Aviation emissions developments and research

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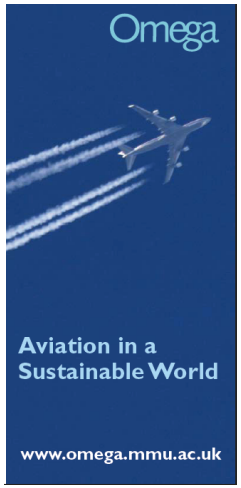
FACC meeting - Wednesday 29th June 2011

Outline

- Omega aide memoire
- Emissions challenges
- Climate change
- Air quality
- Goals and targets
- Response action
- Summary

What was Omega?



- Omega = 9 university, govt funded research partnership,

Manchester Metropolitan University · Cranfield University · University of Cambridge · University of Oxford · The University Of Sheffield. · University of Leeds · University of Reading · Loughborough University · University of Southampton

- Working with stakeholders in the sector, NGOs and Govt
- 8 topics, 41 studies


Climate Change


Local Air Quality


Noise


Aircraft Systems


Operations


Alternative Fuels

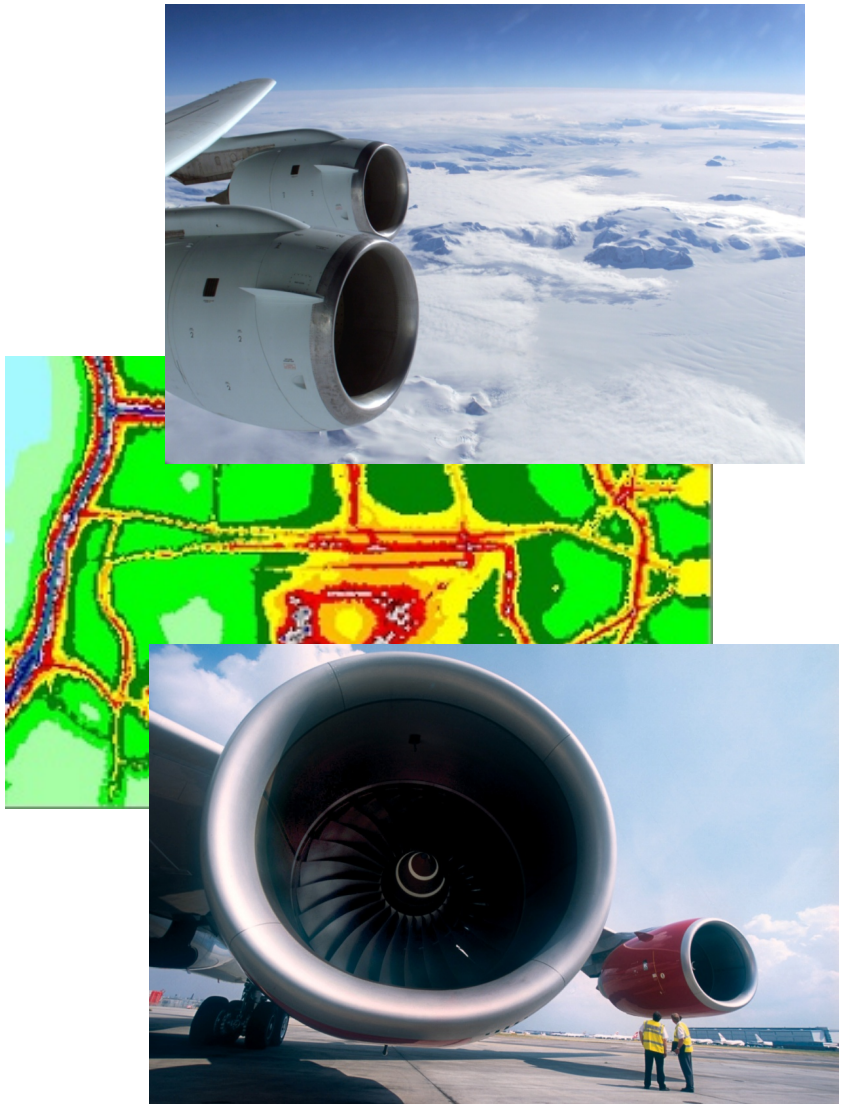

Mitigation Policies


Demand & Economics

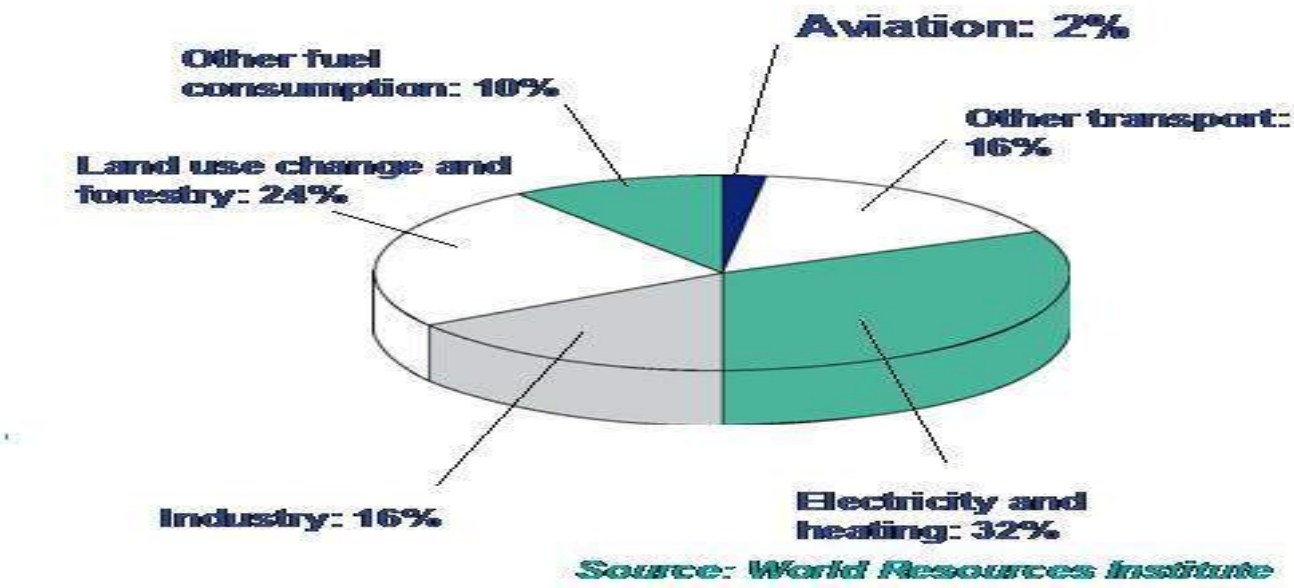
- 2007 to 2010 - wide stakeholder support but….

Emissions challenges

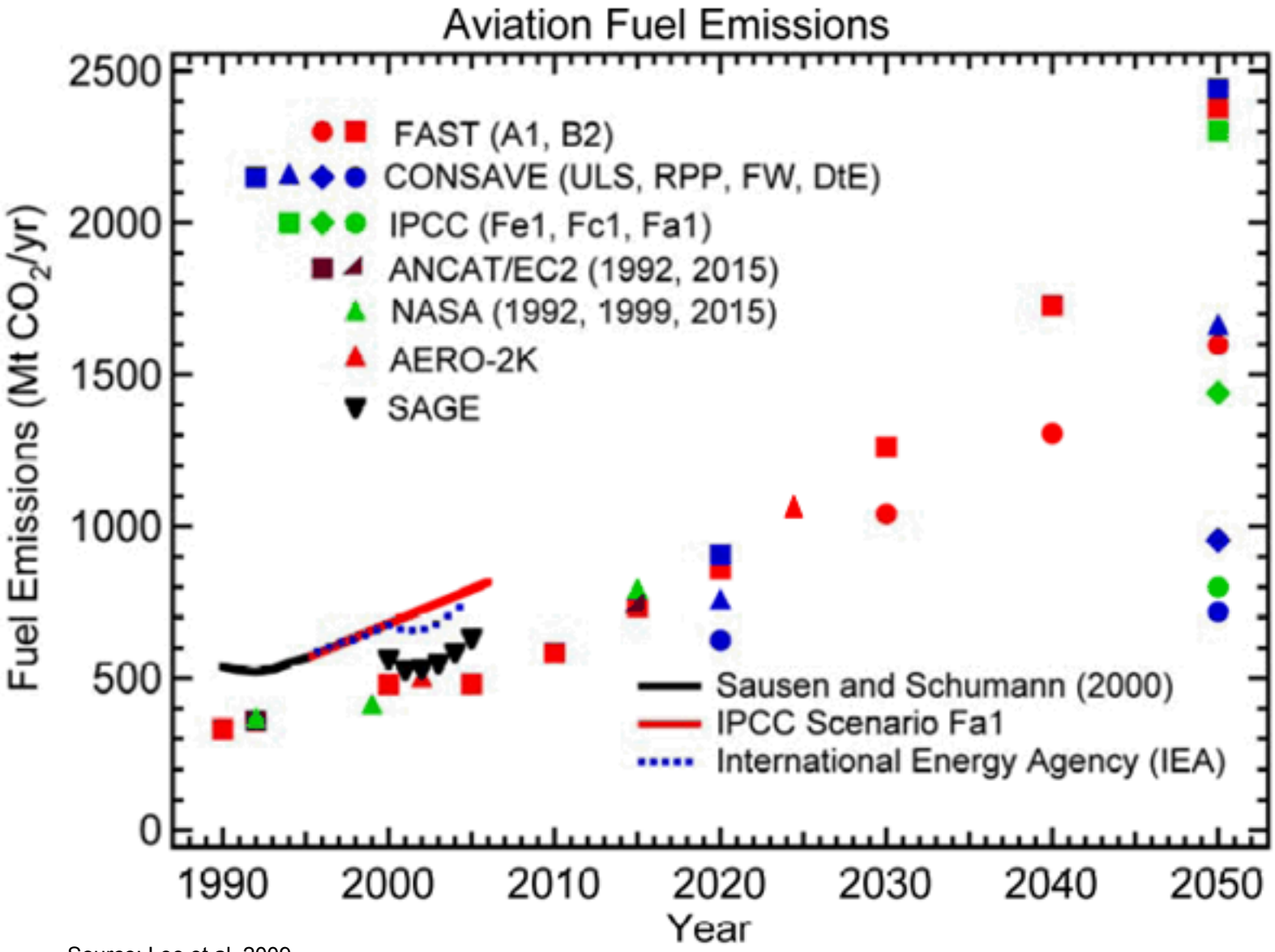
- Climate - a growing share of the carbon cake and solutions that do not yet compensate for growth… and the non-CO2 impacts
- Air quality - EU standards headroom in many locations - but how well can emissions be attributed…. and a growing interest in PM
- Technology development - what will new technology deliver…. and when?
- Will civil air transport be allowed to grow unconstrained - effects of ETS, taxes and charges



