

# Why the LCIA-method IPCC 2013 is insufficient to show realistic climate-impacts of aircraft emissions

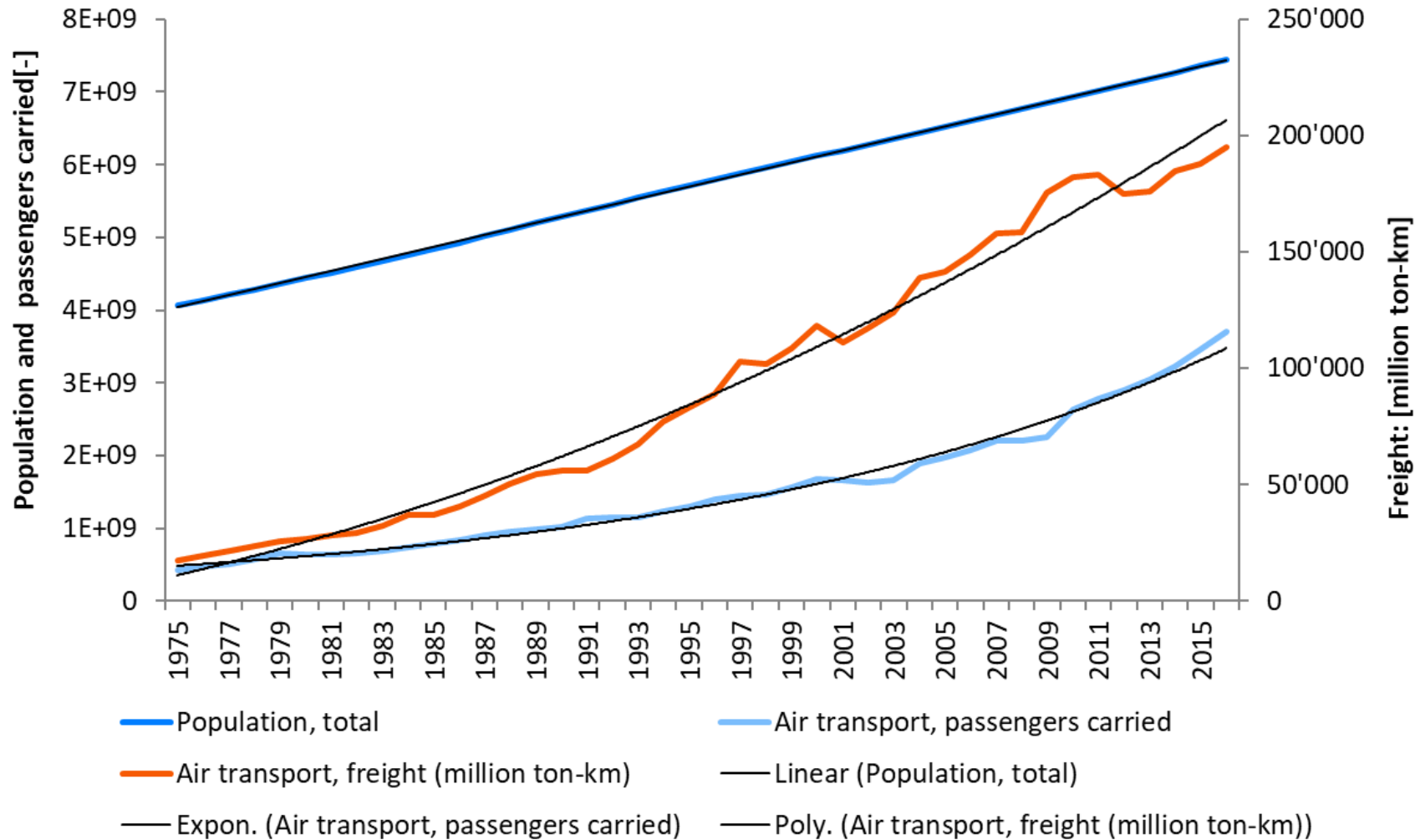
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LCIC 2018

