

ICAO Workshop on Aviation and Alternative Fuels

Overview of Potential Options for Alternative Fuels



Continental Airlines

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Continental's Commitment to the Environment

- Named by FORTUNE magazine as one of ten “Green Giants,” corporations whose environmental policies go beyond what is required
- Named one of the top ten companies in the world on FORTUNE magazine's Global Most Admired list in the Social/Environment category
- Best Workplaces for Commuters - U.S. Environmental Protection Agency and U.S. Department of Transportation

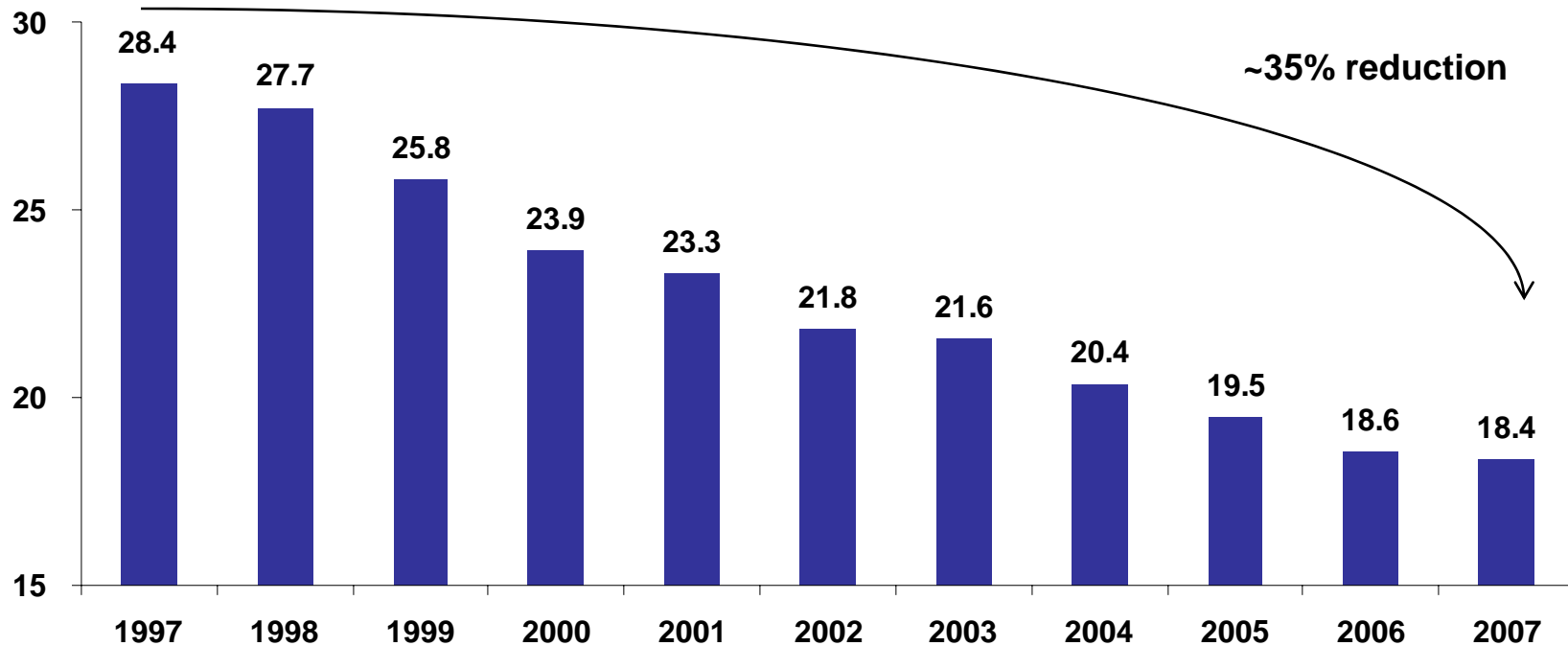


- Received NASA Recognition Award as a result of participation in the Aircraft Particle Emissions eXperiment, which studied the exhaust of jet aircraft and the environment
- Received Environmental Stewardship Award from the U.S. Environmental Protection Agency's Design for the Environment Program for using a more environmentally friendly pretreatment in its aircraft painting process