Aviation CO2 emissions



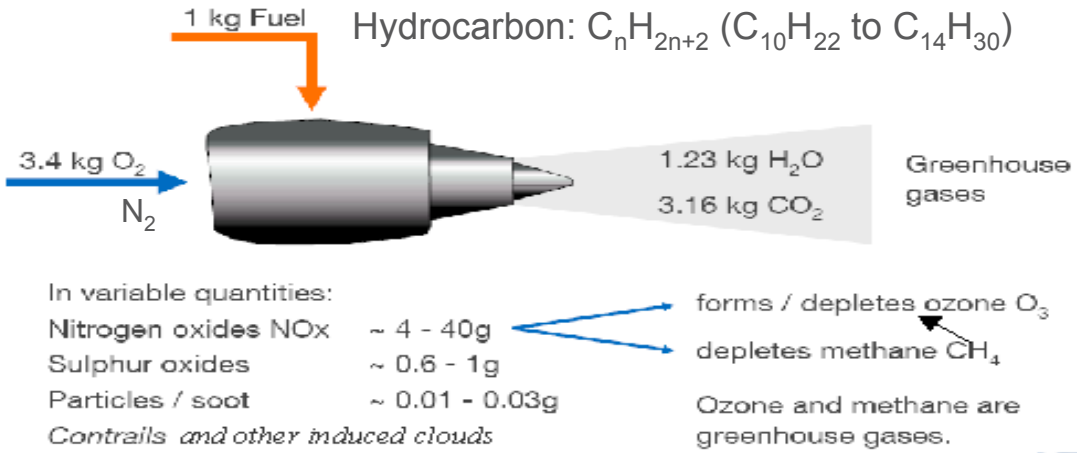
Only 2% now from CO2 but could rise to 5% of global total



Source: Lee et al, 2009

Climate impacts

How aviation affects climate change



Changes in radiative forcing can be caused by

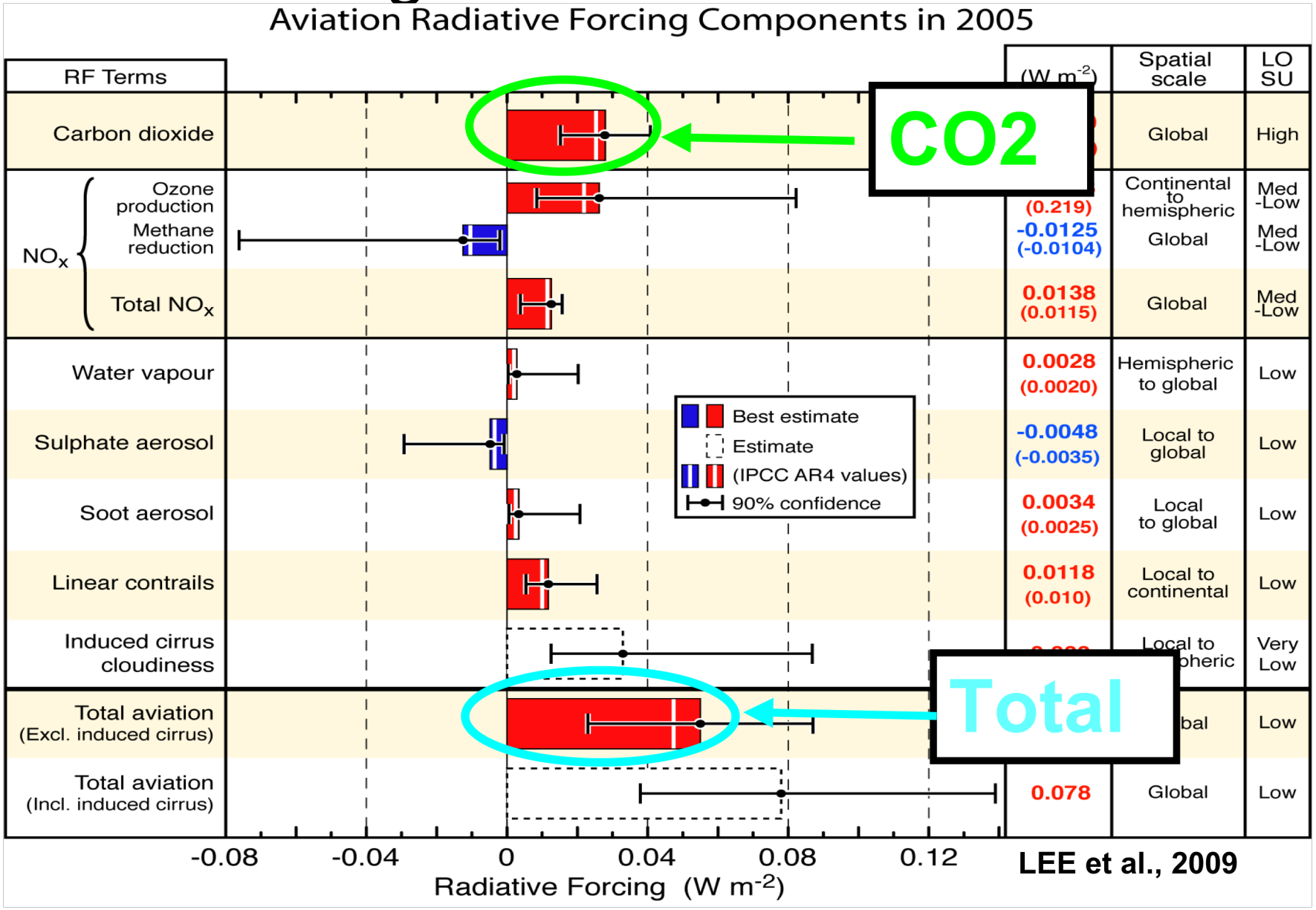
- the emission of greenhouse gases, in particular the long-lived CO_2, but also of water vapour;

included in the Kyoto Protocol, apart from water vapour

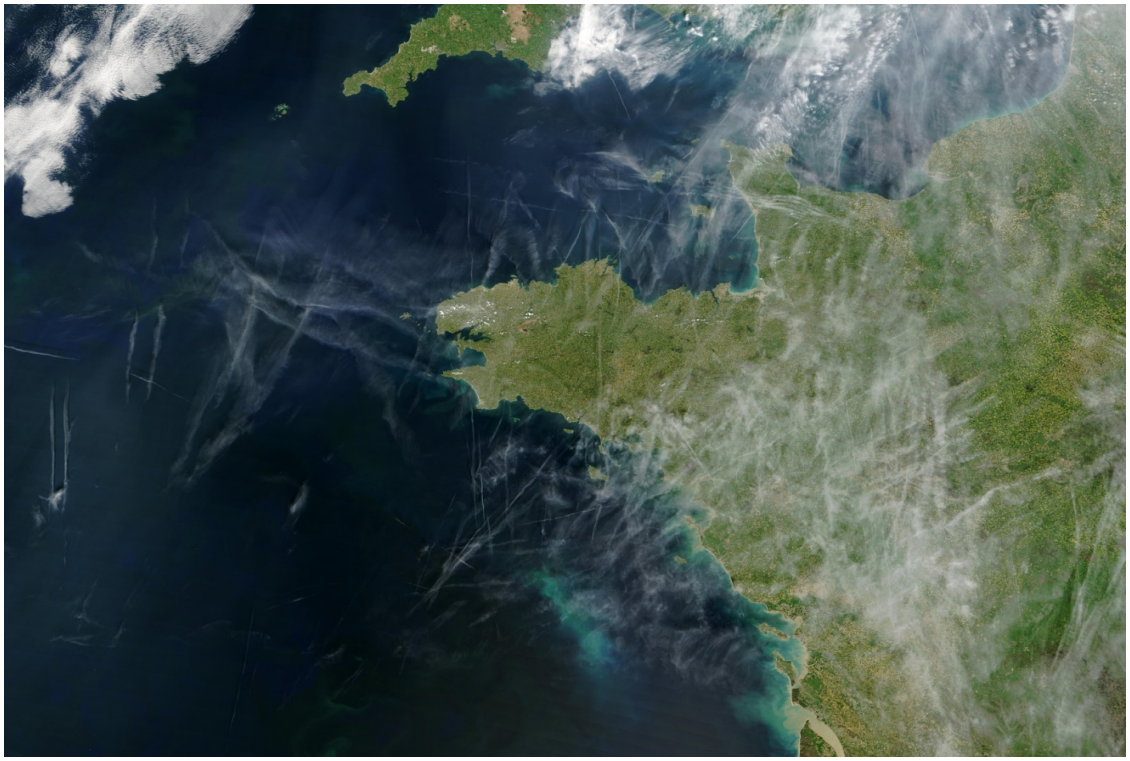
- the emission of ozone precursors, like NO_x,(NO_x also depletes methane, another GHG);
- the emission of particles and their precursors;
- triggering additional clouds (e.g., contrails, contrail cirrus) and by modifying natural clouds (e.g., soot cirrus).

