Aligning aviation with the Paris Agreement: What's possible?

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7 July 2022

ICCT webinar

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Background
- Study design
- Results
- Conclusions and policy implications
- Questions and discussion

Background

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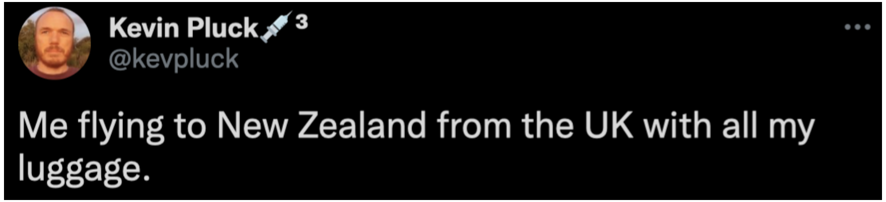
Aviation has a fossil fuel problem



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Postcards from COP 21 (2015)

https://www.cleanenergywire.org/news/cop21-day-6-hard-work-ahead-more-finance-elephants-room

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IMO leapfrogs ahead in 2018

@guilanpour

@rogeradamson

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Aviation attempts a comeback

- Momentum is building for a “Paris moment” for aviation in Montreal this fall.
- A global aviation CO_2 target will unlock new investments and national policies for clean aircraft/fuels.
- Risks:
  - Questions about the achievability of net-zero pathways from some ICAO member states
  - Risk of overshoot, missing Paris targets even if 2050 net-zero is achieved
  - Aspirational targets not followed up by concrete measures
- ICCT’s Vision 2050 aviation roadmap aims to mitigate these risks.

Date	Progress
Feb 2021	Europe’s Destination 2050 net-zero roadmap
Mar 2021	Airlines for America commits to net-zero
Oct 2021	IATA adopts a global aviation industry net-zero goal
Nov 2021	COP 26 International Aviation Climate Ambition Coalition launched
Mar 2022	ICAO concludes that deep GHG cuts are feasible
June 2022	***Vision 2050: Aligning Aviation with the Paris Agreement released***
July 2022	ICAO High Level Climate Meeting
Sept/Oct 2022	ICAO 41st Assembly

Study Design

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ICCT Vision 2050

- ICCT published Vision 2050 in September 2020
  - Strategy to decarbonize global transport by mid-century
  - Global aviation CO_2 could be cut to 300 Mt in 2050 from aircraft technology improvements, alternative fuels

- What is new in this report?
  - New technologies, notably hydrogen, and aggressive mitigation strategies like modal shift and formation flying
  - Partially integrated model (PACE) estimating fuel and carbon prices plus demand response
  - Comparison to other public decarbonization roadmaps

Research question

To what extent can various measures reduce cumulative CO_2 emissions from global aviation in-line with 1.5ºC, 1.75ºC, and 2ºC targets?

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Scenarios

S0: Reference (business-as-usual)

S1: Action

S2: Transformation

S3: Breakthrough

Increasing level of ambition

Key mitigation wedges / technology assumptions

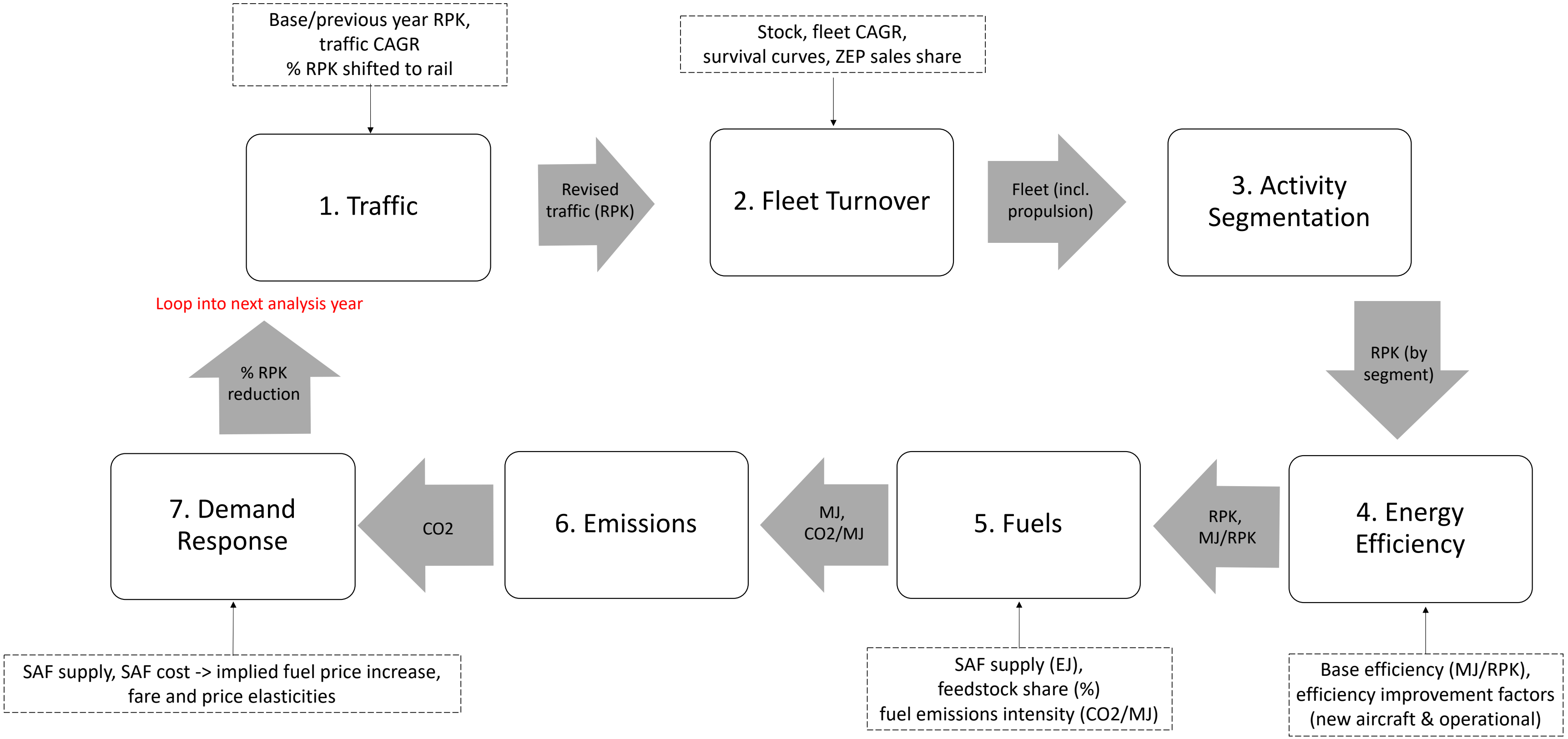
Our three modeling scenarios consider 6 important parameters:

- Aircraft technology
- Operations
- Sustainable aviation fuels (SAFs)
- Zero emission planes (ZEPs)
- Traffic
- Economic incentives

} Demand change

In-depth information on each of the modeling inputs can be found in the study on our website.

