations
- Outputs
OILSEEDS (HARVEST)

FATS, OILS & GREASES

TERMINAL ELEVATOR

HEFA REFINERY

BIOFUELS

BIODIESEL PLANT

EDIBLE OIL MARKETS

IMPORTED OILSEEDS

OILSEED CRUSHER

OILSEED STORAGE

OILSEED MEAL MARKETS

GREEN NAPHTHA

GREEN JET FUEL

BIODIESEL & GREEN DIESEL
Focus on dryland systems

Decisions often based on moisture availability
  - Summer fallow is common in drier areas

Brassicas are viewed as secondary crops with benefits for soil health and grass weed control
COMMON CROPS

SMALL GRAINS
- Winter Wheat
- Spring Wheat
- Barley

PULSES
- Peas
- Lentils
- Garbanzo Beans

BRASSICA OILSEEDS
- Canola/Rapeseed
- Mustard
- Camelina
- Carinata
ANNUAL PRECIPITATION (inches)

- <9"
- 12-9"
- 12-18"
- 18-24"
- >24"

PRISM Climate Group,
Precipitation 30-yr Normal
AGROECOLOGICAL CLASSES

Dynamic/Stable REACCH Agroecological Classification

Legend
- Research Sites
- Rivers

Agroecological Classes
- Annual Crop - Stable
- Annual Crop - Dynamic
- Annual Crop-Fallow Transition - Stable
- Annual Crop-Fallow Transition - Dynamic
- Grain Fallow - Stable
- Grain Fallow - Dynamic
- Irrigated - Stable
- Irrigated - Dynamic
AGROECOLOGICAL CLASSES

GRAIN FALLOW
• >40% fallow

Rotations:
• WW-F
• WW-F-WC-F

TRANSITION
• 10-40% fallow

Rotations:
• WW-SW-F
• WC-SW-F
• WW-SC-F

ANNUAL CROP
• <10% fallow

Rotations
• WW-SW-Pulse
• WW-Pulse
• WW-SW-SC
Figure 15. Spring canola yields obtained using historic weather data.
GRID INPUTS

- 2016 USDA Cropland Data Layer (CDL)
- Canola

Production

Canola
GRID INPUTS

- 2016 USDA Cropland Data Layer (CDL)
- Canola
- 25 km grid (96 cells)
OILSEED STORAGE

- Long-term storage
- Country elevators are typically built along rail
- Country elevators have an average “catchment radius” of 10-30 miles
EXISTING TERMINALS

- Shuttle Elevator
- Barge Terminal
- Major Grain Exporter

- Regional Railroad
- BNSF Railroad
- Columbia & Snake River System
OILSEEDS (HARVEST)

- OILSEED CRUSHER
  - FATS, OILS & GREASES
  - OILSEED STORAGE
    - TERMINAL ELEVATOR
    - IMPORTED OILSEEDS
  - OIL REFINERY
    - HEFA REFINERY
      - GREEN NAPHTHA
      - BIODIESEL & GREEN DIESEL
      - GREEN JET FUEL
    - OILSEED MEAL MARKETS
  - BIODIESEL PLANT
    - EDIBLE OIL MARKETS
DAIRY & CATTLE

Beef Slaughterhouse

Minor Dairy Producing County

Major Dairy Producing County
HEFA REFINERIES

- Often converted from or co-located next to existing petroleum refineries
- Conversion process requires hydrogen
  - Often produced from natural gas
- Produces green diesel and naphtha in addition to green jet fuel
PRELIMINARY MODEL RUN

OILSEEDS
(HARVEST)

OILSEED
CRUSHER

FATS,
OILS &
GREASES

TERMINAL
ELEVATOR

IMPORTED
OILSEEDS

OILSEED
STORAGE

OILSEED
MEAL
MARKETS

EDIBLE
OIL
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HEFA
REFINERY

Biodiesel
Plant

GREEN
JET FUEL

Biodiesel &
Green Diesel

OILSEED
STORAGE

GREEN
NAPHTHA

OILSEED
MEAL
MARKETS
QUESTIONS