short-lived effects NOT included in the Kyoto Protocol, but of particular importance for aviation

Radiative forcing from aviation in 2005



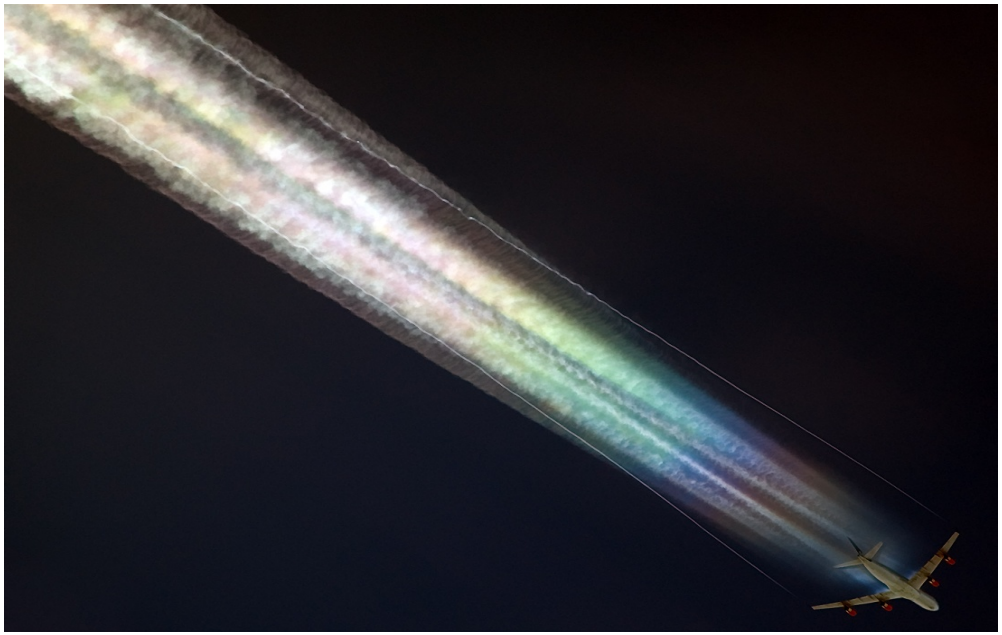
Contrail induced cirrus



- Now estimated to have a greater effect on warming on any give day than all the CO2 emitted since aviation began (Karcher et al, 2010)
- http://news.bbc.co.uk/1/hi/sci/tech/8309629.stm

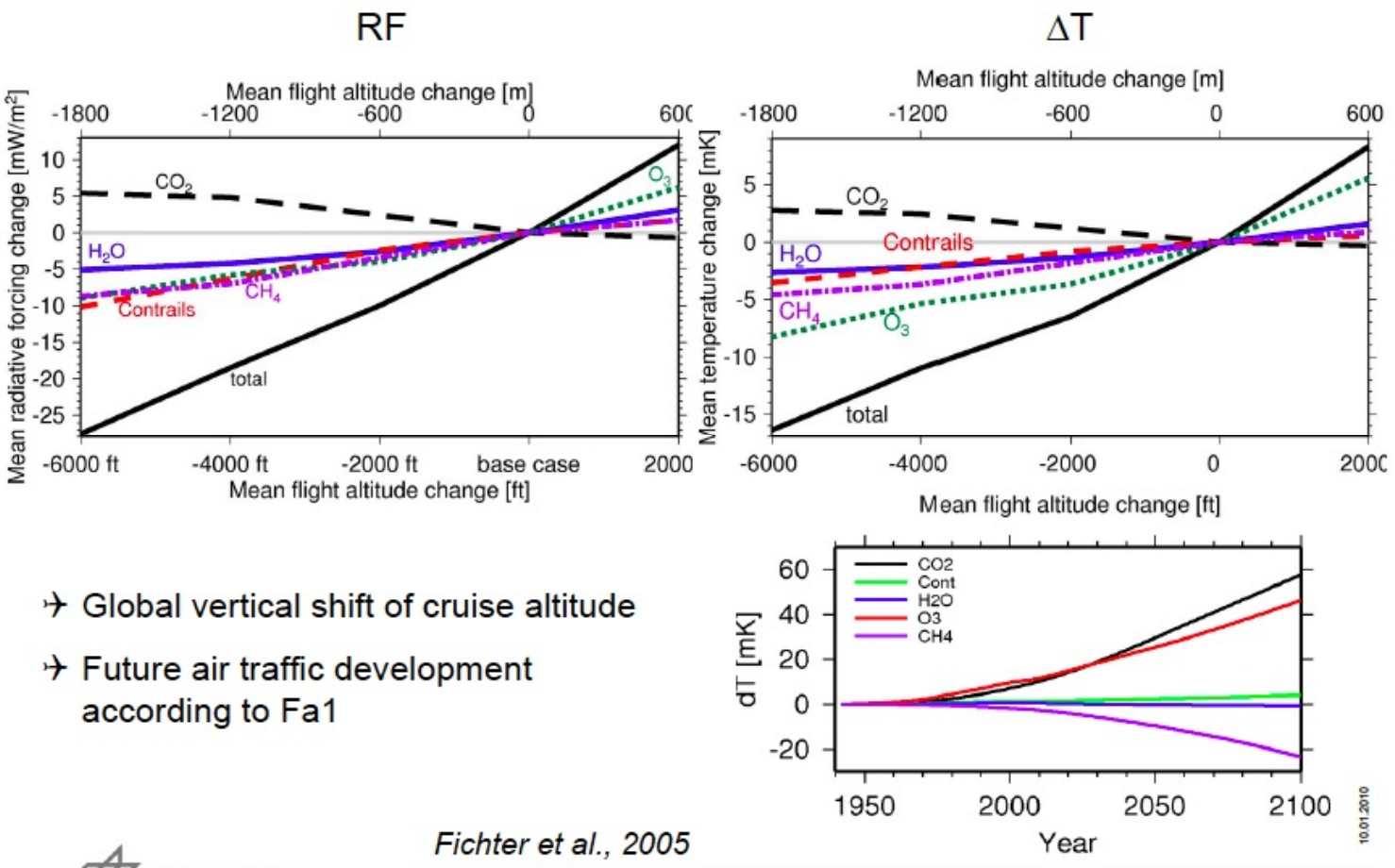
Contrail cirrus

- Significance of:
  - particles to optical depth of contrail cirrus - consider scope to change micro-physical properties
  - Cruise altitude
  - Latitude
- Hardening of certainty on contrail induced cirrus but more work needed to verify and assessment rigour of UN IPCC process



Flight altitude change

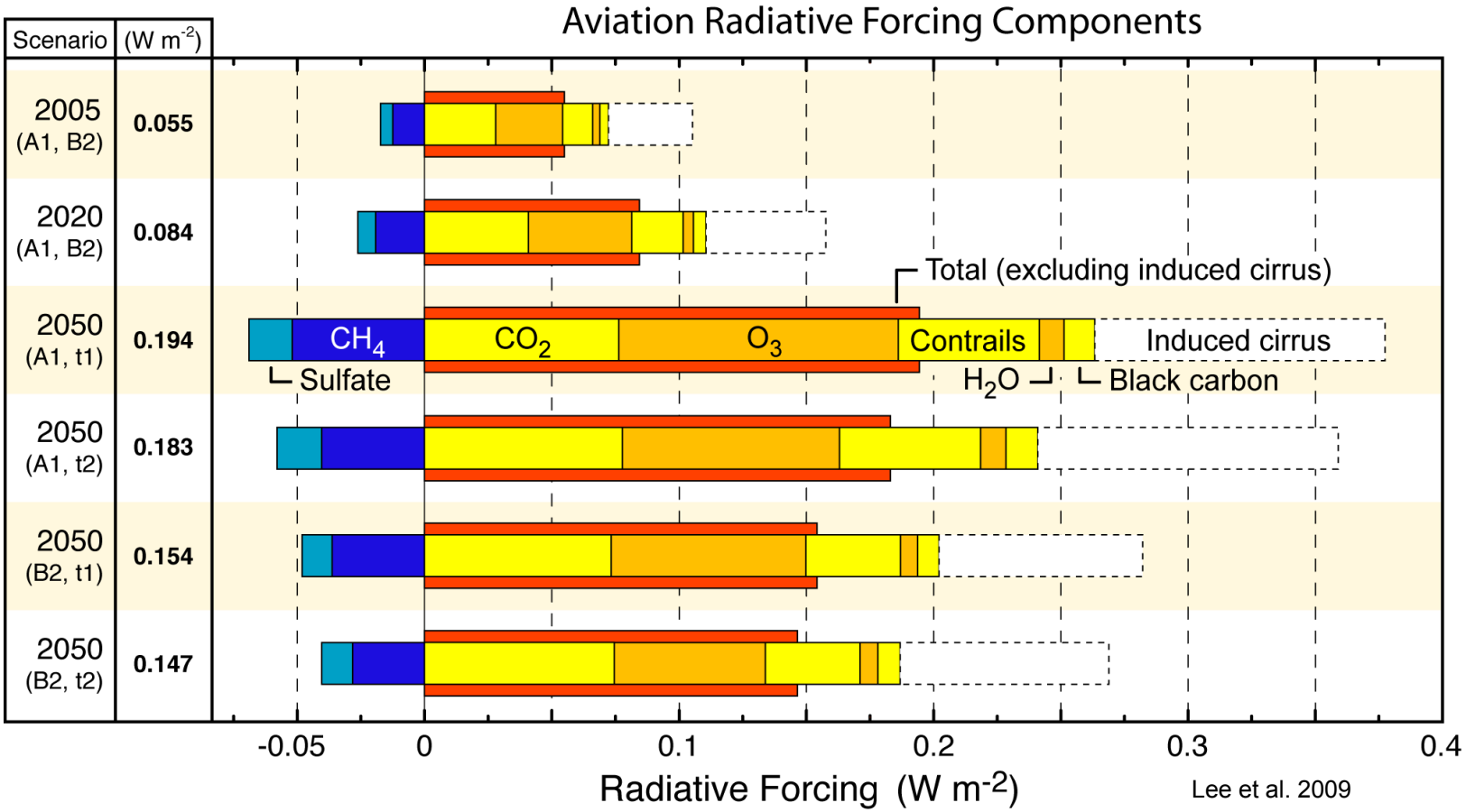
Global RF and ΔT changes in 2100 for mean flight altitude changes