Projection of Aviation Carbon Emissions (PACE) model



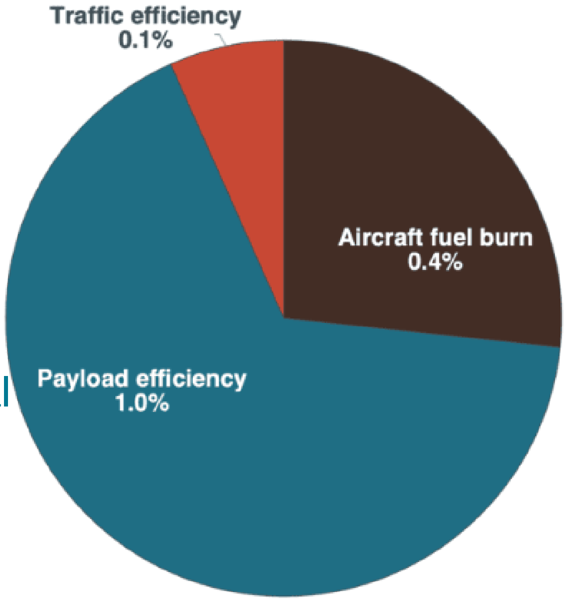
Better characterizing aviation fuel efficiency

Decomposed fuel efficiency into three components

- Aircraft fuel burn
- Payload efficiency
- Traffic efficiency

Operational Efficiency

Key drivers of US airline annual fuel efficiency improvements, 2005 to 2019

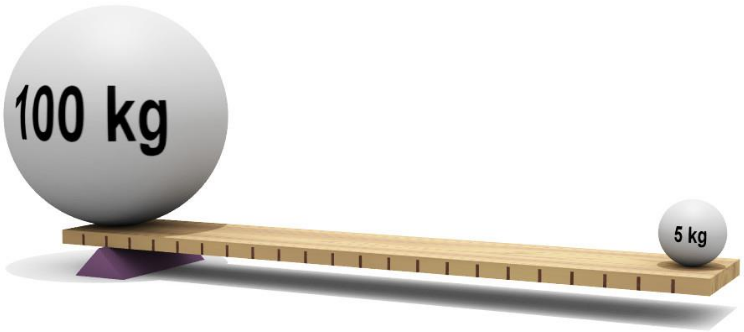


https://theicct.org/aviation-fuel-efficiency-jan22/

Modeling of future fuel costs

To ~2040

2040+



Jet A to SAF cross-subsidy via LCFS, SAF mandate, or ETS with revenue recycling

Fuel, carbon tax, or ETS set at marginal abatement costs.

Results

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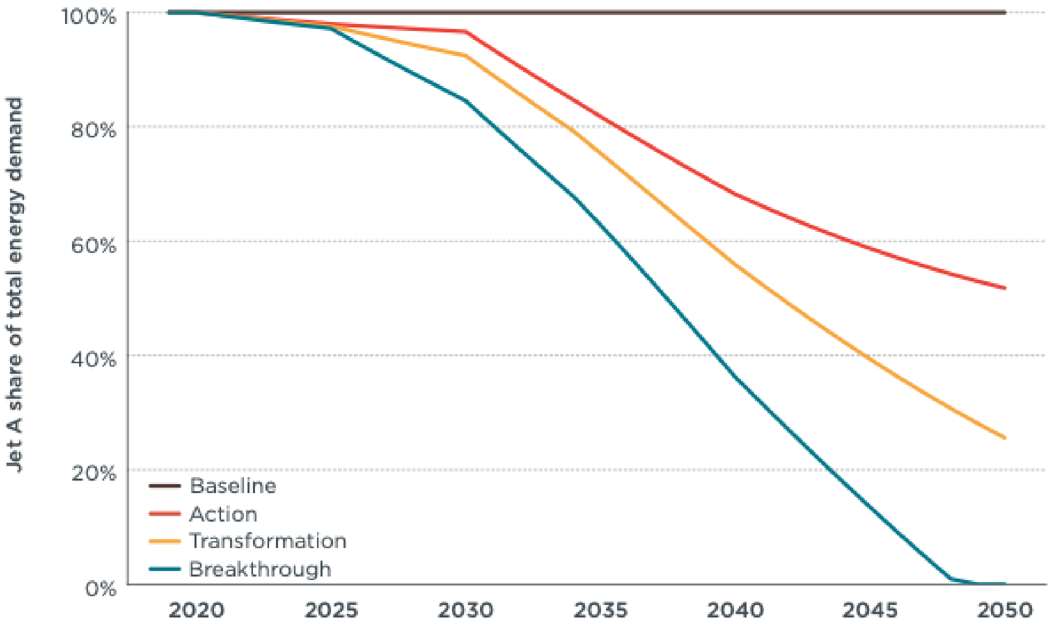
Jet A fuel share

Action: Jet A share of aviation energy almost halves by 2050

Transformation: share drops more than 75% as synthetic fuels come to dominate after 2040

Breakthrough: Jet A demand peaks in 2025, zeros out before mid-century



https://theicct.org/publication/global-aviation-vision-2050-align-aviation-paris-jun22/

Energy demand – Breakthrough scenario

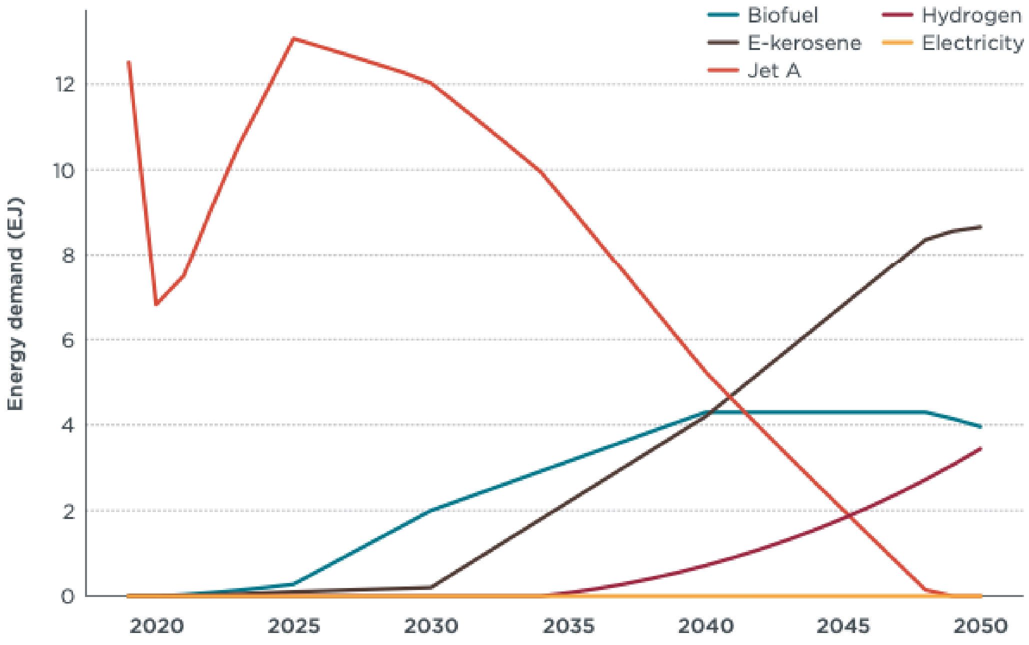
2019: nearly 12.5 EJ of energy was consumed, nearly all Jet A