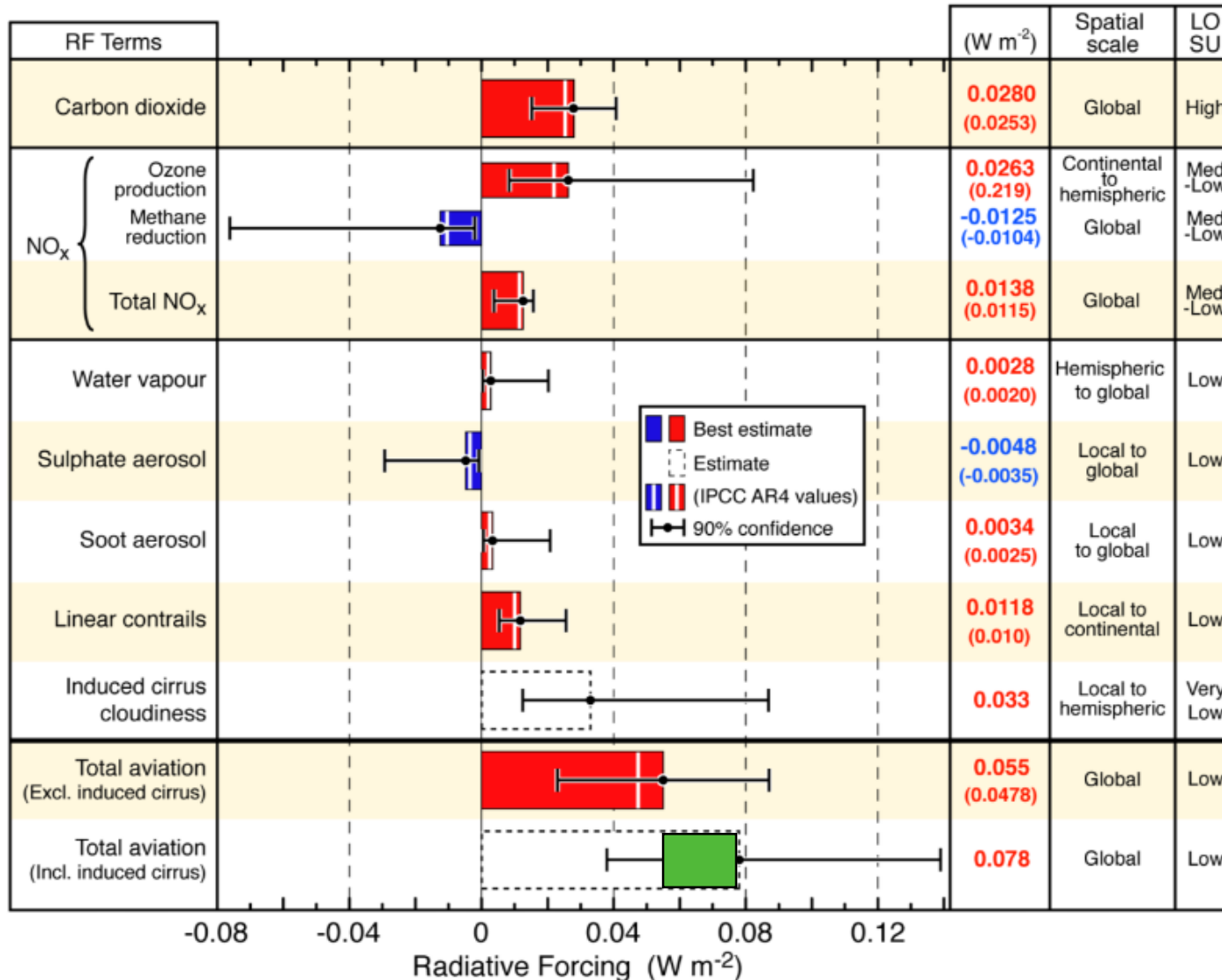
Berlin, 31.08.2018

# Exponential growth in aviation



Data from <http://data.worldbank.org>, online 11.06.2018

# Aviation Radiative Forcing in 2005



## Key question

How to account for global warming effects of aviation which are not due to greenhouse gases in life cycle assessment and carbon footprinting?

