

Sustainable Aviation Fuels: Research, Developments and Deployment



Jim Rekoske
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Tokyo, Japan

Uop
A Honeywell Company

Honeywell

- **Honeywell's Participation in Sustainable Aviation**
- **Overview of Sustainable Aviation Fuel Pathways**
 - Technology Types
 - Trade-offs for Technology Types
- **Certification Processes**
- **Commercial Outlook**
 - Current Status
 - Adoption Barriers
 - Expectations for the Future

Honeywell International

Honeywell

- \$36 billion (2011) in revenues, 50% outside of U.S.
- Nearly 130,000 employees operating in 100 countries
- Morristown, NJ global corporate headquarters

Aerospace



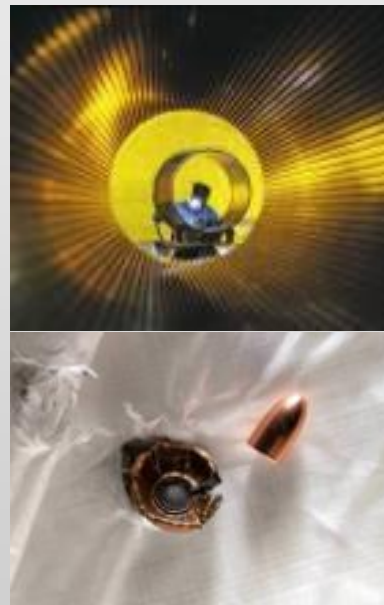
\$10.8-11.2B*

Automation & Control Solutions



\$14.7-15.1B*

Specialty Materials



\$5.0-5.2B*

Transportation Systems



\$4.3-4.5B*

*'11 revenues estimate

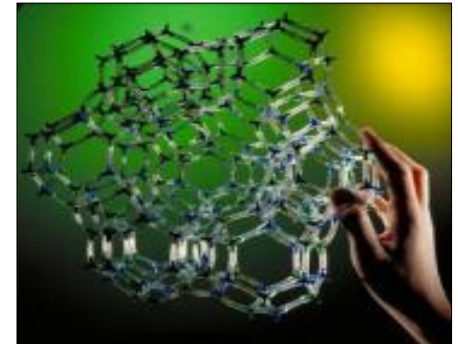
UOP LLC, A Honeywell Company

Honeywell

- Founded in 1914
- A leading international supplier and licensor of processing technology, catalysts, adsorbents, process plants, and technical services.
- Largest process licensing organization in the world.
- 31 out of 36 refining technologies in use today were developed by UOP

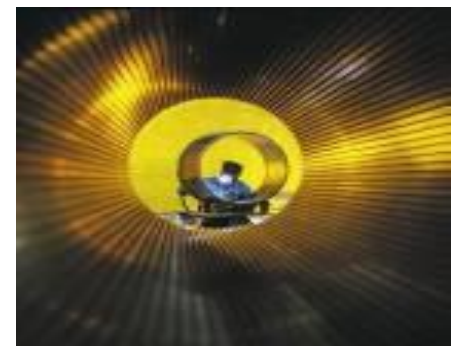
Markets

- Petroleum refining
- Petrochemical production
- Gas processing
- Renewable fuels and chemicals



Products/Services

- Developing and licensing of process technology
- Equipment
- Catalysts
- Adsorbents
- Molecular sieves



We've Known Hydrocarbon Fuels for 100 Years!

Honeywell's UOP: A Global Presence for Sustainable Fuels

Honeywell



Global Initiatives

- SAFUG: Sustainable Aviation Fuels User Group
- ATAG: Air Transport Action Group
- ICAO Sustainable Aviation Fuel Expert Team (Jim Rekoske member)