2025: peak Jet A demand

2030: 14.25 EJ demand, 85% Jet A

2038: Alt fuels overtake Jet A

2050: 16.3 EJ demand, 78% SAFs, 22% H_2



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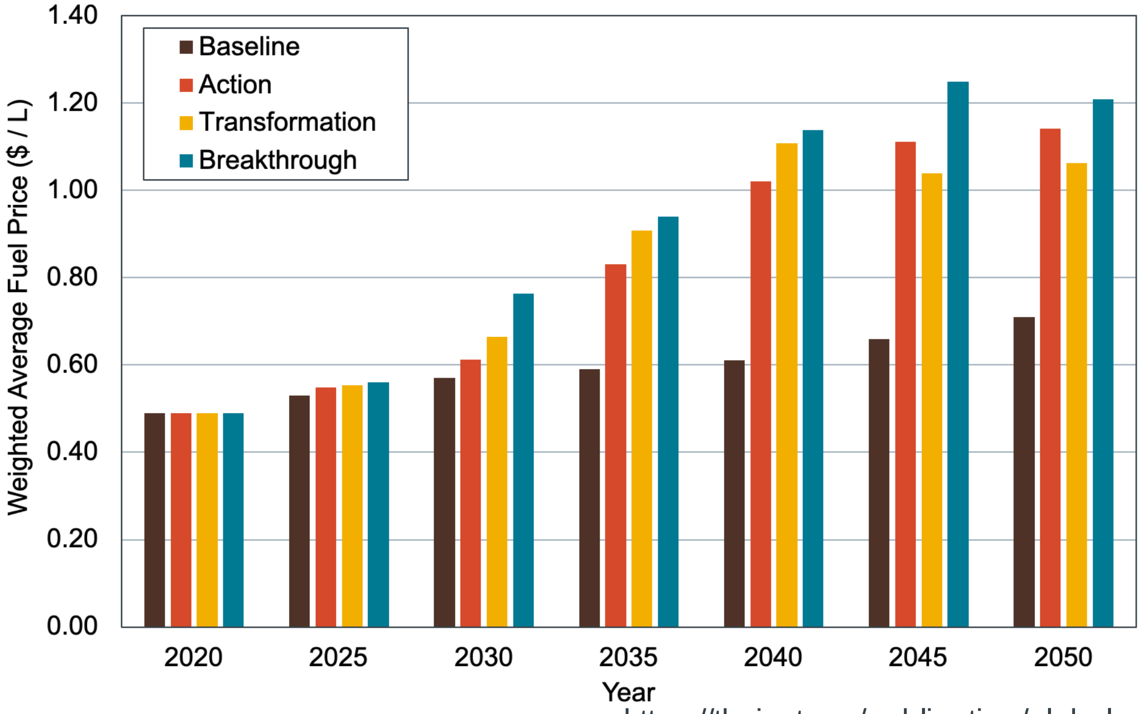
Estimated fuel prices



Action and Transformation: average fuel cost is 60-65% higher than Jet A in 2050

Breakthrough: average fuel cost is 70% higher than Jet A in 2050

Larger SAF volumes and greater use of direct air capture lead to higher fuel costs in Breakthrough

https://theicct.org/publication/global-aviation-vision-2050-align-aviation-paris-jun22/

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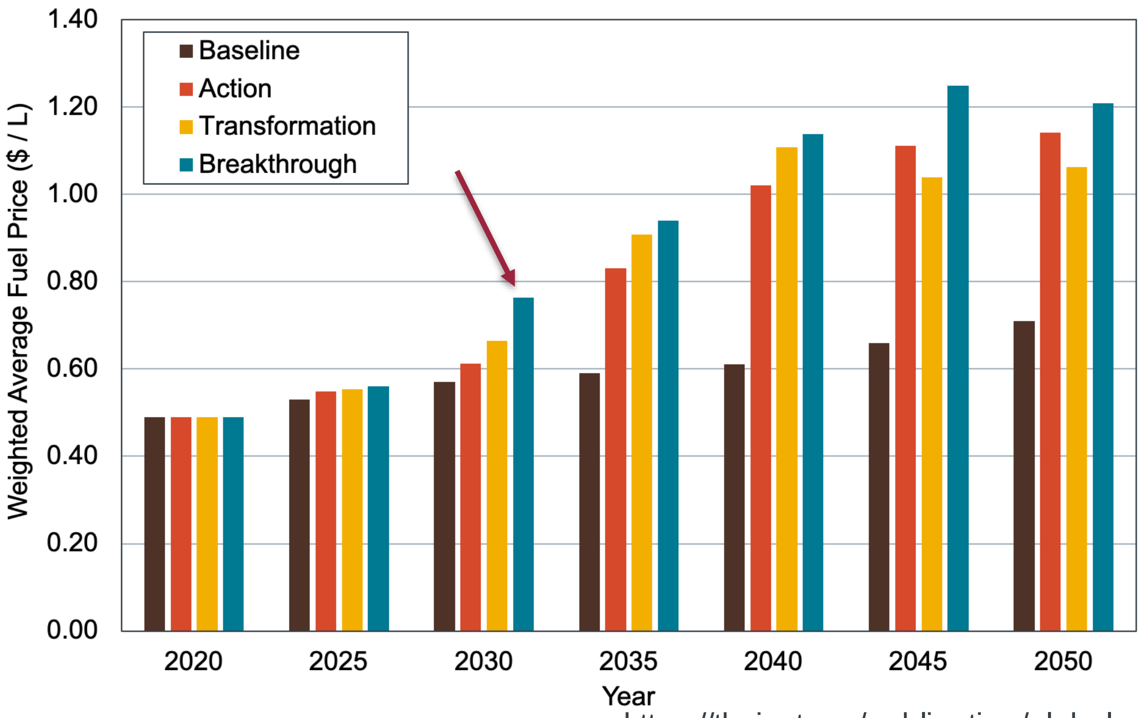

