

# Alternative Fuels R&D – A U.S. Perspective

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# R&D Principles – U.S. view

- **Alternative Jet Fuels must be drop in, have equivalent safety and better environmental performance than petroleum Jet.**
- **Enable as many fuels as possible that meet criteria (certification (safety/performance), environment, cost)**
- **Government should not choose winners**
- **Fund early research**
- **Bridge chasm from development to deployment**



# Outline

- *R&D Focus*
- *U.S. Context (Legislation and Programs)*
- *Commercial Aviation Alternative Fuels Initiative (CAAFI)*
- *R&D Completed*
- *R&D To do*



# R&D focus on evaluating:

- **Fuel options**
  - processes & feedstocks
- **Fuel performance**
- **Environmental Sustainability**
  - Emissions, life cycle analyses (LCA), land use, water
- **R&D metrics (Fuel Readiness Level - FRL)**
- **Reducing production cost**
  - Increase processing efficiency



# U.S. Legislation

- **Energy Independence and Security Act (EISA) of 2007**
  - Renewable Fuel Standard (RFS)
- **Food, Conservation, and Energy Act (FCEA) of 2008 (“Farm Bill”)**
  - Energy Title (Title 9)
- **Economic Stimulus?**



# Forecast for Renewable Fuel Standard (Billion Gallons)

Year	Renewable Biofuel	Advanced Biofuel	Cellulosic Biofuel	Biomass-based Diesel	<i>Undifferentiated Advanced Biofuel</i>	Total RFS
2008	9.0					9.0
2009	10.5	.6		.5	0.1	11.1
2010	12	.95	.1	.65	0.2	12.95
2011	12.6	1.35	.25	.8	0.3	13.95
2012	13.2	2	.5	1	0.5	15.2
2013	13.8	2.75	1		1.75	16.55
2014	14.4	3.75	1.75		2	18.15
2015	15	5.5	3		2.5	20.5
2016	15	7.25	4.25		3.0	22.25
2017	15	9	5.5		3.5	24
2018	15	11	7		4.0	26
2019	15	13	8.5		4.5	28
2020	15	15	10.5		4.5	30
2021	15	18	13.5		4.5	33
2022	15	21	16		5	36

Source: Energy Independence and Security Act of 2007 (H.R. 6)



# U.S. Fuels R&D Programs

- **U.S. Department of Agriculture (USDA)/Department of Energy (DOE) Biomass R&D Initiative (FCEA sec. 9008)** – [\$25m '09]
- **USDA Biorefineries program (FCEA sec. 9003)**
  - [\$75m '09; \$245m '10; possible \$150m more]
- **DOE Biorefineries** – [possible \$200m]
- **U.S. Air Force (USAF) Alternative Fuel Certification Program**
  - 300,000 gallons Hydro treated Renewable Jet (HRJ) in '09.
- **Defense Advance Research Projects Agency (DARPA) Algae**
- **NASA Fundamental Aeronautics**
- **DOE Advanced Biofuel Initiative**
  - Algal Biofuels Roadmap (fall '09)
- **FAA/NASA Continuous Low Energy, Emissions Noise (CLEEN)**



# CAAFI R&D team



***"Define the R&D required to enable the development of commercial aircraft “drop-in” alternative fuels that are derived from a multiple of sources. Identify promising new innovative developments in alternative fuels."***

## **R&D Workshop, Dayton, Ohio 1/27/09**

- **Review Govt. energy funding initiatives**
- **Update on stakeholder activities**
- **Fuel Readiness Level scale**
- **R&D Roadmap**
- **Feedstock Roadmap**