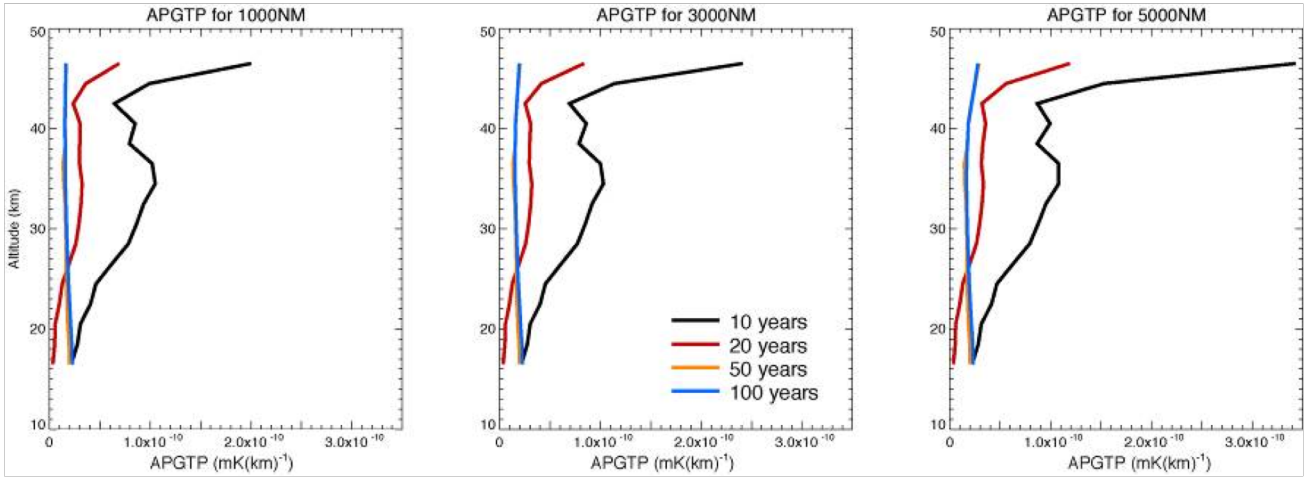
- Global vertical shift of cruise altitude
- Future air traffic development according to Fa1

Fichter et al., 2005

Potential future radiative forcing



Total aviation GTP – dependence on time horizon and mission length



At short time horizons (10, 20 years), the short-lived effects have the dominant effect

3000 NM, Mach 0.85

At longer horizons, CO_2 dominates and gives quite different height dependence

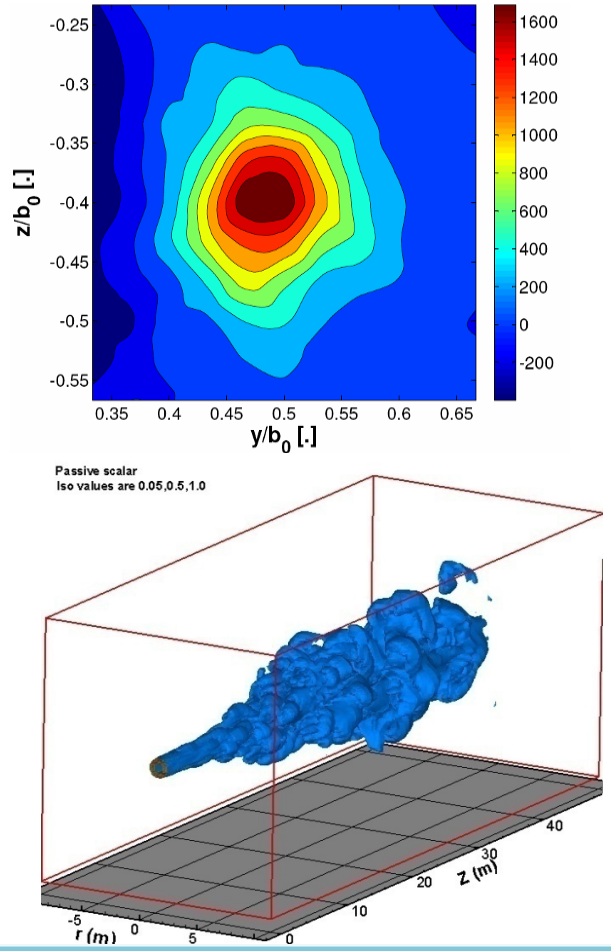
- Concern about use of Global Warming Potential (GWP) as a metric
- Need clarity on the policy goal to establish the right metric to assess and control integrated aviation effects

Local air quality

- EU and UK regs limit emissions - particular pressure on NO2. PM headroom.
- Still don't understand
  - Plume dynamics
    - Initial dispersion
    - Wake vortex interactions
  - Plume chemistry
  - Particulate emissions
  - Tyre smoke
- Need to refine models

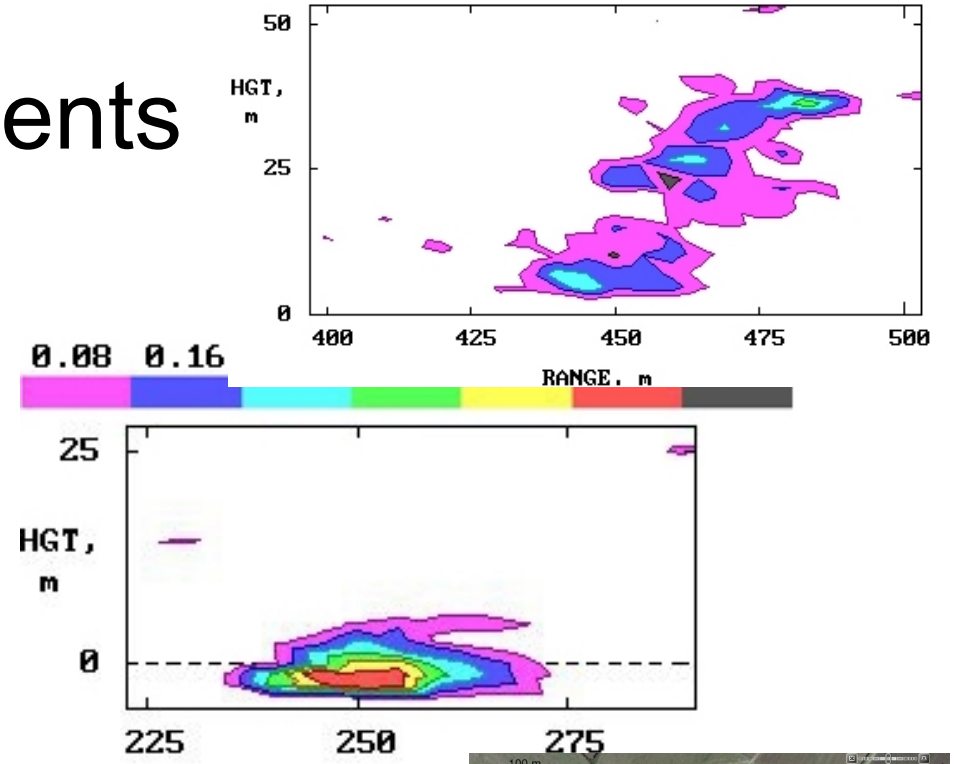
LAQ Highlight: Plume Modelling

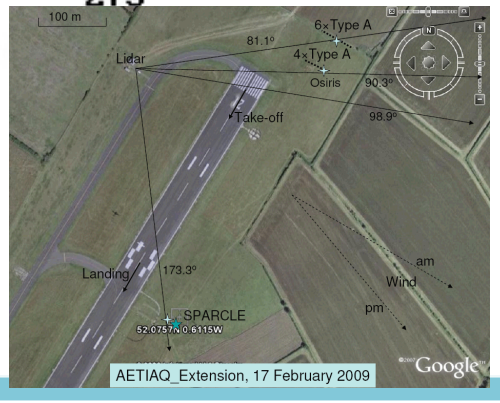
- Uncertainty - what happens to the plume
- CFD and analytical modelling approaches used to understand plume dynamics
- Results validated by LIDAR field measurements
- Physical modelling study of plume-vortex interaction in a wind tunnel