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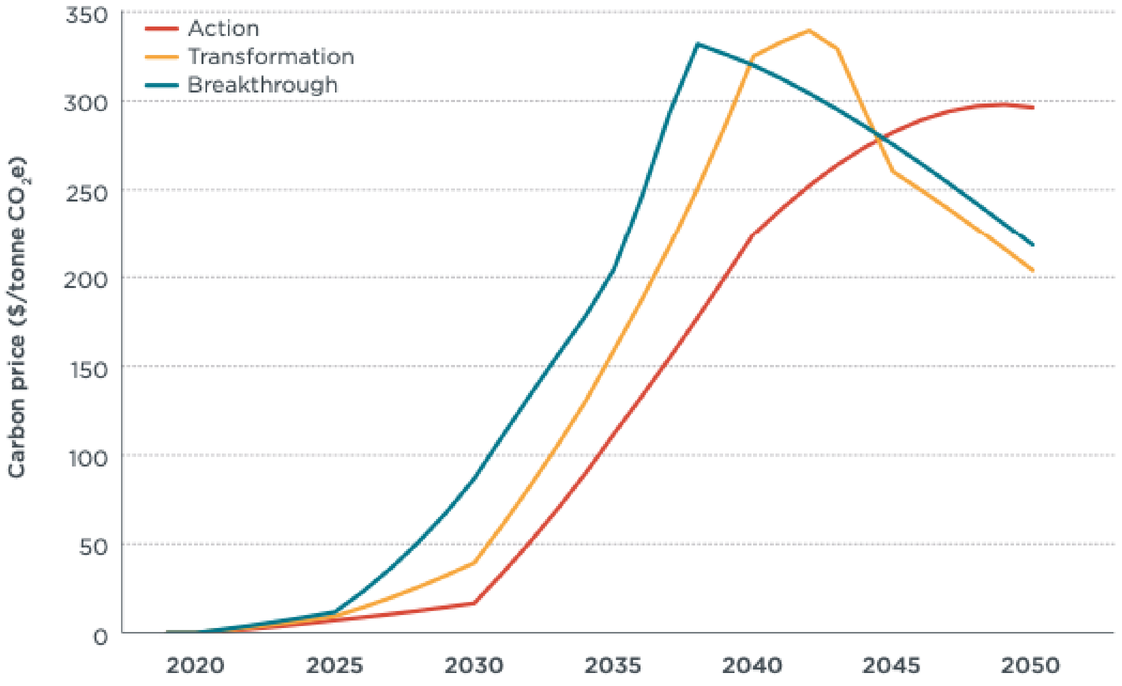
Estimated carbon prices

<u>Action</u>
2030: $15 / tonne
2050: $300 / tonne (peak)

<u>Transformation</u>
2030: $40 / tonne
2042 (peak)
2050: $200 / tonne

<u>Breakthrough</u>
2030: $80 / tonne
2037 (peak)
2050: $225 / tonne



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2030: $80 / tonne
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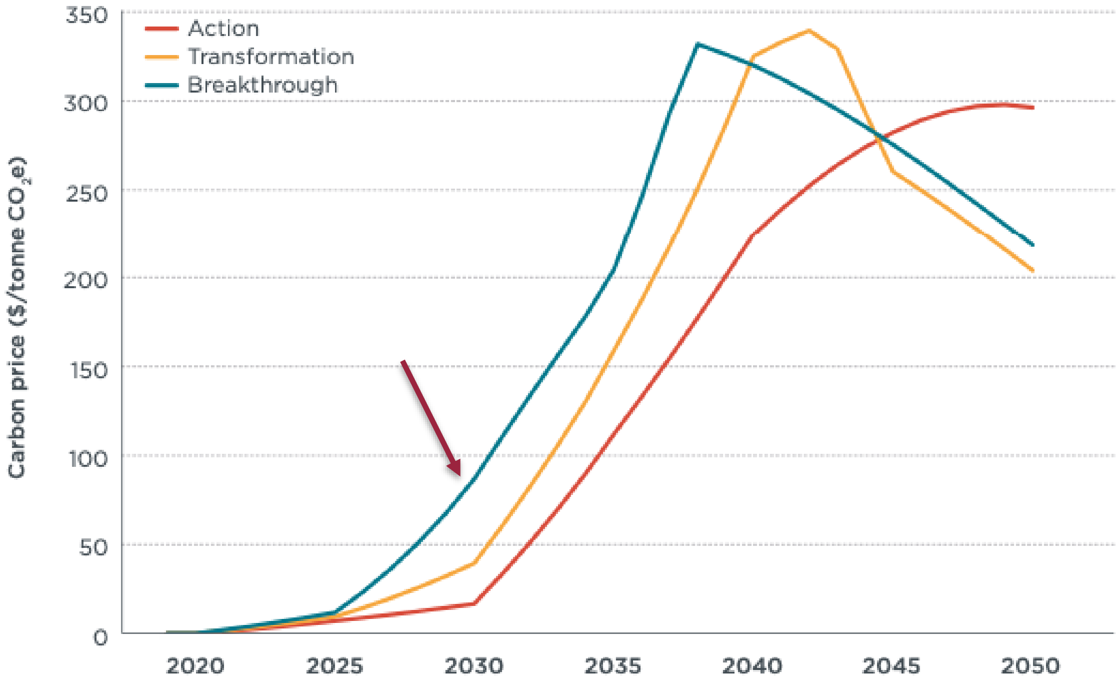
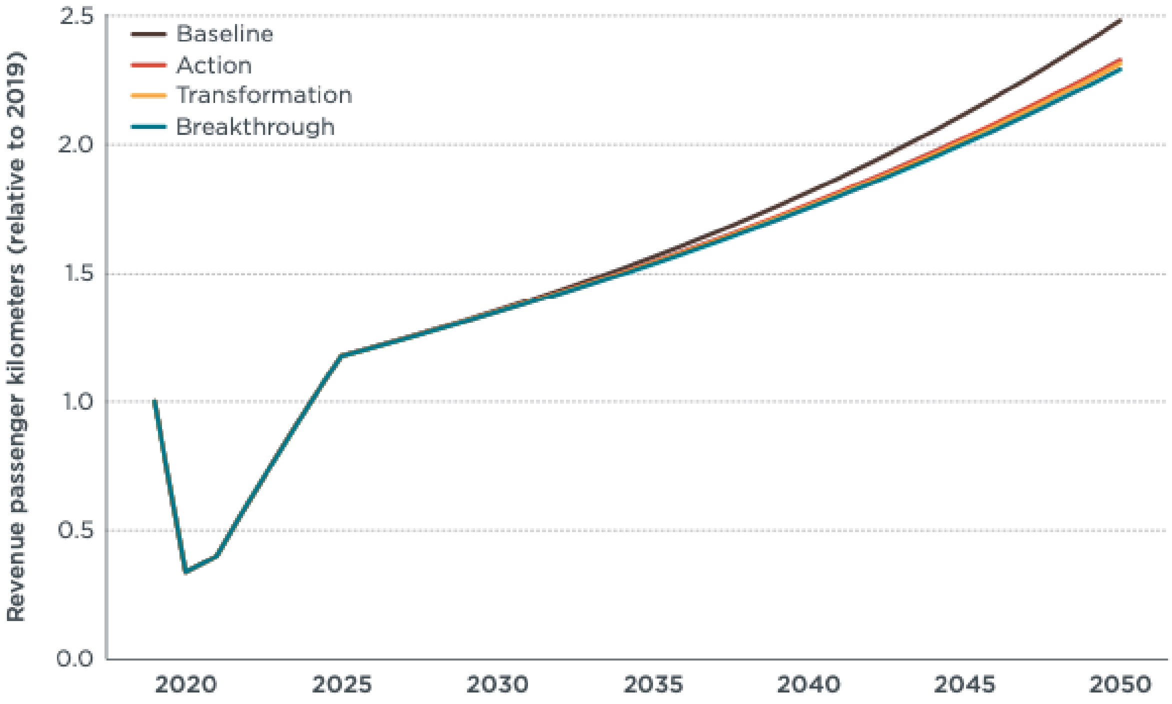