# Exploring Processes to Produce Fuel

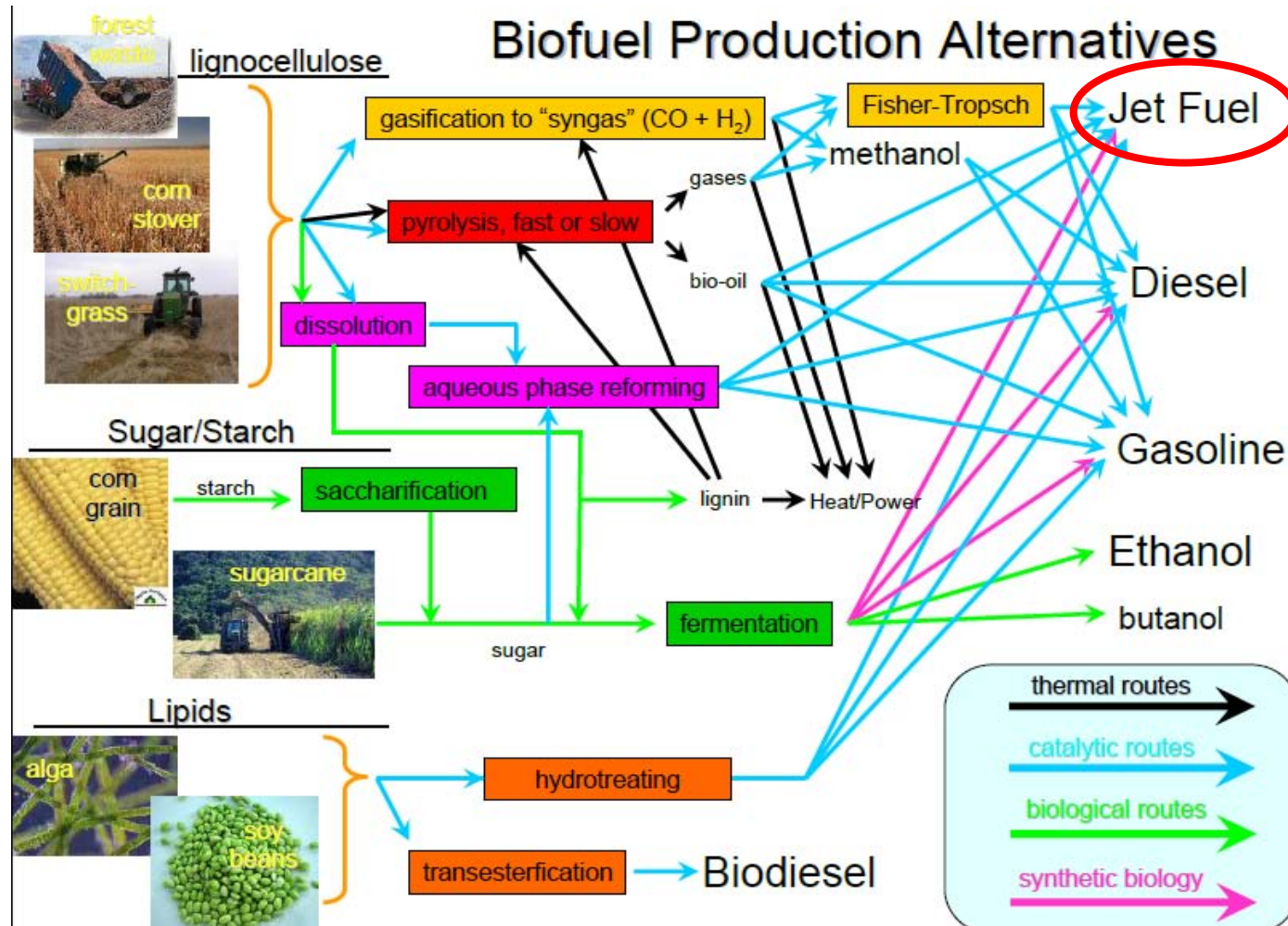
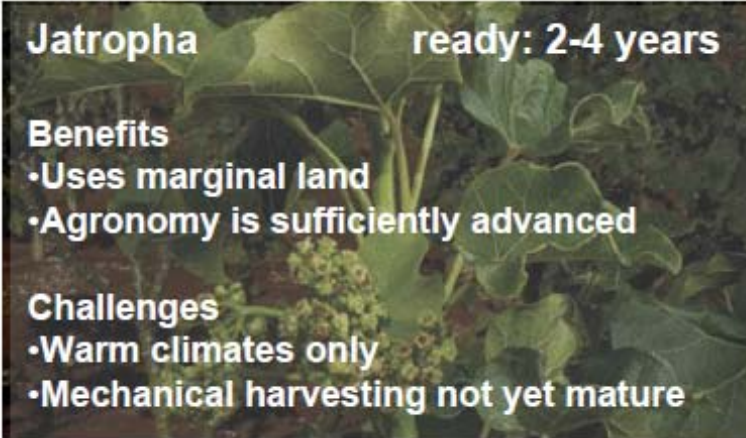


