

Development of Comprehensive Environmental Performance Indicators Aviation from the Perspective of Air Navigation Service Providers.

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Motivation

Net-zero carbon emissions by 2050

Air Navigation Service Providers (ANSPs) and airlines are working together to improve flight efficiency—both through better Air Traffic Management (ATM) and optimized aircraft operations—aiming for operational efficiency levels of up to 95–98%, with a potential 6% reduction in emissions from ATM improvements alone.

6%
ANSP Potential
emission
reduction

AVIATION'S CLIMATE IMPACT:

contrails, NO_x, soot, water vapor...

3%
of flights generate 80%
of contrail warming

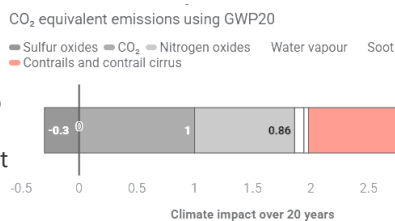
CO₂ 1/3rd
Non - CO₂ 2/3rd (* Still on debate)

New route

Non-CO₂ emissions
must be included in
EU climate policies
and integrated into
existing and **air traffic
legislation**

CO₂ 5% or less extra CO₂...
Contrail impact
...and a big reduction of
contrail warming

Contrails are the largest known non-CO₂ contributor to aviation's climate impact



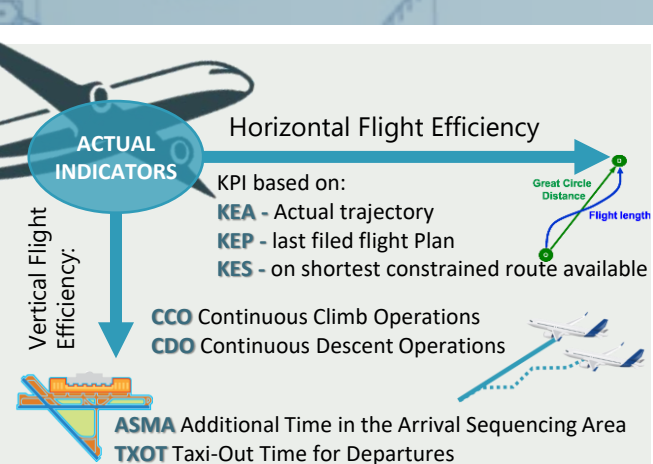
Source: T&E, based on Lee et al. 2021 for sulfur oxides, water vapour, soot and

NEW ENVIRONMENTAL INDICATORS FOCUSING ON Non-CO₂ CONTRIBUTION

State of the art

CO₂ Conversion and Methodological Challenges

- Indicators are being translated into CO₂-equivalent values.
- Challenges include standardizing conversion formulas, integrating fuel and flight data, and normalizing results for different airport contexts.



Some existing CO₂ and non -CO₂ Methodologies

- Cobos-Cuesta, E. (in press). Data-Driven Methodology Characterizing CO₂ Emission Discrepancies Between Actual and Optimum Operations. Journal of Air Transportation.
- Sanajou, K., & Tchepel, O. (2024). Modelling of Aircraft Non-CO₂ Emissions Using Freely Available Activity Data from Flight Tracking. Sustainability
- Lim, Yixiang & Gardi, Alessandro & Sabatini, Roberto. (2015). Modelling and Evaluation of Aircraft Contrails for 4-Dimensional Trajectory Optimization. SAE International Journal of Aerospace

Non-CO₂ Effects & Measurement Gaps

Non - CO₂ increasingly acknowledged lack mature metrics

Advanced Metrics and Research Initiatives (EU projects)

- AEROPLANE & E-CONTRAIL:** AI and satellite data to predict contrail formation and guide climate-optimal routes.
- Green-GEAR:** satellite altimetry and impact-based route charging.
- CONCERTO:** integrates climate metrics into ATM systems and green flight plans. New metrics like Climate Index and Mitigation Index enable real-time climate-informed trajectory decisions.

Policy Recommendations



Objective

Proposal of advanced environmental indicators integrating non-CO₂ emissions

To develop robust **performance indicators for ANSPs** that capture **both CO₂ and non-CO₂** climate impacts, with a focus on contrail mitigation strategies within performance-based regulatory frameworks.

OTHER CONTRIBUTIONS

Bonus-penalty incentive scheme

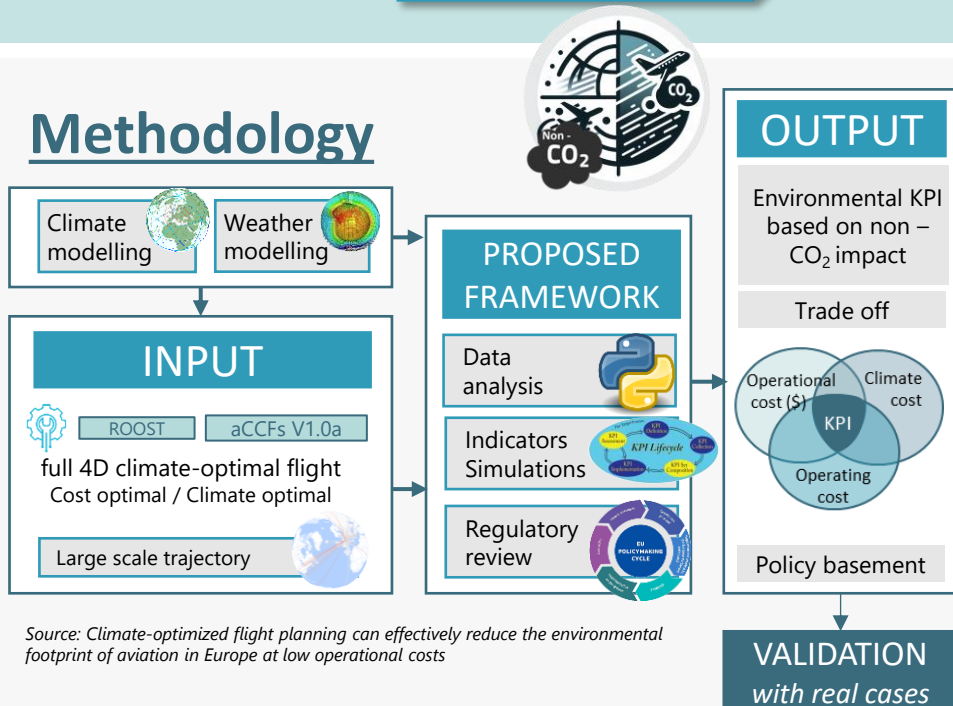
Review of emerging technologies

CO-eq to quantify non-CO₂ impact

International coordination in standardizing

Policy recommendations

Methodology



Source: Climate-optimized flight planning can effectively reduce the environmental footprint of aviation in Europe at low operational costs

Conclusions

In short: a **ROADMAP** toward a sustainable, forward-looking global aviation system.

Key Area	Proposed Action
Non-CO ₂ Impacts	Integrate into environmental performance metrics
Assessment Methods	Improve robustness and scientific relevance
Regulatory Alignment	Stay in sync with evolving frameworks
International Cooperation	Enhance collaboration and global standards
Incentives & Policy Design	Support future-oriented rules and reward systems