LTAG Assessment from a Fuels Perspective

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Introduction

This article describes this work done by the LTAG-TG Fuels sub group, which was tasked to develop emissions reductions scenarios from the use of different types of fuels up to 2070.

For that, the Fuels sub-group gathered and analysed data from various internal and external sources — in a constant relation with the most relevant stakeholders — which were then used to support the definition of fuel classifications, methodology development, and assessments of readiness and attainability. Based on these definitions, the expert group developed projections of fuel volumes and CO_2 emission reductions for three scenarios with increasing ambition, which represent varying levels of introduction of both drop-in and non-drop-in fuels that could reduce the life cycle GHG emissions from aviation. All the work is described in detail in Appendix M5 of the LTAG report.[2]

Fuel classification

The assessment considered three high-level fuel categories, as follows:

- Sustainable aviation fuels (LTAG-SAF): drop-in fuels produced from renewable or waste resources;
- Lower carbon aviation fuels (LTAG-LCAF): drop-in fuels produced from petroleum resources, which demonstrates a well-to-wake carbon intensity of <80.1 gCO_2e/MJ (i.e. >10% reduction in life cycle emissions vis-à-vis conventional jet fuel); and,
- Non-drop-in fuels: fuels that require changes to existing and legacy airframes and fueling infrastructure (i.e. electricity and cryogenic H_2). They are not compatible with current aircraft and engine architectures, and have unique safety and performance considerations.

Various types of fuels were included in these three categories, depending on the carbon source in the fuel feedstock; these are described in Table 1.

	Fuel Category	Fuel Name	Carbon source in fuel feedstock
Drop-in fuels	LTAG - Sustainable Aviation Fuels (LTAG-SAF)	Biomass-based fuel	Primary biomass products and co-products
		Solid/liquid waste-based fuels	By-products, residues, and wastes
		Gaseous waste-based fuels	Waste CO/CO_2
		Atmospheric CO_2-based fuels	Atmospheric CO_2
	LTAG - Lower Carbon Aviation Fuels (LTAG-LCAF)	Lower carbon petroleum fuels	Petroleum
Non drop-in fuels	**Fuel Category**	**Fuel Name**	**Carbon source in fuel feedstock**
	Non drop-in fuels	Electricity	Not applicable
		Liquefied gas aviation fuels (ASKT)	Petroleum gas, "fat" natural gas, flare gas, and propane-butane gases
		Cryogenic hydrogen	Natural gas, by-products, non-carbon sources

TABLE 1: Fuel categorization

1 The co-Leads James Hileman (Federal Aviation Administration, USA) and Matteo Prussi (Politecnico di Torino, Italy) would like to acknowledge the invaluable contribution of the 120 members of the Long-Term Aspirational Goal Task Group's Fuels Subgroup.

2 LTAG Report, Appendix M5, Fuels: https://www.icao.int/environmental-protection/LTAG/Documents/ICAO_LTAG_Report_AppendixM5.pdf

Description of Fuels scenarios

The Fuels sub group developed a high-level methodology to define three fuel deployment scenarios (F1/F2/F3), to reflect low/mid/high potential levels of emissions reductions, which also represent different levels of readiness and attainability. These fuel deployment scenarios, which are described in Table 2, were developed to be aligned with the corresponding scenarios developed by the Technology and Operations sub groups. For non drop-in fuel, the main input of F1/F2 and F3 were the assessments performed by the TECH group, in terms of technologies penetration. For more details please refer to Appendix M3 of the LTAG report.[3]

Fuel production analysis

With the defined scenarios, potential fuel volumes and associated emissions reductions were developed for each fuel category. In some of the Scenarios, the combined projected technical production potential for LTAG-SAF and LTAG-LCAF exceeded total expected aviation fuel demand. In order to meet the expected total fuel demand, the volumes of fuels was constrained, and fuel categories prioritised:

- For F1, the scenario prioritization emphasized low cost GHG reduction, and fuels were ordered by minimum selling price (MSP).
- For F2, selection prioritized cost effective GHG reduction, using marginal abatement cost, expressed in $/kg CO_2reduced.
- For F3, the emphasis was on maximizing GHG reductions, and the fuel LCA values were used as ordering criterion: the lower the LCA value the higher the prioritization.

Fuels were prioritised according to the above mentioned criteria, until reaching the expected aviation fuel demand or when all projected fuel volumes were exhausted, whichever occurs first. For the latter case, remaining expected aviation fuel demand was met with conventional jet fuel use.

The figure 1 shows the fuel use projections for LTAG-LCAF, LTAG-SAF, cryogenic H_2 (LH2), and conventional jet fuel, based on mid traffic forecasts for each of the F1, F2 and F3 fuel deployment scenarios.

	LTAG-TG Scenarios		
	Fuel Scenario 1 (F1) Low GHG reduction from Fuels (LTAG-SAF and LTAG-LCAF)	**Fuel Scenario 2 (F2)** Mid GHG reduction from Fuels (LTAG-SAF and LTAG-LCAF)	**Fuel Scenario 3 (F3)** High GHG reduction from Fuels (LTAG-SAF, LTAG-LCAF and non-drop-in fuels)
Scenario Development	**Emphasize low cost GHG reduction → select fuels by Minimum Selling Price**	**Prioritize cost effective GHG reduction → select fuels by Marginal Abatement Cost**	**Maximize CO_2 reduction → select fuels by Lifecycle Value**
Approved Fuel Use	ASTM Intl approves use of alternative jet fuels at **blend levels above 50%.**	ASTM Intl approve **use of 100% Synthesized Jet Fuel in existing aircraft and engines** without any modification.	
Ground Transportation and Electrification	**Ground transportation and aviation have level playing field** with respect to alternative fuel use.	**Electrification of ground transportation** leads to increased availability of SAF.	**Economy-wide deep decarbonisation.** Extensive electrification of ground transportation and widespread availability of renewable energy.
Incentives	**Low incentives** for LTAG-SAF/LTAG-LCAF production.	**Increased incentives** lead to **reduced LTAG-SAF/LTAG-LCAF fuel cost** for users.	**Large incentives lead to widespread use** of low GHG fuels for aviation.
Fuel Availability	Using waste gases (CO/CO_2) and variety of feedstocks (e.g., oilseed cover crops) for LTAG-SAF.	**Widespread use of waste gases** and increased feedstock availability for LTAG-SAF. **SAF production exceeds jet fuel demand**	**Widespread use of atmospheric CO_2 for LTAG-SAF** and maximum LTAG-SAF feedstock availability. **SAF production exceeds jet fuel demand**
			Sufficient H_2 exists to enable use of cryogenic H_2 fuel in aircraft. Infrastructure developed to enable use of non-drop-in fuels at airports around globe.

