ADVISORY CIRCULAR

Subject	Issuance Date	AC Number	Version
Guidance Material on Innovative/sustainable fuels guide	1-September-2024	156-02	1.0

1. Introduction

1.1 Purpose

The purpose of this advisory circular is to provide an overview of Innovative/Sustainable Aviation Fuels and discuss its environmental benefits.

1.2 Applicability

This advisory circular is applicable to aircraft operators and fuel providers.

1.3 Cancellation

This is the first official version of this advisory circular, and it cancels no other advisory circular on the subject matter.

1.4 Related regulatory references

a) GACAR Part-156.

1.5 Related reading materials and references

a) ICAO Sustainable Aviation Fuel Guide, available at: https://www.icao.int/environmental-protection/knowledge-sharing/Docs/Sustainable%20Aviation%20Fuels%20Guide_vf.pdf
b) ICAO Environmental Report 2022, Chapter 7: Sustainable Aviation Fuels, available at: https://www.icao.int/environmental-protection/Pages/envrep2022.aspx

1.6 Definitions of terms used in this Advisory Circular

CAF: Conventional Aviation Fuel
ICAO: International Civil Aviation Organization
SAF: Sustainable Aviation Fuel
LCAF: Lower Carbon Aviation Fuel

1.7 Approval

This advisory circular has been approved for publication by the Executive Vice President for Safety and Environmental Sustainability of the General Authority of Civil Aviation.

2. Background

a) In 2016, the ICAO Assembly adopted Resolution A39-2: Consolidated statement of continuing ICAO environmental protection and climate change policies. The assembly reaffirmed the two global aspirational goals established at the 37th Assembly in 2010 for the international aviation sector. The goals are to improve fuel efficiency by 2% annually until 2050 and to achieve carbon neutrality from 2020. To achieve the two global aspirational goals and to promote sustainable growth of international aviation, ICAO is pursuing a basket of measures for environmental protection.
b) GACA has consistently upheld its dedication to international environmental objectives in civil aviation, in addition to aligning with the national targets for environmental sustainability. In order to guide the Saudi civil aviation sector towards environmental sustainability, GACA has formulated the Saudi Civil Aviation Environmental Sustainability Program (CAESP). This comprehensive program encompasses seven key environmental pillars, with greenhouse gas (GHG) emissions being of utmost priority.
c) Hence, this advisory circular is aimed to raise the awareness of all affected stakeholders within the aviation sector of the new jet fuel technologies and their anticipated benefits to the aviation industry.

3. ICAO's basket of measures for environmental protection

ICAO's basket of measures for environmental protection has 4 elements that are supported with regulations and standards developed and maintained by its Committee on Aviation Environmental Protection (CAEP). As shown in figure 1, operational improvements, and enhanced aircraft technology by themselves will not be able to underpin neutral carbon emissions growth, considering the global aviation sector growth prospects. The 4 measures are:

a) Operational improvements:
   Airspace management technologies and air navigation procedures being adopted for operational improvements that reduce emissions.
b) Aircraft technology:
   Advancements in aircraft and aircraft engine design and technologies, which are maintained through continuous updates to governing certification regulations and standards.
c) CORSIA
   Implementation of CORSIA program to offset any carbon emissions beyond the agreed baseline by ICAO member states.
d) Sustainable Aviation Fuels
   Utilization of sustainable fuels that have less lifecycle carbon emissions and higher efficiency (e.g., SAF, LCAF, etc.).

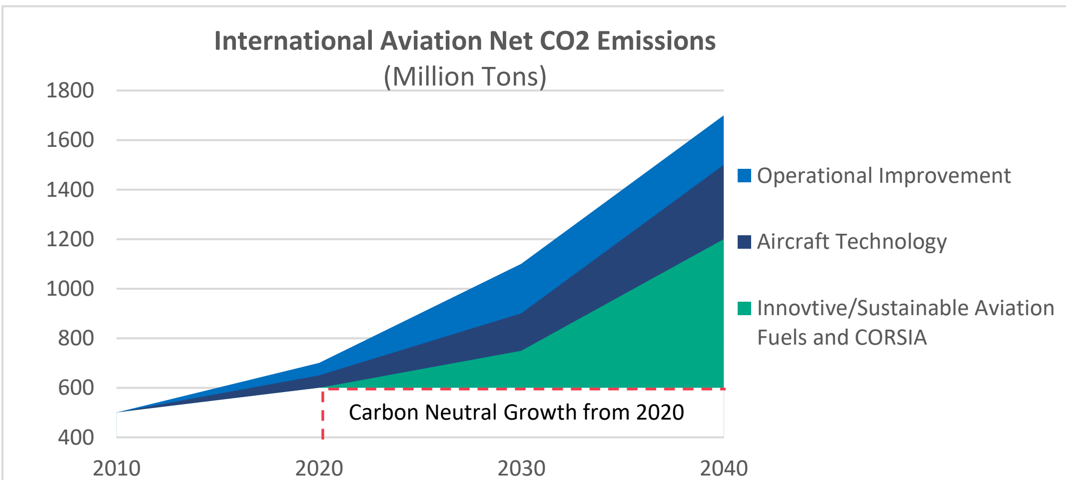

Figure 1: Contribution of ICAO's basket of measure for reducing international aviation net CO2 emissions

4. Innovative/Sustainable Aviation Fuels

Given that aircraft fuel combustion is the primary source of emissions within the aviation sector, the industry is actively investing in innovative fuel concepts that have the potential to yield environmental benefits by lowering the overall carbon emissions across the fuel's lifecycle.