## Recommendation IPCC

- There is no clear recommendation.
- Publications suggest a RFI factor of 2 to 5 that should be multiplied by the total direct CO<sub>2</sub> emissions from burning aviation fuels.

# Literature research in 2013/2018

## Approaches for RFI factors on CO<sub>2</sub> in stratosphere

1. Factor 1: Neglecting all additional impacts
2. Factor 1.2-1.4: Accounting for impacts without cirrus clouds (minimum impacts)
3. Factor 2.7-3: Accounting for all impacts (outdated)
4. Factor 3.9-5.2: Accounting for all impacts (recent)
5. Factor 8.1-8.5: Worst-case (possible overestimation)

## Recommendation ESU-services

- RFI Factor of 5.2 on the CO<sub>2</sub> emissions in the stratosphere (according to share in ecoinvent v2.2 data).
- or factor 2 on total aircraft CO<sub>2</sub> emissions.
- Should be applied as a scenario in any analysis where transport by airplanes is included.

# How to implement in LCA Software?

**General** | Characterisation

Name: IPCC 2013 GWP 100a with RFI      Version: 1 03

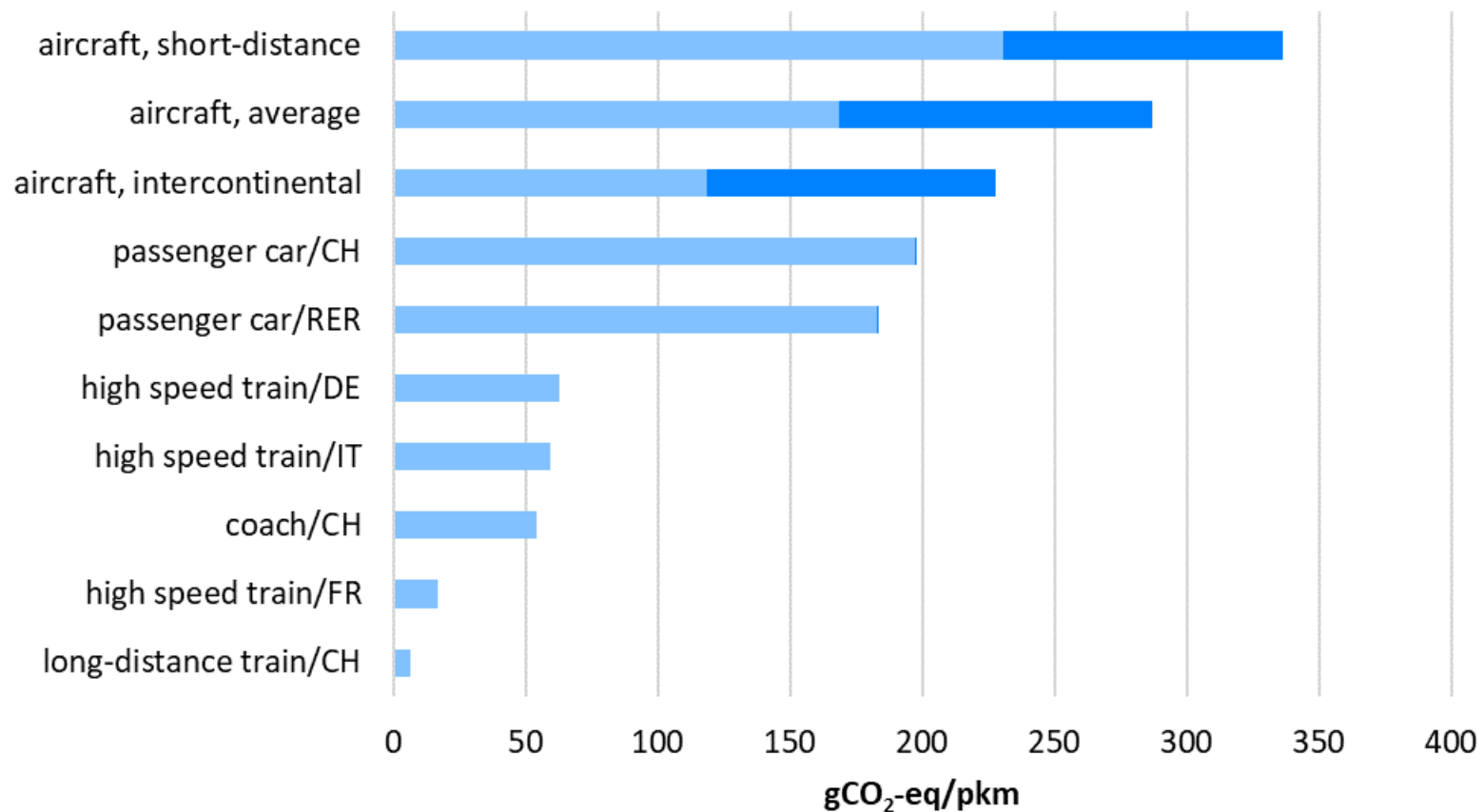
Structure:  Damage assessment     Normalisation     Weighting     Addition