The world's most recognized experts in sustainable fuels



Selected Demonstration Activities

Honeywell



30 January 2009

Feedstock: Camelina, Jatropha and Algal Oil



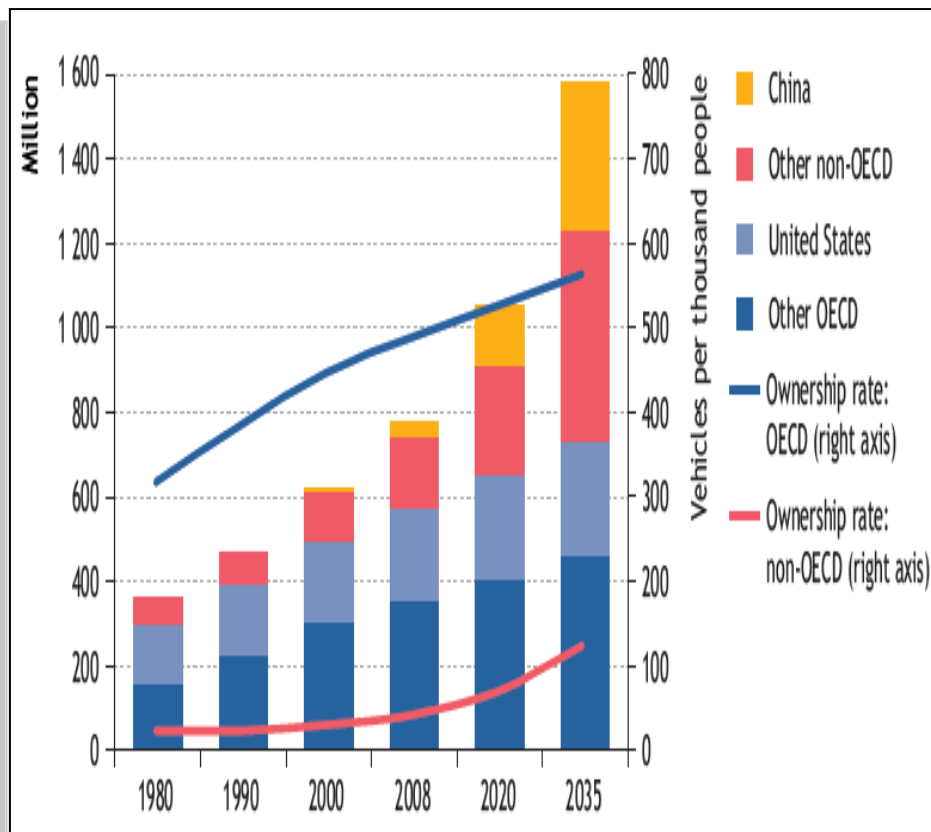
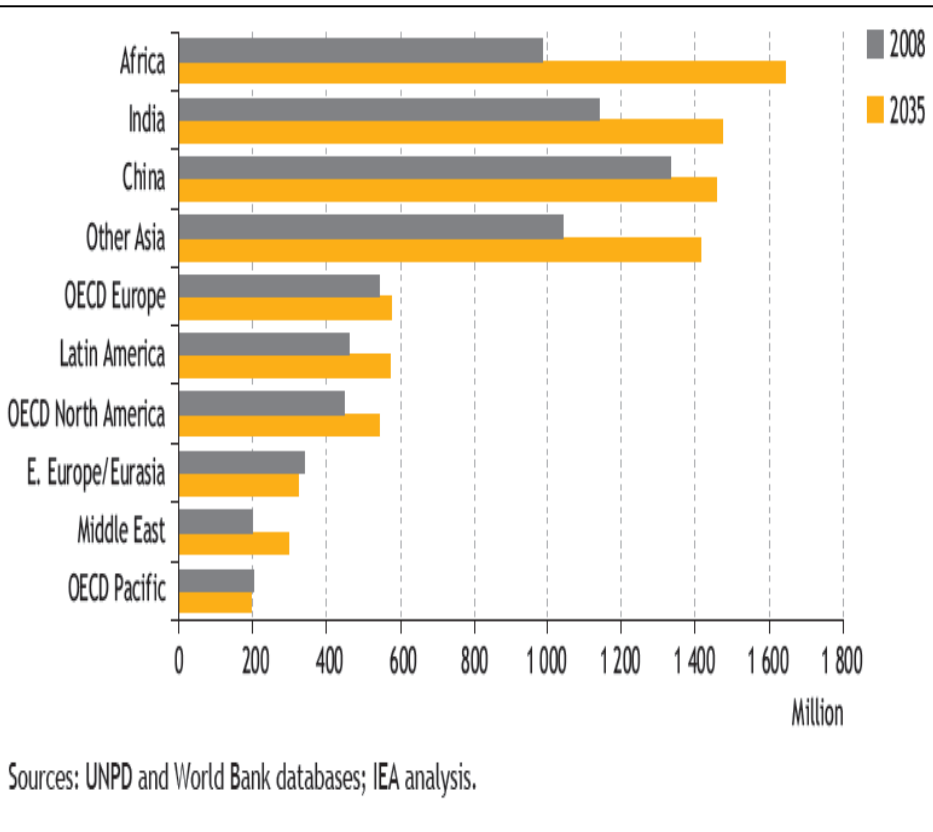
On Friday, June 17 2011, Honeywell Green Jet Fuel completed the first-ever transatlantic biofuel flight