LAQ plume measurements

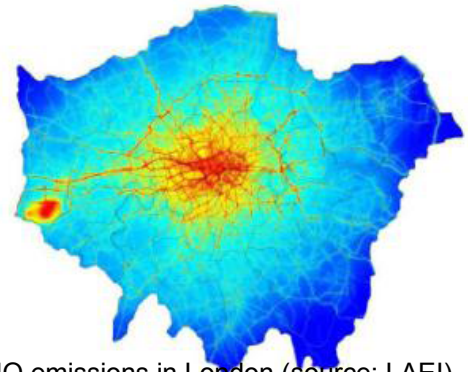
- Better characterization of initial plume dispersion and interaction of wake vortices (LIDAR back-scatter measurements)
- Better understanding of plume chemistry e.g. - NO/NO_2 ,HONO (IDOAS)
- Results are being used to improve dispersion modelling and understanding of plume chemistry





Measurement

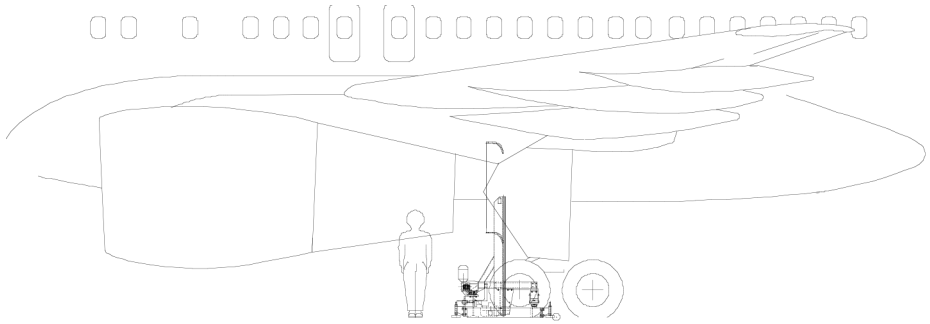
- Mobile Environmental Sensing System Across Grid Environments (MESSAGE) - low cost sensor network
- Measure NO, NO2 and CO
- Improve modelling - Lack of sufficient spacial and temporal granularity
- Heathrow project now started using 50+ sensors to saturate airport environment
- Will help understanding of dispersion and attribution

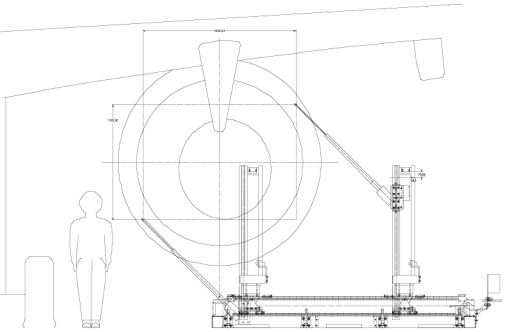


NO emissions in London (source: LAEI)

Source measurement

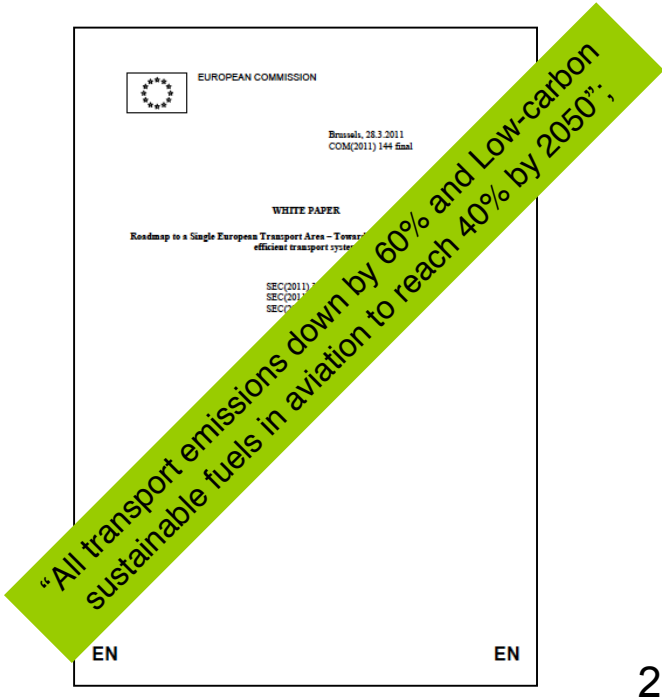
- Still need to characterise PM
- EU SAMPLE project on refined methods for measuring particle mass concentration and composition, particle number concentration and particle size distribution using a combustor rig
- New work in progress to extend measurement using on-wing engine testing
- Goal to improve emission factors



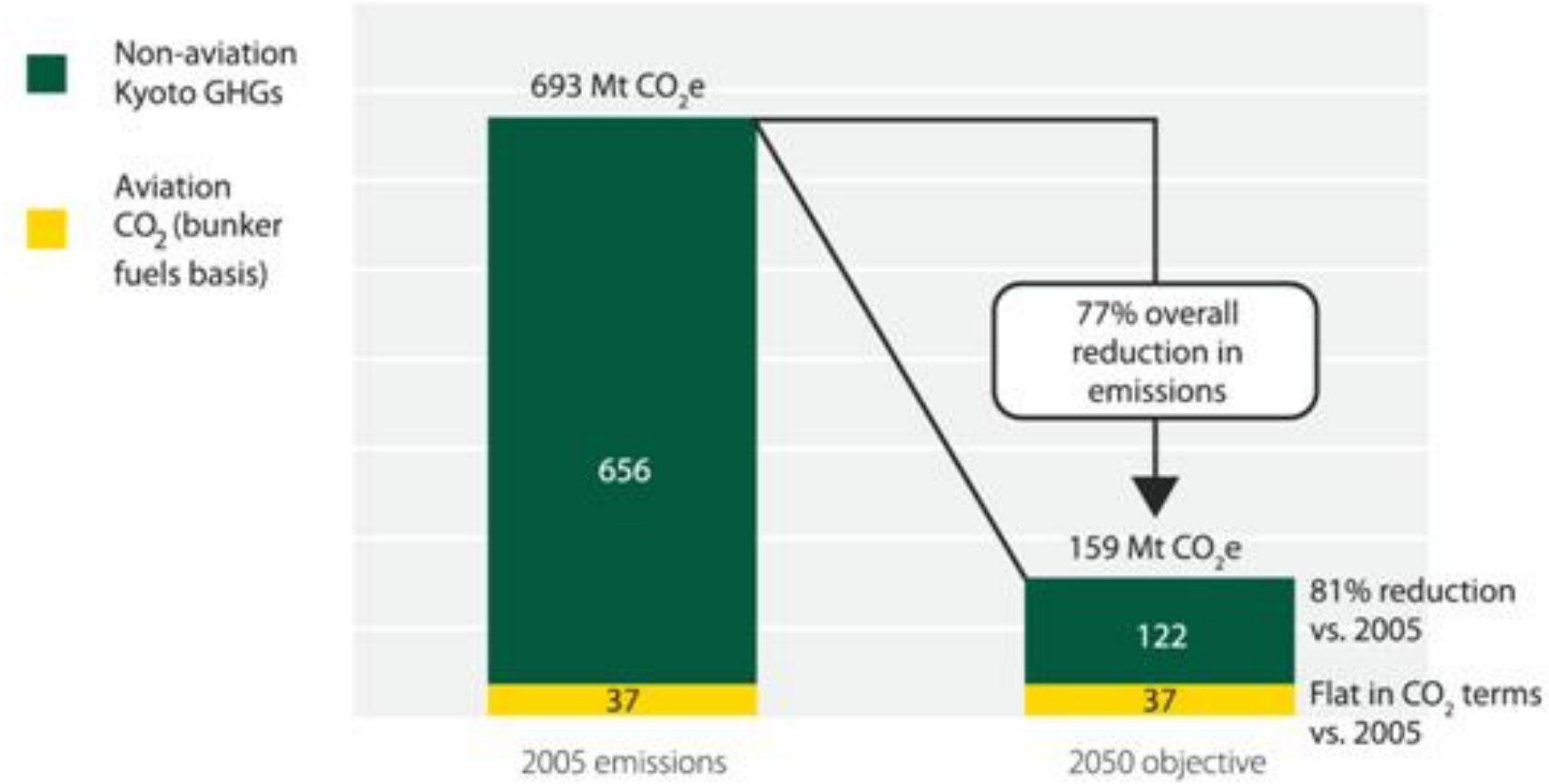


Drivers

- UN 2ºc stabilisation on global warming
- EU 20/20/20 strategy - GHG reduction and renewables
- EU transport WP - 60% reduction by 2050 & 40% sustainable fuels
- IATA - Carbon neutral growth from 2020 & 50% net reduction of aviation emissions by 2050
- ICAO - 2% p.a. fuel efficiency improvement
- UK air transport policy uncertainty



Aviation and total emissions: 2005 - 2050



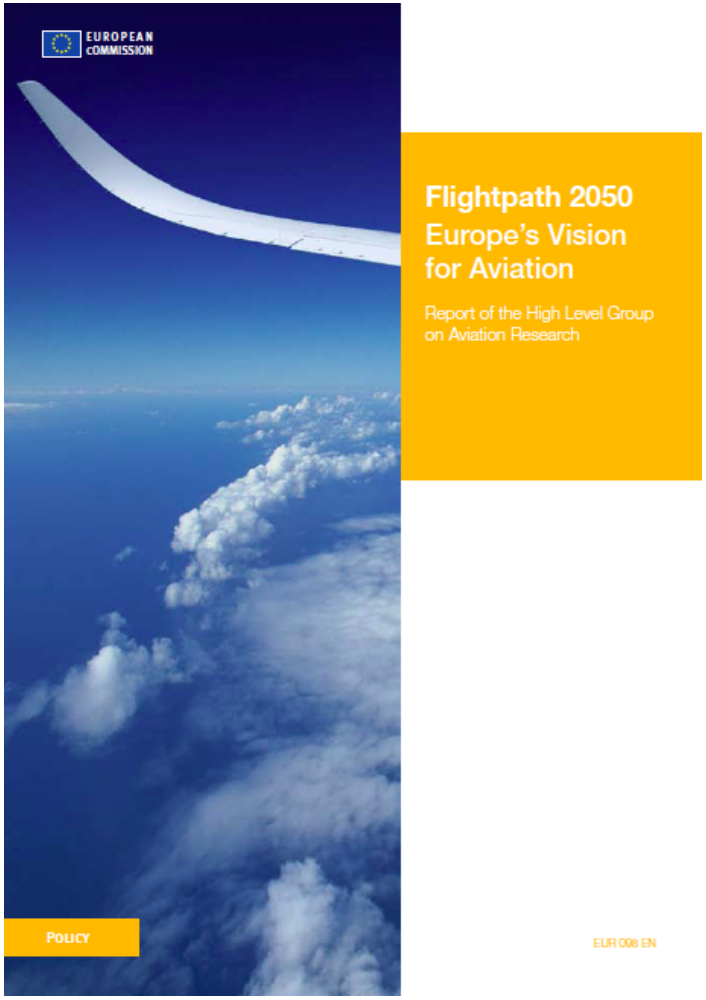
Source: Climate Change Committee, 2009

Govt 2050 target: UK aviation emissions to no greater than 2005 level.

