A change is in the air?

Sustainable fuels for aviation

Siân Foster
Corporate Sustainability & Responsibility Manager,
Virgin Atlantic Airways

Change is in the air?

- Introduction and scene setting
- Virgin Atlantic's sustainability challenge
- Why biofuel?
- What are we looking for in a biofuel?
- What did the demo flight prove?
- What happens next? Our vision for the future

Change is in the air…Virgin Atlantic

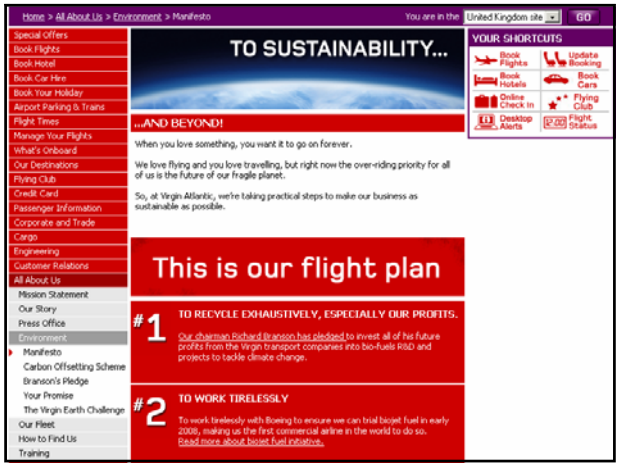
2006-2007 verified carbon footprint:
4,767,000 tonnes CO2

Change is in the air…but why biofuels?

Change is in the air…but why biofuels?

- December 2006: UK Treasury doubles Air Passenger Duty
- October 2007: UK Treasury announces move to per aircraft duty from Nov 2009 as "environmental tax"
- EC agrees Directive to include aviation in EU Emissions Trading Scheme

Change is in the air…but why biofuels?



Change is in the air...but why biofuels?

- **TARGET: 30% better fuel efficiency 2007-2020**
  - Fleet renewal – e.g. B787
  - Fuel Panel Initiatives
  - Weight watchers initiatives
  - Air traffic control efficiencies
- **TARGET: only 50% of waste to landfill by 2012**
- **TARGET: reduce energy consumption 10% 2007-2012 and 20% 2007-2020**
- **etc...**

Change is in the air...but why biofuels?

Change is in the air...but why biofuels?

- Sustainability of supply
  - As traditional oil fields run out, the world moves towards "dirtier" fossil-fuel based kerosene

Change is in the air...what do we need from a biofuel?

- Environmental sustainability
  - Should not lead to deforestation
  - Should not divert water away from food agriculture or drinking water
  - Should have lower life cycle carbon emissions

Change is in the air...what do we need from a biofuel?

- Must be socially sustainable
  - Sustainable agronomy principles should be applied (e.g. equivalent of FSC)
  - Should not conflict with staple food crops

Change is in the air...what do we need from a biofuel?

- Must be economically sustainable
  - Rising crude oil prices
  - Emissions trading scheme – cost of carbon

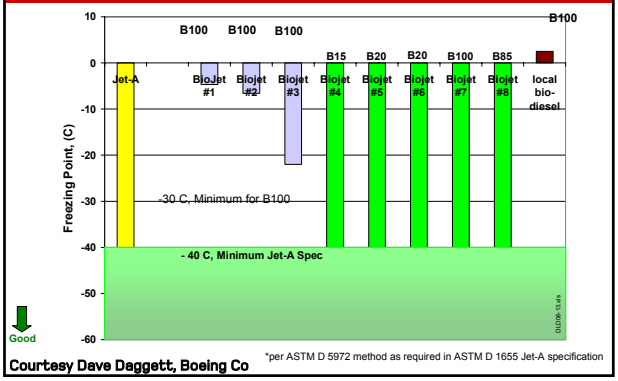
Change is in the air… so, what's Virgin Atlantic doing?

- Demo flight: 24 Feb '08
  - Aim - to prove that it is possible to fly a commercial aircraft on a sustainably-sourced, "drop in" biofuel/kerosene blend

Change is in the air...how did we get to the biofuel demo flight?

- Boeing tested a variety of different fuels, in different blend ratios, arrived at short list
  - Flash point tolerances of min 38°C, max 80°C
  - Freeze point of -40° achieved (or even exceeded)
  - Density should fall between 775 – 840 kg/m^3 (but no lower than 750 kg/m^3)
- Short-listed fuels then underwent further screening tests by Boeing, GE and NASA Glenn, e.g.
  - Viscosity
  - Heat content
  - Thermal stability breakpoint
  - Emissions

Change is in the air...how did we get to the biofuel demo flight?



Courtesy Dave Daggett, Boeing Co

*per ASTM D 5972 method as required in ASTM D 1655 Jet-A specification

Change is in the air...how did we get to the biofuel demo flight?

- Imperium Renewables fuel – derived from babassu and coconut oil through transesterification – identified as preferred option

Change is in the air...how did we get to the biofuel demo flight?

- Detailed testing of Imperium Renewables Biofuel Blend
  - 80% Jet A-1 / 20% Imperium Biofuel
  - Detailed rig & chemical testing
  - Material compatibility testing
  - Engine test cell ground running
  - All procedures agreed with EASA/CAA to fulfil permit to fly requirements
  - Biofuel shipped to VAA for on site blending

Change is in the air…how did we get to the biofuel demo flight?