The Honeywell-operated Gulfstream G 450 aircraft departed Morristown, NJ to fly to Paris, France on a 50/50 blend of Honeywell Green Jet Fuel made from camelina and petroleum-based fuel.

Driver for Our Involvement: Global Population and Prosperity

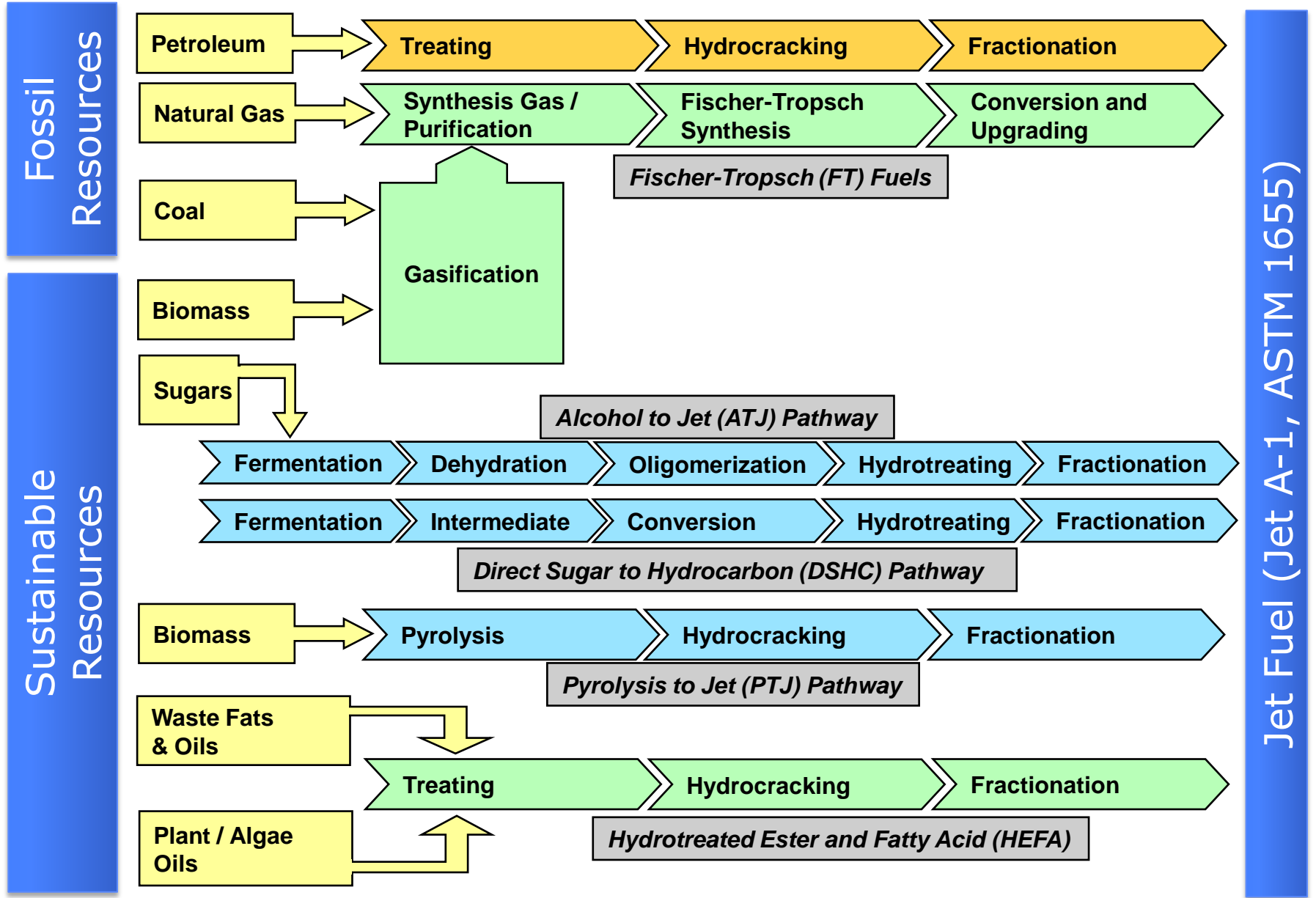
Population Growth

Consumption Growth



Growth of Population (toward 9.0B) and Prosperity Drive Demand

Overview of Alternative Aviation Fuel Paths



Fuel Validation Process



Specification Properties

FRL 4.2



Fit-For-Purpose Properties

FRL 6.1



Component/Rig Testing

FRLs 6.2 & 6.3

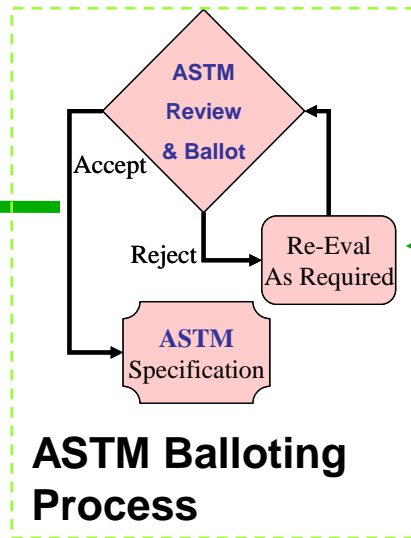


Engine/APU Testing

FRL 6.4



ASTM Specification



ASTM Balloting Process



OEM Review & Approval



ASTM Research Report

FRL 7: Fuel Class Listed in Int'l Fuel Specifications

Slide courtesy of Mark Rumizen, FAA/CAAFI



- **Fischer-Tropsch based fuels available commercially today**
 - Middle East (natural gas) and South Africa (coal)
- **Between military and commercial aviation, more than 1,900 missions have been completed with HEFA sustainable fuels**
- **No commercially sustainable alternative aviation fuels available**
 - HEFA fuels available in modest quantities in few locations
 - Dedicated commercial production likely in 2013 (Europe, US West Coast)
 - Additional commercial plants for similar products being built...
 - Valero (US Gulf Coast), Emerald (US Gulf Coast), ENI (Europe)
 - However, these projects unlikely to produce jet fuel
- **Additional pathways at various stages of approval**
 - Likely 2014 before additional pathways approved

- **Role of Cost as Barrier**

- Much has been written about fuel costs – R&D scale
- At commercial scale, HEFA refining costs greater by \$4-5 per bbl
- Cost of raw material primary barrier
- Petroleum: \$80-100 / bbl; Sustainable HEFA feeds: >\$140 / bbl

