# International Capacity Building for SAF (ACT-SAF programme)

## ICAO/SADC SASO Environmental Workshop

**Alina Viehweber**
Sustainable Aviation Manager

**Kelly Gibson**
Sustainable Aviation Consultant

November 2025
Namibia

Department for Transport

# Today's Presenters

## Alina Viehweber

*Sustainable Aviation Manager*

## Kelly Gibson

*Sustainable Aviation Consultant*

Department for Transport

# Today's Agenda

| Time | Training Module |
|---|---|
| 09:00 – 9:30 | Introductions |
| **09:30 – 10:30** | **Session 1: Introduction to SAF** |
| 10:30 – 10:45 | *Break* |
| **10:45-12:15** | **Session 2: SAF technologies and feedstocks** |
| 12:15-13:15 | *Lunch break* |
| **13:15-14:45** | **Session 3: SAF in the Southern Africa context** |
| 14:45-15:00 | *Break* |
| **15:00-16:00** | **Session 4: SAF sustainability and reporting under CORSIA** |
| 16:00-16:30 | Next steps and available support |

Department for Transport

# Introductions

*What is one thing you are hoping to learn from today's course?*

Department for Transport

# Course Aim

ICF

*This course aims to support ICAO Member States (particularly in the SADC region) build practical knowledge and partnerships to advance SAF deployment.*

Department for Transport

# Learning Objectives

*By the end of the workshop, participants will understand SAF fundamentals, technologies and feedstocks, sustainability and reporting, regional context, and next steps for support.*

*Participants will be able to complete a request for a SAF feasibility study, meet different stakeholders and initiate collaboration on SAF.*

# Introduction to SAF

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Setting the context
  - Introduction to ICAO
  - Regional opportunities
- The role and benefits of SAF
- SAF Lifecycle Assessment
- Current developments in the SAF market

# Introduction to SAF

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Setting the context
  - Introduction to ICAO
  - Regional opportunities
- The role and benefits of SAF
- What is SAF?
- SAF Lifecycle Assessment

# ICAO has supported SAF developments since 2009

**2009**
First ICAO Conference on Aviation and Alternative Fuels (CAAF/1)

**2010**
Inclusion of SAF as a measure to reduce $CO_2$ emissions
(ICAO resolution A37-17)

**2012**
Rio + 20 conference – SAF flight from Montréal to Rio with the ICAO Secretary General

**2013**
Creation of the CAEP Alternative Fuels Task Force (AFTF)

**2015**
Paris Agreement adopted

**2017**
Second Conference on Aviation and Alternative Fuels (CAAF/2)
ICAO vision on SAF

**2018**
CORSIA adoption
(including SAF provisions)


**2019**
First ICAO Stocktaking Seminar on SAF


**2020**
CORSIA methodologies on sustainability and life cycle analysis


**2021**
Socio-economic and environmental sustainability criteria


**2022**
ICAO Assembly adopts Long-Term Aspirational Goal (LTAG) for international aviation
Launch of ACT-SAF


**2023**
Third Conference on Aviation and Alternative Fuels (CAAF/3)
Announcements of 18 projects under ACT-SAF framework

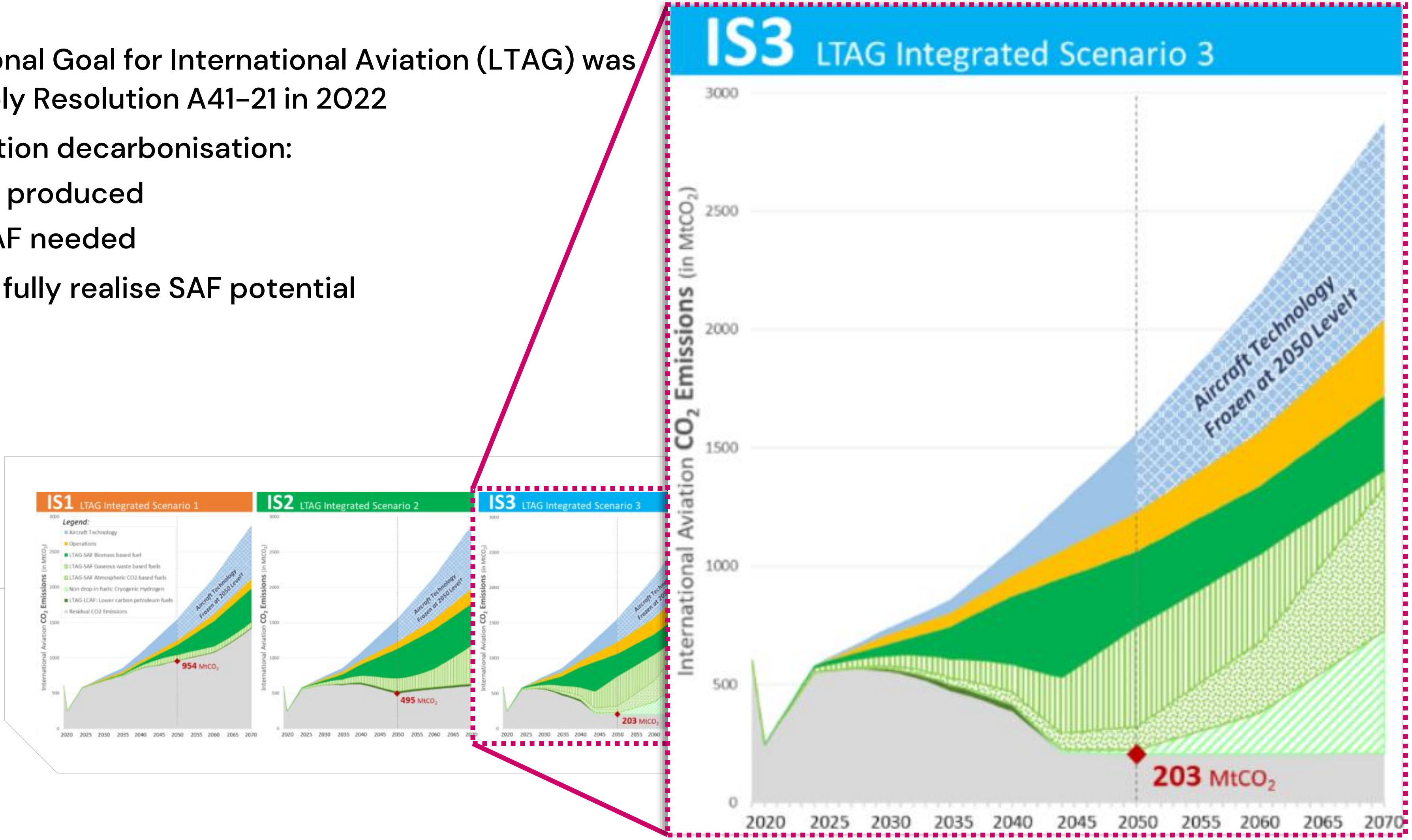
# ICAO Long Term Aspirational Goal (LTAG) was adopted by ICAO in 2022, presenting a substantial role for SAF

The ICAO Long Term Aspirational Goal for International Aviation (LTAG) was adopted by the ICAO Assembly Resolution A41-21 in 2022

SAF will play a key role in aviation decarbonisation:

- 2024: 1.3 billion litres of SAF produced
- 2045: 636 billion litres of SAF needed

Need for immediate action to fully realise SAF potential

# To support the achievement of the LTAG; ICAO and its Member States established a collective global goal at CAAF/3

## *The 2050 Vision was reviewed in the CAAF/3 Conference (November 2023)*

- *New ICAO Global SAF Framework*: Adoption of a new ICAO Global Framework for Sustainable Aviation Fuels (SAF), Lower Carbon Aviation Fuels (LCAF) and other Aviation Cleaner Energies.
- *5% 2030 Reduction Target*: Collective global aspirational Vision to reduce $CO_2$ emissions in international aviation by 5 percent by 2030 (compared to a scenario with zero cleaner energy use).
- *Net-Zero by 2050*: Support the clean energy transition of the aviation sector needed to achieve the current goal of Net-Zero carbon emissions by 2050

# ICAO also launched the Assistance, Capacity-building and Training for Sustainable Aviation Fuels (ACT-SAF) programme in 2022

## What is the purpose of ACT-SAF?

"The programme aims to provide tailored support for States in various stages of SAF development and facilitate partnerships and cooperation on SAF initiatives under ICAO coordination and serve as a platform to facilitate knowledge sharing and recognition of all SAF initiatives around the globe."

### What is ACT-SAF?

- An initiative to facilitate the development and deployment of SAF
- Tailored support for States
- Facilitate cooperation under ICAO coordination
- A platform to facilitate knowledge sharing and progress monitoring

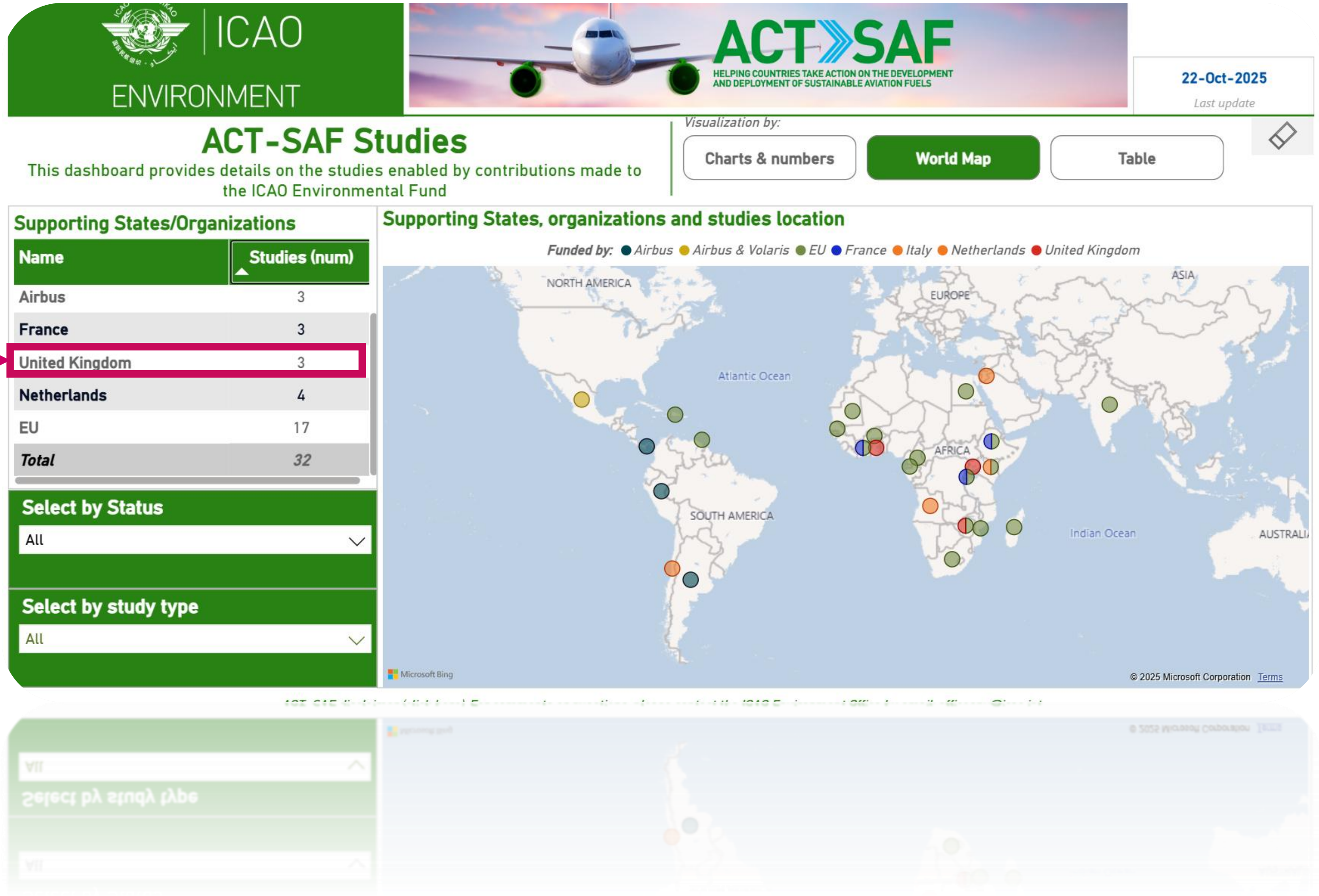
### Why ACT-SAF?

- Builds on existing 'ACT' experience, through partnerships and State cooperation
- ICAO LTAG report foresees largest $CO_2$ reductions coming from clean fuels
- Need for immediate action to fully realise SAF potentials

# UK Department for Transport (DfT) is supporting SAF scale up across the world as a part of the ICAO ACT-SAF programme

*UK DfT has been an active contributor since 2022.*

The aim is to support states to implement policies to increase the production and uptake of SAF globally.



# The ACT-SAF Programme consists of 3 steps

**Training**
*2 days in-person*

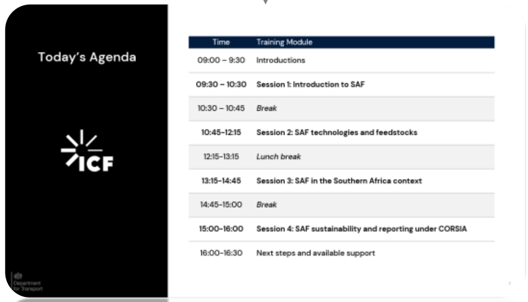
First step in building SAF understanding

**Feasibility Study**
*6 months*

National SAF Roadmap: Feedstock and technology

**Business Implementation**
*6 months*

Bottom up SAF facility design & technoeconomic analysis


Today's Agenda

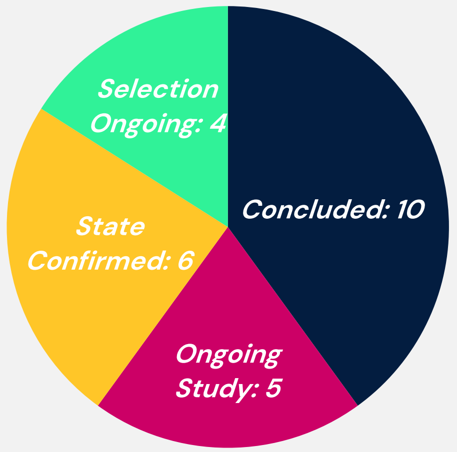
| Time | Training Module |
|---|---|
| 09:00 – 9:30 | Introductions |
| 09:30 – 10:30 | Session 1: Introduction to SAF |
| 10:30 – 10:45 | Break |
| 10:45–12:15 | Session 2: SAF technologies and feedstocks |
| 12:15–13:15 | Lunch break |
| 13:15–14:45 | Session 3: SAF in the Southern Africa context |
| 14:45–15:00 | Break |
| 15:00–16:00 | Session 4: SAF sustainability and reporting under CORSIA |
| 16:00–16:30 | Next steps and available support |


# As of October 2025, 10 feasibility studies have been completed

***Feasibility studies use State-specific information to inform:***

i. Available feedstocks (e.g., ethanol, MSW)
ii. Viable conversion technologies (e.g., HEFA/AtJ)
iii. Required capacity-building and assistance needs
iv. Different sources of financing
v. Options for enabling policies to promote SAF development

An additional *15 States are planning or progressing feasibility studies* to assess SAF potential:





2017 | 2018 | 2023 | (2025)

# Introduction to SAF

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Setting the context
  - Introduction to ICAO
  - Regional opportunities
- The role and benefits of SAF
- What is SAF?
- SAF Lifecycle Assessment

# SAF interest is emerging across the region

**2022**
- Namibia sign EU green H2 project (EUR 2 million)
- WWF study shows South Africa has potential to produce up to 4.5 billion litres of SAF per year

**2023**
- Zimbabwe SAF feasibility study launched under ICAO ACT-SAF
- Zambia requests ICAO and World Bank support to conduct a SAF feasibility study

**2024**
- UK hosts ACT-SAF training for Angola, Tanzania, Equatorial Guinea, Cameroon, Democratic Republic of the Congo and Gabon
- NCAA, in collaboration with EASA, hosted a regional SAF workshop reinforcing ambition to become regional SAF hub

**2025**
- Tanzania hosts SAF training workshop, in partnership with EASA
- Angola plans to host AFRAA-Boeing Sustainability workshop in Dec 2025

**2026**
- 10 SADC states will voluntarily participate in CORSIA

**2050**
- Commitment to net-zero by 2050 across the SADC states

# Tourism is expanding, increasing regional demand for jet fuel

*"Improved air connectivity unlocks a range of benefits: it streamlines travel, opens doors for new tourism markets, and strengthens regional economic ties." – SADC Tourism Alliance*

- SADC's Protocol on Transport recognise the importance of aviation for trade, tourism, and connectivity across member States
- Expanded frequencies by airlines are boosting tourism in the region, particularly for Southern Africa's safari destinations

As connectivity and tourism grows, so do emissions. Jet fuel demand is forecast to grow in the region, and SAF offers a practical pathway to decarbonise aviation.