Continental's History Reducing Emissions

Continental has improved its fuel efficiency per Revenue Passenger Mile (RPM) by about 35% over the last 10 years (equal to a 35% reduction in greenhouse gas emissions) due to a \$12 billion investment in aircraft and related equipment

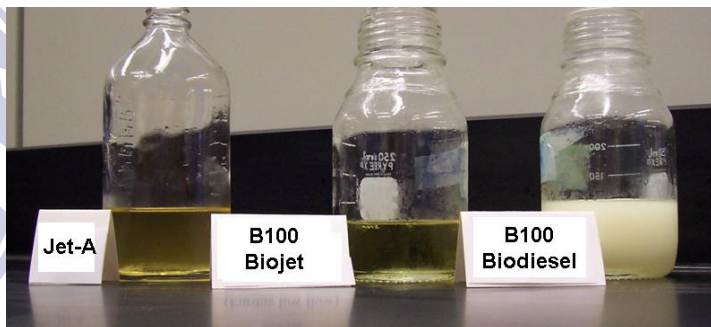
Fuel Efficiency per Revenue Passenger Mile
(Gallons per 1,000 RPMs)



Source: DOT Form 41, 1997-2007

Continental's Efforts to Reduce Aircraft Emissions

- Continental flies more people, more miles, to more places than we did a decade ago while creating 2 million metric tons **less** greenhouse gas emissions per year than what we would have created had we not modernized our fleet
 - That is the same as 366,000 fewer cars on the road
- Continental has committed to invest in additional new, fuel-efficient aircraft and ground equipment worth more than U.S. \$11 billion, with even cleaner technology, through 2015 – including 25 Boeing 787's
 - Continental was the first U.S. carrier to order the Boeing 787
- Continental was the first major U.S. carrier to announce plans to team with Boeing and CFM in a flight test to highlight advancements in sustainable biofuels that can help to further reduce carbon emissions



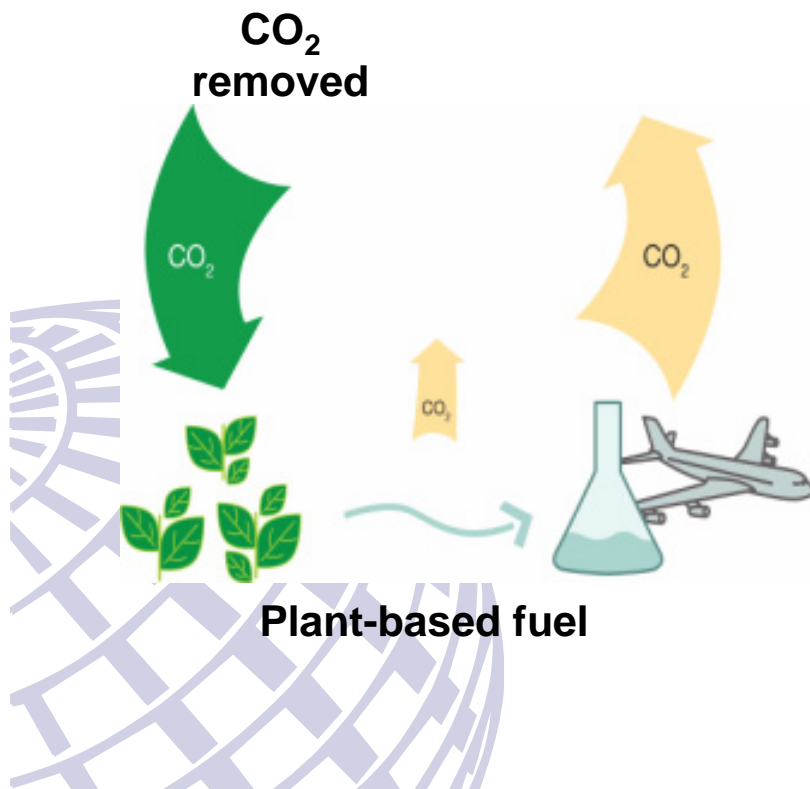
Why the Interest In Alternative Fuels?