- In the days leading up to the demo flight…
  - Neat biofuel and kerosene blended in dedicated bowser (20:80 ratio)
  - Field testing of biofuel blend: visual, free water, freeze point, flash point, density.; full AFQRJOS Checklist 22 tests carried out overnight at local laboratory
- The day of the demo flight…
  - Aircraft fuel system configured "Tank to Engine" for starting, taxiing and in-flight: only No 4 Engine received biofuel blend from No 4 Tank
  - Normal engine start and dispatch procedures

✓

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Change is in the air…what did we prove from the biofuel demo flight?

- In-flight procedures
  - Flight operated as per Standard Operating Procedures
  - Onboard observers monitored performance of No 4 Engine throughout flight
  - Pilots and observers noted no difference in performance between No 4 Engine and other Engines

✓

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Change is in the air…what did we prove from the biofuel demo flight?

- Post flight checks…
  - On arrival in AMS, No 4 Engine cross-fed to flush out remaining biofuel blend
  - Aircraft entered into scheduled "C-Check" on arrival in AMS
  - Fuel samples taken and analysed
  - No 4 Engine and No 4 Tank pumps removed for workshop visit and inspection
  - No issues identified through detailed maintenance procedures

✓

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Change is in the air…what did we prove from the biofuel demo flight?

- It *is* possible to fly a commercial aircraft on a "drop in" fuel, containing a high proportion of sustainably-sourced biofuel!

✓

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Change is in the air…what happens next?

Guaranteeing AVAILABILITY of sustainable (socially, environmentally, economically) fuel in viable quantities

Gaining ACCEPTANCE from all relevant stakeholders (airlines, airports, manufacturers, fuellers, NGOs, Govts)

Ensuring APPROVAL of biofuels and certification by manufacturers, MoD and other relevant bodies.

VISION: A truly sustainable market for aviation biofuels

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Change is in the air?…availability

- Immediately move past 1st generation biofuels and processes
  - Significant concerns re: sustainability of feedstocks, e.g. corn (food v fuel debate) and oil palm (deforestation)
  - Refining/processing technologies: fuel not of high enough standard, e.g. freeze point; energy density; impact on fuel systems
  - Inefficient source of oil

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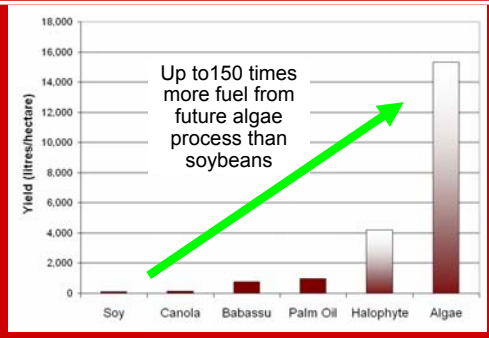
Change is in the air?...availability

- 2nd and 3rd generation fuels more promising
  - Suited to marginal areas not viable for food crops
    - Arid or substantially degraded soil, e.g. jatropha
    - Salt water tolerant, e.g. halophytes
    - Brackish water or water treatment plants, e.g. algae
  - Refining technologies (e.g. licensed by UOP) create better quality fuels more suitable for aviation; increasingly feedstock "agnostic"
  - More efficient – both feedstock and technology – source of fuel
- *HOWEVER*.... No 2nd or 3rd generation fuels yet being produced in significant volumes

Change is in the air...what happens next?



Courtesy Dave Daggett, Boeing Co

Change is in the air...what happens next?

- Availability - different regions may offer different feedstock solutions

Algae farms in Australasia?

Jatropha plantations in Brazil?

Salt water tolerant halophytes in the Middle East?

Change is in the air...availability

- So, what are we doing about it?
  - Production capability: reasonable estimate that within 5-10 years could be potential to generate 1% of global jet fuel requirement
  - Working with other industry stakeholders
  - Engagement with key environmental NGOs; talking to Governments
  - Algal Biomass Organisation: objective to share knowledge and catalyse commercialisation of algae

Change is in the air?...acceptance

- Difficult to act unilaterally – need to achieve critical mass within industry
  - Complex fuel supply infrastructure: common use fuel pipelines, co-mingled tanks under airports, shared ground handling equipment and services, would have to blend with "traditional" kerosene – need buy-in from throughout the supply chain
  - Increasing numbers of airlines publicly supporting lower carbon biofuels, e.g. Japan Airlines, Continental, Air New Zealand, BA, bmi, easyJet, Lufthansa, Air France/KLM, SAS...

Government policy needs to support us

Change is in the air?...approval

- Future fuels *must* be "drop in", i.e. meet performance criteria contained in existing jet fuel specifications
  - Energy density
  - Flash point tolerance
  - Freeze point of at least -40°C (-47°C for Jet A1)
  - Viscosity
  - Material compatibility testing
  - Etc, etc.....

Change is in the air?...approval

- Well-established protocols for certifying new fuels:
  - ASTM D1655
  - Def Stan 91/91 (UK Defence Fuels Group)
  - Current specifications and tests based on model from 1950s and only accepts fossil-fuel based kerosene
  - But CAAFI targets: 50% biofuel blend certified by 2010, 100% by 2013

Change is in the air?...approval

- What next?
  - Educating ourselves and getting involved in the certification process – not something in which many airlines have got involved before
  - Continuing to demonstrate that biofuels are of critical interest to us
  - Pushing for (whilst still ensuring strict safety and reliability criteria standards are adhered to) an acceleration of the fuels certification process

Change is in the air?...conclusions

- There are sustainable alternatives to kerosene - you can fly a plane on biofuel!
- Lessons have been learned from the 1st generation feedstocks and biofuels – more efficient and more sustainable 2nd generation fuels will soon be available
- With ever-rising crude oil prices and the cost of carbon associated with ETS, there's a strong business case for researching and developing lower carbon renewable alternatives
- There's no silver bullet but biofuels could contribute to the sustainable future of the international aviation industry

Thank You