Across a sample of States (Angola, Botswana, Namibia, and Zambia), jet fuel demand is expected to increase by more than half in the next 20 years.

# There's abundant feedstock and industrial opportunity across the region

## *Feedstock Potential*

Bush Biomass

Used Cooking Oil (UCO)

Sugarcane Residues

Municipal Solid Waste (MSW)

Biomass from clearing of Invasive Alien Plants (IAPs)

Animal Fat

Sun

*Key feedstock for Power-to-Liquid SAFs*

## *Industrial Capabilities*

Across the region there are several fossil-based, and biofuel refineries. The infrastructure is available to support plans to produce SAF.

*Sonangol biofuel refinery in Angola*

*South Africa has multiple operational refineries (Sapref, Enref, Natref)*

*Namibia-Botswana planned joint oil refinery. 60,000-100,000 bpd*

*Mozambique major oil refinery project with Nigeria. 240,000 bpd.*

Department for Transport

*Are there any SAF developments in your country that you would like to share?*

# Introduction to SAF

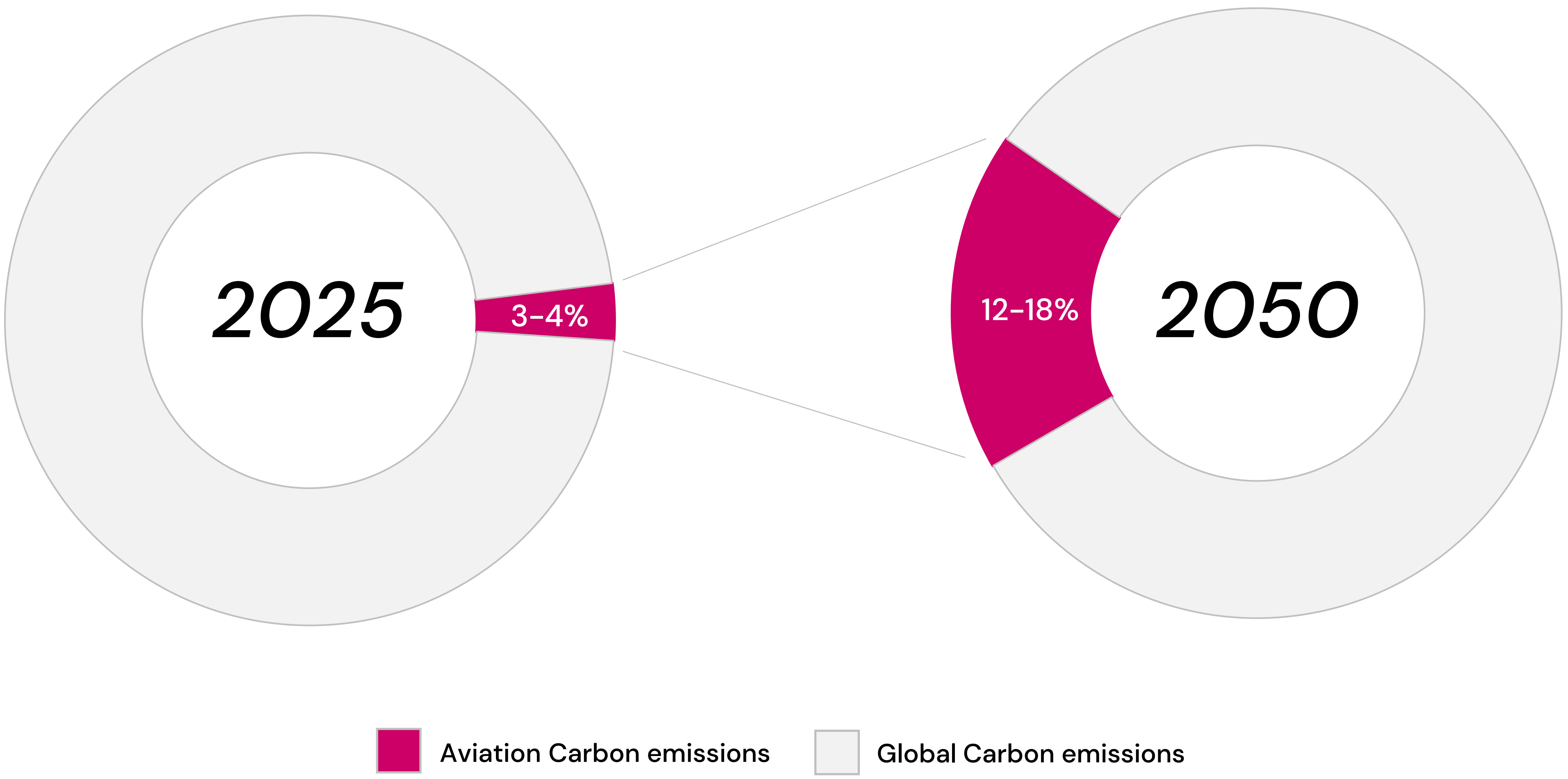
Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Setting the context
  - Introduction to ICAO
  - Regional opportunities
- The role and benefits of SAF
- What is SAF?
- SAF Lifecycle Assessment

# Share of aviation emissions compared to global emissions are expected to increase

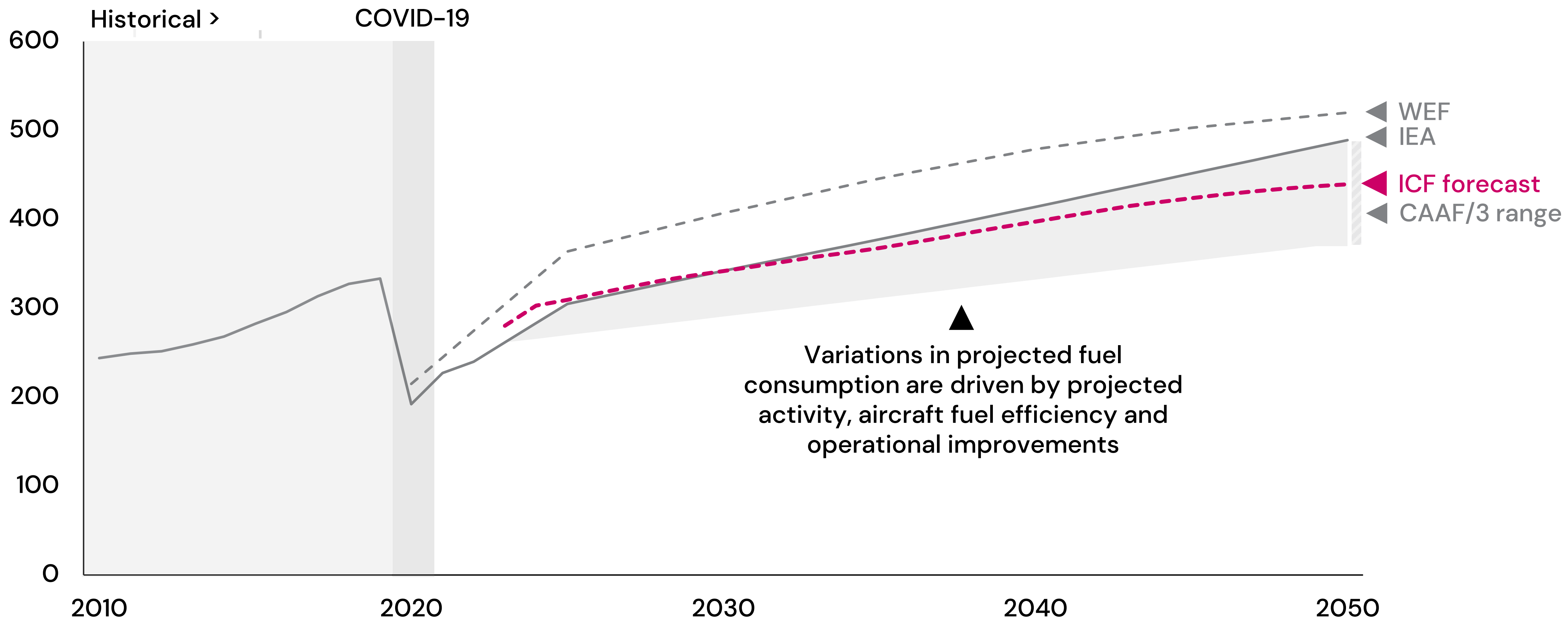
**Global aviation emissions as a share of global emissions**

Percent (%)



# Aviation is expected to grow by an estimated 2% annually until 2050, reaching a projected jet fuel consumption of approximately 450 MT/yr

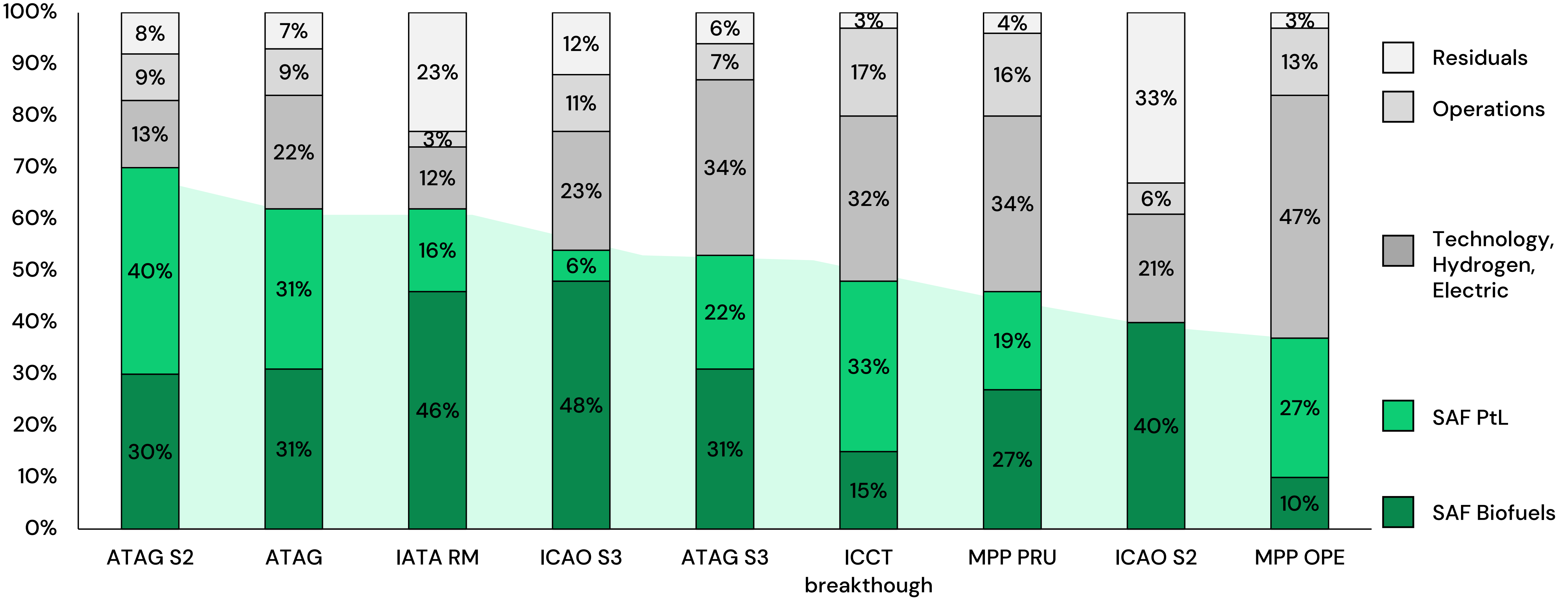
Projected Fuel Consumption, Global, 2010-2050
Million tonnes




ICF | Department for Transport

# Achieving aviation decarbonisation by 2050 will require a range of solutions – global studies highlighting SAF as the most promising option

**2050 Aviation Decarbonization Roadmaps**
IATA, 2023



# While hydrogen and electric aircraft will grow, SAF will remain the most critical tool to decarbonise aviation

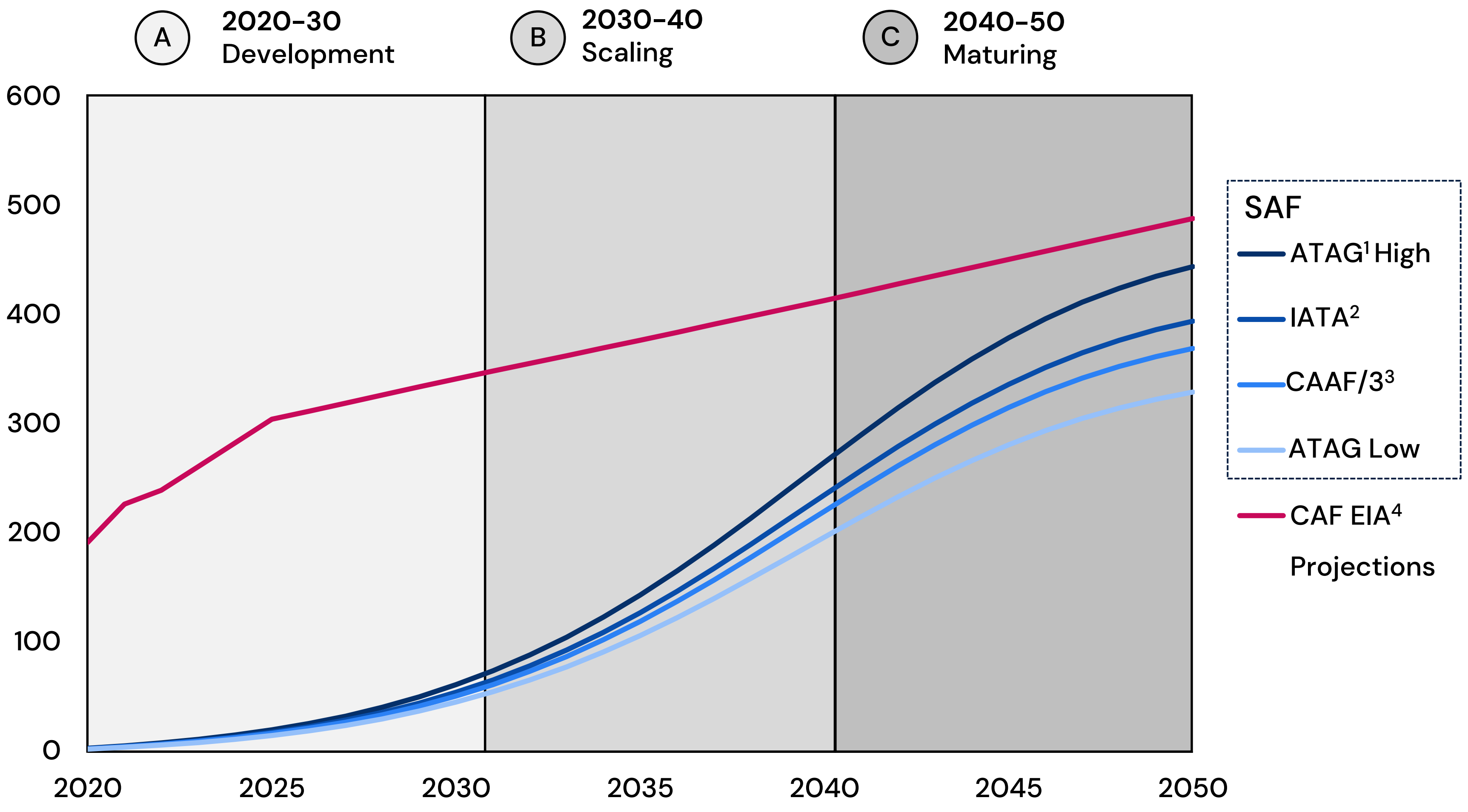
- 73% of the global aviation emissions are driven by medium to long haul flights.
- Hydrogen and electric aircraft have very limited potential for such long-distance flights.
- However, as a drop in fuel SAF can be used for such flights, reducing majority of the aviation emissions.

| | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 | |
|---|---|---|---|---|---|---|---|---|
| **Commuter**<br>» 9-50 seats<br>» <60 minute flights<br>» <1% of industry $CO_2$ | SAF | **Electric** or **hydrogen fuel cell** and/or SAF | **Electric** or **hydrogen fuel cell** and/or SAF | **Electric** or **hydrogen fuel cell** and/or SAF | **Electric** or **hydrogen fuel cell** and/or SAF | **Electric** or **hydrogen fuel cell** and/or SAF | **Electric** or **hydrogen fuel cell** and/or SAF | ~27% of $CO_2$ emissions |
| **Regional**<br>» 50-100 seats<br>» 30-90 minute flights<br>» ~3% of industry $CO_2$ | SAF | SAF | **Electric** or **hydrogen fuel cell** and/or SAF | **Electric** or **hydrogen fuel cell** and/or **SAF** | **Electric** or **hydrogen fuel cell** and/or **SAF** | **Electric** or **hydrogen fuel cell** and/or **SAF** | **Electric** or **hydrogen fuel cell** and/or **SAF** | |
| **Short-haul**<br>» 100-150 seats<br>» 45-120 minute flights<br>» ~24% of industry $CO_2$ | SAF | SAF | SAF | SAF potentially some **hydrogen** | **Hydrogen** and/or **SAF** | **Hydrogen** and/or **SAF** | **Hydrogen** and/or **SAF** | |
| **Medium-haul**<br>» 100-250 seats<br>» 60-150 minute flights<br>» ~43% of industry $CO_2$ | SAF | SAF | SAF | SAF | SAF | SAF | SAF potentially some **hydrogen** | ~73% of $CO_2$ |
| **Long-haul**<br>» 250+ seats<br>» 150 minute + flights<br>» ~30% of industry $CO_2$ | SAF | SAF | SAF | SAF | SAF | SAF | SAF | |

*Note: SAF refers to maximum blend available, that is currently 50%, but assumed as 100% in the long term*

# SAF is expected to play a key role to reduce aviation emissions – but requires a rapid scale up to meet ambitions

**Estimated SAF volumes**
Million tonnes




**Estimated scale up**

| | |
|---|---|
| A | ▪ Scaling of high-TRL production pathways<br>▪ Development of low-TRL SAF production pathways |
| B | ▪ Increased SAF production and upstream infrastructure |
| C | ▪ Ensure long-term SAF supply |

ICF | Department for Transport

*Source: 1. ATAG: Air Transport Action Group: ATAG; 2. International Air Transport Association; 3. CAAF/3: Third Conference On Aviation And Alternative Fuels ICAO – CAAF/3, 4. . US Energy Information Administration: EIA Energy Outlook; LEK Insights ; Clean Skies for Tomorrow*

# Drop-in nature of SAF makes it interchangeable and compatible with conventional aviation fuels

## Drop in compatibility

SAFs can currently be blended at up to 50% with conventional jet fuel, and re-certified – it is handled in the same way as conventional aviation fuels. No changes in the aircraft or its engines, nor in infrastructure, which would imply major logistical, safety and cost issues

## Environmental benefit

SAF can provide significant reductions in overall $CO_2$ lifecycle emissions compared to fossil fuels. Since it contains fewer impurities and has cleaner burning properties, it also results in a reduction of $NO_x$, $SO_x$, soot, and contrail formation

## Economic and social benefit

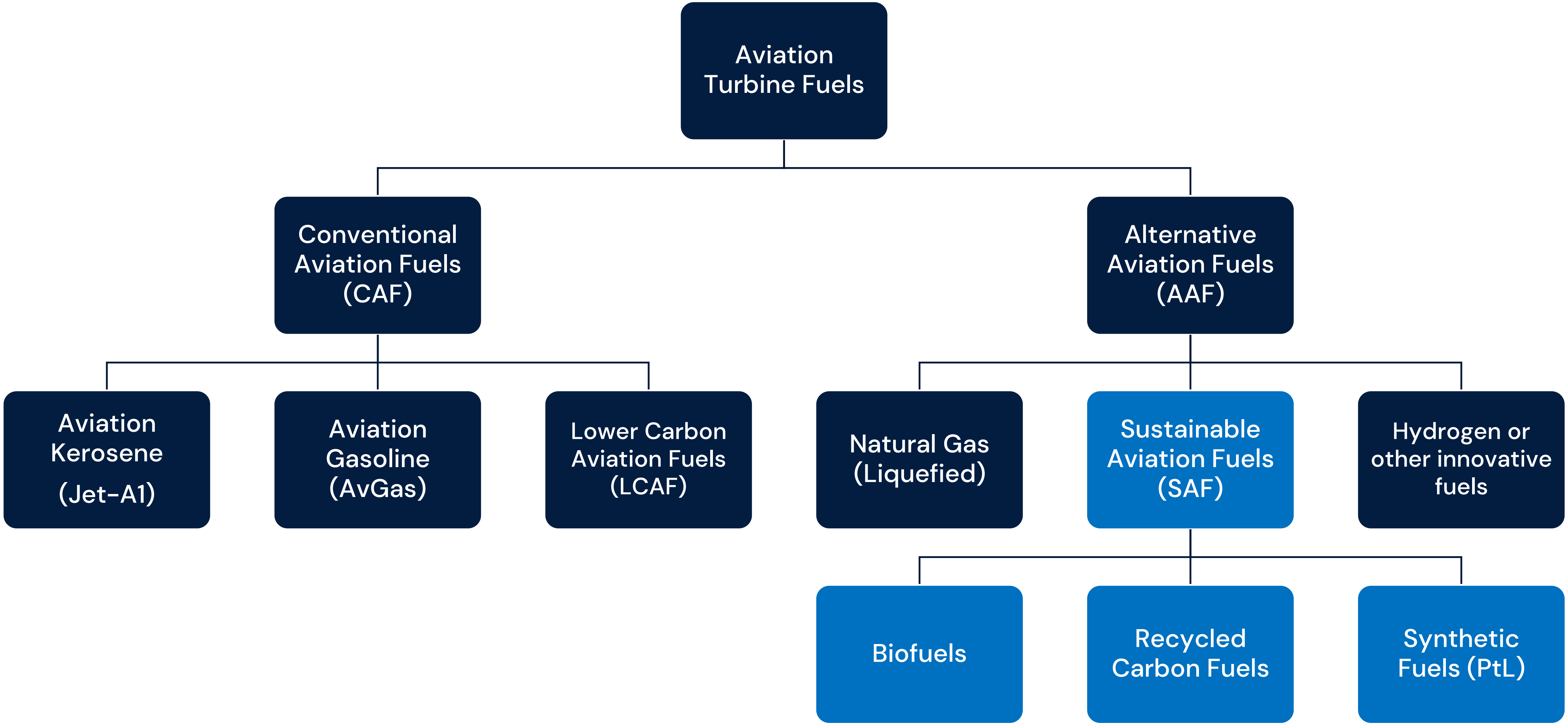
SAF industry can provide opportunities for economic growth, employment, and enhanced energy security. Establishing domestic SAF production helps diversify energy sources and reduce reliance on imported fossil fuels, while also creating potential for fuel export. Development of the SAF value chain can generate a wide range of skilled jobs and stimulate regional economies.

# Introduction to SAF

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Setting the context
  - Introduction to ICAO
  - Regional opportunities
- The role and benefits of SAF
- What is SAF?
- SAF Lifecycle Assessment

# Sustainable Aviation Fuels (SAF) are low carbon alternatives to Conventional Aviation Fuels (CAF)




*Note: While LCAF is a CORSIA eligible fuel, it is a type of more efficiently produced conventional fuel, so has been defined under CAF*
*Source: adjusted from Chiaramonti et al., 2021*

# There are a lot of acronyms that go around

**ATF = Aviation Turbine Fuel** also known as JET Fuel

- The specifications for ATF are ASTM D1655, DEF STAN 91-091 and other national standards
- Fuel produced to these specifications is known globally as Jet A or Jet A-1

**SBC = Synthetic (Kerosene) Blend Component used in fuel specification documentation**

- This is the synthetic component blended with ATF to process SATF *(e.g. ASTM D7566, DEF STAN 91-091)*

**SATF = Synthetic Aviation Turbine Fuel in the context of ATF specifications**

- Currently SATF can contain up to 50% synthetic blend component

**SAF = Sustainable Aviation Fuel** is defined as a *'renewable or waste-derived aviation fuel that meets the CORSIA Sustainability Criteria'* *(Ref ICAO SARPs Annex 16 Volume IV)*

**SAF = SATF + Sustainability**

# How is SAF defined?

## Definition

SAF is defined as a renewable or waste-derived aviation fuel that meets sustainability criteria.

*Reference: Annex 16 Vol IV – CORSIA*

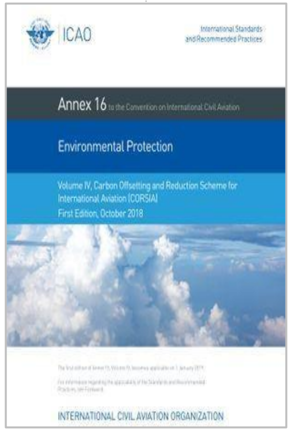
### *How is 'waste' defined?*

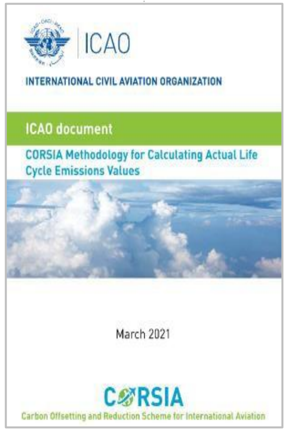
A feedstock with inelastic supply and no economic value (e.g. municipal solid waste, used cooking oil, waste gases etc.)

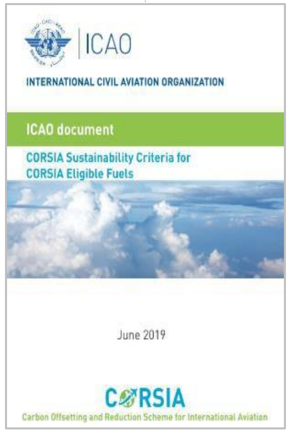
*Reference: ICAO document "CORSIA Methodology For Calculating Actual Life Cycle Emissions Values*

### How is *'Sustainability Criteria'* defined?

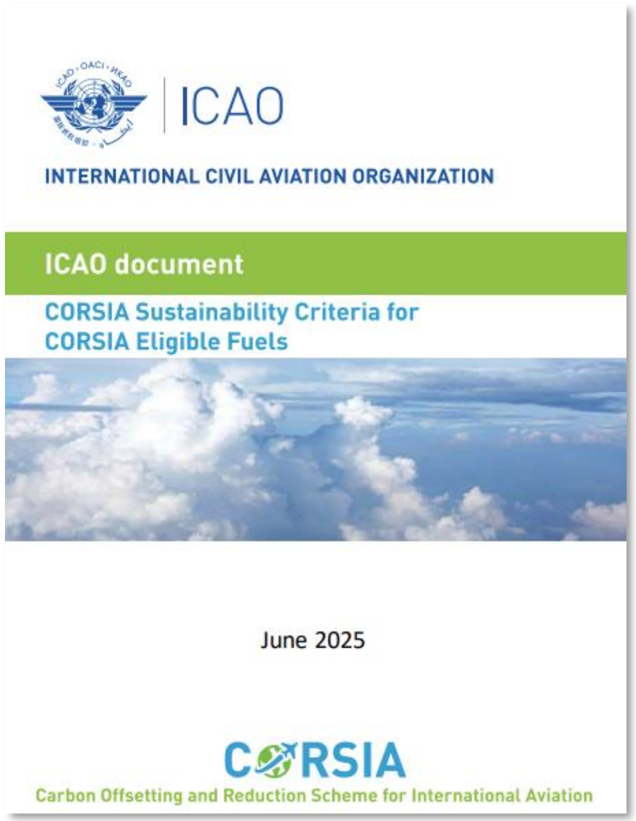
Criteria defined in the ICAO document *"CORSIA Sustainability Criteria for CORSIA Eligible Fuels"*



# The CORSIA sustainability criteria is the first global approach for sustainability for any sector


ICAO
INTERNATIONAL CIVIL AVIATION ORGANIZATION
ICAO document
CORSIA Sustainability Criteria for CORSIA Eligible Fuels
June 2025
CORSIA
Carbon Offsetting and Reduction Scheme for International Aviation

| Sustainability Themes |
|---|
| 1. Greenhouse Gases (GHG) |
| 2. Carbon stock |
| 3. GHG reduction permanence |
| 4. Water |
| 5. Soil |
| 6. Air |
| 7. Conservation |
| 8. Waste and Chemicals |
| 9. Seismic and Vibrational Impacts (only for LCAF) |
| 10. Human and labour rights |
| 11. Land use rights and land use |
| 12. Water use rights |
| 13. Local and social development |
| 14. Food security |

Themes 1–2: Carbon reduction themes – CORSIA pilot phase, 2021–2023

Themes 3–14: Environmental and socio-economic Themes for CEF (after CORSIA pilot phase, from 2024)

# Feedstock eligible for SAF production is defined differently under UK and EU legislations

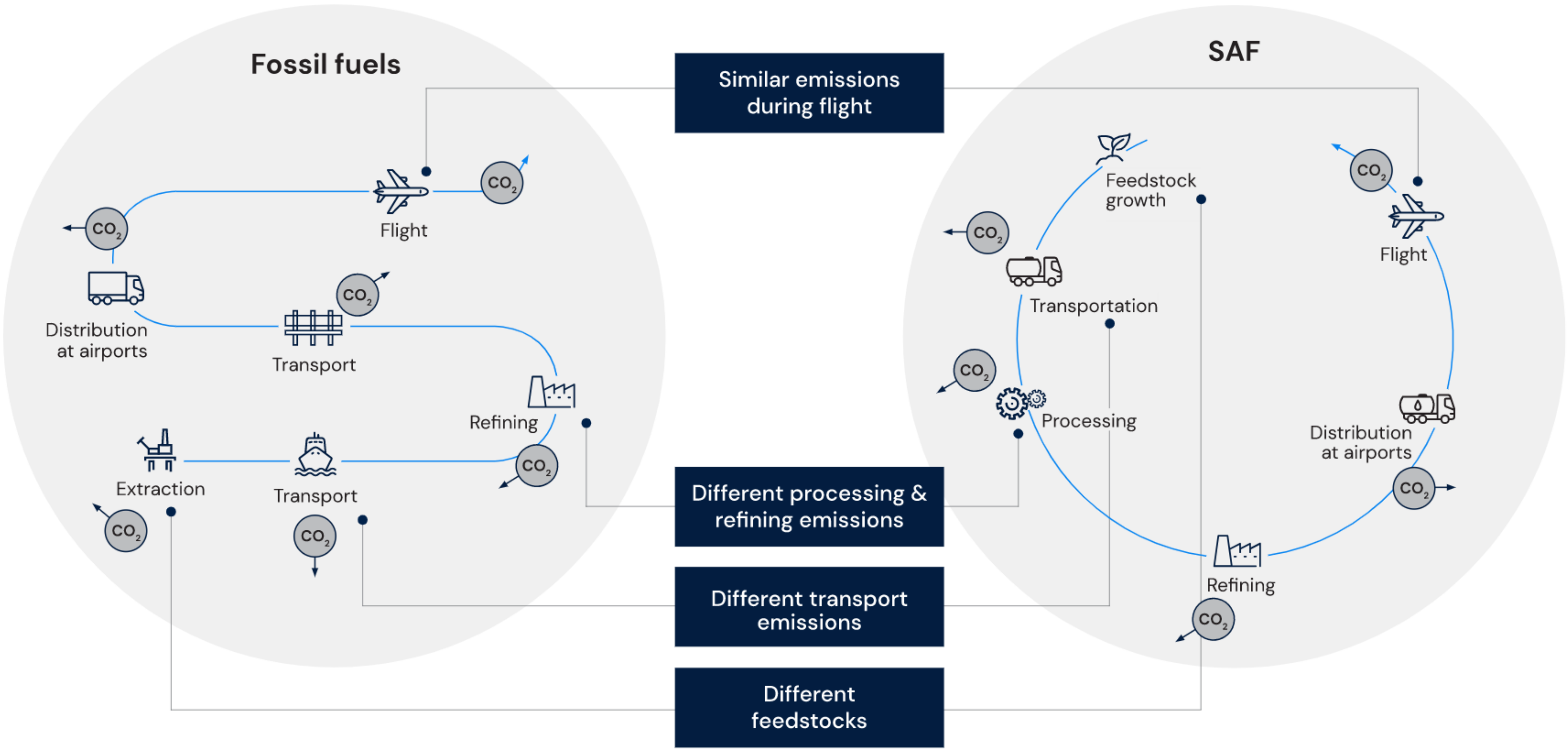
| UK SAF Eligibility | EU SAF Eligibility |
|---|---|
| Eligible SAF must be made from sustainable, wastes or residues derived from:<br><br>• biogenic waste (e.g. used cooking oil or forestry residues)<br><br>• fossil wastes that cannot otherwise be avoided, reused or recycled (such as unrecyclable plastics)<br><br>• renewable or nuclear power<br><br>• SAF produced from food, feed or energy crops is not eligible.<br><br>SAF must achieve a minimum GHG emissions reductions of 40% relative to a fossil fuel comparator of 89gCO2e/MJ. | SAF Sustainability Framework in line with the Renewable Energy Directive (EU) 2018/2011 – RED II.<br><br>These feedstocks include:<br>• Agricultural or forestry residues, algae, bio-waste, and certain other feedstocks like used cooking oil and inedible animal fats<br>• Fuels derived from food, feed, or energy crops, fossil sources without waste origin, or non-renewable hydrogen are not eligible.<br><br>All sustainability and GHG criteria must be certified under recognised EU voluntary schemes (e.g., ISCC EU, RSB EU).<br><br>SAF must achieve a minimum GHG emissions reductions of 65%+ relative to a fossil fuel comparator of 94gCO2e/MJ. |