- Extension of Continental's environmental initiatives
- Continental is hopeful about “drop-in” alternative fuels for the following reasons:
 - Environmental Benefits – potentially smaller carbon footprint than traditional petroleum based fuels (reduced life cycle carbon dioxide emissions)
 - Improved Fuel Availability and Energy Security - less reliance on foreign energy sources
 - Fuel Costs – potential reduction in overall fuel costs through the availability of alternatives

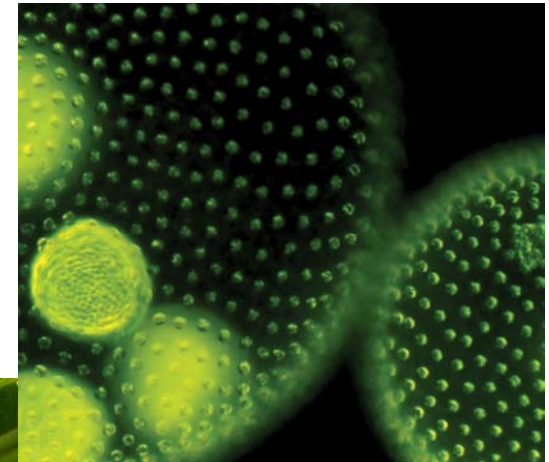


Why Sustainable Biofuel?

- Selected sustainable, second-generation energy sources that did not impact food crops or drinking water resources or contribute to deforestation
- Plant feedstocks absorb carbon dioxide (CO_2) emissions as they grow (such as algae, jatropha, camelina, etc.)



Algae



Jatropha



Why Do a Flight Demonstration?

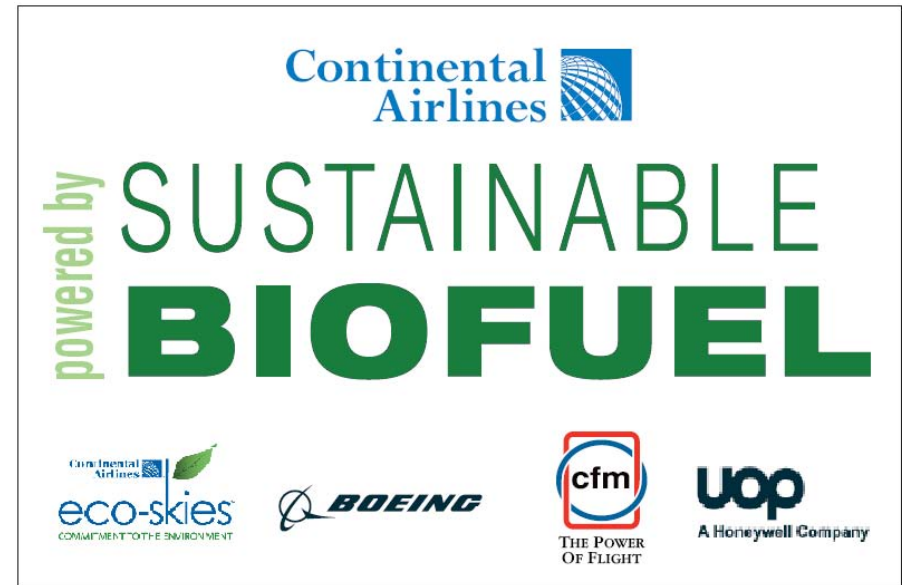
- Helps provide needed data to support fuel qualification / certification for use by the aviation industry
- Shows the public that biofuel is safe and that it works
- Identifies the promising biofuel suppliers
- Stimulates research and development for biofuel
- Creates additional supplier interest generating more alternatives