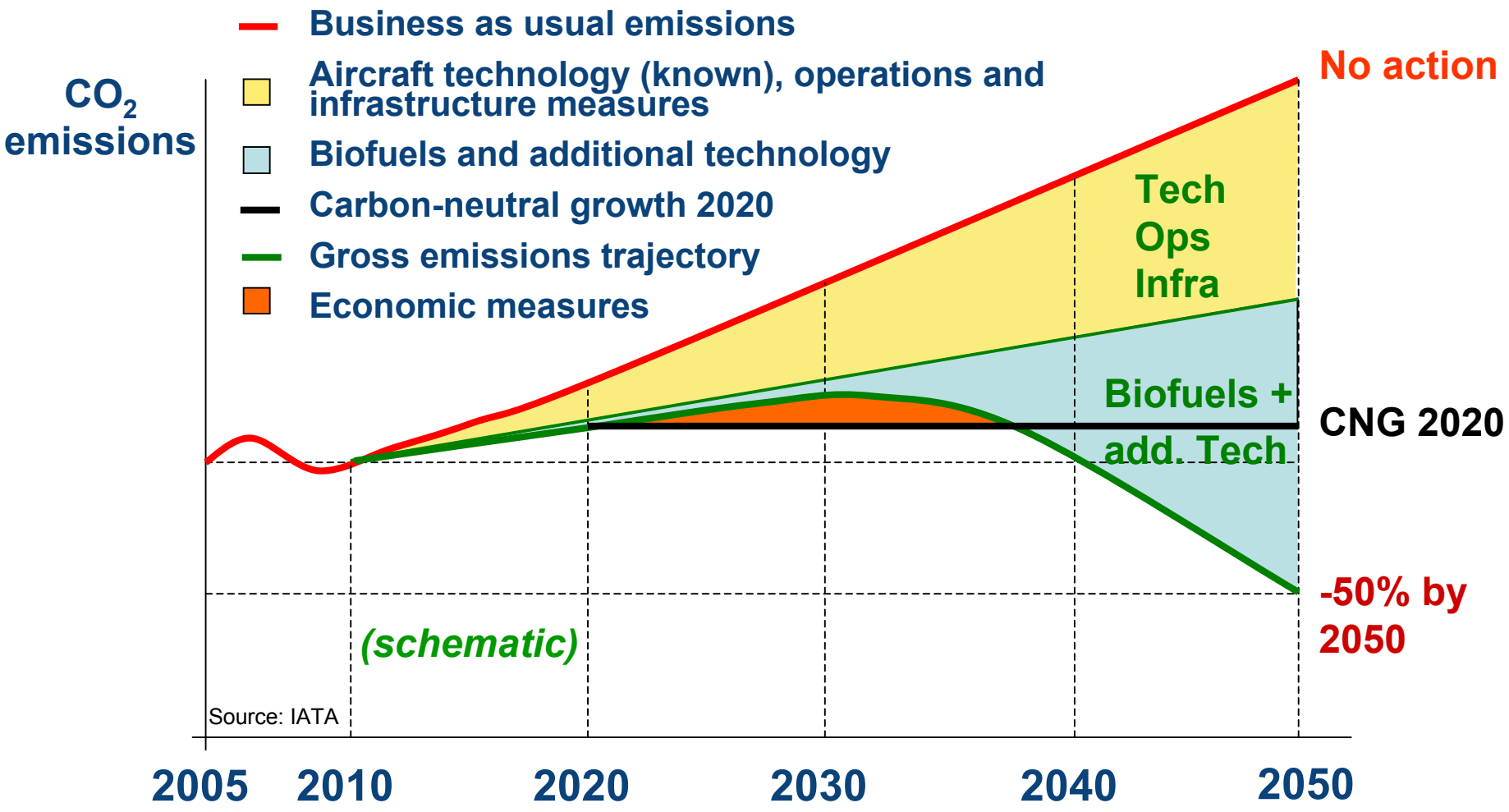
Will help UK meet its 80% CO2 reduction goal for 2050 only if other sectors make much heavier reductions.

ACARE Flightpath 2050 goals

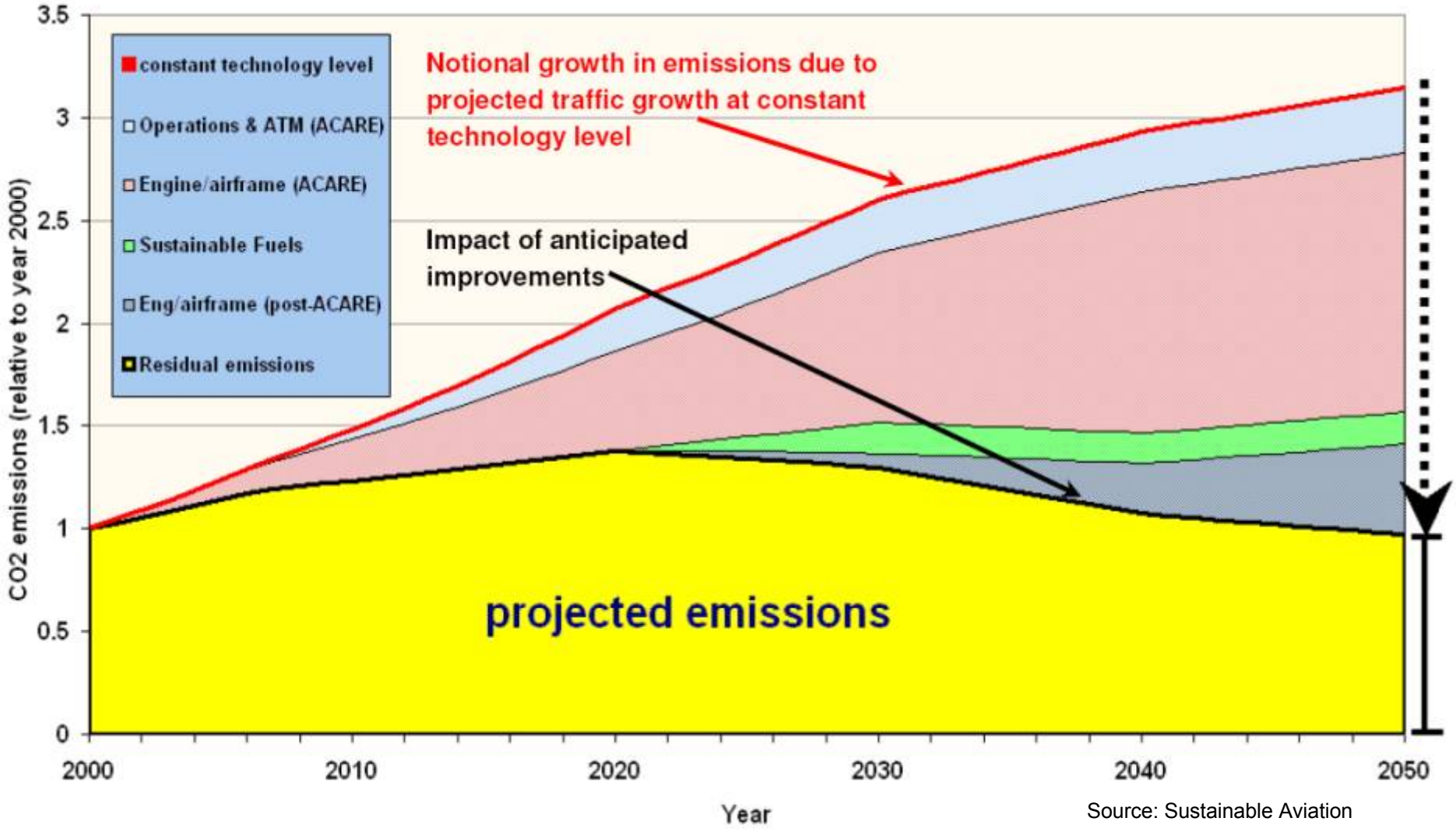
1. In 2050 technologies and procedures available allow a 75% reduction in CO2 emissions per passenger kilometre to support the ATAG target[10] and a 90% reduction in NOx emissions. The perceived noise emission of flying aircraft is reduced by 65%. These are relative to the capabilities of typical new aircraft in 2000.
2. Aircraft movements are emission-free when taxiing.
3. Air vehicles are designed and manufactured to be recyclable.
4. Europe is established as a centre of excellence on sustainable alternative fuels, including those for aviation, based on a strong European energy policy.
5. Europe is at the forefront of atmospheric research and takes the lead in the formulation of a prioritised environmental action plan and establishment of global environmental standards