# Introduction to SAF

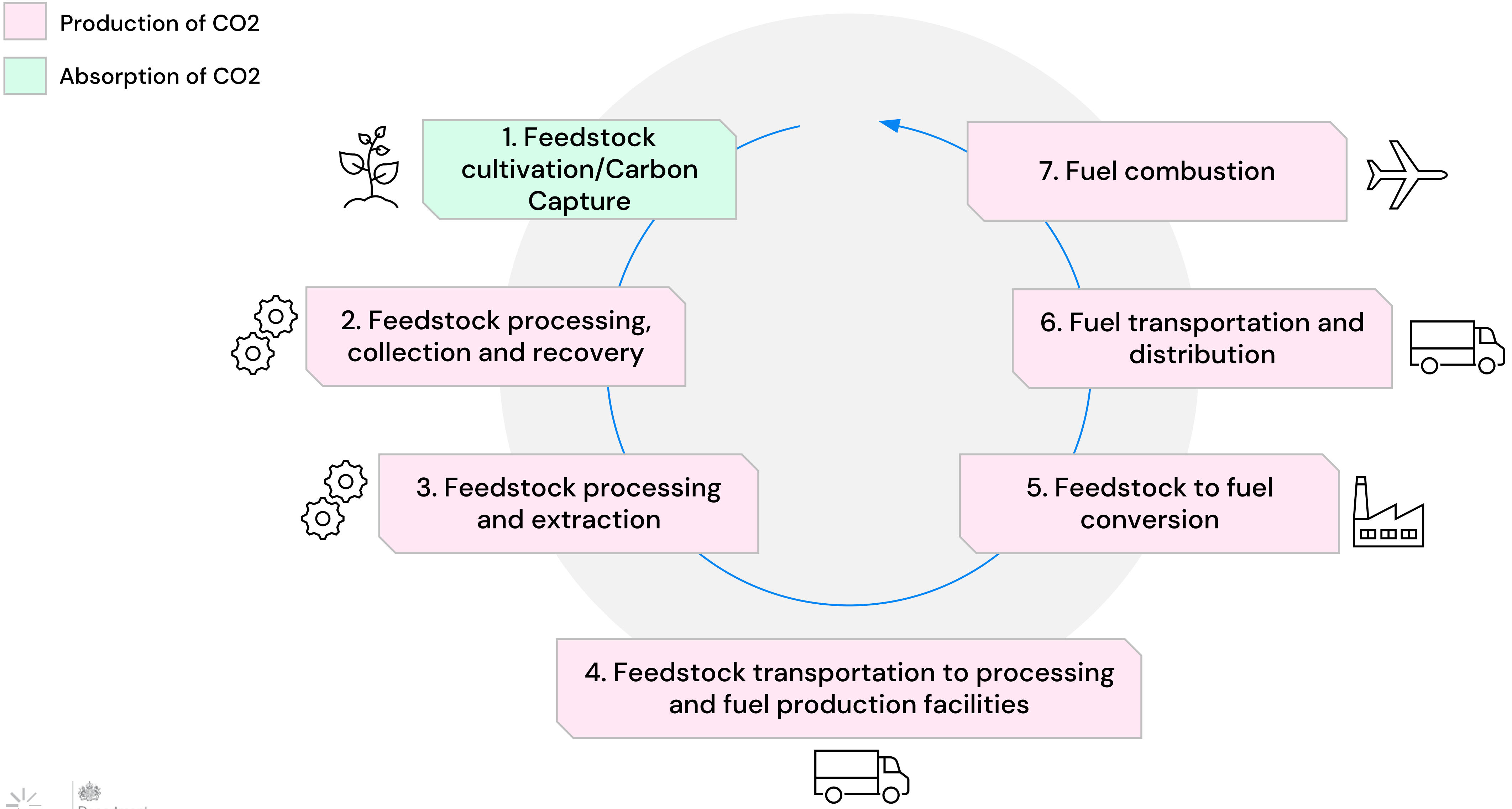
Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Setting the context
  - Introduction to ICAO
  - Regional opportunities
- The role and benefits of SAF
- What is SAF?
- SAF Lifecycle Assessment

# Carbon emissions are considered on a total lifecycle basis

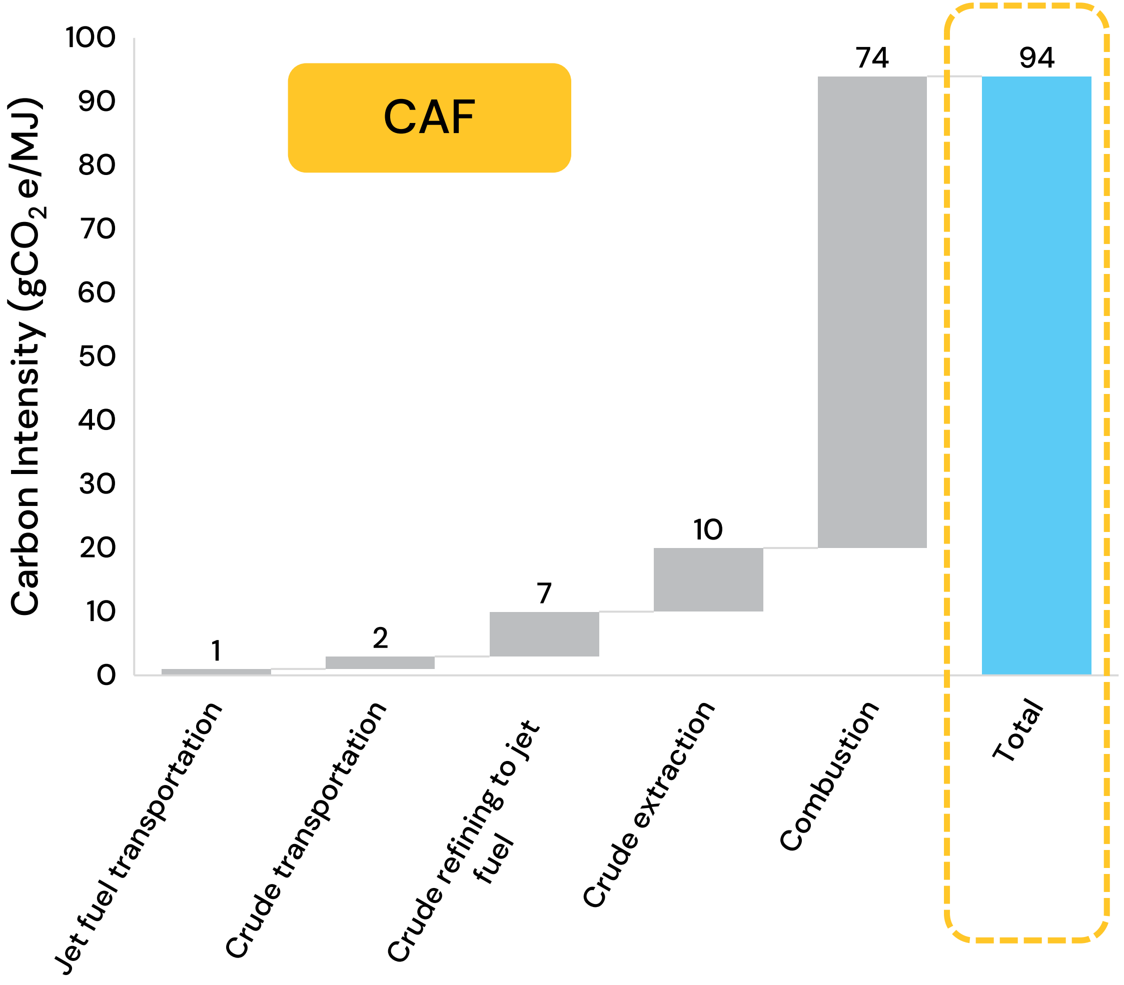


# The Life Cycle Assessment (LCA) accounts for emissions associated with all steps of SAF production and use

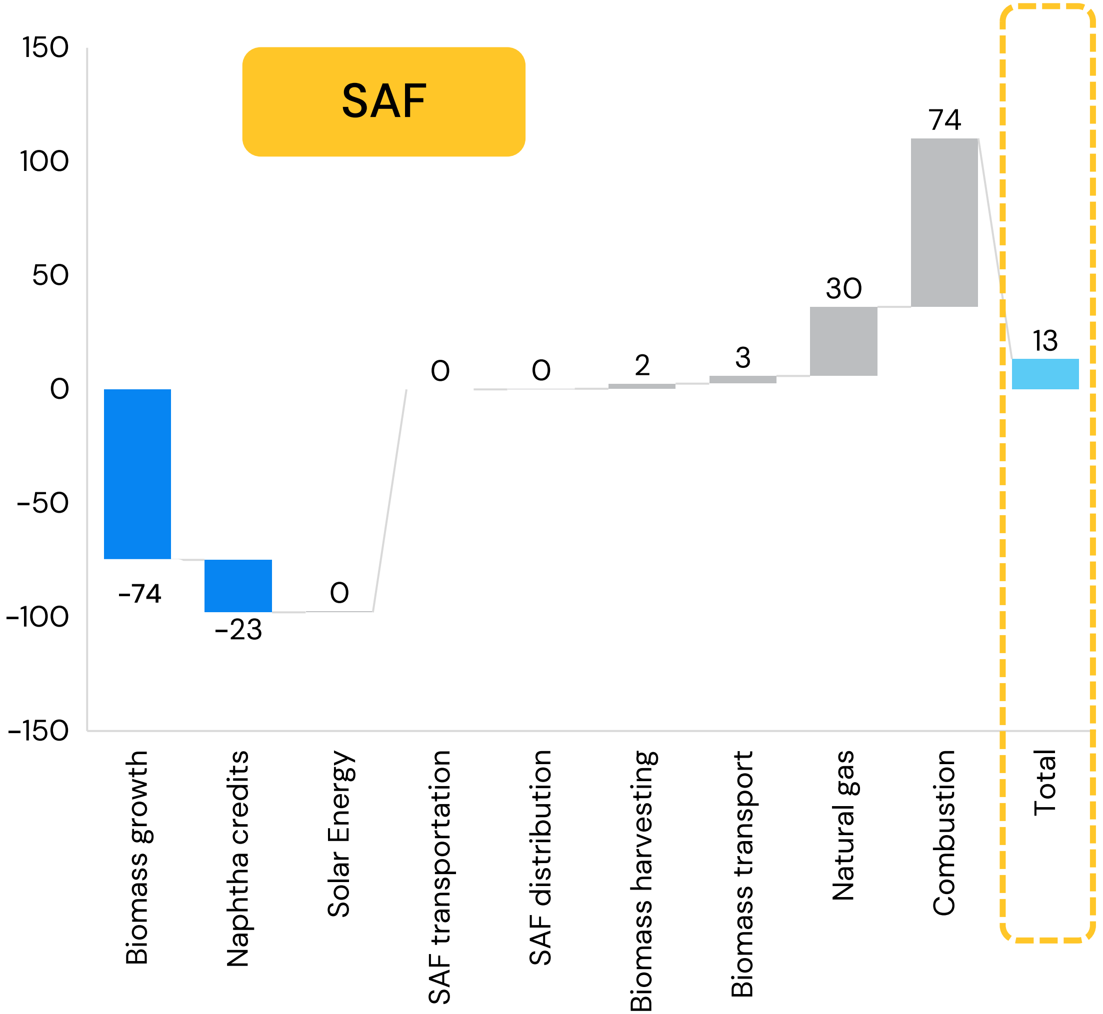


# CI of fossil kerosene shows that ~80% of emissions are related to combustion

*CAF life-cycle emissions*




*SAF life-cycle emissions*

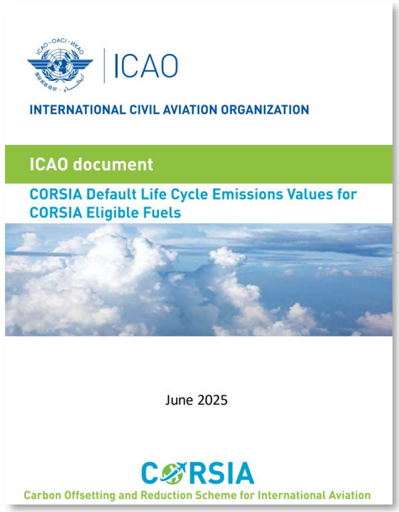





Source: EU CI baseline data

# There are two options to obtain life cycle emissions in CORSIA

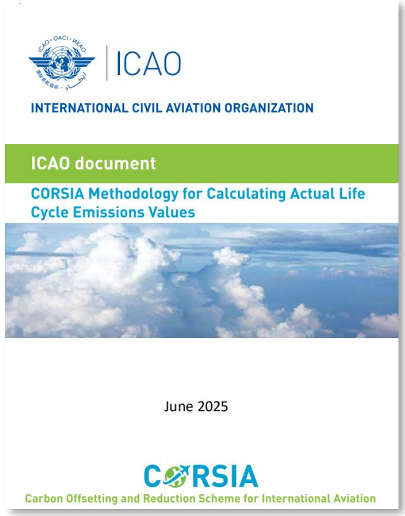
1


ICAO
INTERNATIONAL CIVIL AVIATION ORGANIZATION
ICAO document
CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels
June 2025
CORSIA
Carbon Offsetting and Reduction Scheme for International Aviation

### Default Life Cycle Emissions

**ICAO document "CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels"**
Default emission values, as a function of the feedstocks and conversion processes.