Algae Oil

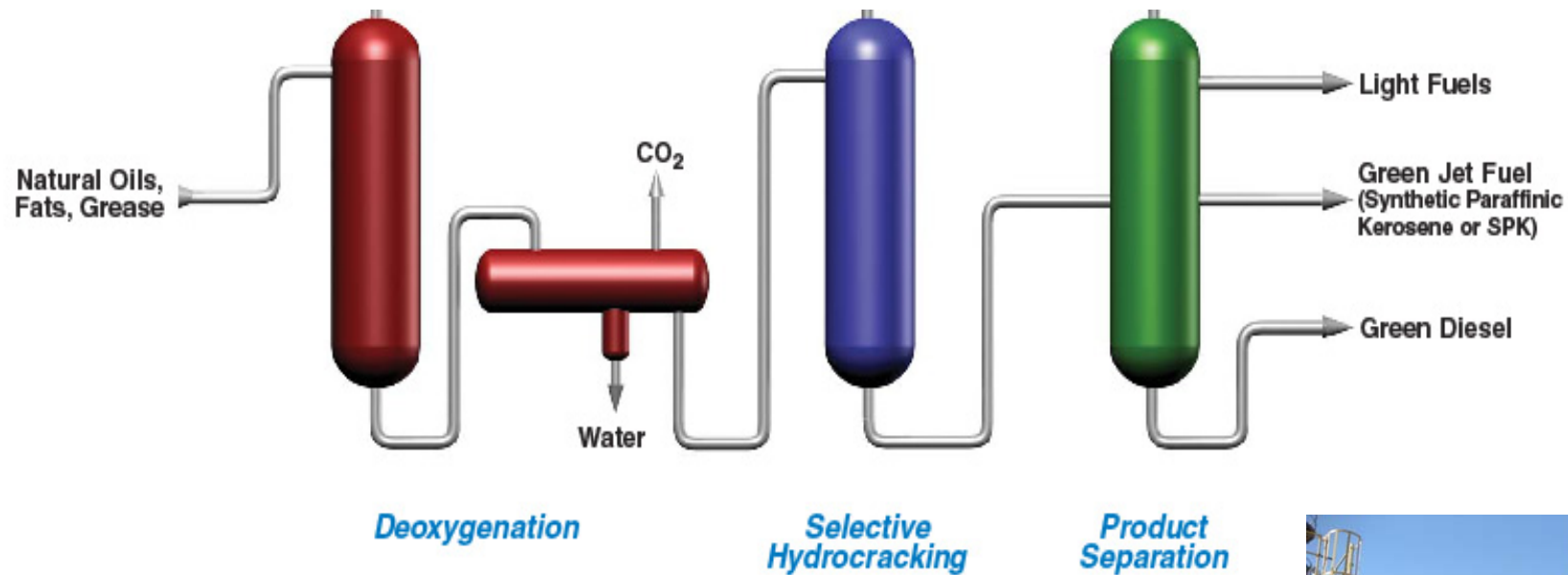
Coordinating the Flight Demonstration

- To make it all come together, Continental had a cross divisional team that worked closely with our partners for many months to prepare for the flight demonstration



