Fixing Flight Impacts: A Dynamic Passenger-Level Aviation Emissions Model

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The Context

The aviation industry is responsible for:

~ 2.5% of global annual CO_2 emissions

~ 0.1°C increase in global temperature by 2050

~ 1 billion litres of jet fuel consumed globally per day (pre-pandemic, 2016-2019)

The industry's contribution to greenhouse gas emissions underscores the urgent need for **accurate** and **reliable** methods to quantify the carbon footprint of commercial aviation.

The Challenge

There is no single "correct" flight carbon footprint; **route choice**, **boundary scope**, **allocation rules** and **non-CO_2 climate impacts** all change the result. Assumptions need to be clearly stated.

Current carbon calculators fall short on **scope**, **accuracy**, **transparency**, and **effectiveness of communication**.

The Solution

Air Travel Passenger Dynamic Emissions Calculator (ATP-DEC) is a peer-reviewed, life cycle assessment-embedded, dynamic passenger emissions calculator designed for transparent, accurate, and comparable results.

ATP-DEC uses a **life cycle assessment (LCA)** approach to quantify an air-travel passenger's full **cradle-to-grave** climate footprint. [1]

Well-to-Tank emissions (WTT)

Tank-to-Wake emissions (TTW)

Cargo Factor (CF)

Luggage Factor (LF)

In-Flight Services (IFS)

Airport Life Cycle Factor (APF)

Aircraft Life Cycle Factor (AF)

Non-CO_2 Impacts (N)

Core model: a **modular** equation that converts flight activity into **per-passenger CO_2e**, combining **dynamic routing** and **non-CO2 effects**.

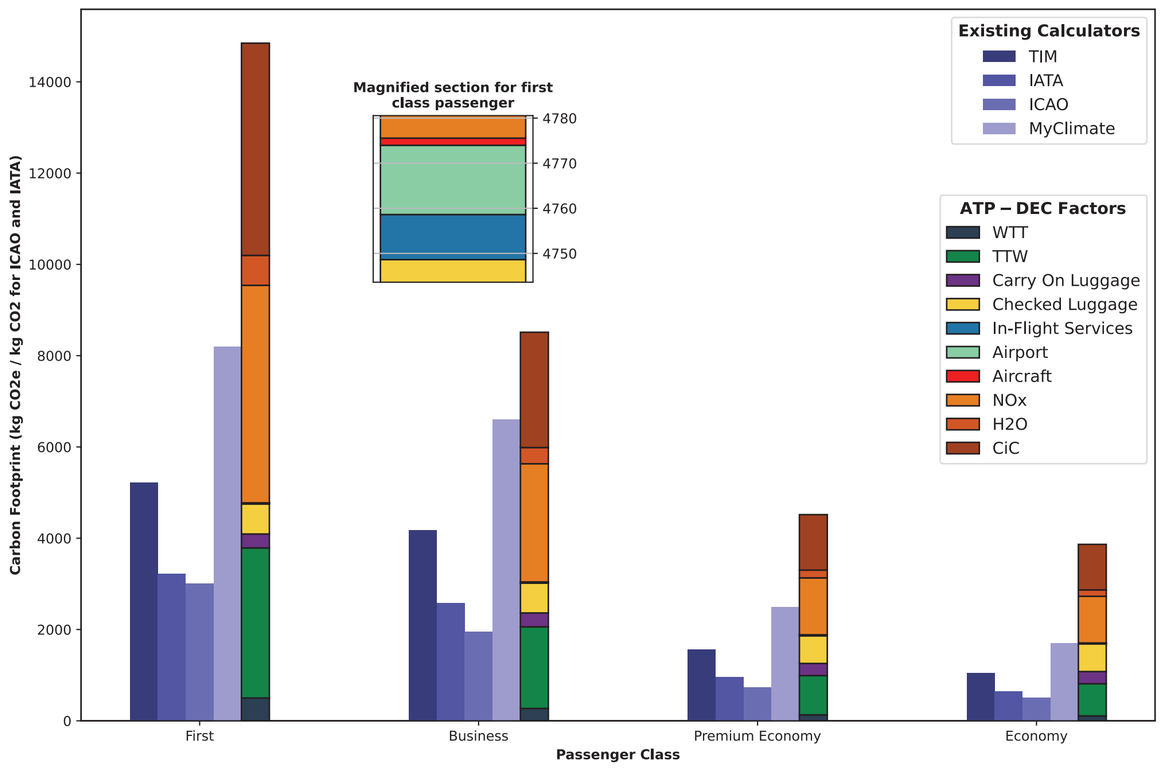
$$\mathrm{CO_2e\ per\ pax} = \mathcal{G}\left(\frac{f\,(\mathrm{D}) \times (\mathrm{WTT} + \mathrm{TTW}) \times \mathrm{DT} \times \mathrm{CF} \times \mathrm{LF} \times \mathrm{CW}}{\mathrm{PLF}}\right) + L + (\mathcal{V} \times \mathrm{IFS}) + \mathrm{APF} + \mathrm{AF} + (\mathcal{Z}_1 \times \mathrm{N}(\mathcal{Z}_2))$$

