Lifetime emissions from aircraft under a net-zero budget

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Outline

- Background
- Research questions
- Methods
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- Conclusions
- Questions

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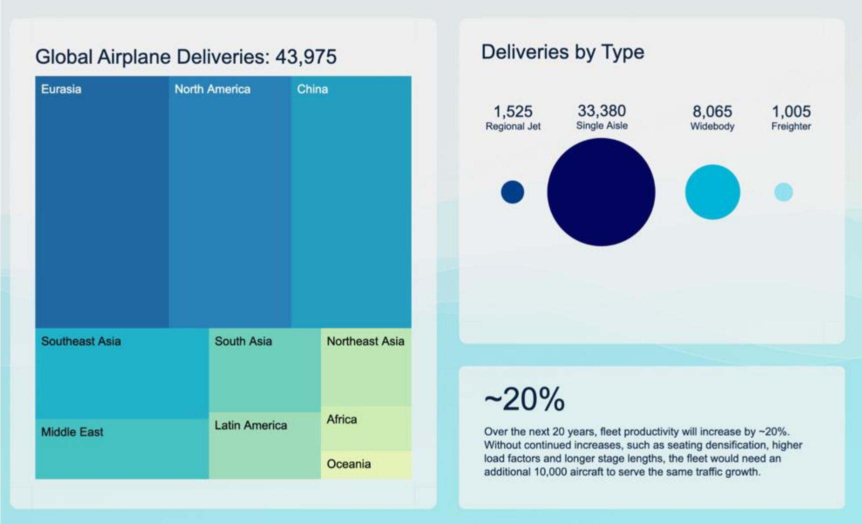
Background

- Industry groups including ICCAIA, IBAC, and IATA have committed to a 2050 net-zero CO_2 target
- Bullish on emissions reductions from SAF, aircraft-level improvements are needed
- Over 40,000 aircraft deliveries projected over the next 20 years



Boeing Commercial Market Outlook, 2023

Manufacturers' progress to-date

- OEMs have started to calculate and report Scope 3 emissions from annual deliveries
- Boeing, Airbus, and Embraer have committed to the 2050 net-zero target and 100% SAF compatibility by 2030
- Airbus has set a target to reduce Scope 3 emissions by 46% by 2035

Research questions

By what year do all new aircraft need to be zero-emission to meet the 2050 net-zero CO_2 target?

1. What are the lifetime emissions of a) today's fleet and b) 20-year deliveries?
2. How accurate are OEM estimates of Scope 3 emissions from their delivered aircraft?

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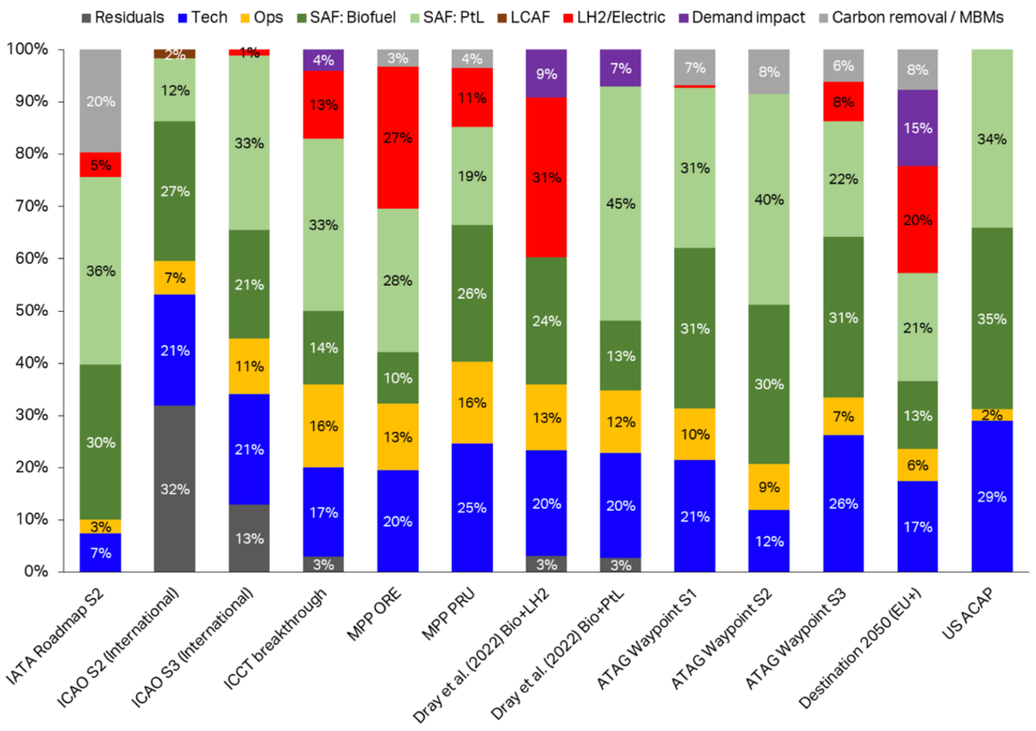
Net-zero roadmaps = 18.4 Gt CO_2 TTW