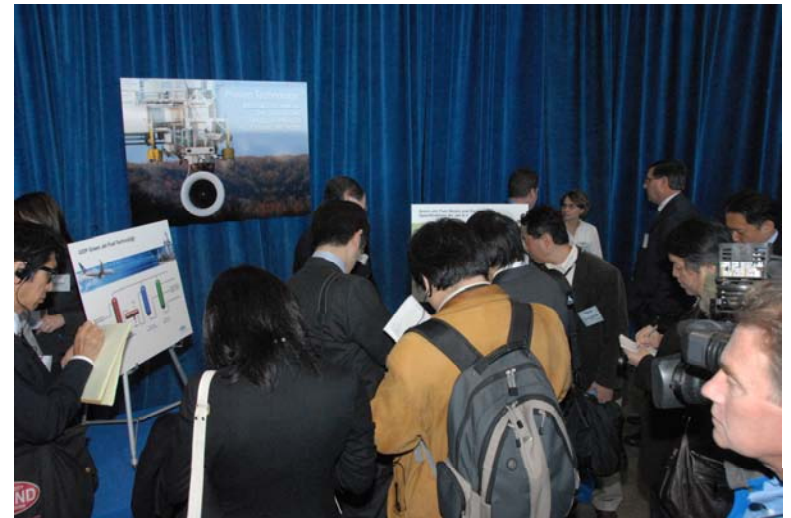
Developing the Biofuel Blend

- UOP's Hydrotreated Renewable Jet (HRJ) process produced a Synthetic Paraffinic Kerosene (SPK) from a blend of 5% algae and 95% jatropha



Testing the Biofuel Before the Demonstration Flight

- Fuel property and performance tests were performed on the biofuel prior to the flight demonstration, including:
 - Boeing tests (freeze, density, flash, distillate, JFTOT, heat of combustion, materials compatibility, dielectric constant)
 - Fuel Processor tests (ICP for metals and GC-MS)
 - Third Party tests (ASTM D 1655 Table 1 plus BOCLE)
 - Air Force Research Lab (AFRL) tests (ASTM D 1655 Table 1, ICP, and GC-MS)



Exhibits were used to explain fuel sources and testing to reporters

Testing the Biofuel in an Engine on the Ground

- CFM compared the biofuel to Jet-A in back-to-back tests performed on a CFM56-7B development engine at their Ohio test facility in November 2008. CFM ran tests for performance, operability, and emissions
- Performance testing measured specific fuel consumption (SFC) at several power settings from ground idle to take-off
- Operability testing included:
 - Start times
 - Lean-blow out margin
 - Acceleration / deceleration times
- Emissions testing included gaseous emissions and smoke levels for the biofuels



- **RESULT:**
 - **Ground testing showed equivalent engine performance to the baseline Jet-A with no adverse engine behavior.**
 - **Boeing and CFM technical groups gave approval for the flight demonstration and issued a No Technical Objection**

Preparing the Aircraft for the Flight Demonstration

Engines & Systems

- No physical modifications were made to the aircraft or systems
- No special instrumentation was installed
- #2 engine was supplied by with biofuel blend from #2 tank
- #1 engine and auxiliary power unit was supplied with Jet A fuel from #1 tank
- A borescope inspection was done on the engine before & after the demonstration flight and the engineers observed no change in engine condition

Operations

- Aircraft was taken out of service and placed into Experimental status
- No passengers or cargo were carried (non-revenue flight)
- Engine ground runs took place the night prior to the flight
- Flight departed & returned to Houston, TX