ATP-DEC vs Common Calculators

Most tools output a single number; ATP-DEC provides a **full breakdown** of the footprint so flyers and policymakers can see what drives it.

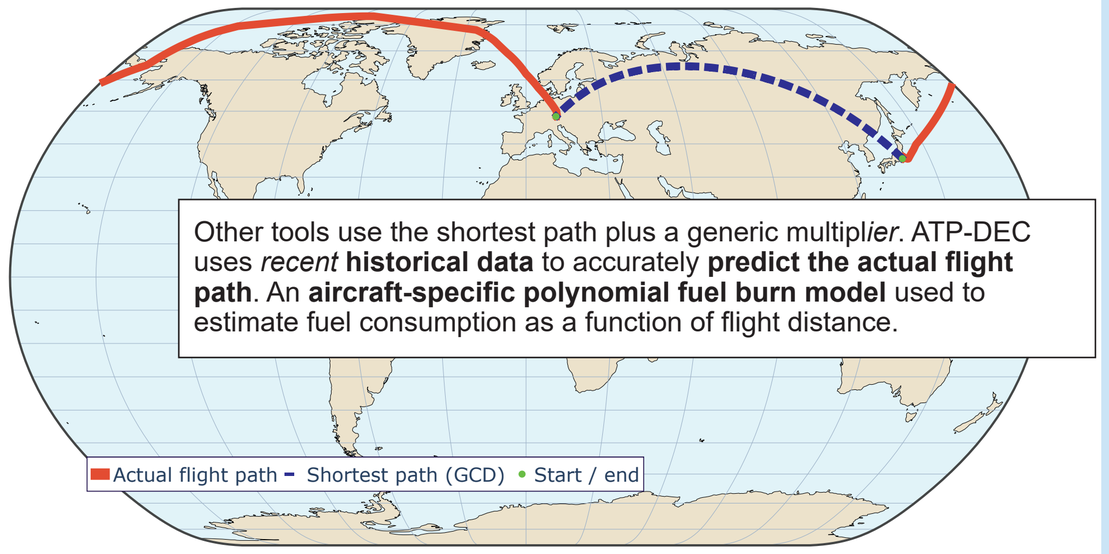
Including non-CO_2 and dynamic routing can materially **increase the footprint**; in this case **non-CO_2 exceeds CO_2**.

Example flight from Singapore (SIN) to Zurich (ZRH) [2]



Why Dynamic Routing Matters

Example flight from Haneda (HND) to Munich (MUC)



Other tools use the shortest path plus a generic multipl*ier*. ATP-DEC uses *recent* **historical data** to accurately **predict the actual flight path**. An **aircraft-specific polynomial fuel burn model** used to estimate fuel consumption as a function of flight distance.

Static methods can undercount emissions when routing deviates.

For a case study on flights from London Heathrow (LHR) to Incheon (ICN) in 2023, a static method **underestimated** the emissions (without non-CO_2 impacts) by **23,150 tCO_2e** vs. ATP-DEC overestimated by just **51 tCO_2e**.

Impact & What Next

Published in the high impact **Nature Communications Earth and Environment**. The article is in the **99th percentile** of articles of a similar age in all journals for engagement. [2]

Covered by several media outlets including **New Scientist** and **The Conversation**.

Its irrefutable, transparent results are already **reshaping disclosure**, pushing stakeholders to **re-evaluate how environmental data are presented**.

[1] Images generated using ChatGPT (OpenAI) (2026).
[2] McFall, F. et al. Aviation passenger carbon footprint calculator with comprehensive emissions, life cycle coverage, and historical adjustment. Communications earth & environment 6, 855 (2025).

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