TABLE 2: LTAG Fuels scenario descriptions

3 LTAG Report, Appendix M3, Technology: https://www.icao.int/environmental-protection/LTAG/Documents/ICAO_LTAG_Report_AppendixM3.pdf

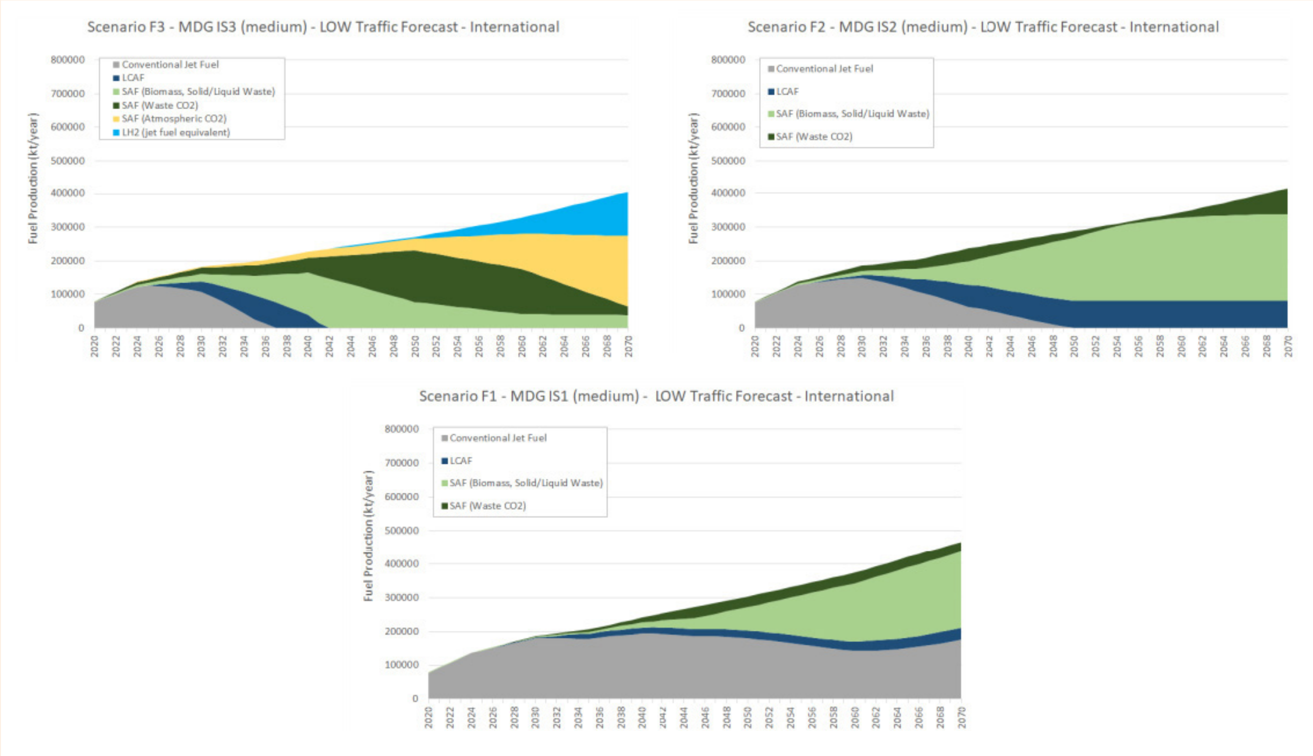

FIGURE 1: Fuel use projections for F1, F2 and F3 based on mid traffic forecasts

Emissions reduction analysis

Based on the fuel production projections for the F1, F2 and F3 fuel deployment scenarios, and the calculated life cycle assessment (LCA) values for each of the fuel categories, the potential GreenHouse Gases (GHG) saving was evaluated. This value was used to determine an overall Emissions Reductions Factor (ERF) for each of the fuel deployment scenarios across 2035, 2050, and 2070, as reflected in Table 4 below. The ERF expresses the perceptual reduction in the GHG emissions, compared to baseline constituted by the conventional fuel; this reflects the effects the use the LTAG-SAF, LTAG-LCAF, and non-drop in fuels, in accordance with projected fuel volumes and aviation fuel demand.

Key findings

The analysis carried out shows that the technical potential for the LTAG-SAF may exceed aviation demand for the F2 and F3 scenario. The benefit, in terms of GHG savings, potentially associated with the use of LTAG-SAF, LTAG-LCAF and non drop-in fuels range from 20% (F1) to 81% (F3) in 2050, and could reach the value of 90%, in 2070 (F3).

	F1	F2	F3
2035	5%	20%	37%
2050	20%	56%	81%
2070	28%	66%	88%

TABLE 4: Emissions Reduction Factors for the fuel mix under F1, F2 and F3.