2


ICAO
INTERNATIONAL CIVIL AVIATION ORGANIZATION
ICAO document
CORSIA Methodology for Calculating Actual Life Cycle Emissions Values
June 2025
CORSIA
Carbon Offsetting and Reduction Scheme for International Aviation

### Actual Life Cycle Emissions

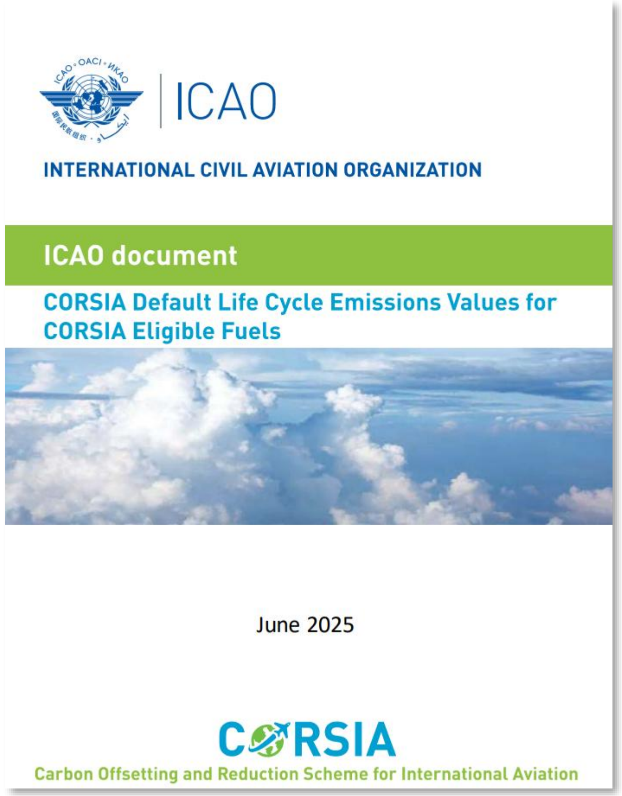
**ICAO document "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values"**
Allows calculation of specific emissions values to a given SAF or LCAF

# Default Lifecycle Values

*Example – HEFA Fuel Conversion Process*

**Table 2. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels produced with the Hydroprocessed Esters and Fatty Acids (HEFA) Fuel Conversion Process**

| Region | Fuel Feedstock | Pathway Specifications | Core LCA Value | ILUC LCA Value | $LS_f$ ($gCO_2e/MJ$) |
|---|---|---|---|---|---|
| Global | Tallow | | 22.5 | 0.0 | 22.5 |
| Global | Used cooking oil | | 13.9 | | 13.9 |
| Global | Palm fatty acid distillate | | 20.7 | | 20.7 |
| Global | Corn oil | Oil from dry mill ethanol plant | 17.2 | | 17.2 |
| USA | Soybean oil | | 40.4 | 24.5 | 64.9 |
| Brazil | Soybean oil | | 40.4 | 27.0 | 67.4 |
| Global | Soybean oil | | 40.4 | 25.8 | 66.2 |
| EU | Rapeseed oil | | 47.4 | 24.1 | 71.5 |
| Global | Rapeseed oil | | 47.4 | 26.0 | 73.4 |
| Malaysia & Indonesia | Palm oil | At the oil extraction step, at least 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized. | 37.4 | 39.1 | 76.5 |
| Malaysia & Indonesia | Palm oil | At the oil extraction step, less than 85% of the biogas released from the Palm Oil Mill Effluent (POME) treated in anaerobic ponds is captured and oxidized. | 60.0 | 39.1 | 99.1 |

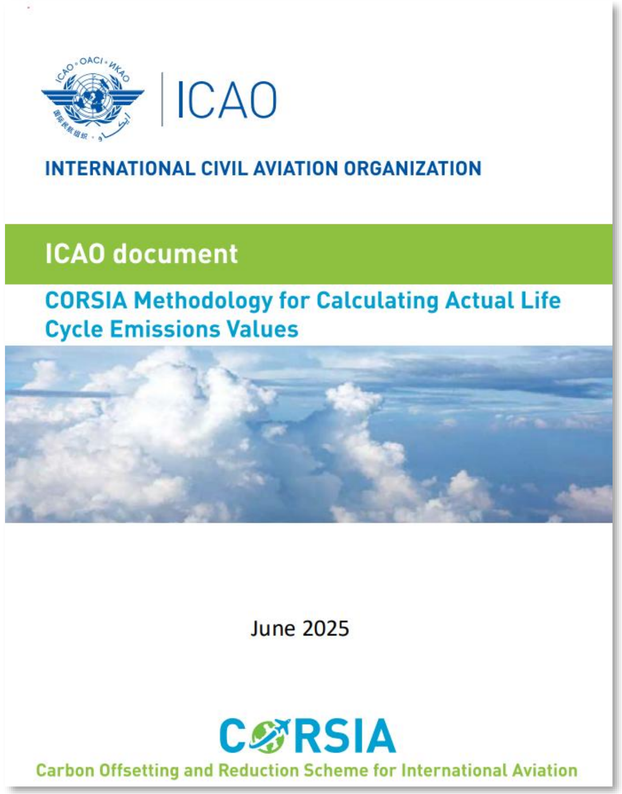



For additional information, please refer to ICAO document: Link

Note: ILUC = indirect land use change. The unintended emissions caused when land used for biofuels displaces food or feed crops, causing land elsewhere to be cleared for such crops, releasing additional emissions.

# Actual Lifecycle Values

- ICAO document [‘CORSIA Methodology for Calculating Actual Life Cycle Emissions Values’] allow for the calculation of specific emissions values to a given CORSIA SAF
- ICAO document provides further details on the methodology, such as:
  - Technical report requirements
  - Feedstock categories (wastes, residues, byproducts = zero ILUC)
  - Low land use change risk practices (zero ILUC)
  - Emissions credits




For additional information, please refer to ICAO document: Link

# Questions?

*15-minute break*

# SAF Technologies and Feedstocks

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# SAF Technologies and Feedstocks

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

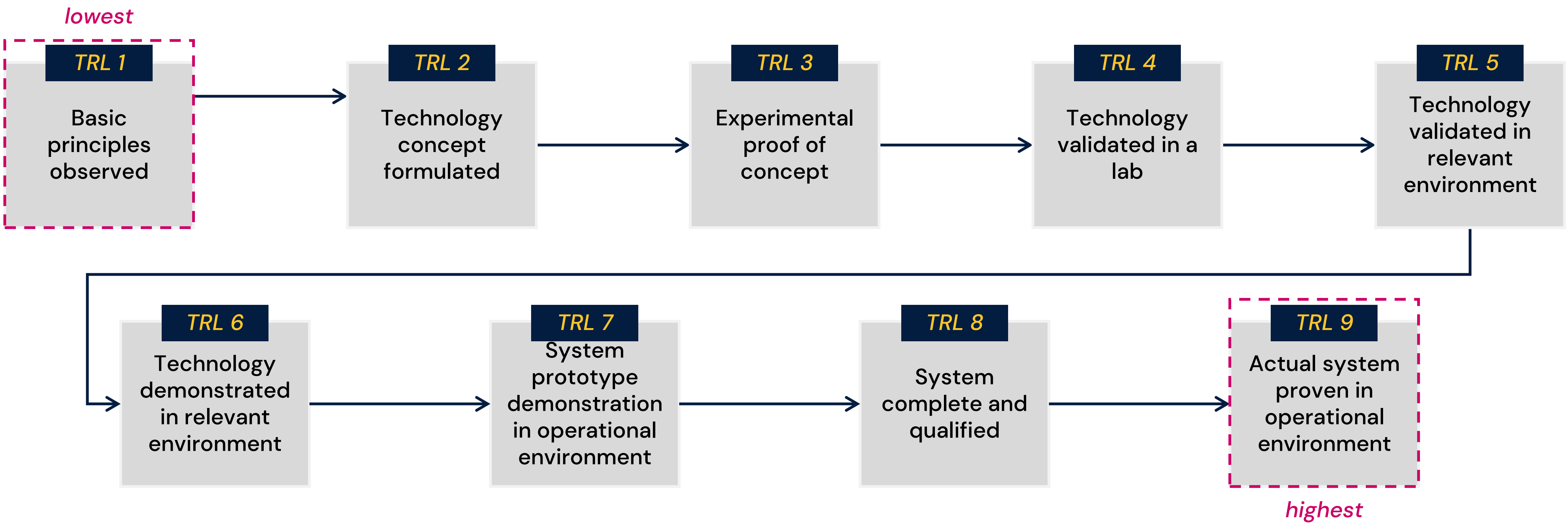
- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# Today, there are 11 ASTM-approved pathways for the production of SAF - each with specific feedstock and maximum blending limits

| ASTM | Pathway Abbreviation | Conversion Process | Feedstock | Max. Blend Percentage |
|---|---|---|---|---|
| D7566 A1 | FT-SPK | Fischer-Tropsch synthesis | Biomass or waste | 50% |
| D7566 A2 | HEFA-SPK | Hydroprocessing | Fats, oils and greases | 50% |
| D7566 A3 | SIP | Hydroprocessing | Sugars | 10% |
| D7566 A4 | FT-SPK/A | Fischer-Tropsch synthesis | Biomass or waste | 50% |
| D7566 A5 | ATJ-SPK | Dehydration and oligomerisation | Alcohols (currently only ethanol and iso-butanol) | 50% |
| D7566 A6 | CHJ | Catalytic Hydrothermolysis | Fats, oils and greases | 50% |
| D7566 A7 | HEFA-SPK/A | Hydroprocessing | Fats, oils, greases and specific algae | 10% |
| D7566 A8 | ATJ-SKA | Dehydration and oligomerization | Alcohols | 50% |
| D1655 A1 | Co-Processing of FOG | Co-Processing with petroleum | Fats, oils and greases | 5% |
| D1655 A1 | Co-Processing of FT | Co-Processing with petroleum | Hydrocarbons from Fischer-Tropsch | 5% |
| D1655 A1 | Co-Processing of HEFA | Co-Processing with petroleum | Hydrocarbons from hydroprocessed fats, oils and greases | 10% |

# The production pathways have varying Technology Readiness Levels

Technology Readiness Levels (TRLs) are a type of measurement system used to assess the maturity level of a particular technology. There are nine technology readiness levels.



# There are various Pros and Cons of 100% SAF drop-in and non-drop in fuel types

| Fuel Type | Aviation Impact | Expected benefits | Remarks |
|---|---|---|---|
| Drop-in 100% SAF Certified to ASTM D7566/D1655 | None<br>No hardware Engine/aircraft/APU or ground fuelling infrastructure changes required | CO2 reduction using sustainable feedstock<br><br>Non-CO2 reduction from lower aromatics and zero sulphur | Will require new ASTM Specification – expected 2025 |
| Non-drop-in new fuel type/specification | Changes to engine/aircraft/APU hardware may be required (seals) - not backward compatible.<br>Multi-fuel airport storage – cost and safety | CO2 reduction using sustainable feedstock<br>Further non-CO2 reduction from zero aromatics and zero sulphur.<br>Wider feedstock available | Airbus Jet-X |

# Various feedstocks can be utilised for each technology pathway

| 1st Generation Feedstocks | 2nd Generation Feedstocks | 3rd Generation Feedstocks | 4th Generation Feedstocks |
|---|---|---|---|
| *Edible biomass derived from food crops* | *Waste and non-food crops* | *Future feedstocks* | *Advanced approaches* |
| • **Oil-seed crops:** camelina, oil palm, rapeseed, soybean, sunflower, salicornia<br>• **Sugar and starchy crops:** corn, wheat, sugarcane, sugar beets | • **Oil-seed / grass / wood energy crops:** jatropha, castor bean, switch grass, miscanthus, poplar, willow, eucalyptus<br>• **Agricultural and forestry residues:** corn stover, sugarcane bagasse, wood harvesting / processing residues<br>• **Food, animal and municipal waste** : used cooking oil, animal fats, biogenic fraction of municipal solid waste | • This includes but is not limited to microalgae | • **Non-biological feedstocks:** $CO_2$, renewable electricity, water (synthetic fuels, e-fuels)<br>• **Genetically modified organisms (GMO)** |
| HEFA / AtJ / Gas + FT | HEFA / AtJ / Gas + FT | Pyrolysis / HTL | PtL (FT) |

Conventional Technology → Advanced Technology

Source: ICF Analysis

# Each feedstock has challenges and advantages

**1st Generation Feedstocks**

- Climate limitations, high water demand
- Accepted under CORSIA as long as sustainability criteria are met

**2nd Generation Feedstocks**

- **Oil-seed / grass / wood energy crops:** No food value, accepted under CORSIA – however, has low yields, large scale planting needs and expensive inputs
- **Agricultural and forestry residues:** Requires advanced conversion technologies (expensive), and establishment of a large collection network
- **Food, animal and municipal waste:** Possesses high potential across the world, but has limited quantity for UCO

**3rd Generation Feedstocks**

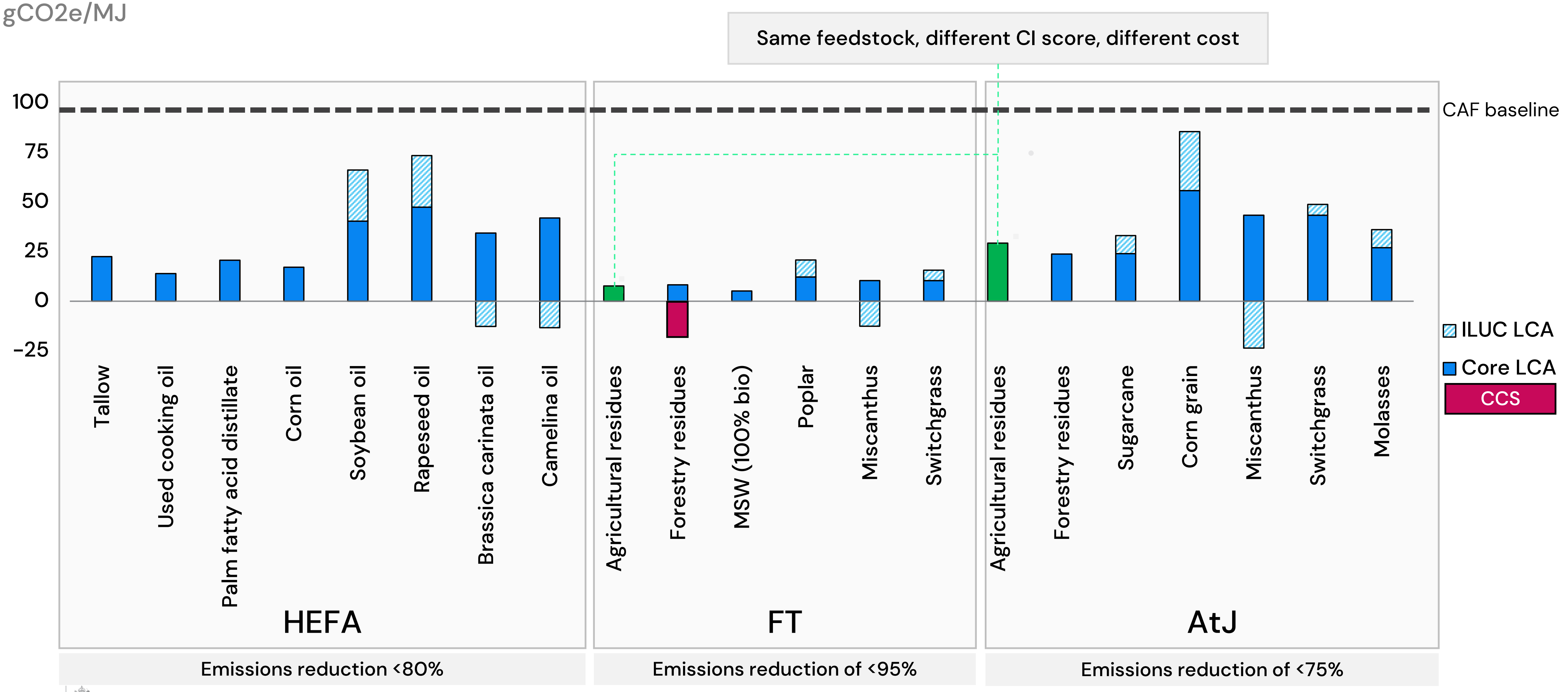
- High annual growth rates
- No competition with food crops
- Low TRL – Needs ASTM approval

**4th Generation Feedstocks**

- Very high CAPEX
- Requires deployment of carbon capture, electrolyser and renewable energy technologies