https://theicct.org/publication/global-aviation-vision-2050-align-aviation-paris-jun22/

Impact of fuel prices on passenger traffic



Breakthrough

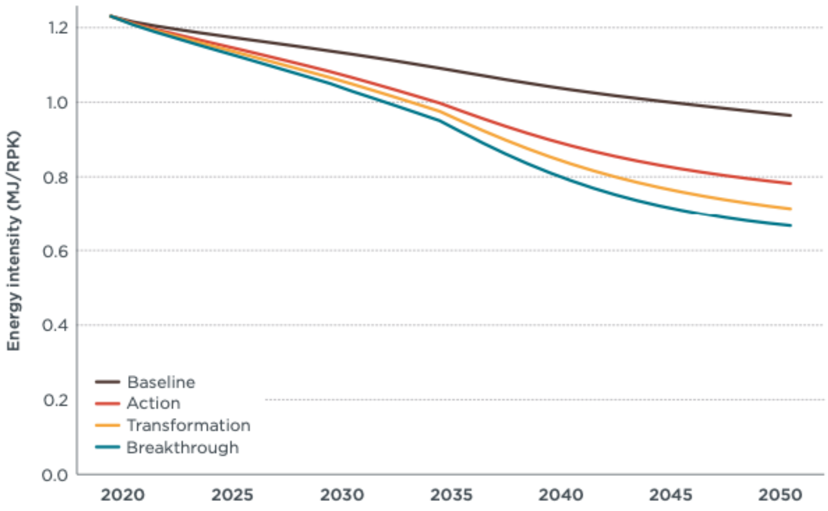
2050
passenger traffic
▼ 7%

2019-2050
cumulative
passenger traffic
▼ 2.5%

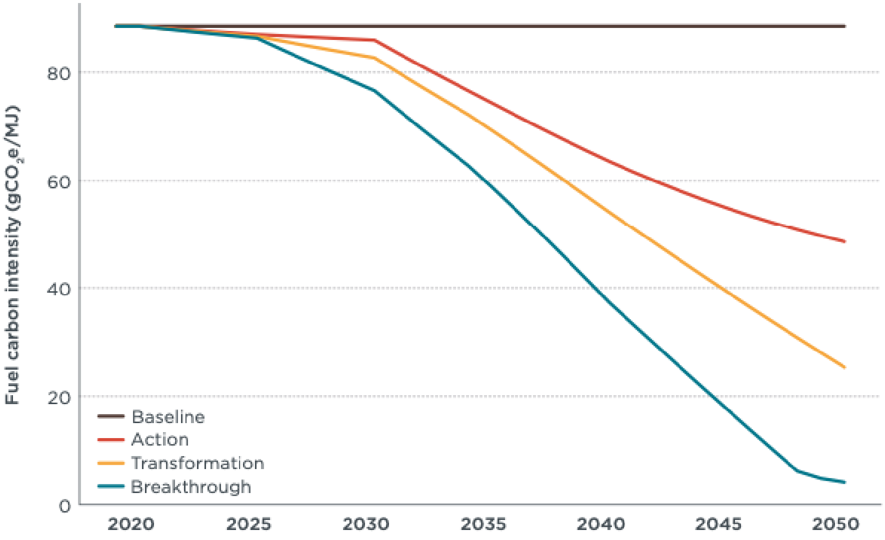
https://theicct.org/publication/global-aviation-vision-2050-align-aviation-paris-jun22/

Energy and carbon intensities – passengers

Energy intensity (MJ/RPK)



Carbon intensity (g CO_2e/MJ)

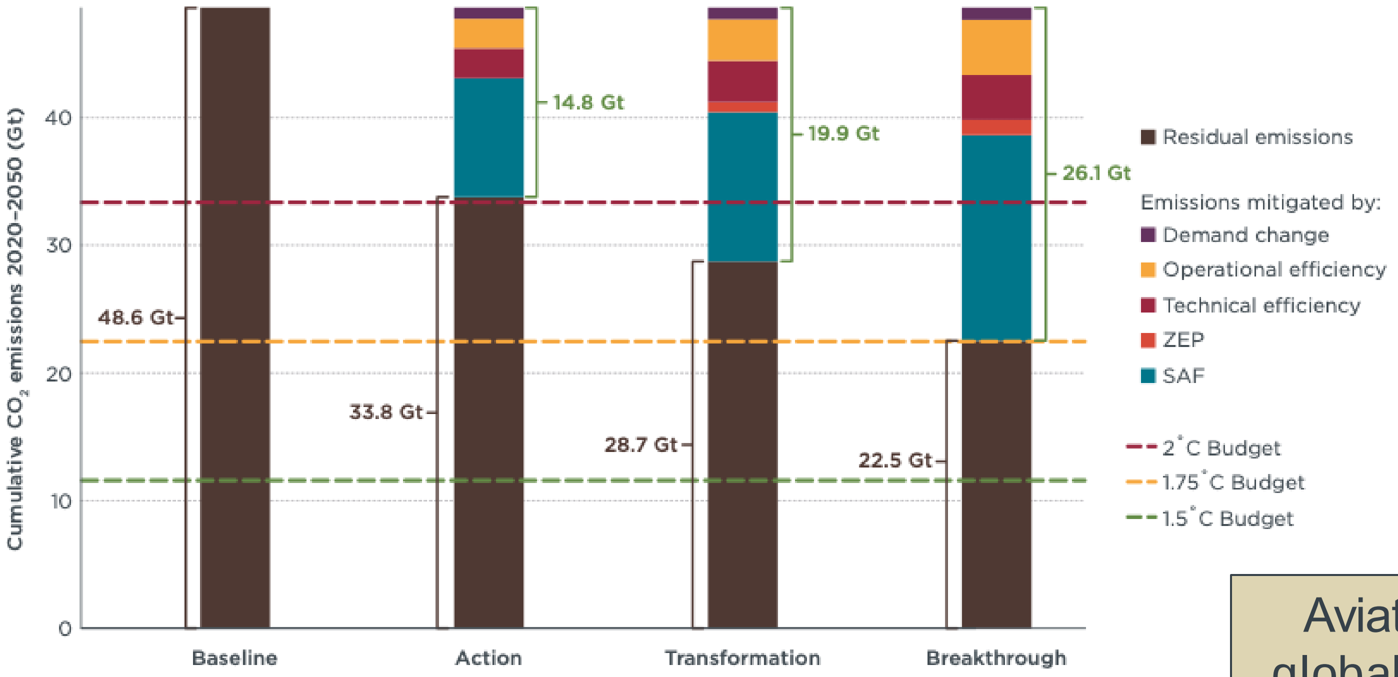


https://theicct.org/publication/global-aviation-vision-2050-align-aviation-paris-jun22/

