Environmental Aspects of Aviation and its Decarbonization

Cranfield Environment Centre

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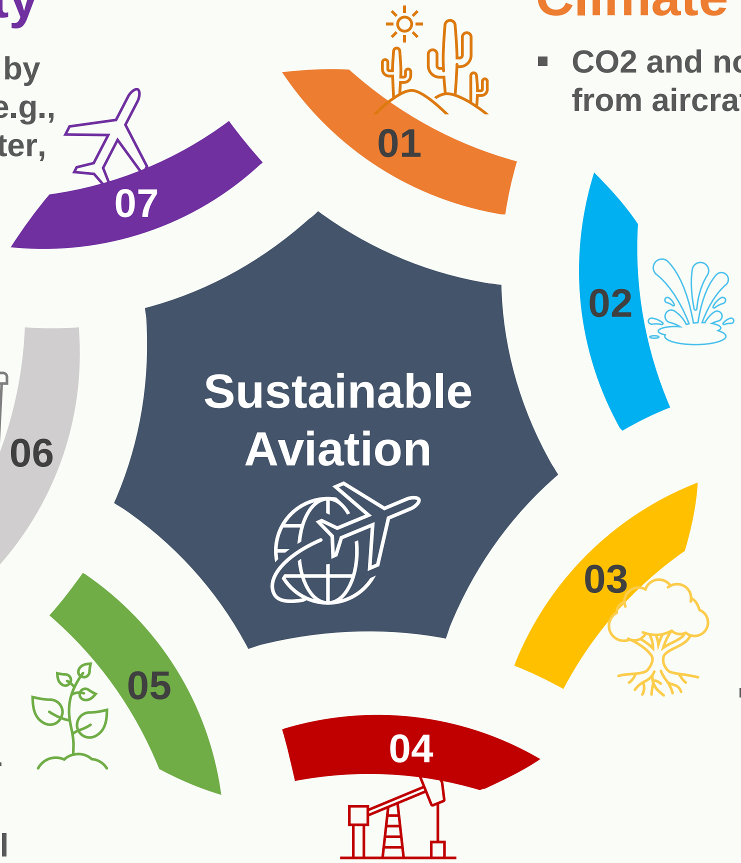
1 Sustainable Aviation

Air Quality

- Air pollution caused by aviation emissions (e.g., NOx, Particulate Matter, etc.)

Climate Change

- CO_2 and non-CO_2 emissions from aircraft and airport



Water

- Water pollution to nearby water bodies
- Water consumption to maintain the operation of airport and aircraft

Waste

- Various waste from airport and aircraft

Land Use

- Direct/indirect impact of land use change due to airport, fuel and wider infrastructure

Biodiversity

- Noise pollution near airport
- Disruption of natural habitats around airports.

Resources

- Depletion of non-renewable energy resources (heavily dependence on fossil fuel)

Fig. 1 *Environmental impacts addressed by sustainable aviation*
(Presentation created with PresentationGO templates and graphics (www.presentationgo.com))

"Sustainable aviation is a multi-disciplinary field aimed at improving the environmental and societal impacts of air transportation."

From an environmental perspective, it is expected to address the environmental impacts shown in Fig.1.

2 Challenges in Aviation Decarbonization

Some Key facts and figures

Aviation's CO_2 emissions make up about **2.5%** of global totals, but its potential for global warming could be much higher due to the **non-CO_2 impacts**

Non-CO_2 impacts contribute **two-thirds** of aviation's net radiative forcing

By 2050, over **10 billion** air passengers are expected to travel **22 trillion km** annually, potentially generating nearly **2,000 Mt** (Megatonnes) of CO_2

From **2005 to 2019**, aviation fuel efficiency improved by ~ **39%**, but absolute emissions growth far more than efficiency gains

Why is aviation a difficult sector to decarbonise ?

Long replacement time for aeroplane
(commercial aircraft can last between 20 to 30yrs)

Investment required for decarbonisation
(e.g., Capital expenditure on SAF production facilities is estimated at up to $1.45 trillion over 30 years)

Bold investment and breakthroughs required in R&D

Lack of adequate regulatory support

Requirement for global collaboration and coordination

Passenger reluctance on the cost of decarbonisation solutions

3 Solutions for Jet Zero

Utilisation of alternative fuels

- Sustainable Aviation Fuel (SAF)
- Hydrogen (H_2)
- Electric (propulsion)
- Ammonia

Improvements in aircraft fuel efficiency

- Aircraft design
- Efficient engine
- Lightweight materials
- Improved systems

Enhancements in air traffic control & operational measures

- Optimised flight planning
- Dynamic airspace management
- Artificial Intelligence (AI)

Strategies for non-CO2 emission

- Alternative fuel
- Avoidance of Contrail cirrus formation
- Aircraft design
- Advanced engine technology

4 Environmental Consequence

Environmental Consequence (H_2)

- Zero carbon emissions (in flight)
- Reduction in climate impact: 75%-90% reduction for H_2 fuel cell; 50%-75% reduction for H_2 turbine
- Improved air quality (NO_2 reduction: 100% for fuel cell; 50%-80% for H_2 turbine)
- Increased contrail coverage due to the additional water vapor emission

Environmental Consequence (SAF)

- 70%-80% reduction in CO2 emission, with a potential of up to 100% (well-to-wake)
- Significant reduction in soot and SO_2
- 10% -40% reduction in contrail formation (high uncertainty)
- Induced Land Use Change emissions

5 Research Activities in Cranfield University

Pilot-scale practicality and environmental impact of SAF manufacture

Fig. 2 *National Environment Sector Decarbonisation Accelerator (NESDA) test facility*

Environmentally friendly ways of making crop-based SAF

Fig. 3 *Mixed food-fuel cropping for SAF production by applying multi-cropping techniques.*

Integration of hydrogen and SAF systems in the Cranfield Global Research Airport

Fig. 4 *Cranfield's UKRIC 'Living Laboratory' campus*

Reducing the climate impact of aircraft (CO_2 and non-CO_2 emissions)

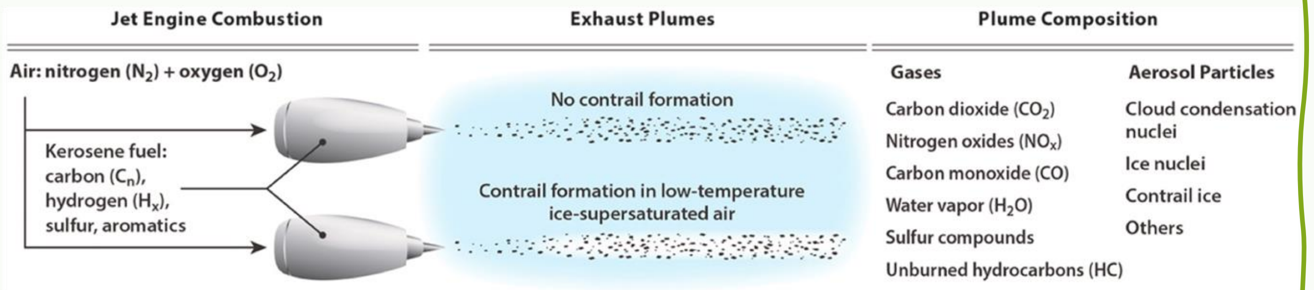


Fig. 5 *Aviation CO_2 and non-CO_2 emissions, adapted from Lee et al. (2021)*