# Feedstocks and production processes yield different carbon intensities

**Life cycle emissions factor for CORSIA eligible fuel**
gCO2e/MJ



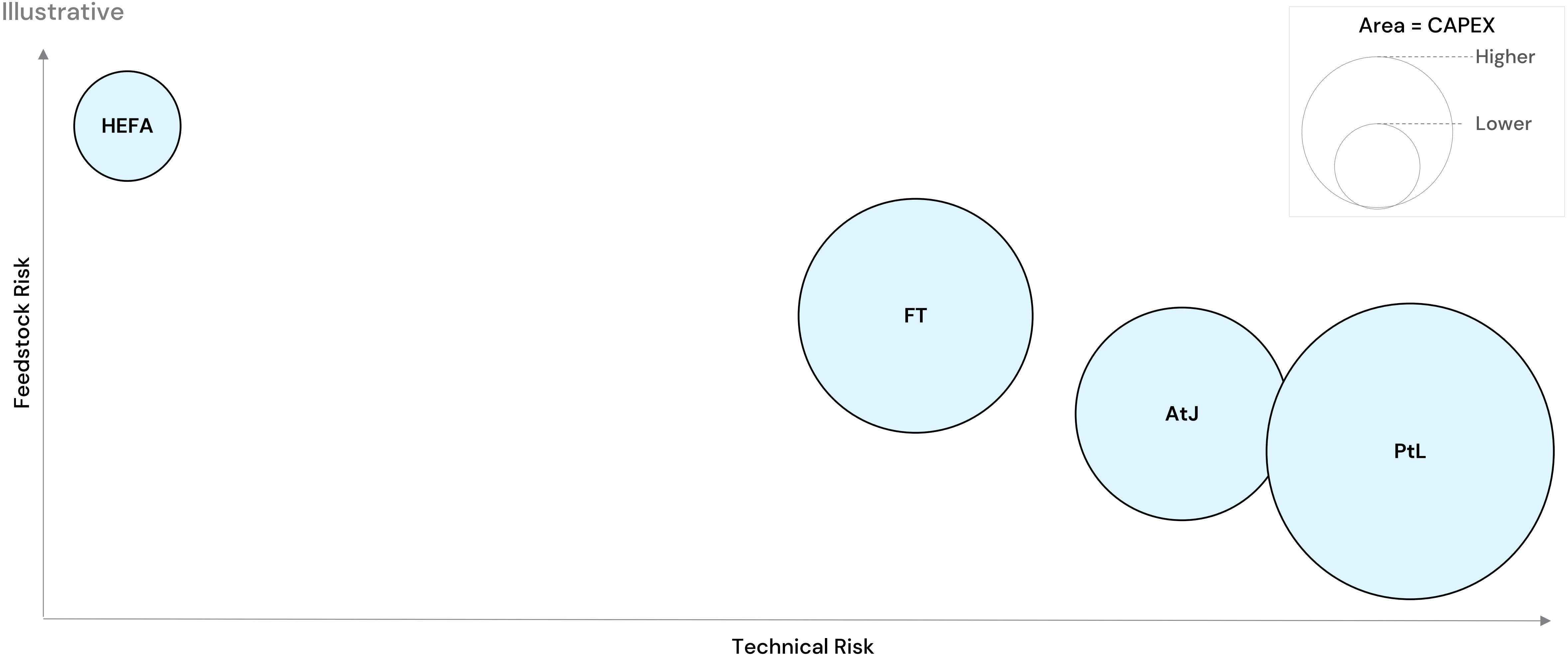



Sources: CORSIA Default Life Cycle Emissions Values

# SAF production technologies have varying levels of feedstock and technical risks

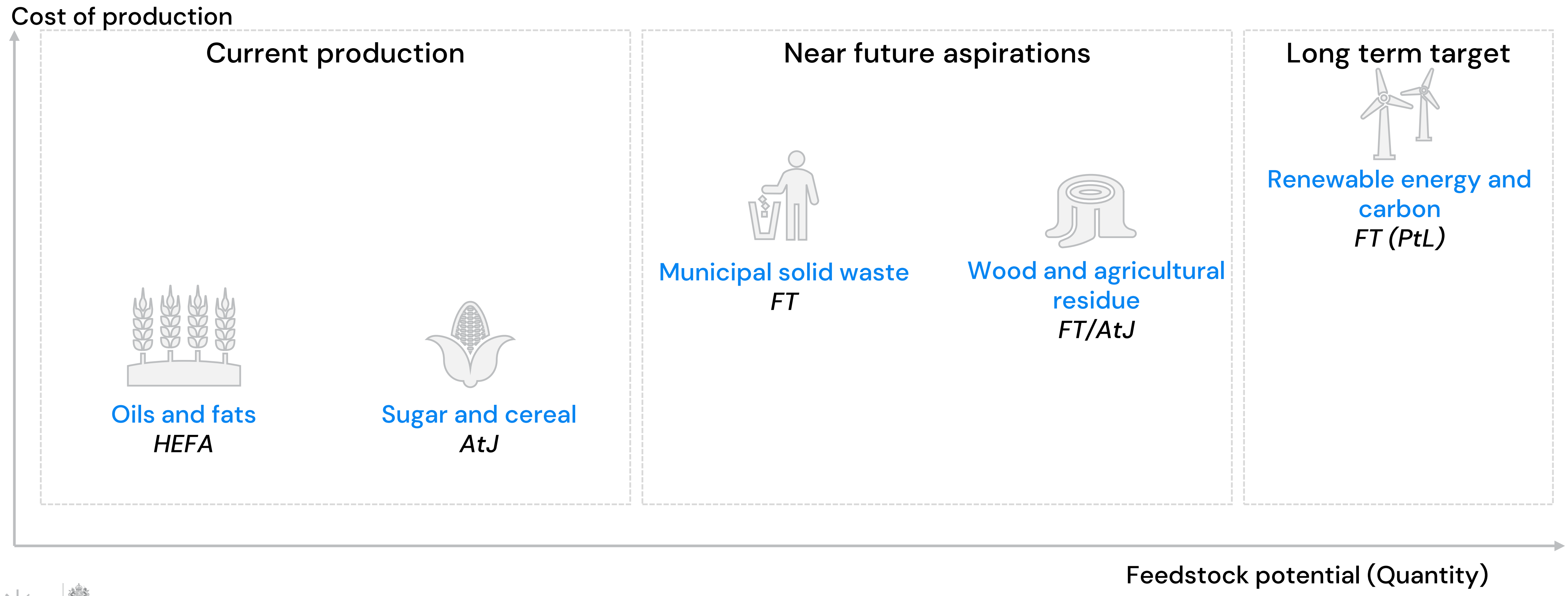
**Feedstock and technical risk by technology**

Illustrative



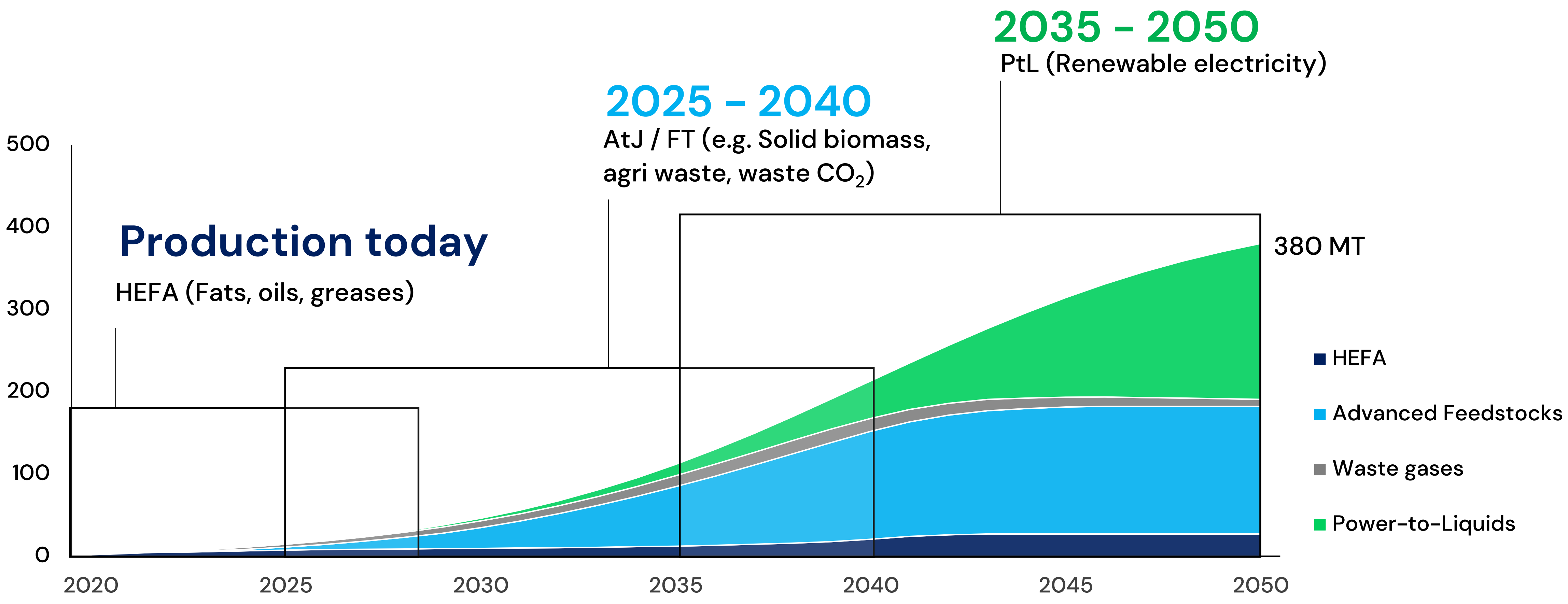
# The five main feedstock families have different constraints

- SAF production feedstocks can be separated in five main families: oils and fats, sugar and cereal, municipal solid waste (MSW), Wood and agricultural residue, as well as renewable energy and carbon. Each of these categories uses a particular production technology.
- Each family of feedstock is constrained by different factors with the main ones being cost and availability.



# FOG feedstocks are limited, therefore alternative technologies for SAF will be AtJ and FT, complimented by PtL in the long term

**2050 SAF Roadmap**
Illustrative




ICF | Department for Transport

# SAF Technologies and Feedstocks

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# The HEFA conversion pathways is currently the only commercially viable SAF conversion pathway

| Attribute | Description |
|---|---|
| ASTM Approval | ASTM D7566 Annex A2, Hydroprocessed Esters and Fatty Acids Synthetic Paraffinic Kerosene (HEFA-SPK) |
| Year of Qualification | 2011 |
| Technology-Readiness Level (TRL) | 9 (commercially approved technology) |
| Blending | Required to be blended with petroleum-based jet fuel, up to a 50% maximum level |
| Proprietary Technology | NEXBTLTM is a Neste proprietary technology for production of HEFA-SPK, patented 25 years ago after many years of research and development |

# HEFA can be produced from a wide array of oils and fats which constitute triglycerides or fatty acids

## Waste and residue oils and fats

*most commonly used today*

- Animal fat from food and industry waste
- Used cooking oil
- Vegetable oil processing waste and residues (e.g. PFAD, POME, SBEO)
- Tyre Pyrolysis Oil (TPO)
- Technical corn oil
- Tall oil based raw materials

## Crop-based and Non-Edible Crops

*Crop-based*

- Rapeseed oil
- Soybean oil

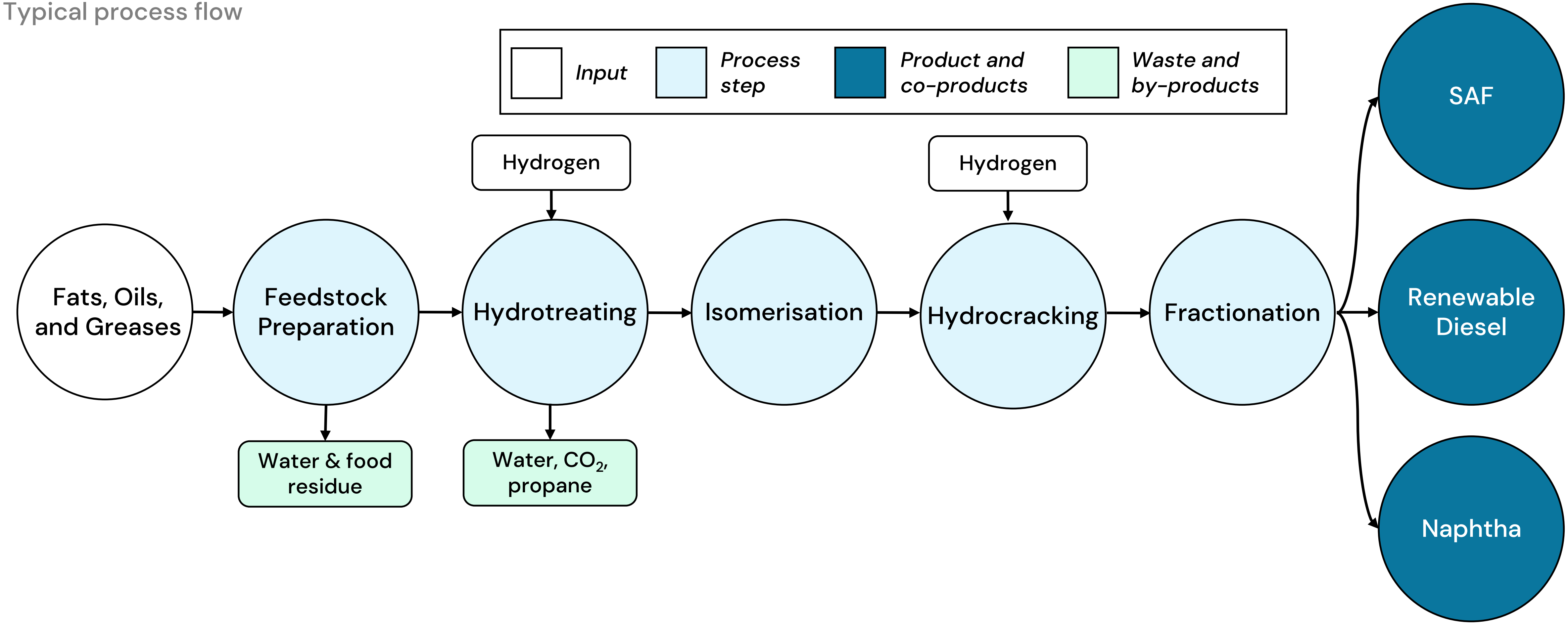
*Non-Edible Crops*

- Jatropha oil
- Carinata oil
- Camelina oil

# The HEFA process converts fats, oils and greases to a blend of renewable fuels, and includes five key process steps

**Hydroprocessed Esters and Fatty Acids (HEFA) Process**

Typical process flow



# Today, Neste is the leading producer of HEFA-SAF

# Neste largest facility has been operational since 2010, with an annual production capacity of 2.6 million tonnes renewable fuel

## Zooming in on SAF production at Neste Singapore refinery

- Refinery operations since 2010 with annual production capacity of 2.6 million tonnes of renewable and circular solutions
- Expansion in 2023 increased SAF capacity to a production capability of 1 million tonnes
- The expansion also added a hydrogen production unit
- Located in Tuas, West of Singapore

ICF | Department for Transport

# SAF Technologies and Feedstocks

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

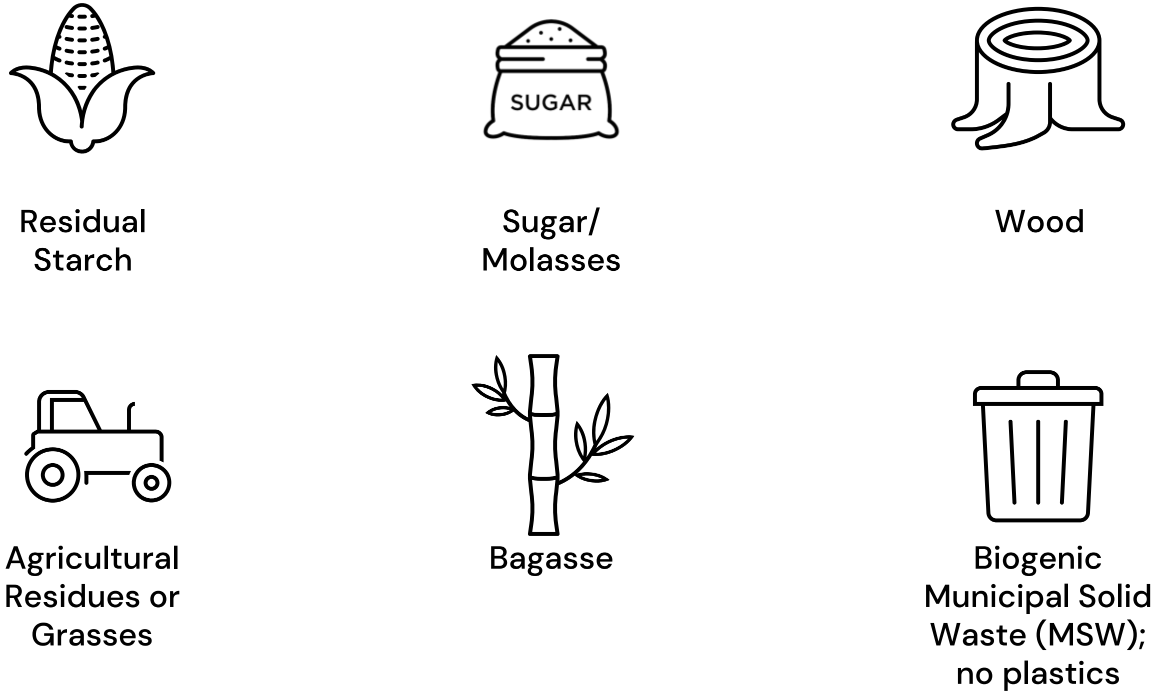
- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# Alcohol-to-Jet (AtJ) is an early-stage technology with significant promise of scaling in regions like the United States

| Attribute | Description |
| --- | --- |
| ASTM Approval | • Annex A5, Alcohol to Jet Synthetic Paraffinic Kerosene (AtJ-SPK)<br>• Annex A8, Alcohol to Jet Synthetic Paraffinic Kerosene with Aromatics (AtJ-SKA) |
| Year of Qualification | • AtJ-SPK in 2016<br>• AtJ-SKA in 2023 |
| Technology-Readiness Level (TRL) | 7-8 (pre-commercial scale) – *no commercial AtJ production globally* |
| Blending | Required to be blended with petroleum-based jet fuel, up to a 50% maximum level |
| Proprietary Technology | Feedstock choice significantly impacts the scalability, economics, sustainability and carbon footprint. Customers prefer a sustainable business system with max reduction of carbon footprint and a manageable price premium. |