Emissions reduction roadmap



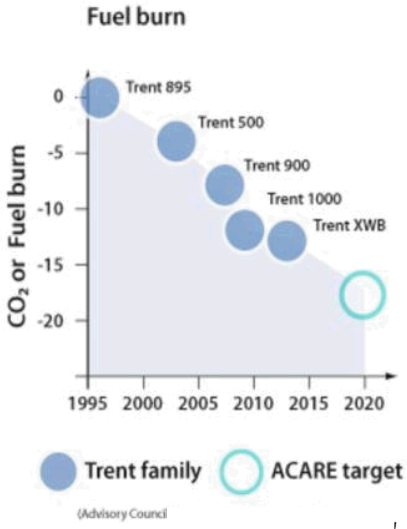
UK Sustainable Aviation CO2 roadmap

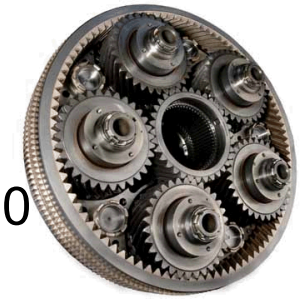


Sustainable Aviation CO2 roadmap to be updated and revised

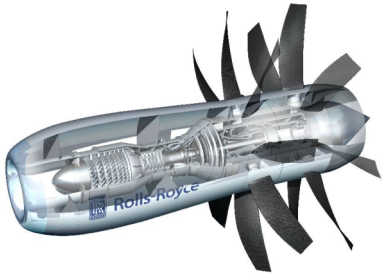
Progress against targets

- Engine developments tracking progress line fairly well towards 2020 ACARE goal - but slow integration into fleet
- Emerging technologies heading towards 2030
- New aircraft emerging - B787 imminently, A350 soon and A320 Neo this decade
- Radical aircraft designs slipping back well into the 2020s





Source: Pratt and Whitney



Source: Rolls-Royce

Advancing technologies

- Composites already integrated, in some cases up to 50%
- Laminar flow technology testing in next few years
- ‘More electric aircraft’ trend to reduce weight
- Fuel cell APUs being considered
- Riblets imminent

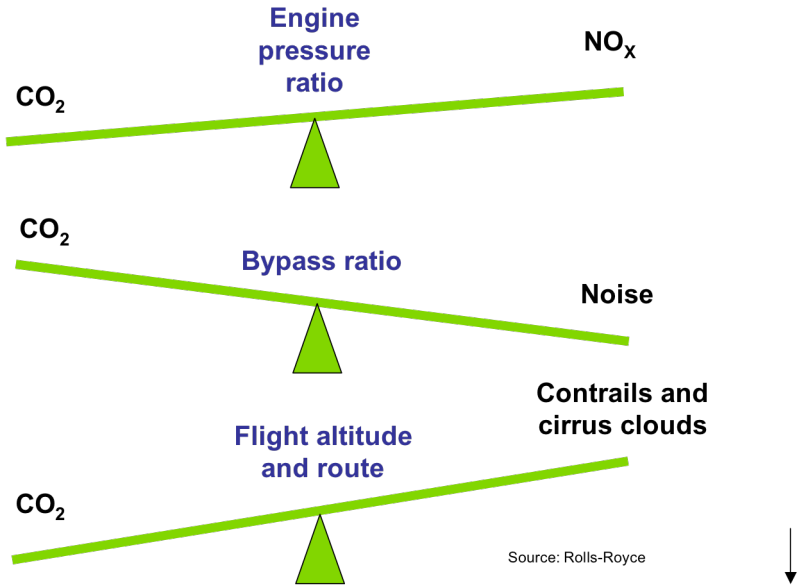
- Many international collaborative and industry programmes in train

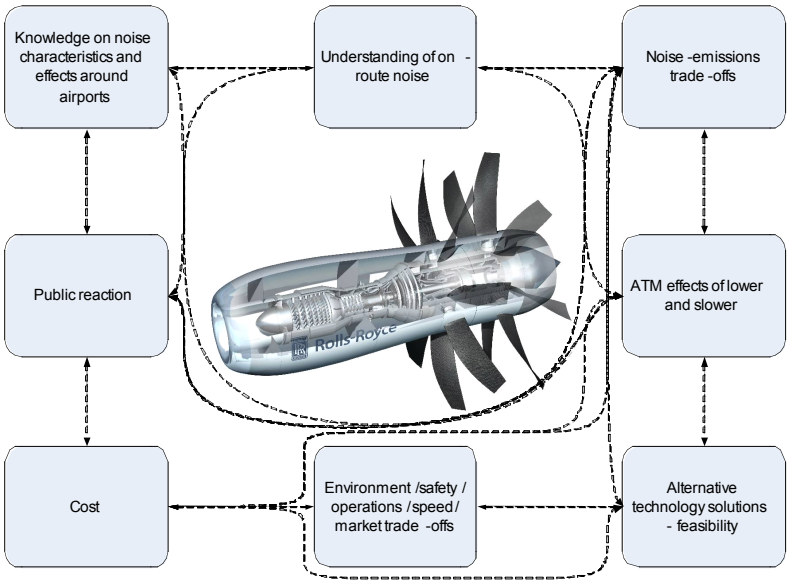
EU “Clean Sky” technology evaluator

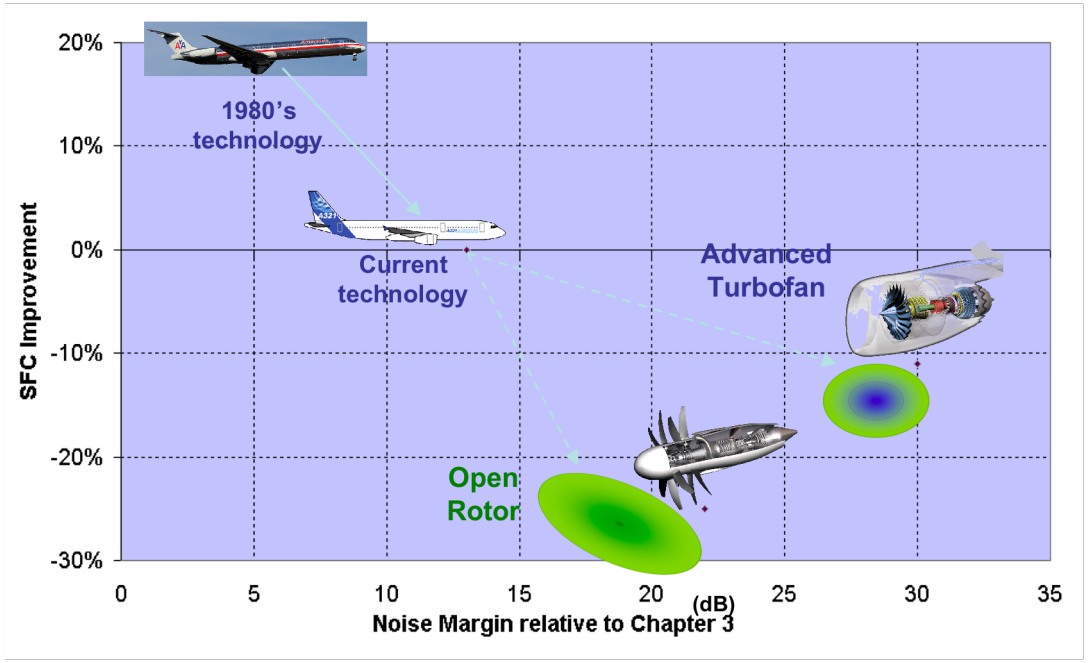
Operational measures

- Scope remains to improve efficiency
  - ATM - optimised trajectories and reduced holding and delays
  - Stop tankering
  - Ground towing & reduced engine taxi
  - Direct - v - hub & spoke
  - Reduced cabin weight
- Business model and political obstacles remain

Environmental trade-offs



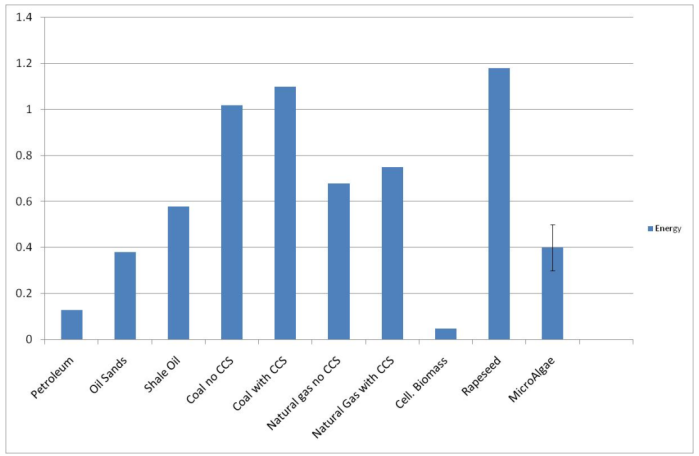




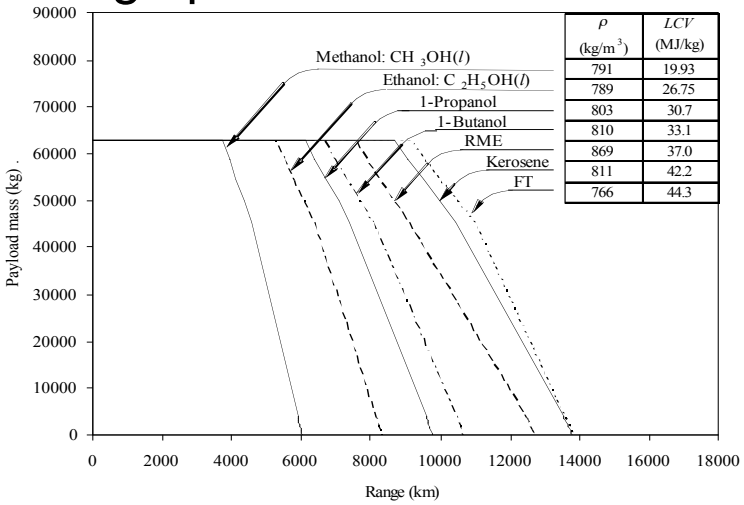
Source: Rolls-Royce, Noise & Specific Fuel Consumption improvement