- **Cost of Feedstock Driven by Supply**

- Sustainable feedstocks available, supply limited
- Opportunities exist to expand supply without other disruptions
- Market in infancy – time needed, particularly in agricultural markets

Costs at scale can be competitive with petroleum

- **Alternative products from sustainable resources creating competition**
 - Fine Chemicals
 - Commodity Chemicals
 - Other fuels, most notably diesel fuel
- **Economic considerations difficult to avoid**
 - Fine, commodity chemicals more valuable than fuel
 - Consumer pull for renewable alternatives ⇒ considerable premium
- **Technology advances, regulatory balance, and unique business approaches needed**
 - Without creativity, fuel will remain the low priority

Regulatory models which align values needed in short term

- **HEFA availability and cost positions improve in 2013 through commercial unit operations**
 - Europe, US West Coast
- **Studies fostered by US Government investment in sustainable biofuels**
 - Programs unlikely to complete study phase in 2013
 - No expected volumes from this program in 2013
- **New technologies emerge in 2013 – approval in 2014**
 - Pending pathways involve more abundant feedstocks
 - Alcohols and biomass
- **Airlines form partnerships to insure access**

- **Sustainable aviation fuels are technically feasible**
 - Some pathways already approved, in use
 - Additional pathways pending, promising
- **Markets and Supply Chains are immature**
 - Economic inefficiencies from scale, coordination costs
 - Supply likely to be constrained in medium term
- **New paradigms are required for commercial success**
 - Methods needed to shorten value chains
 - Access to supply only certain if facilitation provided
 - Regulatory certainty, priority needed for aviation fuels

Significant progress in 6 short years!