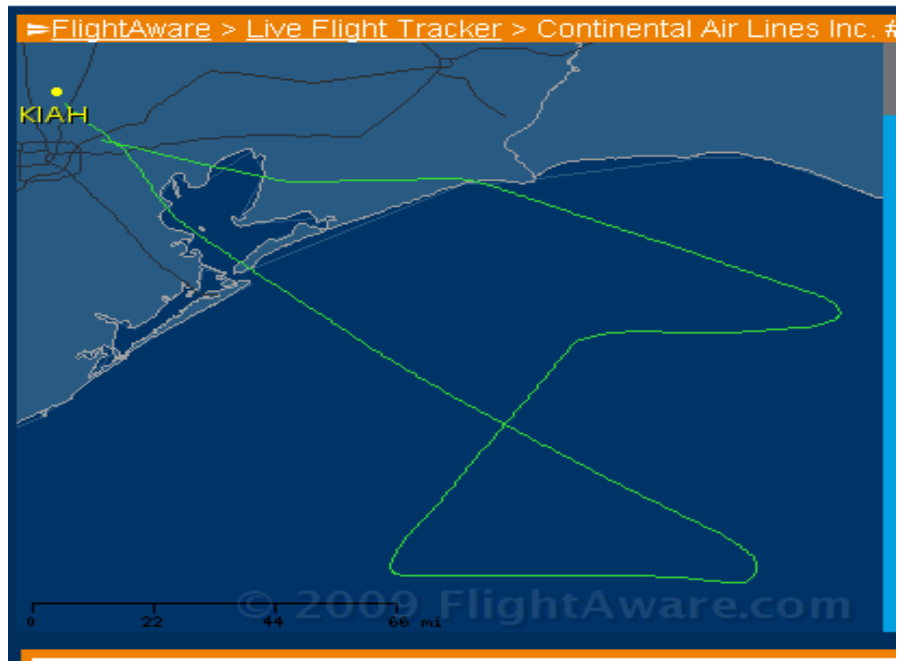
The Flight Demonstration

- A new Continental B737-800 equipped with two CFM56-7B engines was used to test a blend of 50% algae/jatropha biofuel mix with 50% typical jet A fuel
- The experimental flight was flown out of Houston, Texas (IAH) on January 7, 2009, with only the test pilots and propulsion engineer on board allowing them to perform test maneuvers for approximately two hours
 - Many international and domestic media attended
- **FLIGHT TEST WAS SUCCESSFUL**
 - **All parameters of merit met or exceeded test expectations and objectives**
 - **Aircraft was returned to service the next day**



Pilots Performed the Following Flight Procedures

- Engine start, taxi, takeoff, and land using biofuel
- APU was left running for the entire flight to ensure backup capability for added safety
- The aircraft climbed to cruise altitude and waited until engine readings were stabilized
- Rapid throttle excursions were conducted to verify engine operability
- #2 engine was shut down and a stabilized in-flight restart was conducted
- Additional test maneuvers such as repeat engine restarts and simulated go-around engine acceleration on landing



Did Biofuel Perform Like Jet A?

→ YES

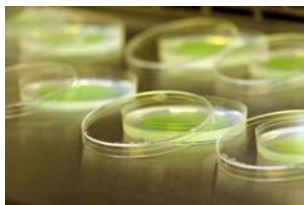
→ Alternative Fuel performance challenges were met:

- Density
- Freezing point
- High temperature thermal stability
- Energy density
- Storage stability
- Elastomeric compatibility
- A Jet-A replacement solution



Summary of Goals for Flight Demonstration

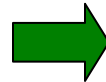
- Encourage sustainable biofuel development for aviation
 - Reduce CO₂ emissions, improve fuel availability and cost
- Coordinate with manufacturers, fuel suppliers, and engine companies
- Demonstrate biofuel production, test, operability and benefits



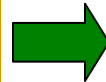
Evaluate & select
2nd generation feedstocks



Identify & pilot
processing
methods



Help create “drop-in”
CO₂ neutral,
sustainable biofuel



Demonstrate use of biofuel

What Do We Do Next?

- Work with our partners to put together all of the test data in a report to share with other stakeholders
- Work together to get the biofuel certified for use by the aviation industry
- Encourage more biofuel research and development
- Move on to the production phase of biofuels and work together to overcome infrastructure challenges



Continental Continues to Reduce Its Emissions

→ **Aircraft:** Continental continues to reduce aircraft emissions through fleet modifications and operational measures



→ **Ground Service Equipment:** We are committed to invest in additional new, fuel-efficient ground equipment with even cleaner technology and we are testing alternative fuel and fuel additives for long-term use in ground service equipment



→ **Facilities:** We are committed to build new facilities according to U.S. EPA "Energy Star" and U.S. Green Building Council LEED (Leadership in Energy and Environmental Design) standards where most effective





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