# AtJ requires converts ethanol (derived from various sources) into SAF

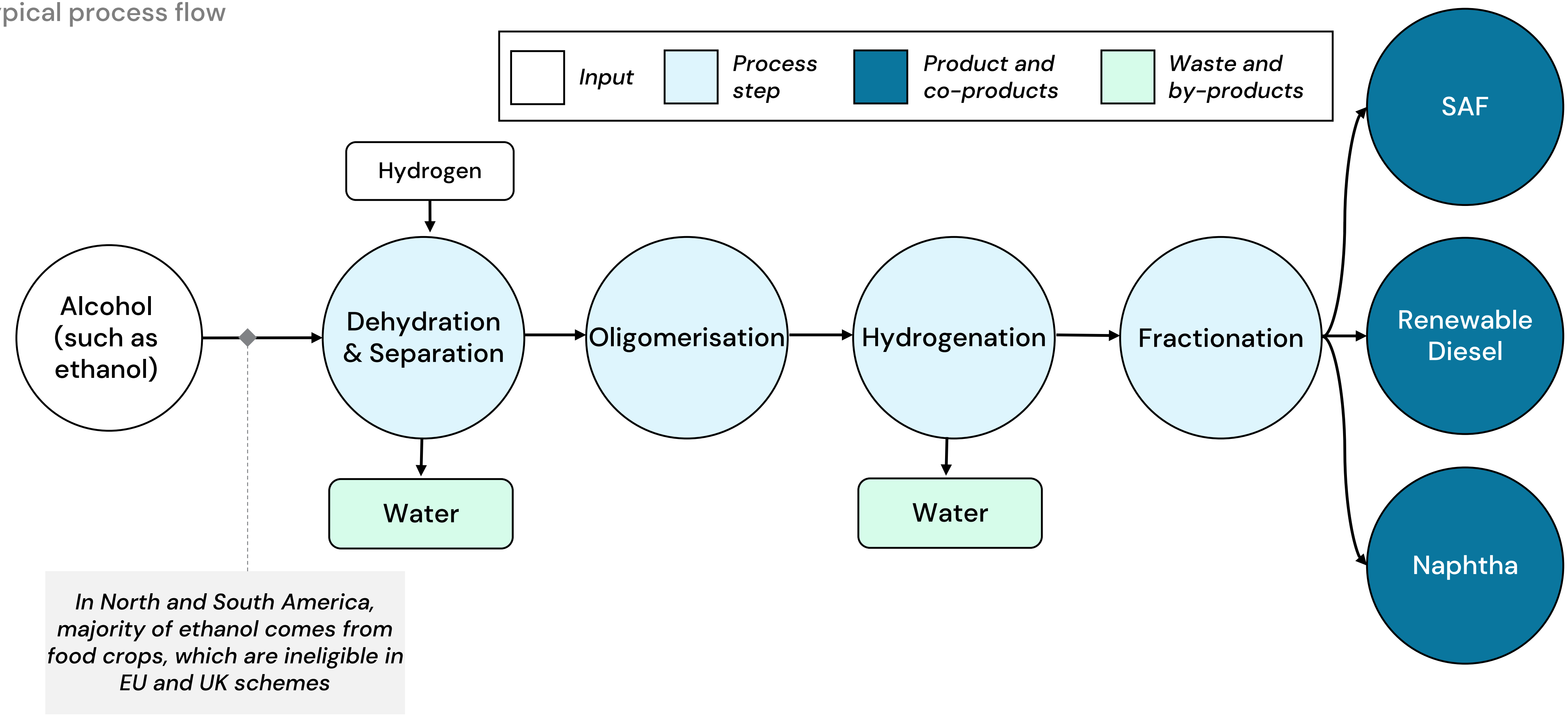
- The alcohol can be derived through a range of processes, including fermentation of lignocellulose feedstocks or grains, fermentation of syngas or through fermentation of concentrated carbon industrial waste gases.
- The selection of the feedstock can significantly impact scalability, capital cost, operating cost, carbon score and sustainability.



# The Alcohol to Jet (AtJ) process converts ethanol (or another alcohol) to a blend of renewable fuels, and includes four key process steps

**Alcohol-to-jet (AtJ) Process**

Typical process flow



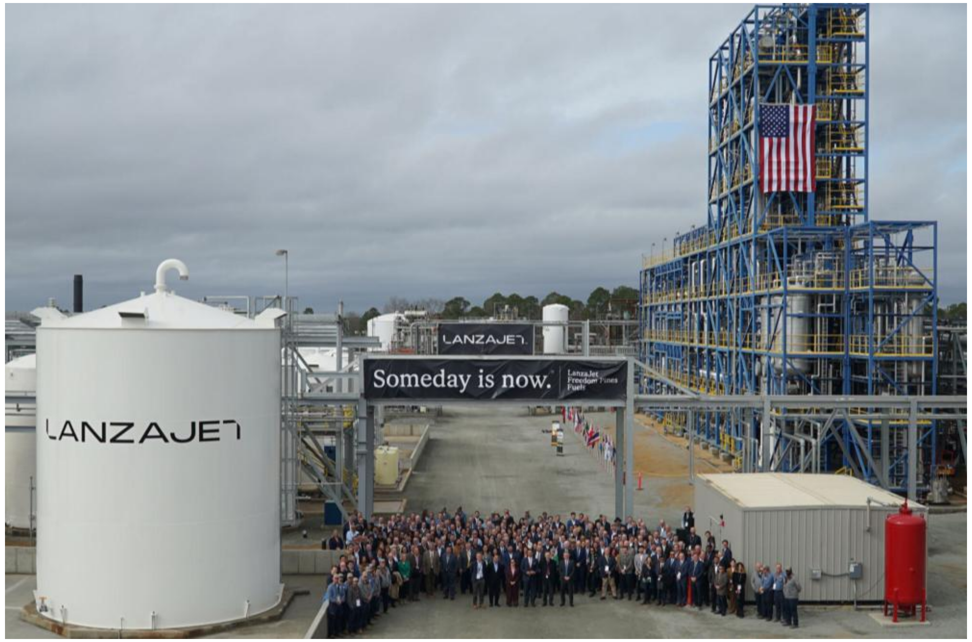
# LanzaJet is one of the leading AtJ SAF producers, with its first commercial plant opening in Soperton, Georgia, in 2024

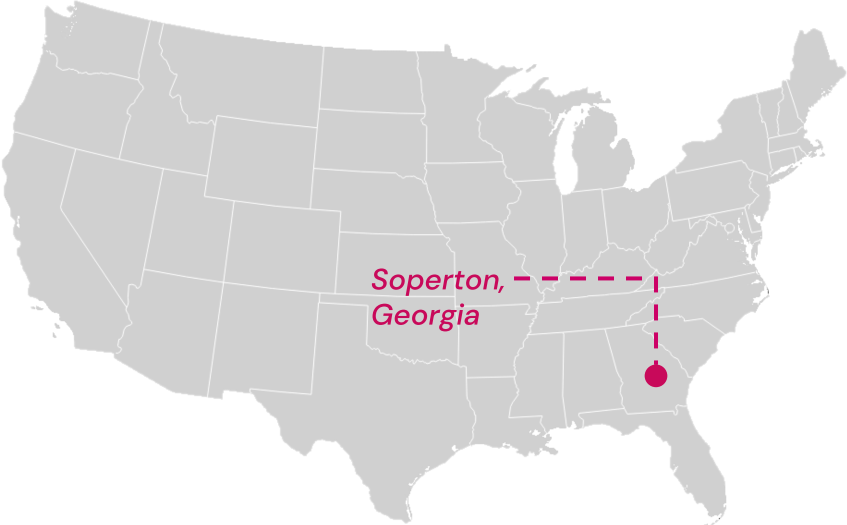
LanzaJet was formed through investments from LanzaTech, Suncor, Mitsui, along with support from ANA. Investments from US DoE, Microsoft, Shell and Breakthrough Energy.

Business model is anchored in licensing their technology and providing expert project development and operations services. They also build, own, and operate plants.

The first commercial SAF plant, Freedom Pines Fuels, is near Soperton, Georgia, USA

- *Capacity*: 10 million (US) gallons per year.
- *Source*: sustainable and waste-based ethanol
- *Offtakes:* British Airways and ANA have contracted to take a significant portion of the SAF produced at facility




Source: ICF Analysis

# SAF Technologies and Feedstocks

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# Fischer-Tropsch (FT) is an established technology that is much more capital intensive but requires lower operating costs than HEFA

| Attribute | Description |
|---|---|
| ASTM Approval | • Annex A1, Fischer-Tropsch Hydroprocessed Synthesised Paraffinic Kerosene (FT-SPK)<br>• Annex A4, Synthesized Kerosene with Aromatics derived by alkylation of light aromatics from non-petroleum sources (FT-SKA) |
| Year of Qualification | • FT-SPK in 2009<br>• FT-SKA in 2015 |
| Technology-Readiness Level (TRL) | 6-8 (pre-commercial scale) |
| Blending | Required to be blended with petroleum-based jet fuel, up to a 50% maximum level |
| Proprietary Technology | Abundance of feedstock possibilities, some potentially generating additional revenues. For example, in some cases producers can be paid to collect other's unwanted Municipal Solid Waste (MSW) |

# The gasification process allows for a wide range of feedstocks – However, majority of producers are using two feedstock sources

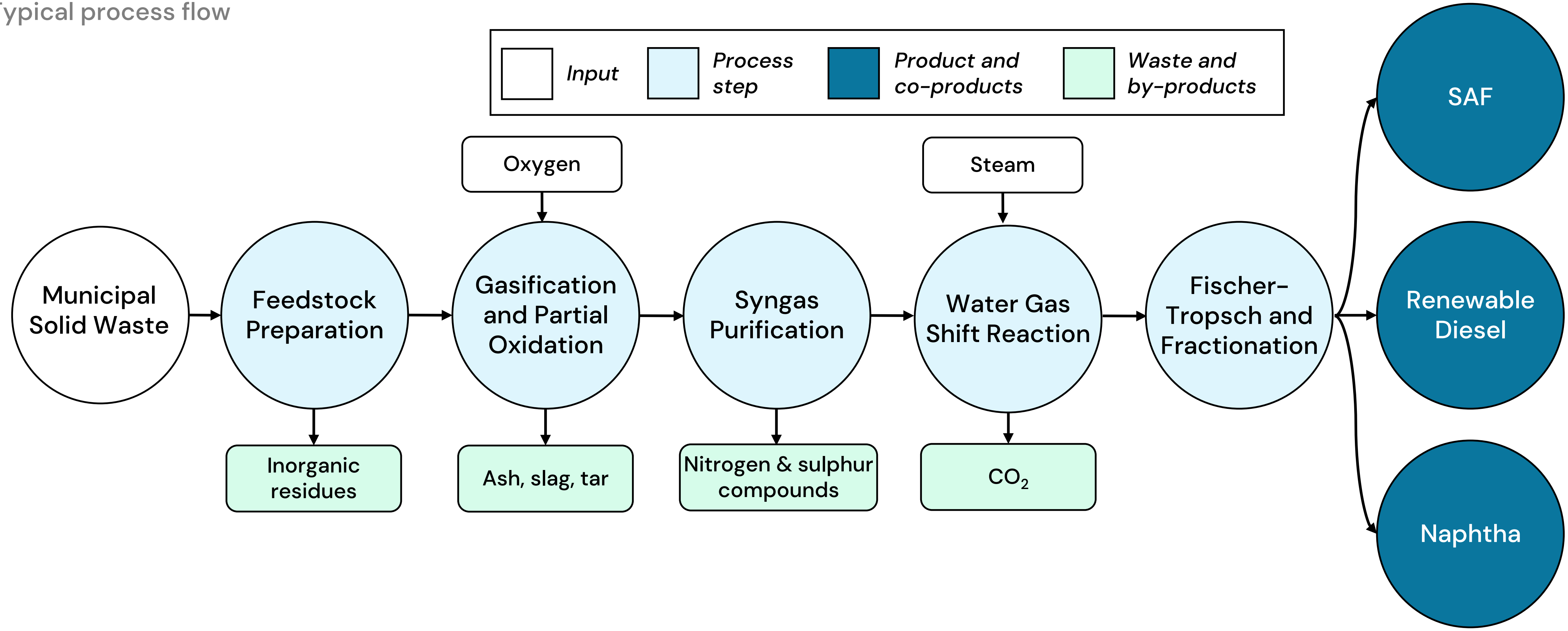
- The main challenge of this feedstock is its accessibility, as it is difficult to obtain enough feedstock near large processing plants to take advantage of the “economies of scale”. It has a high cost associated with the harvest, transportation, and storage, but also has a low-energy density, and is not easy to process from a technological perspective

| Woody biomass | Municipal Solid Waste (MSW) |
| --- | --- |
|  |  |

# Gasification Fischer-Tropsch (FT) process converts solid waste into liquid hydrocarbons in five processing steps

**Gasification Fischer-Tropsch Process**

Typical process flow



# Today, there are several global producers utilising the FT-pathway

Enerkem

VELOCYS

Fulcrum BIOENERGY

الفنار alfanar

Source: ICF research

# SAF Technologies and Feedstocks

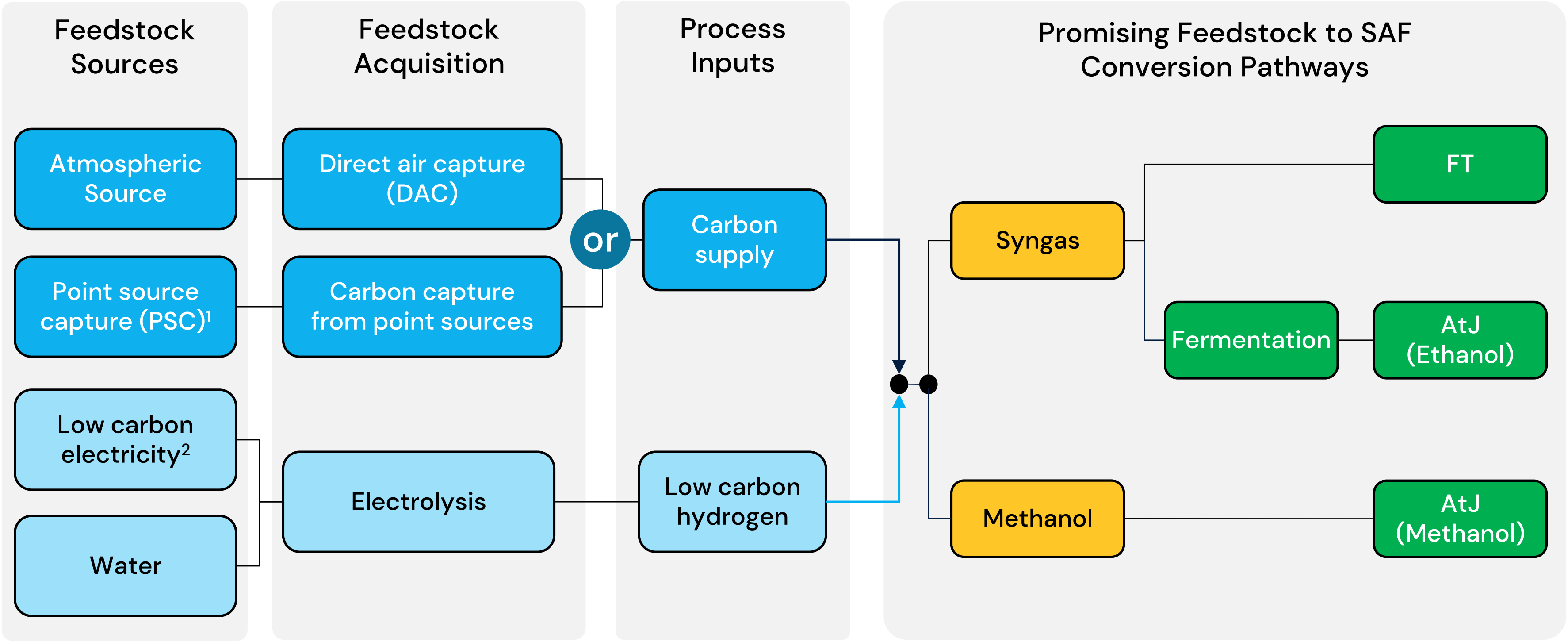
Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# Power to Liquid (PtL) process converts CO2 and hydrogen, produced by electricity, into liquid hydrocarbons through several potential pathways

