Assessing the climate impact of a multi-fuel blended wing body: Results from the AHEAD EU-project

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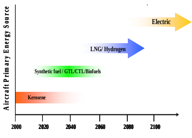
Motivation

Future (2050+) aviation faces various challenges, such as

- Mitigation of climate change (ACARE goals)
- Fuel supply

EU-project AHEAD

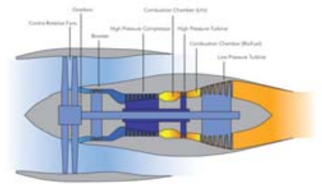
In the AHEAD EU-project, we addressed these open questions by investigating a multi-fuel blended wing body:



Rao and van Buijtenen, 2011

Two future fuels with 30% of propulsion energy from either LNG or LH2 and 70% from biofuels burnt in flameless combustion.
⇒ **Low CO_2 and low NO_x**

Engine and aircraft



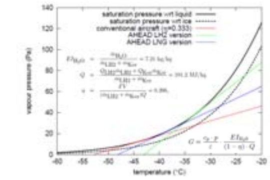
- Two combustion chambers
  - LNG / LH2
  - Biofuel burnt in hot and vitiated environment ⇒ flameless combustion with very low NO_x and CO emissions
- Successfully tested at test-rigs

- Similar size and range as conventional a/c e.g. B777-200ER
- LNG and LH2 can be stored in the rear and biofuels in wings.

Tools and Methods

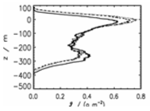
Contrail formation

Adapted Schmidt-Appleman Criterion;
Mixing Slope G in the H_2O-T phase diagram



Properties of the early contrail

Large-Eddy Simulations to determine contrail depth and ice crystal numbers
⇒ Contrail depth similar, but ice crystal number lower for LH2-fuel

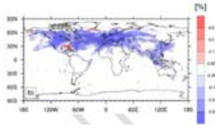


Vertical profile of ice mass after 5 minutes

dotted: BWB+LH2
solid: Conv+kerosene
dashed: BWB+kerosene

Contrail-Cirrus

Climate model with contrail-cirrus parametrisation (2-moment-scheme)



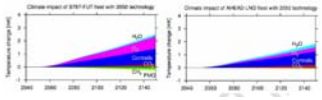
Change in coverage by contrail-cirrus due to a full fleet replacement

Climate impact assessment

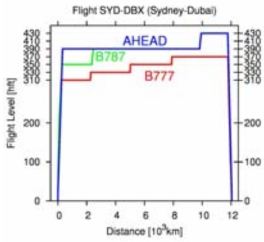
Reference: „Future“-B787/B777-200ER
Scenario: EIS 2050 Full fleet: 2075
Average Temperature Response
Time Horizon: 2050-2150

Climate impact

Climate-chemistry response model AirClim was adapted and used to estimate the impact of MF-BWB on climate .

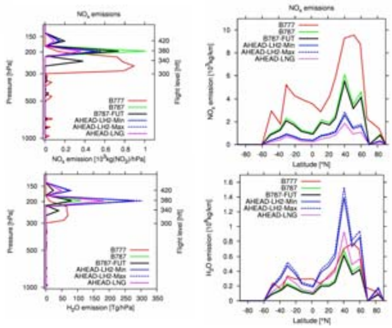


Trajectories and Emissions

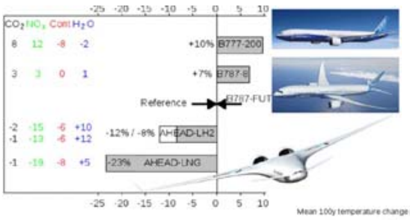


Parameters for the scenarios	Value
Entry into Service (EIS)	2050
Full fleet size	2075
Constant share of the fleet	2075-2150
Annual flown reference distance for full fleet	5.4 10^8 km
Number of city pairs	10
Reference aircraft with year 2000 technology	B777-200ER
Reference aircraft with year 2014 technology	B787-8
Reference aircraft with year 2050 technology	B787-FUT
Future fuel efficiency improvement (B7878-FUT)	10%
Carbon neutral contribution by drop-in biofuels.	25% (2050)

- Trajectory calculations show distinc differences between the aircraft.
- Higher altitudes for BWB
- Emission Indices are calculated using experimental results combined with detailed modelling.
- Ten represenatative city pairs are chosen to calculate global emission data
- Low NO_x emissions from BWB
- But larger H_2O emissions, especially at high altitudes



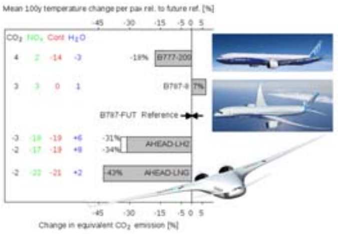
Climate Impact Assessment



Left: MF-BWB with LNG reduces the longterm climate impact by roughly 20 to 25% compared to conventional technology.

Less NO_x and contrail impacts

More H_2O impact



Right: Climate impact reduction per pax-km is even more pronounced (right).

Conclusions

- The use of a multi fuel blended wing body has the potential to significantly reduce the climate impact from aviation.
- Most promising is the reduction in
  - contrail-cirrus climate impact (partially due to reduced ice particle number densites) and
  - NO_x climate impact via ozone, methane and primary mode ozone (feedback from methane changes)
- Water vapour climate impact is enhanced by MF-BWBs
- LNG more promising than LH2, especially since production of LH2 is not considered.

Next steps:

- Analysis of atmospheric uncertainties on the results.
- Engine integration, Boundary Layer Ingestion, …

Further reading:

http://www.ahead-euproject.eu/

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