Innovative/sustainable fuels include:

- Sustainable Aviation Fuel (SAF)
- Lower Carbon Aviation Fuel (LCAF)
- Hydrogen

Both SAF and LCAF were acknowledged as CORSIA eligible fuels, allowing aircraft operators who use these fuels, with the approved conditions, to reduce their offset requirements.

4.1 Sustainable Aviation Fuel (SAF)

SAF is the result of blending conventional kerosene (fossil-based) with renewable hydrocarbon. SAF is currently certified as “Jet-A1” fuel and can be used without any technical modifications to the aircraft. While the combustion of SAF emits similar quantities of CO2 to these emitted by CAF, SAF still provides an environmental benefit on a life cycle basis. A fuel lifecycle includes multiple steps, including; extraction, processing, refining, transport, distribution at the airport, combustion. At each of the steps, GHG emissions are likely to be produced. The total carbon footprint of the fuel is obtained by adding all these emissions together. When considering all these emissions SAF would produce less emissions than CAF, with exact reductions depending on the feedstock, production practice, conversion technology (pathway), logistics, as well as the land-use change incurred by bioenergy expansion.

The lifecycle carbon emissions of SAF can be reduced by up to 80% compared to traditional jet fuel, depending on the sustainable feedstock used, the production method and the supply chain. Overall, SAF enables emissions reduction in the combustion phase of the fuel lifecycle, where the CO2 emitted is absorbed by the feedstock, shifting the fuel production process from linear to circular model.

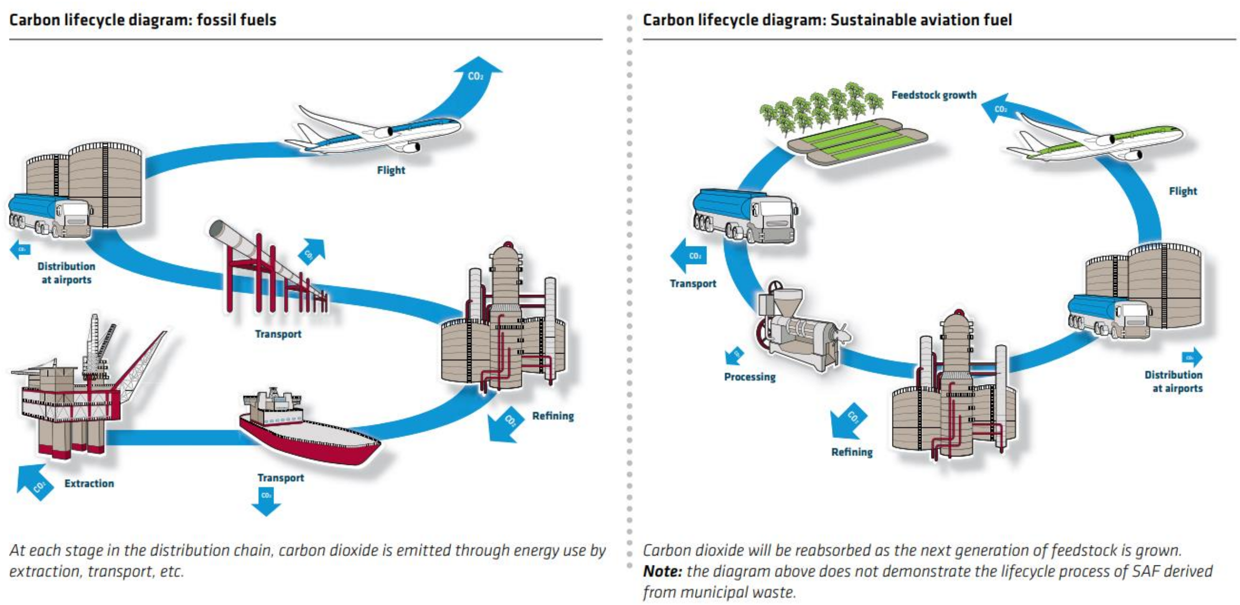

Figure 2: Comparison between SAF and CAF lifecycle emissions

Source: Beginner’s Guide to Sustainable Aviation Fuel

SAF has several feedstock resources, including:

- Corn grain
- Oil seeds
- Algae
- Other fats, oils, and greases
- Agricultural residues
- Forestry residues
- Wood mill waste
- Municipal solid waste streams
- Wet wastes (manures, wastewater treatment sludge)
- Dedicated energy crops

When it comes to SAF, aviation industry has been focused on “drop-in fuels”, which have chemical and physical characteristics almost identical to CAF. Therefore, these biofuels can be safely mixed with CAF and use the same supply infrastructure and do not require the adaptation of aircraft or engines. These drop-in fuels, also meet other important sustainability criteria, including:

- Reduced lifecycle carbon emissions comparing to CAF
- Limited freshwater requirements
- No competition with needed food production (from land-use change or converting food to biofuel)
- No deforestation

Currently, the conversion technology of these feedstocks into aviation fuel is organized by the ICAO, with specific criteria governing the different aspects of the conversion, including the possible feedstock and maximum blend ration with CAF. Each of these technologies is called Conversion process or technology pathway. The number of the approved conversion processes is continuously increasing, 9 approved processes as of April 2023 with 8 additional processes under evaluation.