Comment: NJ, March 2017: IPCC aviation, Scenario added for including indirect global warming effects of aviation. Total RFI factor estimated with 5.2 based on Lee et al. 2009 and Peters et al. 2011.

Compartment	Subcompartment	Substance	CAS number	Factor	Unit
Air		Butanol, 2,2,3,4,4,4-hexafluoro-1-	000382-31-0	17	kg CO2 eq / kg
Air		Carbon dioxide	000124-38-9	1	kg CO2 eq / kg
Air	stratosphere	Carbon dioxide	000124-38-9	5.2	kg CO2 eq / kg
Air	stratosphere + troposphere	Carbon dioxide	000124-38-9	5.2	kg CO2 eq / kg
Air	stratosphere	Carbon dioxide, biogenic	000124-38-9	4.2	kg CO2 eq / kg
Air	stratosphere + troposphere	Carbon dioxide, biogenic	000124-38-9	4.2	kg CO2 eq / kg
Air		Carbon dioxide, fossil	000124-38-9	1	kg CO2 eq / kg
Air	stratosphere	Carbon dioxide, fossil	000124-38-9	5.2	kg CO2 eq / kg
Air	stratosphere + troposphere	Carbon dioxide, fossil	000124-38-9	5.2	kg CO2 eq / kg
Air		Carbon dioxide, land transformation	000124-38-9	1	kg CO2 eq / kg
Soil		Carbon dioxide, to soil or biomass stock	000124-38-9	-1	kg CO2 eq / kg



