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Global economic and environmental impacts of deploying synthetic jet fuels in the aviation sector

<u>Lucas Desport^{1,2}</u>, Sergey Paltsev³, Jennifer Morris³, Howard Herzog³, Angelo Gurgel³, Henry Chen³, Sandrine Selosse¹

¹Mines Paris, PSL University, Centre for Applied Mathematics, Sophia Antipolis, France, <u>lucas.desport@minesparis.psl.eu</u>

²TotalEnergies, OneTech R&D, La Défense, France

³Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology, USA



THE AVIATION SECTOR: WHY 'HARD TO ABATE'?

- Roughly 2% of global GHG emissions
- Long lifespan of airplanes
- Costly alternatives
- Hard to electrify
- Safety constraints





IEA, Direct CO2 emissions from fossil jet kerosene combustion in the Net Zero Scenario, 2000-2030, IEA, Paris https://www.iea.org/data-andstatistics/charts/direct-co2-emissions-from-fossil-jet-kerosene-combustion-in-the-net-zero-scenario-2000-2030

THE AVIATION SECTOR: WHAT OPTIONS?

IATA's strategy towards net-zero in 2050



RESOLUTION ON THE INDUSTRY'S COMMITMENT TO REACH NET ZERO CARBON EMISSIONS BY 2050

At the 66th IATA AGM in 2010, IATA member airlines adopted a resolution which endorsed three ambitious goals to address aviation's CO₂ emissions, namely: an average improvement in fuel efficiency of 1.5% per year between 2010 and 2020; a cap on net aviation CO₂ emissions from 2020; and a reduction in net aviation CO₂ emissions of 50% by 2050 relative to 2005 levels. Since then, a lot of progress has been made. Airlines have achieved an average annual improvement in fuel efficiency of over 2%, with a cumulative improvement between 2009 and 2019 of 21.4%, largely through the investment of hundreds of billions of dollars in more efficient aircraft.

Meeting aviation's climate goals cannot be achieved with a standalone commitment and action by airlines.

Governments must implement constructive policy frameworks that focus on production incentives for sustainable aviation fuels (SAF) and helps to realize cost-effective new technologies that together will support the Paris Agreement objectives and secure a sustainable future for aviation.

Aircraft and engine manufacturers, fuel-producing companies, airports, and air navigation services providers must each individually take responsibility to address the environmental impact of their policies, products, and activities.

Collectively, all industry stakeholders must work together to deliver sustainable products and services and ultimately break aviation's dependance on fossil fuels.

RESOLUTION

The 77th IATA Annual General Meeting:

Adopts the collective target to achieve net zero carbon emissions by 2050 in support of the Paris Agreement goal and reaffirms the airlines' full support for the ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) as an effective measure to stabilize net emissions from international aviation at 2019 levels in the short- to medium-term.

Calls on ICAO to provide strong unwavering leadership that aligns governments to address aviation emissions through a global approach with coordinated policies, rather than a patchwork of regional, national, or local measures.

Calls on the governments of ICAO Member States to agree on a long-term goal equivalent to the ambition of the industry and ensure that:

- the industry's action is supported by a coherent and coordinated policy framework which drives innovation and initiative; and
- does not rely on cost-ineffective instruments with little or no environmental benefits such as ticket and carbon taxes.

Encourages all IATA member airlines to continue to improve the efficiency of their operations to achieve sustained in-sector emissions reductions and to lead the urgent transition to sustainable aviation fuel.

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SUSTAINABLE AVIATION FUELS

HHC

Feedstocks



Blend ASTM(1) approved pathways limit **Fischer-Tropsch Paraffinic** 50% FT Kerosene (FT-SPK) 50% **HEFA** Hydroprocessed Esters and Fatty Acids (HEFA-SPK) SIP Hydroprocessed fermented 10% Synthesized Isoparaffins FT-A FT SPK with Aromatics 50% Isobutanol and Ethanol to Jet ATJ 50% Synthesized Paraffinic Kerosene Catalytic hydrotherolysis jetfuel 50% CHJ

Biological derived hydrocarbons

Technology pathways

Blending Components

Drop-in Jet



E Low Carbon Electricity



ASTM – American Society for Testing and Materials. Fuel specification approvals by CAAFI (Commercial Aviation Alternative Initiative) in the US
SBC – Synthetic Blending Component (commonly called neat SAF on the market)

10%

) CBC – Conventional Blending Component (conventional jet fue

from algae

RESEARCH QUESTION

- In terms of economics and environmental impacts, how synthetic jet fuels can contribute to the decarbonization of the aviation sector in the long run?
 - How does it compete with biojets?
 - How does it affect prices and demands for jet fuels globally?