https://www.iata.org/contentassets/8d19e716636a47c184e7221c77563c93/nz-roadmaps.pdf

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Modeled Scenarios

Mitigation Measure	Baseline	Optimistic SAF	Optimistic SAF + Fuel Efficiency
SAF	None	RefuelEU-level volumes applied globally	
		2030	6%
		2035	20%
		2050	70%
Fuel Efficiency Improvements	No new types through 2042		Aggressive fuel burn improvements from new types phased in starting in 2034

Existing fleet composition

Breakdown of existing fleet and representative aircraft types, 2023

	Aircraft class			
	Regional jet	Narrowbody passenger	Widebody passenger	Freighter
Number of aircraft	3,207	17,021	3,841	1,559
Average age (years)	15.0	11.5	11.8	19.6
Representative aircraft types	Embraer 175	Boeing 737-800 Airbus A320	Boeing 787-9 Airbus A330-200	Airbus A330-200 Freighter Boeing 777 Freighter

Data source: International Bureau of Aviation (2024)

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Aircraft survival and activity curves

Figure 2. Survival Curves by Aircraft Class

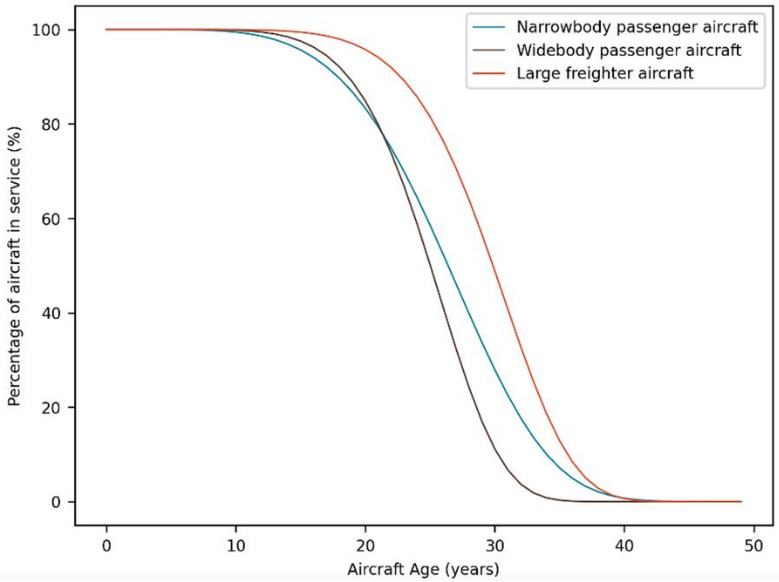
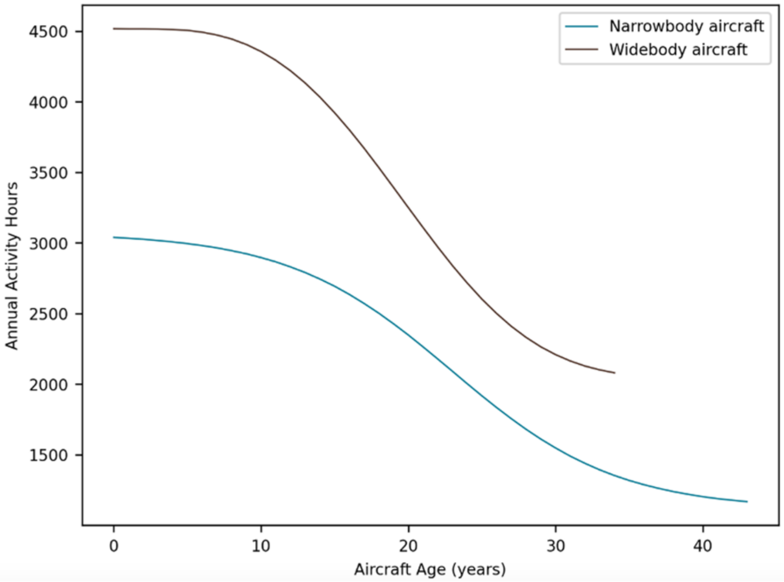