Notes on cumulative emissions

- CO_2 emissions in this analysis are well-to-wake (WTW)
- Non-CO_2 climate impacts are not included
- IPCC global climate budget with temperature targets at 67% probability used
- Aviation's share of global carbon budget maintained at 2.9% fuel use (2.4%) and upstream fuel production (0.5%)

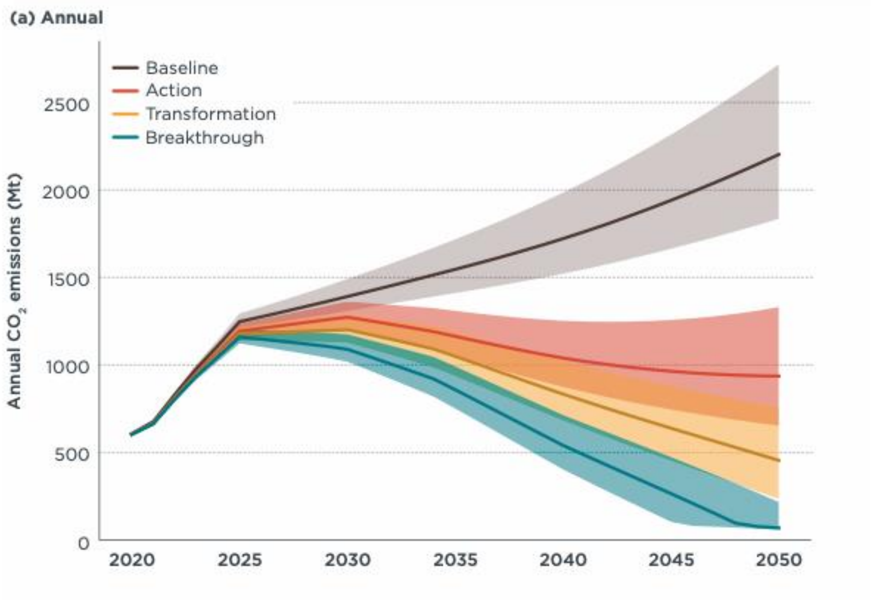
Global cumulative CO_2 emissions and mitigation

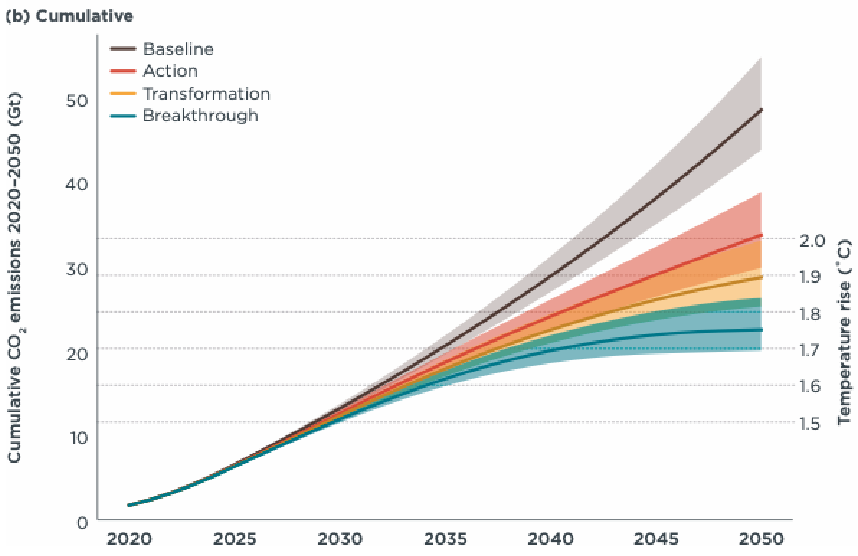


Aviation's share of global carbon budget maintained at 2.9%

Global CO_2 emissions by scenario and traffic assumptions

Global aviation CO_2 emissions by scenario and traffic forecast, 2020-2050





The solid line depicts the central traffic forecast; the shaded area depicts the range between the low and high forecasts.

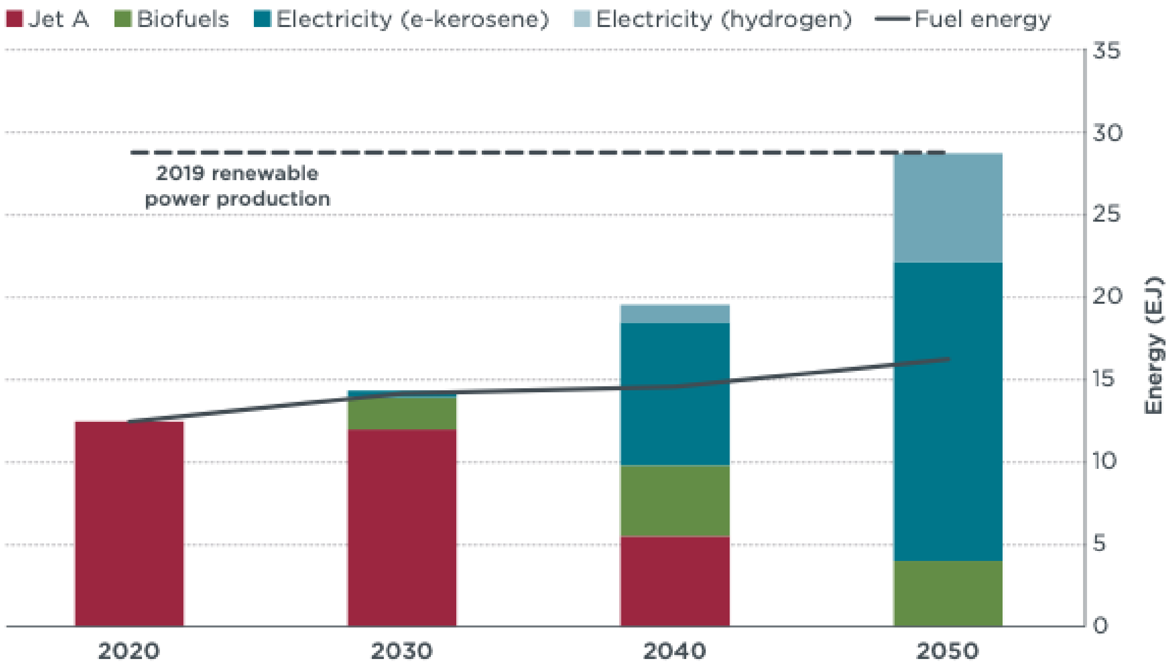
Here's what it would take to create synthetic fuels…