(1) ASTM – American Society for Testing and Materials. Fuel specification approvals by CAAFI (Commercial Aviation Alternative Initiative) in the US
(2) SBC – Synthetic Blending Component (commonly called neat SAF on the market)
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3) CBC – Conventional Blending Component (conventional jet fuel

THE MIT EPPA MODEL

- **Computable General Equilibrium** (CGE) model of the world ٠ economy with regional and sectoral detail
- **Goal:** economy, energy, and emissions projection ٠
- Recursive dynamic (maximization of welfare) ٠
- International trades •
- Endogenous prices, investments & Capital accumulation ٠



MIT Economic Projection and Policy Analysis (EPPA) Model

Covers all sectors of economy, with additional detail in energy sectors





Chen, Yen-Heng Henry, Sergey Paltsev, Angelo Gurgel, John M. Reilly, and Jennifer Morris. 2022. "A Multisectoral Dynamic Model for Energy, Economic, and Climate Scenario Analysis." Low Carbon Economy 13 (02): 70-111. https://doi.org/10.4236/lce.2022.132005.

EPPA regions:

ANZ Australia &

RRA Brazil CAN Canada CHN China

ASI Dynamic Asia

EUR Europe (EU+)

IDZ Indonesia

ND India

New Zealand

JPN Japa

RUS Russia USA United States

Korea

MODELING OF SAF IN EPPA

 CO_2

- The modeling of **biojet** was already present in the model (Winchester et al., 2013)
- The Fischer-Tropsch technology for synthetic jet fuels

Synthetic fuels are 4 to 5 times more

expensive than convention jet fuel

- Low temperature and low pressure
- Exothermic reaction Electricity



fuel

Syn. diesel

Syn. gasoline







Winchester, Niven, Dominic McConnachie, Chrisoph Wollersheim, and Ian Waitz. 2013. "Market Cost of Renewable Jet Fuel Adoption in the United States." **7** 238. MIT Joint Program on the Science and Policy of Global Change. <u>https://globalchange.mit.edu/sites/default/files/MITJPSPGC_Rpt238.pdf</u>.

Electrolysis + RWGS +

Fischer-Tropsch reaction +

distillation

MODELING OF SYNTHETIC JET FUELS IN EPPA





 \rightarrow All scenarios are consistent with the Paris Agreement

Name	Reference	SAF65	SAF100	SAF65-FT	SAF65-IND
Scope	All SAF	All SAF (biojet and FT)		Only FT	Only FT from industry
Share of SAF in 2050	N/A	65%	100%	100%	100%





RESULTS – JET FUEL YIELD



PSL

MINES PARIS

CONVJET Conventional jet fuelsBIOJET Biojets

RESULTS – JET FUEL YIELD

MINES PARIS



Biojets

BIOJET

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RESULTS – DEPLOYING JET FUELS



- SYNJETN Synthetic jet fuels made of climate-neutral CO₂
- SYNJET Synthetic jet fuels made of fossil CO₂
- CONVJET Biojets

PSL

MINES PARIS

RESULTS – PRICES

Relative prices of jet fuel among regions of the world over time





RESULTS – CO2 EMISSIONS

1200

MINES PARIS

CO₂ emissions of the aviation sector in the five scenarios



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CONCLUSION

- The model never chooses to combine synthetic jet fuels with biojets to decarbonize the aviation sector. Instead, it prefers to **rely on biojets** and **offset the remaining emissions**. However, our modeling does not consider the adverse impact of bioenergy production.
- **2. Deploying synthetic jet fuels reduces dramatically the production** (and demand) of jet fuels globally. Jet fuels become so expensive that the global GDP is affected by 2% compared to the Reference scenario.
- 3. Although synthetic jet fuels are expensive, they do not generate indirect CO₂ emissions and **enable the aircraft to generate fewer emissions compared to biofuels** (cradle to gate)
- 4. Synthetic jet fuels made of fossil CO_2 captured from the industry sector are not interesting due to the expensiveness and the CO_2 it generates.
- 5. Deploying biojets early and massively enables to benefit from the **learning-by-doing** effect and eliminates direct CO_2 emissions of the aviation in 2050.



FUTURE IMPROVEMENTS

Fischer-Tropsch processes fed with low-carbon intermittent electricity equipped with batteries

- \rightarrow Sensitivity analysis to the cost of DAC
 - Limit the availability of negative emissions in the Reference scenario



Next steps

THANK YOU!



Feel free to contact me at

lucas.desport@minesparis.psl.eu



ANNEX: NESTING STRUCTURE OF SYNTHETIC JET FUELS





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