Table 1:Approved Conversion Processes

Conversion process	**Abbreviation**	**Possible Feedstocks**	**Maximum Blend Ratio**
Fischer-Tropsch hydroprocessed ynthesized paraffinic kerosene	FT	Coal, natural gas, biomass	50%
Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids	HEFA	Bio-oils, animal fat, recycled oils	50%
Synthesized iso-paraffins from hydroprocessed fermented sugars	SIP	Biomass used for sugar production	10%
Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	FT-SKA	Coal, natural gas, biomass	50%
Alcohol to jet synthetic paraffinic kerosene	ATJ-SPK	Biomass from ethanol or isobutanol production	50%
Catalytic hydrothermolysis jet fuel	CHJ	Triglycerides such as soybean oil, jatropha oil, camelina oil, carinata oil, and tung oil	50%
Synthesized paraffinic kerosene from hydrocarbon - hydroprocessed esters and fatty acids	HC-HEFA-SPK	Algae	10%
co-hydroprocessing of esters and fatty acids in a conventional petroleum refinery	co-processed HEFA	Fats, oils, and greases (FOG) co-processed with petroleum	5%
co-hydroprocessing of Fischer-Tropsch hydrocarbons in a conventional petroleum refinery	co-processed FT	Fischer-Tropsch hydrocarbons co-processed with petroleum	5%

Currently, Sustainable Aviation Fuel (SAF) is regarded as a mid-to-long-term solution due to its limited production and distribution in comparison to Conventional Aviation Fuel (CAF), accounting for less than 2% of global production. Nevertheless, SAF is gaining momentum rapidly, with 300 million liters produced in 2022, compared to 100 million liters in 2021. This growth is anticipated to accelerate further, driven by the increasing global environmental awareness and the financial advantages it can offer to airlines, particularly as CORSIA becomes mandatory, and its broader economic benefits to countries.

4.2 Lower Carbon Aviation Fuel (LCAF)

LCAF is a fossil-fuel based aviation fuel that has Lower carbon emissions during its lifecycle. LCAF is considered a CORSIA eligible fuel, when meeting the sustainability criteria, including a 10% reduction in

lifecycle emissions compared to the conventional aviation fuel baseline of 89 g CO_2/MJ. Despite having less lifecycle carbon emissions reduction comparing to SAF (For example, five billion liters of LCAF at 80 gCO_2/MJ could provide the equivalent GHG emissions reduction of about one billion liters of SAF at 45 gCO_2/MJ.), LCAF offers a scalable short-term solution to reduce the GHG intensity of aviation fuel.
LCAF's reduced lifecycle emissions result from optimizing and/or adding additional measures to the current fossil-fuel production process. These measures take place in the crude oil production phase (upstream) while others take place in the crude refining phase to produce the aviation fuel (downstream).
Technology measures to produce LCAF include:

- Energy conservation through energy efficient design of plants, advanced computer controls, advanced modelling of reservoirs to increase production efficiencies, new extraction and processing methods, and improved technologies for monitoring the efficiency of equipment in the oilfield
- Methane Emissions Reduction; through Flare Management and Gas Recovery
- Oil vessels venting control
- Fugitive emissions detection
- Carbon capture, utilization and storage (CCUS)
- Utilization of renewable energy

4.3 Hydrogen

In its analysis on how to achieve the long-term aspirational goals (LTAG) for international aviation of net-zero carbon emissions by 2050, ICAO has projected Hydrogen as an aviation fuel. Also, in its criteria for CORSIA eligible fuels, liquid state is not a must for eligibility, leaving the door open for gaseous state fuels, including Hydrogen.
To date, several factors still hinder a possible use of hydrogen in commercial flights, such as on-board storage, safety concerns, the high cost of producing the fuel and the need for dedicated infrastructure at airports. However, research projects are ongoing to demonstrate the feasibility of hydrogen propulsion and to overcome these challenges, in support of longer-term environmental objectives for civil aviation.

5. Conclusion

With many of ICAO member states have communicated net-zero targets, they will have to consider and capitalize on all currently available and future solutions to reduce the carbon footprint of the aviation sector, whether during fuel production phase or combustion phase. The adoption strategy and timeline of LCAF, SAF or Hydrogen should be assessed based on the specific conditions of each state, airport, airline and service provider.

GACA Contact:
For any further information, please contact General Directorate of Environmental Sustainability at envi@gaca.gov.sa.

H.M

EVP, Aviation Safety & Environmental Sustainability
Captain/ Sulaiman Saleh Almuhaimedi