Estimated electricity used to generate aviation fuels:

<u>2020</u>: 0 EJ
<u>2050</u>: 25 EJ

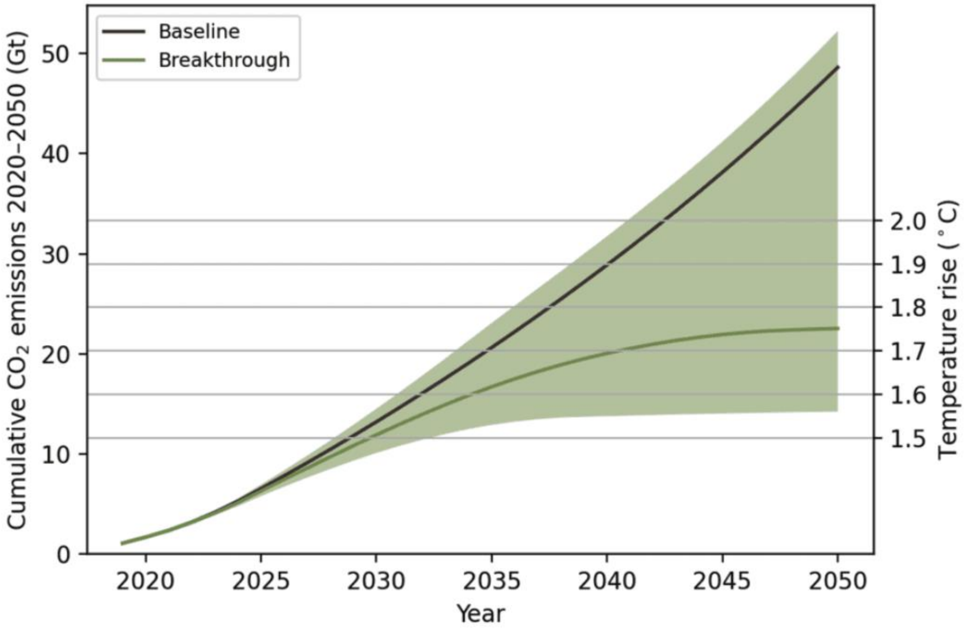
Additional 12.5 EJ energy needed to generate hydrogen and carbon for synthetic aviation fuels

Fuel energy (line) and life-cycle energy (bar) by fuel type under the Breakthrough case



… and don't forget about traffic growth.

Cumulative global aviation CO_2 emissions by scenario and traffic forecast, 2019-2050



Max tech + 7% p.a. traffic

Min tech + base traffic

Max tech + base traffic

Max tech + 2019 traffic

https://theicct.org/global-aviation-race-jun22/

Conclusions and Policy Implications

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Conclusions and policy implications

- Aligning aviation with the Paris Agreement's Below 2ºC aspiration is possible but requires significant ambition and investment.
- Most ambitious scenarios are consistent with 1.75ºC future where aviation doesn't increase its share of global carbon budget.
- To get to 1.5ºC, direct atmospheric removals and/or significant direct curbs to traffic growth would be needed.
- CO_2 emissions from aircraft need to peak by 2030 at latest, and as soon as 2025, to align aviation with the Paris Agreement.
- Cumulative targets, rather than an absolute emissions goal for a given year, are recommended.

Thanks to the Brandon Graver, Sola Zheng, Jayant Mukhopadhaya, Erik Prong, Gary Gardner, and Zoë Bowen Smith!

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Questions?

Enter into the chat or email dan@theicct.org

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Supplemental Information

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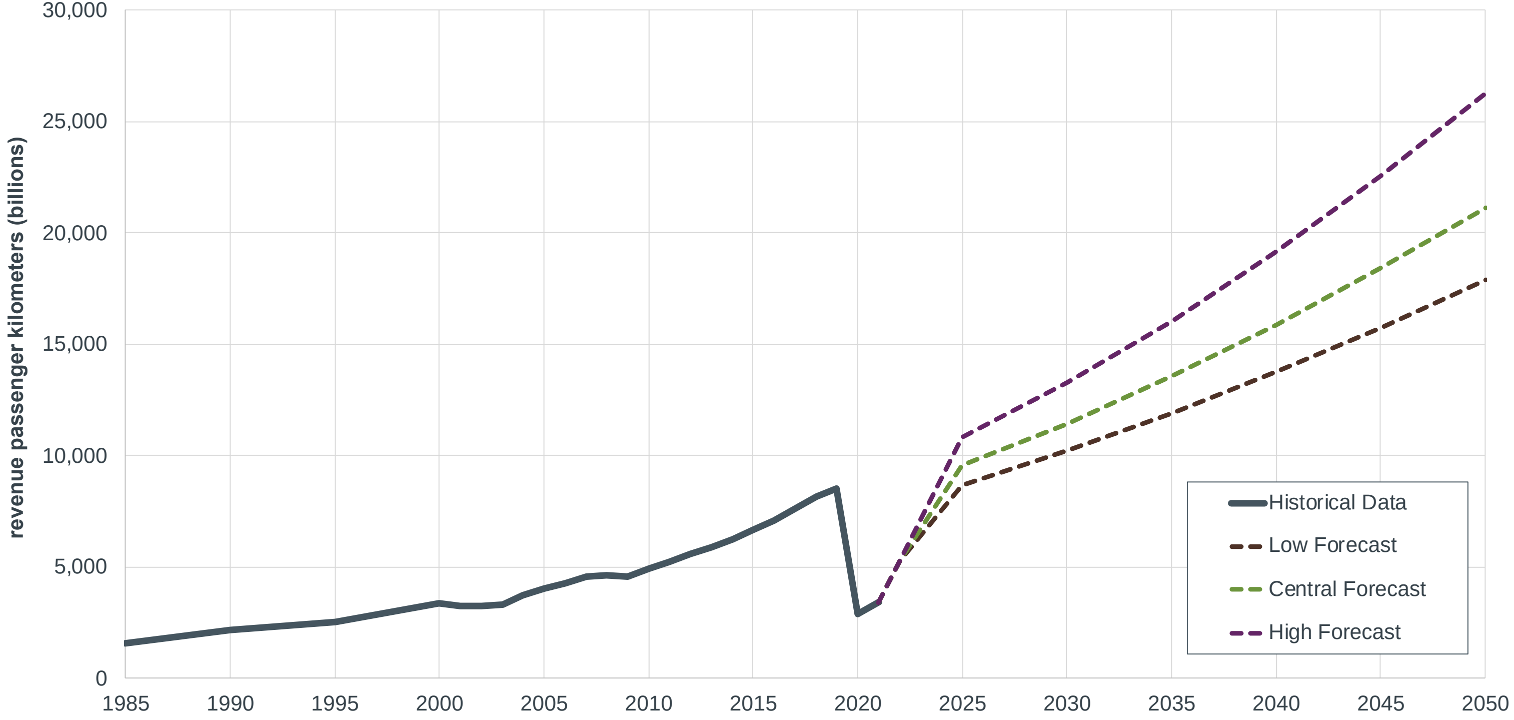
Traffic forecasts – passenger