Image: John Regalbuto, NSF

# Exploring Sustainable Feedstocks



**Jatropha** ready: 2-4 years

**Benefits**

- Uses marginal land
- Agronomy is sufficiently advanced

**Challenges**

- Warm climates only
- Mechanical harvesting not yet mature



**Algae** ready: 8-10 years

**Benefits**

- High productivity
- Potential for scale

**Challenges**

- Major process tech. innovation needed
- GMO risks



**Halophytes** ready: 2-4 years

**Benefits**

- Uses desert land and salt water
- Part of system designed for GHG reduction

**Challenges**

- Proven at pilot scale to-date
- Improve agronomy for cost reduction



**Camelina** ready: now

**Benefits**

- Ready-to-go
- Can integrate with traditional agriculture

**Challenges**

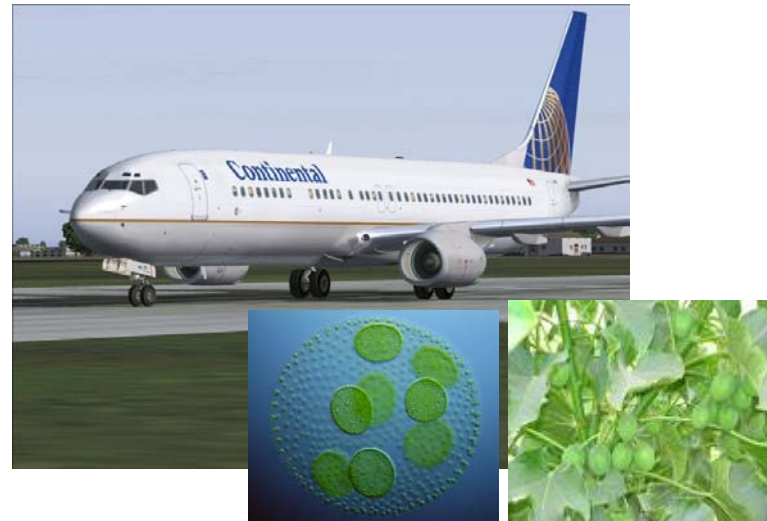
- Limited total potential owing to yield
- Somewhat tied to grain market swings

Image: Boeing

# High Visibility Biofuels Flight Tests

In past 2 months, 3 HRJ flight tests:

- Boeing / Continental / CFM on 1/7/2009 in Houston, TX



- Boeing / Air New Zealand / Rolls Royce on 12/30/2008
- Boeing / JAL / Pratt & Whitney on 1/30/2009

# Measuring Environmental Impacts

- Environmental Impacts being measured
- Advances in Life Cycle Analyses (LCA)

*More details presented this afternoon*



# CAAFI Fuel Readiness Levels (FRL)

FRL	Description	CAAFI Toll Gate	FRL	Description	CAAFI Toll Gate	Fuel Qty	MRL	USAF TRL
1	Basic Principles Observed and Reported	Feedstock and process basic principles identified					1	
2	Technology Concept Formulated	Feedstock and complete process concept identified					2	
3	Proof of Concept	Small Fuel Sample Available from Lab Basic Fuel Properties Validated (Thermal Stability/Freezing Point)				500 ml	3	1. Basic Fuel Properties Observed and Reported
4.1 4.2	Preliminary Technical Evaluation	System Perf. & Integration Studies Entry Criteria/Specification Properties Evaluated (MSDS/D1655/MIL 83133)				10 gal	4	2. Fuel Specification Properties
5.1 5.2 5.3 5.4	Process Validation	Laboratory Production Development Subscale Production Demonstrated Scalability of Production Demonstrated Pilot Plant Capability Enabled	6.1 6.2 6.3 6.4	Full-Scale Technical Evaluation	Fit-For-Purpose Prop's Evaluated Turbine Hot Section Component/Rig/Emissions Testing Engine/APU Testing	80 gal 4K gal 20K gal 225K gal	5 6 7 8	3. Fit for Purpose 4. Extended Lab Fuel Property Test 5. Component Rig Testing 6. Small Engine Testing
								7. Pathfinder
			7	Fuel Approval	Fuel Class/Type Listed in Int'l Fuel Standards			8. Validation/Certification 9. Field Service Evaluations
8	Commercialization Validated	Business Model Validated for Production Go-Ahead Airline/Military Purchase Agreements						
9	Production Capability Established	Full Scale Plant Operational					9-10	

Legend:

R & D

Certification/Qualification

Business & Economics



# R&D Completed

- **Fuel options identified**
  - FT and HRJ options
- **Fuel Performance evaluated**
  - Fuel properties
  - Engine and Flight tests
- **Environmental Impacts being measured**
  - Engine emissions – Sulfur Oxides (SOx), particulate matter (PM)
  - Greenhouse Gas (GHG) LCA
- **FRL scale created**



# R&D To Do:

- **Fuel options**
  - ID additional processes & feedstocks
- **Fuel performance**
  - Test additional fuels
- **Environmental Sustainability**
  - Continue LCA, land use, water data gathering
- **Reducing production cost**
  - Identify process efficiency gains



**Questions?**