Figure 3. Activity Curves by Aircraft Class



Rutherford, D. & Singh, N. (2011). Projection of Aviation Energy Use and Related Characteristics

The calculation

Equation 1. Average Aircraft CO_2 emissions (kg/hour)

$$\text{Aircraft } CO_2 \text{ emissions } \left(\frac{kg}{hour}\right) = \text{Mission Speed}\left[\frac{km}{hour}\right] x \text{ Fuel Burn}\left[\frac{kg}{km}\right] x \text{ Fuel Specific Energy}\left[\frac{MJ}{kg}\right] x \text{ TTW Fuel Carbon Intensity}\left[\frac{gCO_2e}{MJ}\right]$$

Equation 2. Estimated Lifetime Emissions from Aircraft

$$\text{Lifetime } CO_2 = \sum_{1}^{a} n_a \times \frac{CO_2}{hour} \times \sum_{0}^{t} \frac{hours}{year} \times \% \text{ of surviving aircraft}$$

Where:

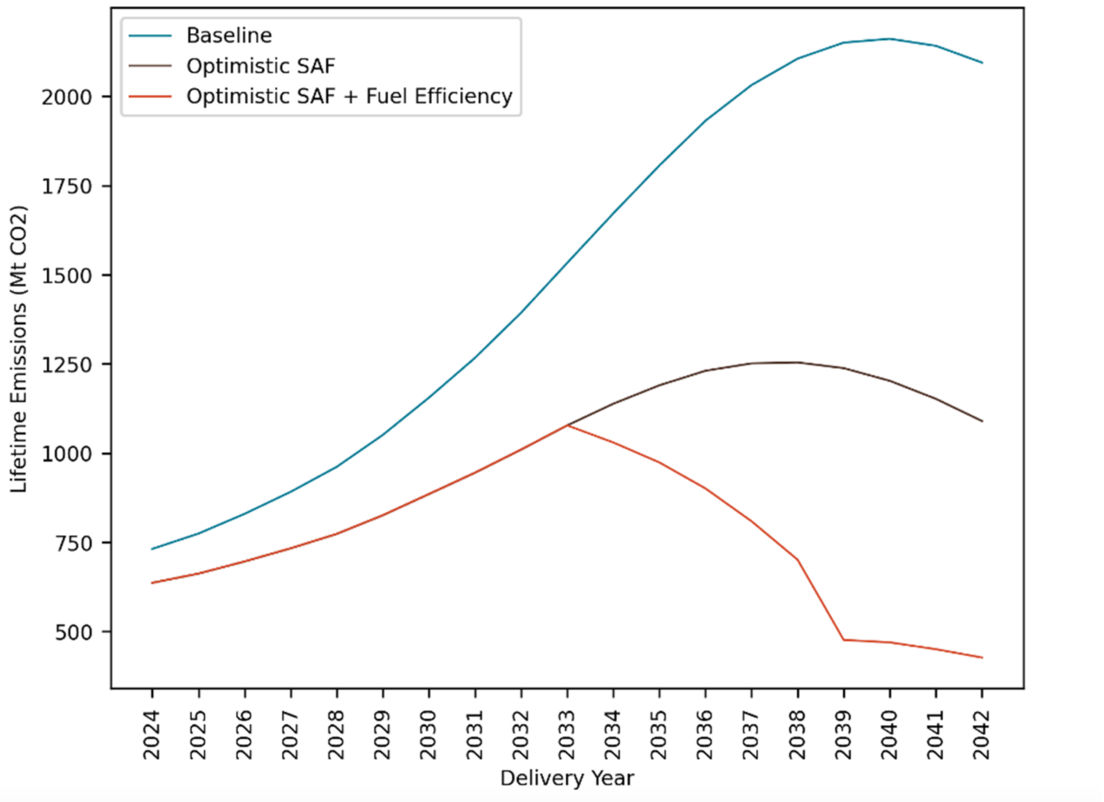
a is each representative aircraft type
n_a is number of aircraft for each representative aircraft type
t is the year in operation