Traffic forecasts

Low	Central	High
Passenger: +2.4%	**Passenger:** +3.0%	**Passenger:** +3.7%
Freight: +2.6%	**Freight:** +3.5%	**Freight:** +4.2%

per annum growth rates, RPK and RTK, 2019-2050

Aircraft technical efficiency

Scenario 1: Action	Scenario 2: Transformation	Scenario 3: Breakthrough
Passenger: -1.08% 2019-2034 -1.15% 2035-2050	**Passenger:** -1.08% 2019-2034 -1.83% 2035-2050	**Passenger:** -1.08% 2019-2034 -2.16% 2035-2050
Freighter: -1.00% 2019-2050	**Freighter:** -1.25% 2019-2050	**Freighter:** -1.50% 2019-2050

per annum energy reduction rates
MJ/RPK for passenger aircraft
MJ/RTK for freighter aircraft

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Aircraft payload efficiency

Payload efficiency reflects how much of the maximum payload is being carried on each flight. The closer a passenger flight is to full capacity, the better its payload efficiency.

Scenario 1: Action	Scenario 2: Transformation	Scenario 3: Breakthrough
-0.20%	-0.35%	-0.50%

per annum energy reduction rates, MJ/RPK, 2019-2050

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Aircraft traffic efficiency

Scenario 1: Action	Scenario 2: Transformation	Scenario 3: Breakthrough
-0.1% MJ/RPK per annum, 2019-2050		
No formation flying		**Formation flying:** -0.2% in 2030 -0.7% in 2040 -1.9% in 2050

per annum energy reduction rates

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Zero emission planes

<table>
<tr><th>Scenario 1: Action</th><th>Scenario 2: Transformation</th><th>Scenario 3: Breakthrough</th></tr>
<tr><td>Electric:
None</td><td colspan="2">Electric:
2030 EIS for commuter aircraft
50% of new aircraft, 2030
100% of new aircraft, 2050</td></tr>
<tr><td rowspan="2">Hydrogen:
None</td><td colspan="2">Hydrogen:
2035 EIS for regional & narrowbody</td></tr>
<tr><td>12.5% of new aircraft, 2030
25% of new aircraft, 2050</td><td>12.5% of new aircraft, 2030
50% of new aircraft, 2050</td></tr>
</table>

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Fuels (1/3)

Scenario 1: Action	Scenario 2: Transformation	Scenario 3: Breakthrough
12 Mt biofuels, 2030 (3% of fuel use)	23 Mt biofuels, 2030 2 Mt e-fuels, 2050 (8% of fuel use)	46 Mt biofuels, 2030 5 Mt e-fuels, 2030 (17% of fuel use)
100 Mt biofuels, 2050 120 Mt e-fuels, 2050 (50% of fuel use)	100 Mt biofuels, 2050 150 Mt e-fuels, 2050 (80% of fuel use)	100 Mt biofuels, 2050 215 Mt e-fuels, 2050 (100% of fuel use)

Fuels (2/3)

Scenario 1: Action	Scenario 2: Transformation	Scenario 3: Breakthrough
e-fuel carbon (point / DAC) 2030: 100% / 0% 2040: 67% / 33% 2050: 67% / 33%	e-fuel carbon (point / DAC) 2030: 67% / 33% 2040: 58% / 42% 2050: 50% / 50%	e-fuel carbon (point / DAC) 2030: 67% / 33% 2040: 46% / 54% 2050: 25% / 75%
No hydrogen aircraft	Hydrogen (blue/green) 2030: 75% / 25% 2040: 50% / 50% 2050: 0% / 100%	Hydrogen (blue/green) 2030: 50% / 50% 2040: 33% / 67% 2050: 0% / 100%

Fuels (3/3)

Scenario 1: Action	Scenario 2: Transformation	Scenario 3: Breakthrough
Average costs (biofuel / e-fuels, $/L)	Average costs (biofuel / e-fuels, $/L)	Average costs (biofuel / e-fuels, $/L)
2030: 1.81 / 1.79 2040: 1.98 / 1.59 2050: 2.03 / 1.26	2030: 1.81 / 2.00 2040: 1.98 / 1.65 2050: 1.40 / 1.36	2030: 1.81 / 2.00 2040: 1.36 / 1.72 2050: 1.40 / 1.52

Modal shift

Scenario 1: Action	Scenario 2: Transformation	Scenario 3: Breakthrough
Domestic and intra-European routes of less than 750 km Number of passengers greater than 100,000 annually 20% traffic shift from air to rail, starting in 2030		

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Panel of Experts

As part of this work, we established a panel of experts to review our assumptions and inputs related to carbon reductions.

- Boeing: Bryan Yutko
- CE Delft: Stefan Grebe
- EasyJet plc: Lahiru Ranasinghe
- International Energy Agency: Praveen Bains
- NATS: Jarlath Malloy
- SkyNRG: David Dweck and Amy Malaki
- SVD Consulting: Susan van Dyk
- United Airlines: Aaron Robinson

Modeling Comparison: ICCT vs ATAG

	This analysis: Breakthrough[a]	Waypoint 2050: Scenario 1[b]
2050 annual emissions	70 Mt	With offsets: 0 Mt Without offsets: 140 Mt
2050 energy use	16 EJ	25 EJ
Total reduction from Baseline, 2050 annual emissions	97%	With offsets: 100% Without offsets: 93%
2020-2050 cumulative emissions	22.7 Gt	With offsets: 19.6 Gt
Cumulative emissions temperature pathway	1.75°C	With offsets: 1.78°C (ICCT estimate)
Share of emission reductions, 2050	Technology: 18% Operations: 17% Fuels: 62% Demand change: 4%	Technology: 22% Operations: 10% Fuels: 61% Offsets: 7%
Zero-emission plane energy share, 2050	Hydrogen: 22% Electricity: 0.01%	Hydrogen: 20% Electricity: 2%

[a] WTW basis. [b] Modified TTW basis.