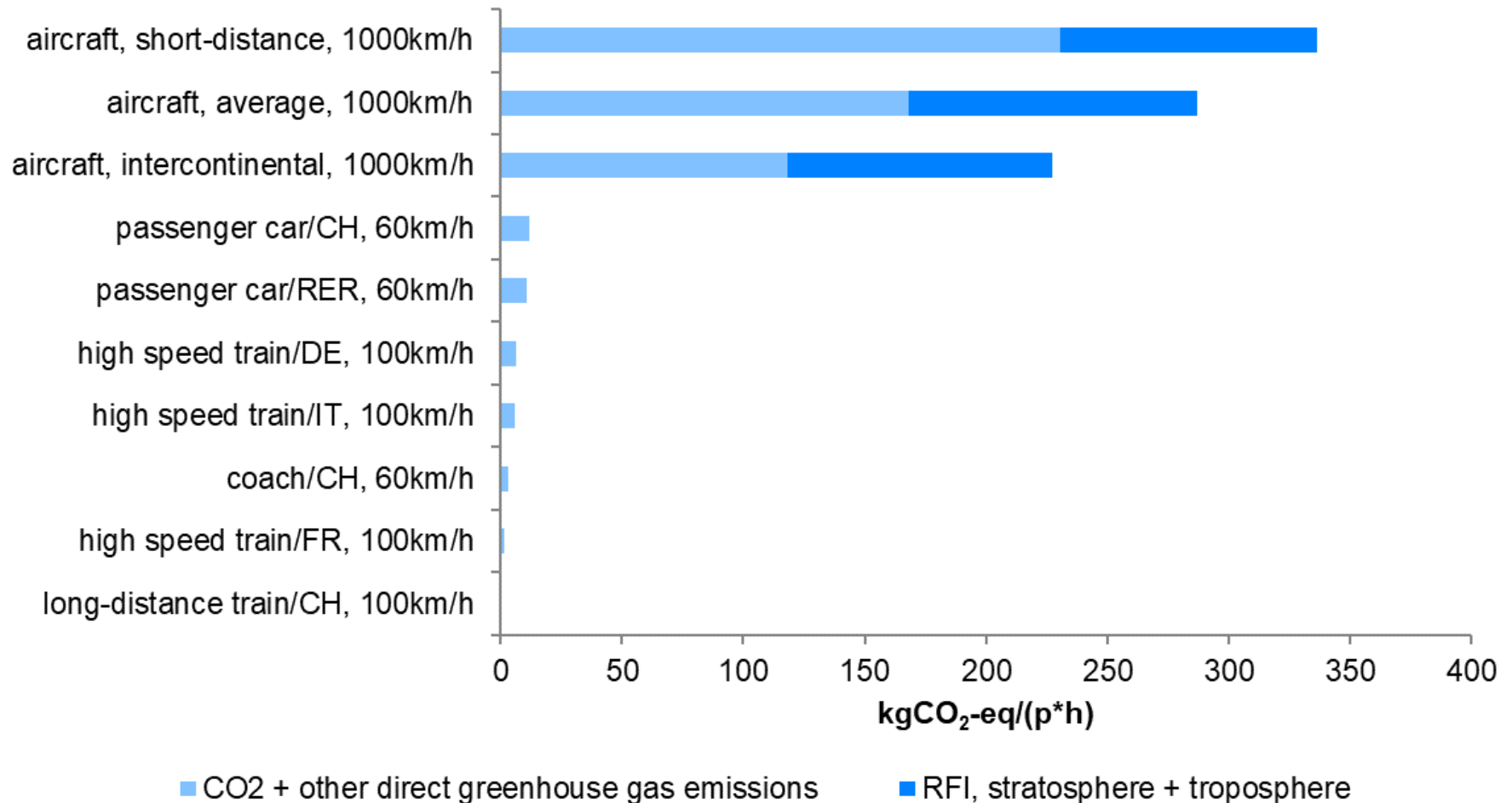
# Change in impact of transportation per pkm (ESU database 2018)



■ CO<sub>2</sub> + other direct greenhouse gas emissions

■ RFI, stratosphere + troposphere

# Change in impact of transportation per p\*hour (ESU database 2018)



# Outlook

- Factor for LCIA needs to be revised if the ratio on “higher atmosphere” emissions changes in LCI data
- Working paper available under [www.esu-services.ch/ourservices/pcf/](http://www.esu-services.ch/ourservices/pcf/)
- Peer-reviewed paper to be published.