Comparisons of ICCT Scope 3 estimates to OEMs

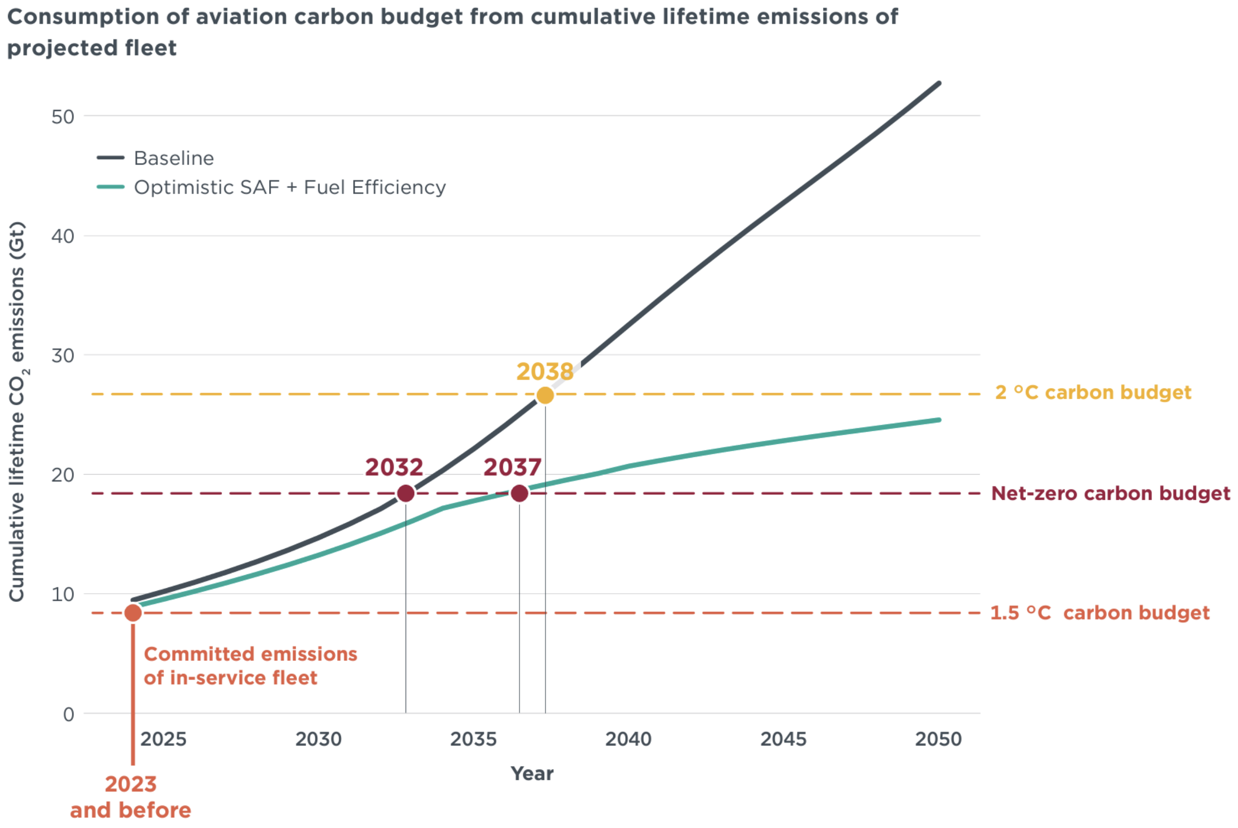
Comparison of reported and modeled well-to-wake Scope 3 emissions from 2022 deliveries