Alternative fuels - lower carbon growth

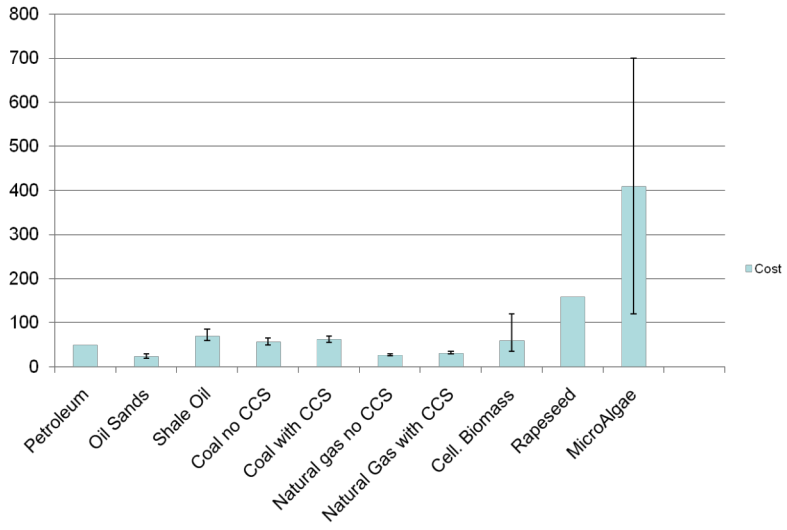
Energy use



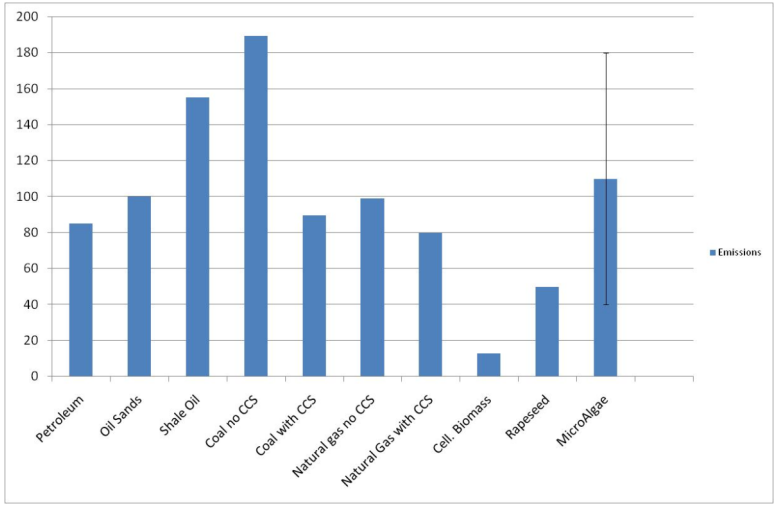
Range performance



Cost



GHG equiv. Emissions gCO_2- equivalent/$MJ_{Product}$



Alternative fuel challenges

- Technology issues can be solved and fairly quickly
- Must be a ‘drop-in’ fuel
- Adequate sustainable supply - microalgae and salt water plants attracting attention
- Economics of supply and delivery
- Regulatory level playing field

- Massive research effort and industry impetus - rapid developments
- Is it the silver bullet?

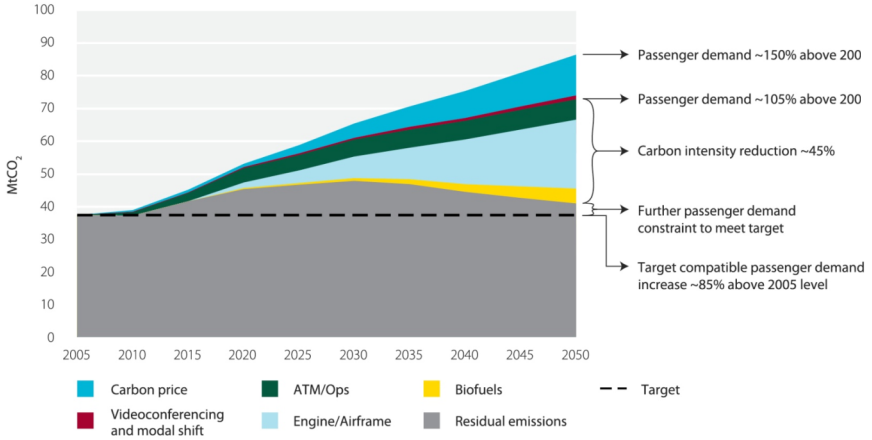
Media

Green jet fuel from Honeywell powers first transatlantic biofuel flight
23 June 2011

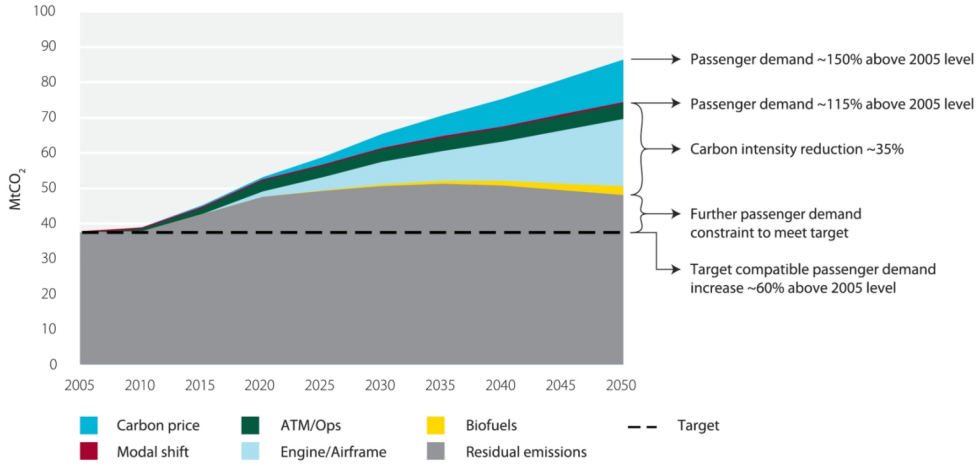
The first international flight to be fuelled by biofuels successfully landed at Paris-Le Bourget Airport on 18 June 2011.

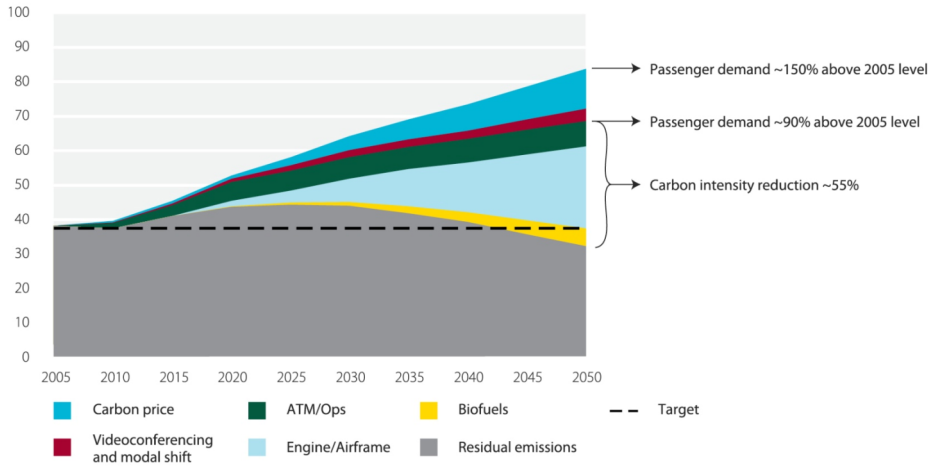
The Gulfstream G450 became the first aircraft to fly from North America to Europe using a 50/50 blend of Honeywell's green jet fuel and petroleum-based jet fuel, which powered one of the aircraft's Rolls Royce engines

UK CCC: Likely, optimistic and speculative scenarios



Source: Climate Change Committee, 2009





Government due to respond to CCC in July 2011

Planned new UK academic initiative

- Growing sense of need to replace Omega with a new activity
- Plans for a new network of academics and stakeholders reacting to need for:
  - visibility on academic work;
  - strategic view and roadmap on future research needs responding to external goals, agendas and pressures;
  - neutral forum for debate and prioritisation;
  - Sandpit for research collaboration
- Constructed around ‘interdependencies’ challenge
- Current work drafting a proposal to UK research councils involving 15 universities and as many key stakeholder

Summary

- Some very tough emissions goals exist and the sector has set itself equally tough targets to achieve
- Massive technology and operational research investment but significant lack of understanding on impacts and projections
- Is there a sustainability gap? Yes, alternative fuels and ETS may help but the trend is for growing aircraft emissions
- Radical solutions needed as diminishing returns from existing approaches
- Some complicated trade-offs and interdependencies to deal with
- UK academia looking to reassert an independent voice and help stakeholders with solutions.