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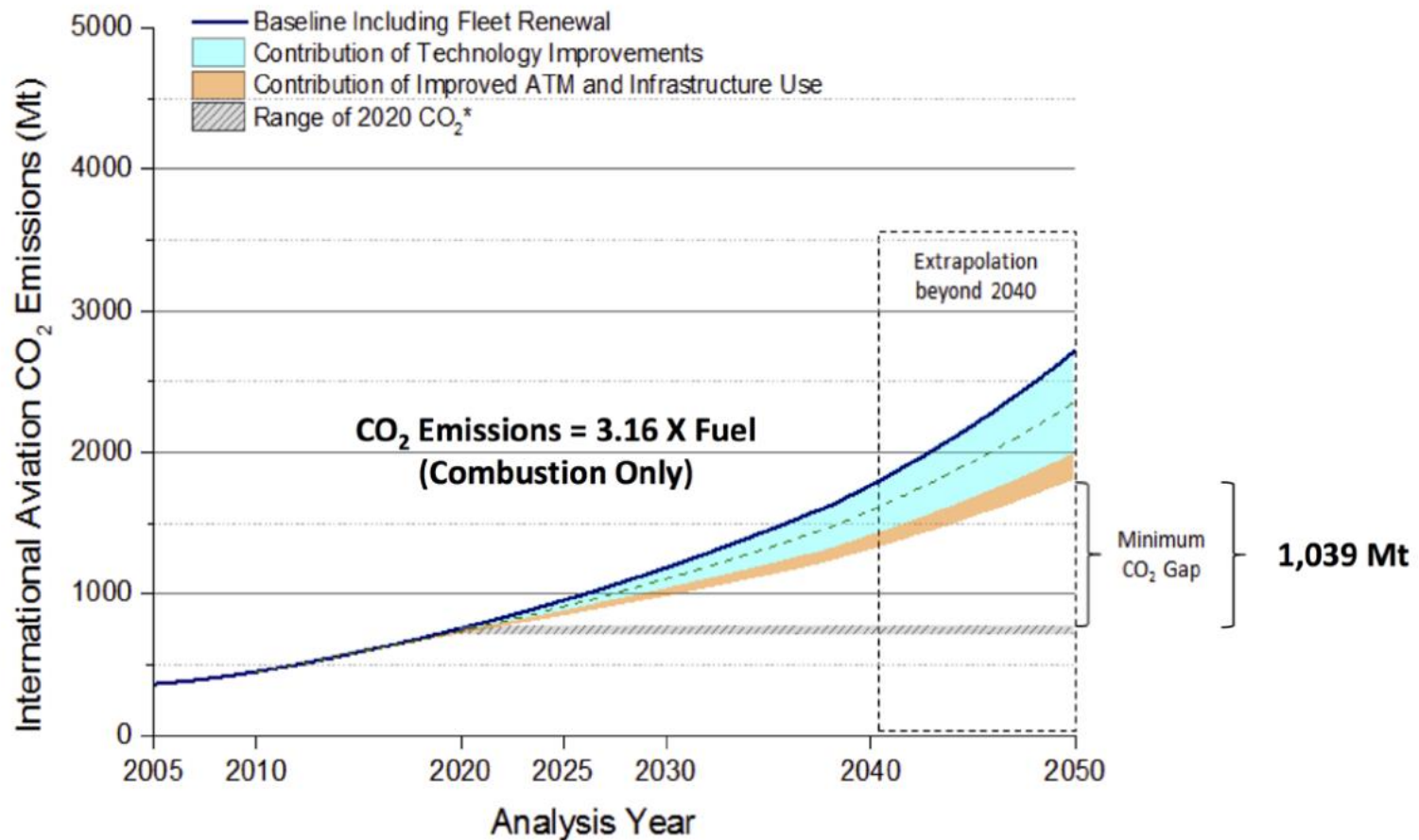
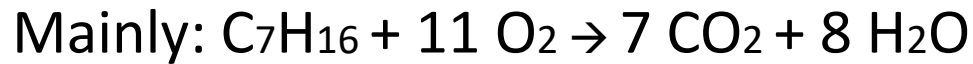
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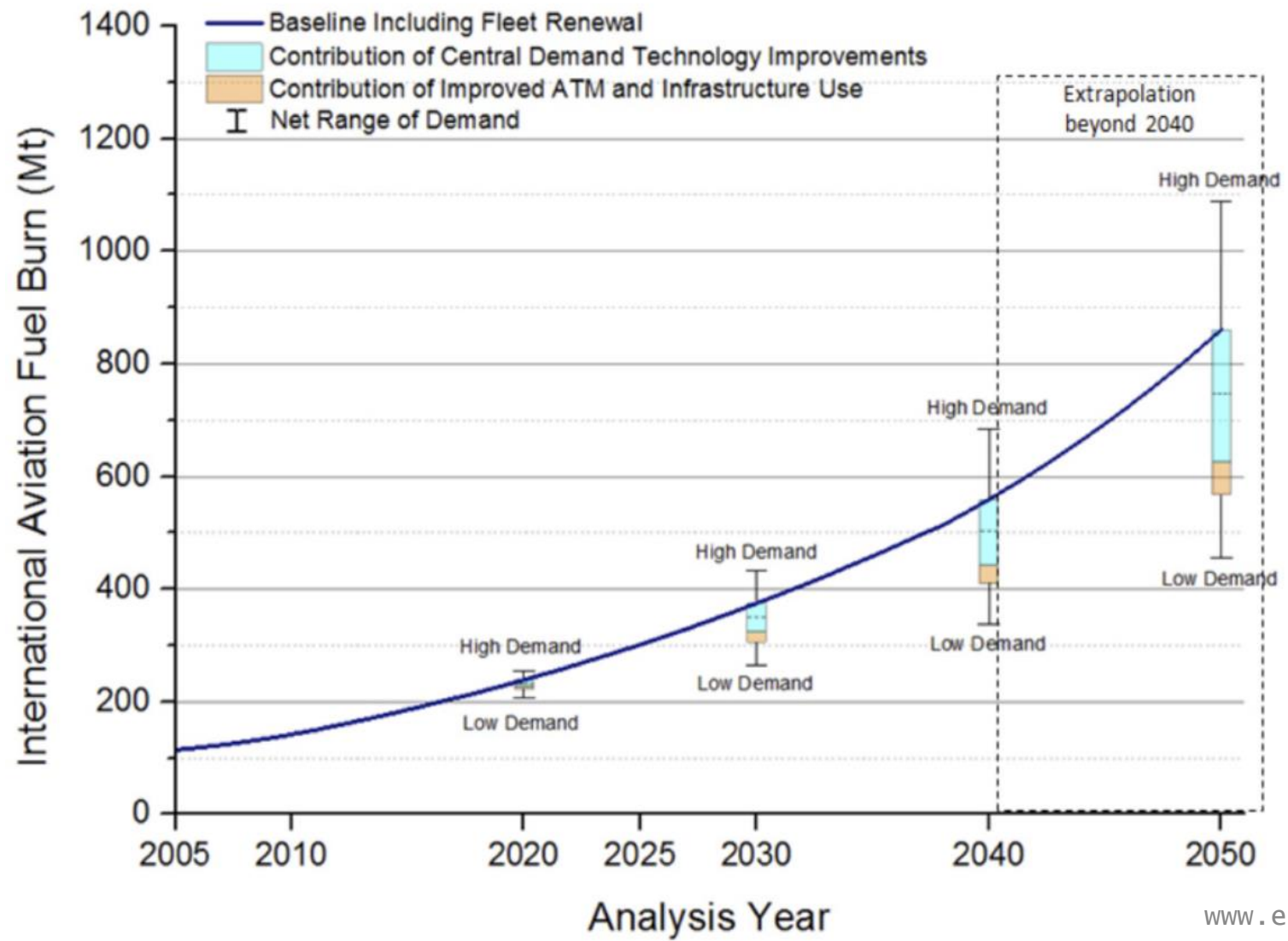
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# Direct CO<sub>2</sub>-emissions



\*Actual carbon neutral line is within this range  
Dashed line in technology contribution sliver represents the "Low Aircraft Technology Scenario."  
Note: Results were modelled for 2005, 2006, 2010, 2020, 2025, 2030, and 2040 then extrapolated to 2050.

# Using aviation fuel



ICAO sustainability report 2016, online 11.06.2018