Manufacturer	Manufacturer estimate (Mt CO_2e)	ICCT model estimate (Mt CO_2e)	Difference (ICCT versus manufacturer)
Boeing	363	455	+25%
Airbus	494	490	-1%
Embraer	15.6	53	+240%
Total	**873**	**998**	**+14%**

Projected lifetime emissions by scenario

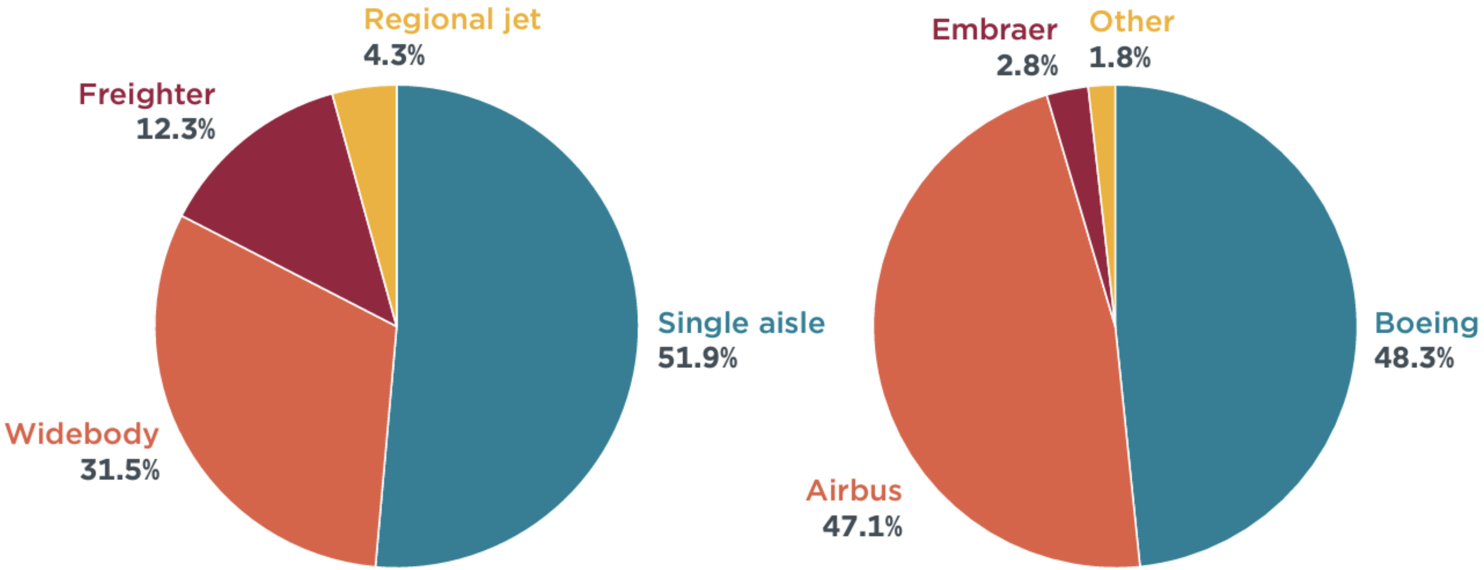


Comparison to carbon budgets

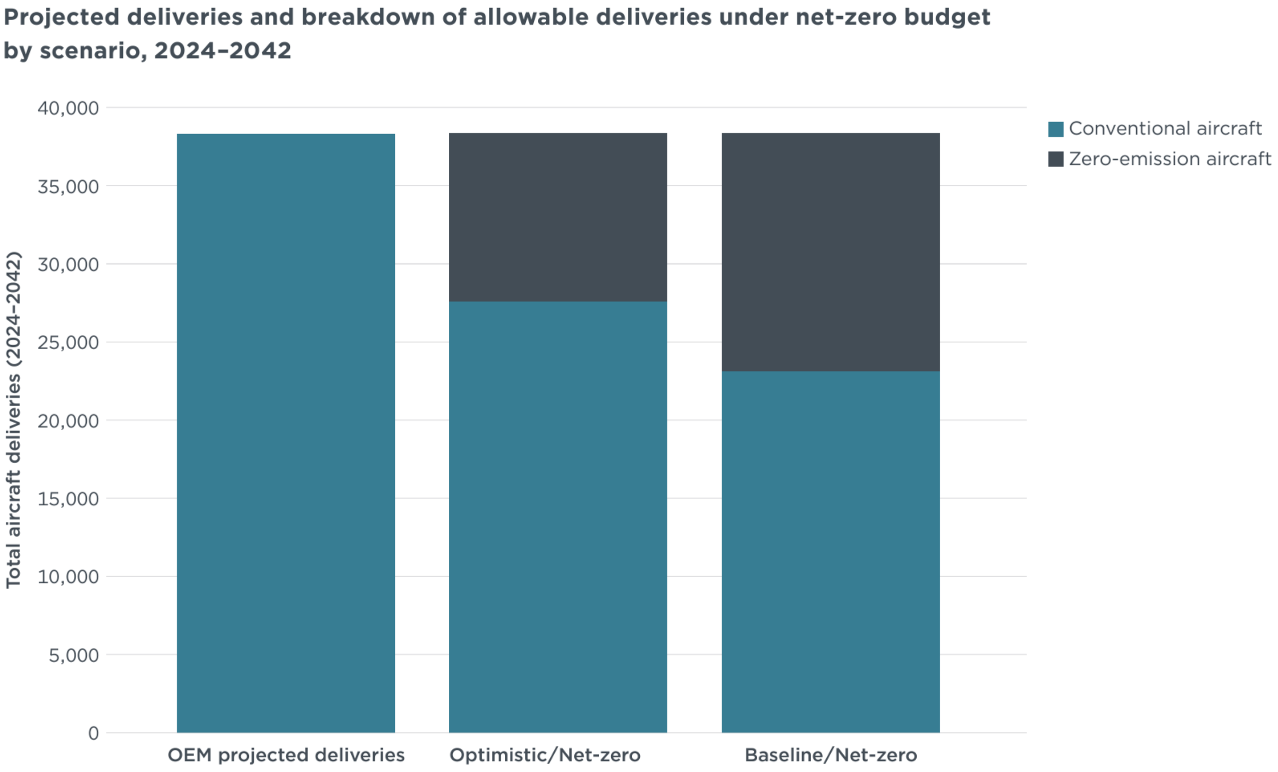


Breakdown of emissions from in-service fleet

Committed emissions from the 2023 in-service fleet by aircraft class (left) and manufacturer (right), Baseline Scenario



Market for new aircraft by scenario



CDR volumes required

- Estimated CDR volumes needed in the form of DAC to remove emissions after depletion of carbon budget
- Ranged from 5-22 Gt depending on mitigation measures in place
- Over 2,500 times the global capacity of DAC facilities in currently in advanced stages for use by all industries

International Energy Agency. (2024). CO2 capture by direct air capture, planned projects and in the Net Zero Emissions by 2050 Scenario

Conclusions

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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.
- Aircraft must be **net-zero** starting in 2035 to enable airlines to meet 2050 net-zero target
    - Ensure all aircraft can burn 100% SAF beginning in 2030
- Implies large investments in zero emission planes, not just SAF

Questions?

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