**Potential Power-to-Liquid pathways**

Typical process flow



# PtL can deliver the highest carbon abatement due to its feedstock sources but is currently commercially and technically constrained

- Directly uses Carbon and Hydrogen atoms to produce Hydrocarbon fuel, SAF
- PtL can source CO2 from the atmosphere or industrial emissions
- DAC consumes more electricity and has a lower technology maturity than PSC

| Waste industrial carbon dioxide / Direct Air Capture | Renewable electricity and green hydrogen |
|---|---|
|  |  |

ICF | Department for Transport

# Several PtL producers have emerged

norsk e-fuel

twelve

INFINIUM™

Arcadia™

eFuels

# SAF Technologies and Feedstocks

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

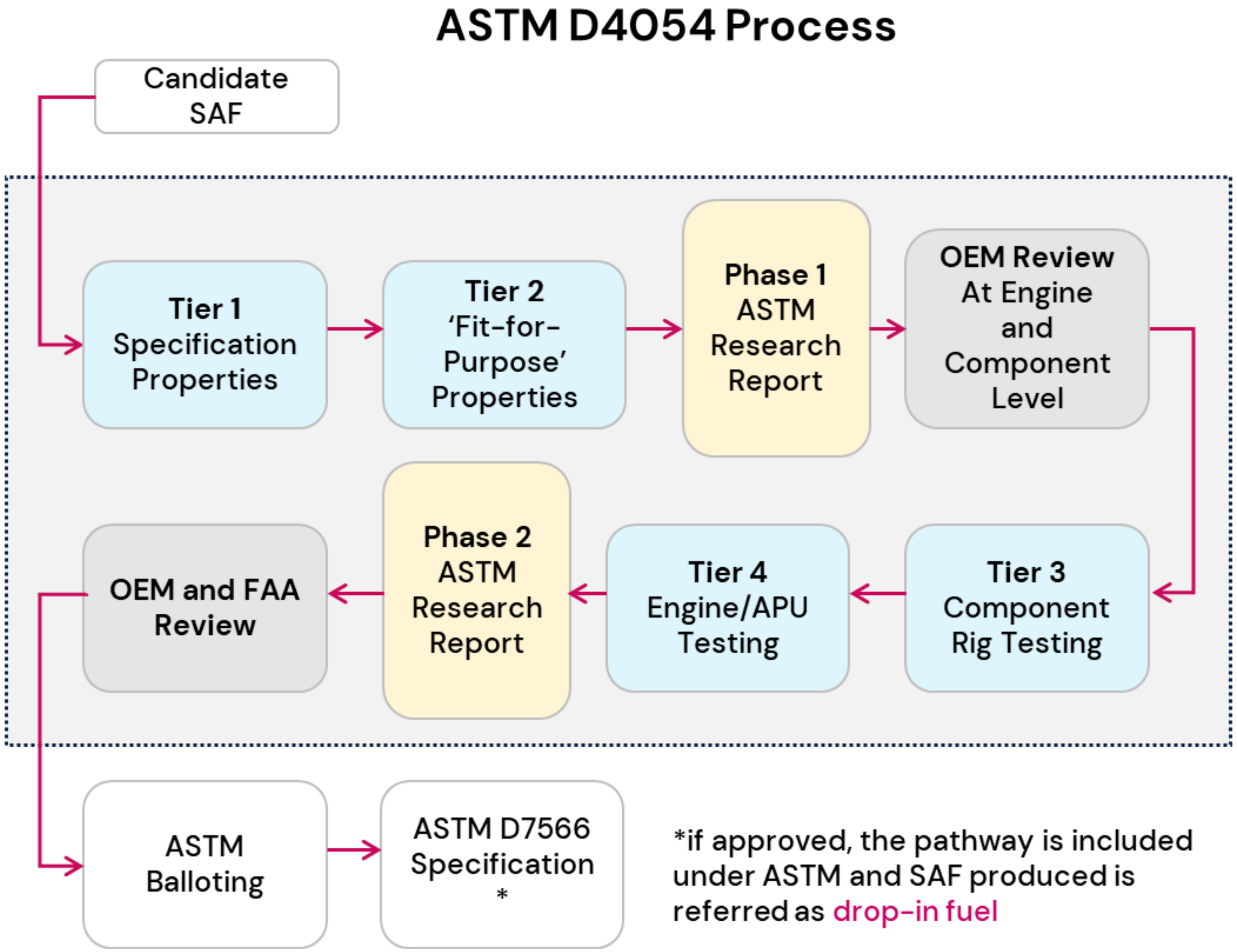
- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# A four-tiered process has to be followed to achieve ASTM approval

- Jet engines and aeroplanes are certified by National Aviation Authorities (NAAs), or equivalent certification organisations, to operate on a fuel that is specified by ASTM. Any new fuel, therefore, must meet conventional fuel ASTM specifications and be approved through the ASTM D4054 process, or it cannot be used in commercial flight

- ASTM D4054, Standard Practice for Evaluation of New Aviation Turbine Fuels and Fuel Additives, was developed to ensure safe and reliable operation of aircraft on alternative aviation fuels

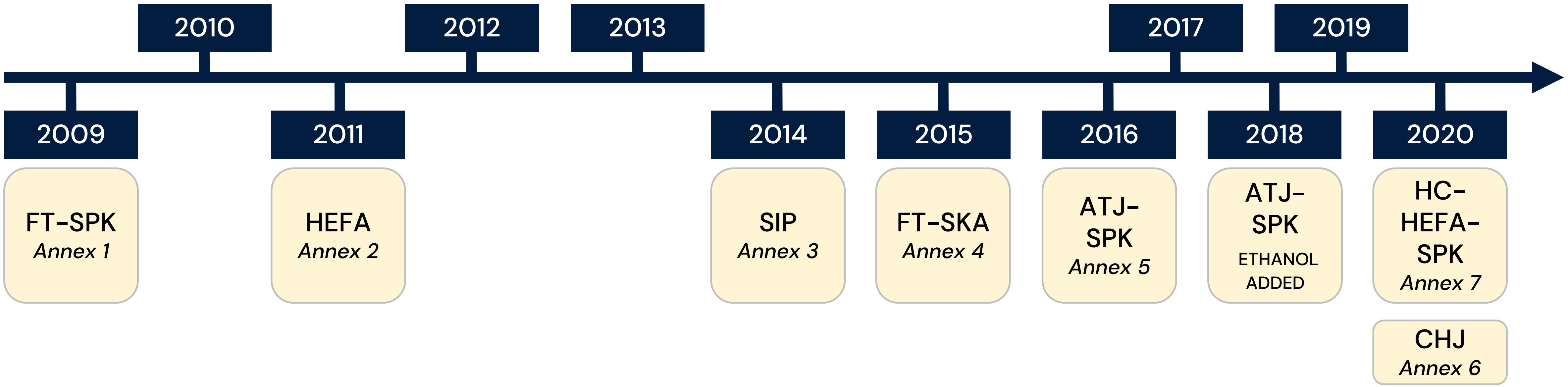
- This standard practice comprises a four-tiered process for testing new aviation fuels and fuel additives with two reports submitted for OEM review and approval




*if approved, the pathway is included under ASTM and SAF produced is referred as drop-in fuel

Department for Transport

# The following provides a timeline of SAF technology ASTM approvals



# The UK SAF Clearing House helps fuel producers manage testing and certification under ASTM D4054 process

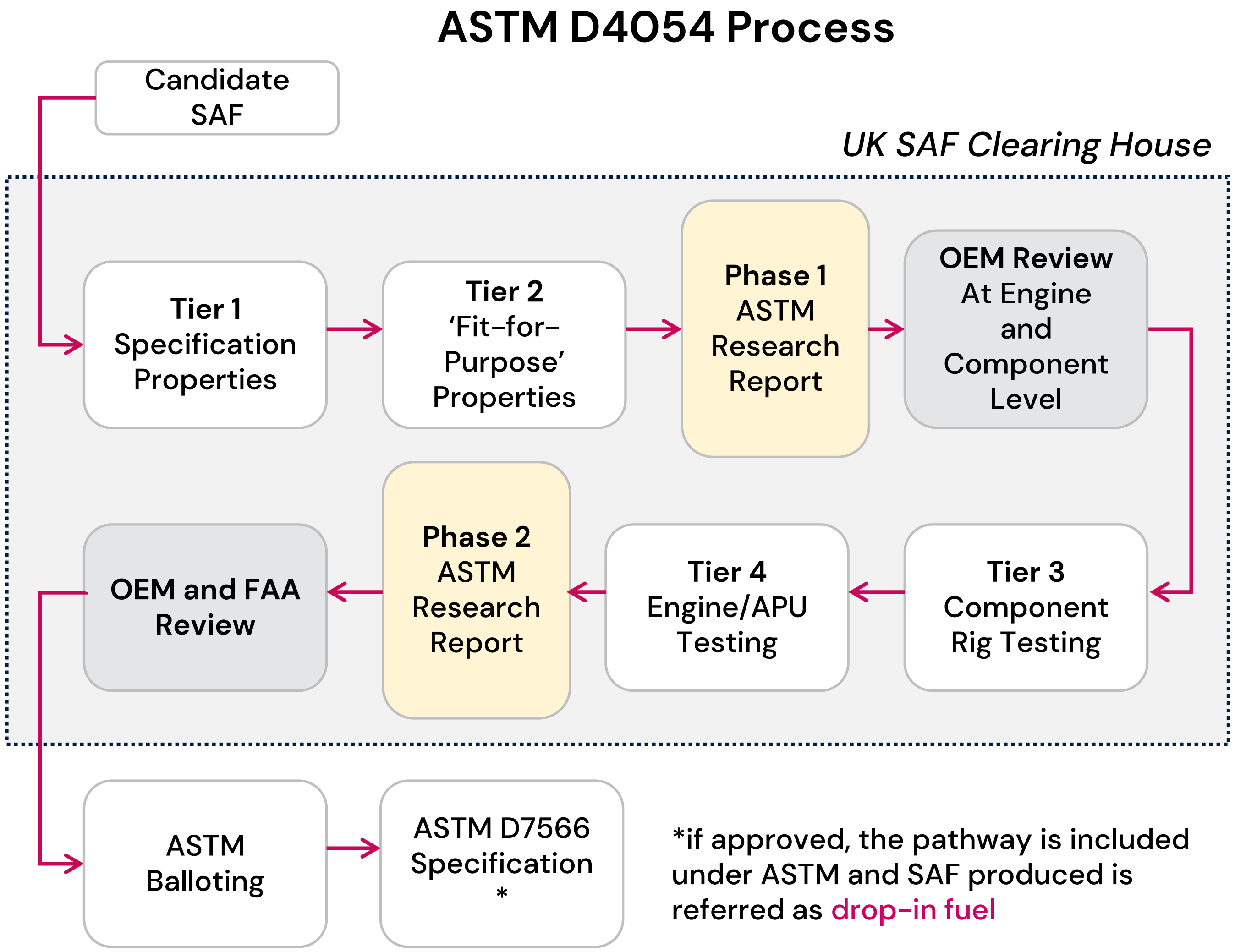
Department for Transport

University of Sheffield

UK SAF Clearing House is a *Department for Transport (DfT)* funded programmed, led by the *University of Sheffield's Energy Institute*

## *UK Clearing House Goals*

- *Providing expert advice to prospective SAF producers* on SAF approval process and guiding producers who wish to enter the process
- *Funding and carrying out early testing.* Includes coordinating testing with the appropriate facilities, collecting/interpreting results and supporting the production of research reports
- *Process simplification by acting as a "one-stop shop" for fuel producers,* guiding communication with key stakeholders, particularly OEMs, and providing access to testing facilities

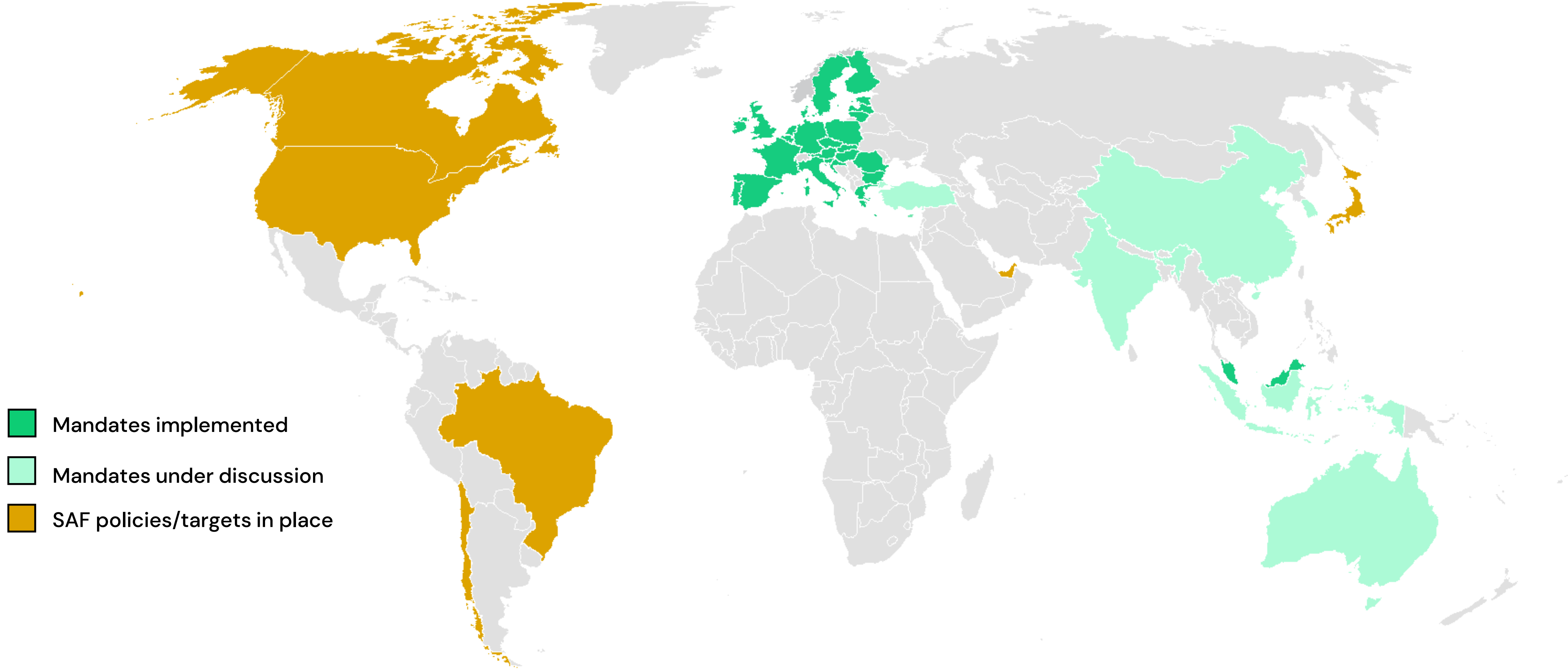


# SAF Technologies and Feedstocks

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Production Pathways
  - HEFA and Co-Processing
  - Alcohol-to-Jet (AtJ)
  - Fischer-Tropsch (FT)
  - Power-to-Liquid (PtL)
- ASTM certification and SAF Clearing House
- Current market developments

# The global SAF policy context is rapidly developing with major developed and developing countries taking a step towards SAF implementation

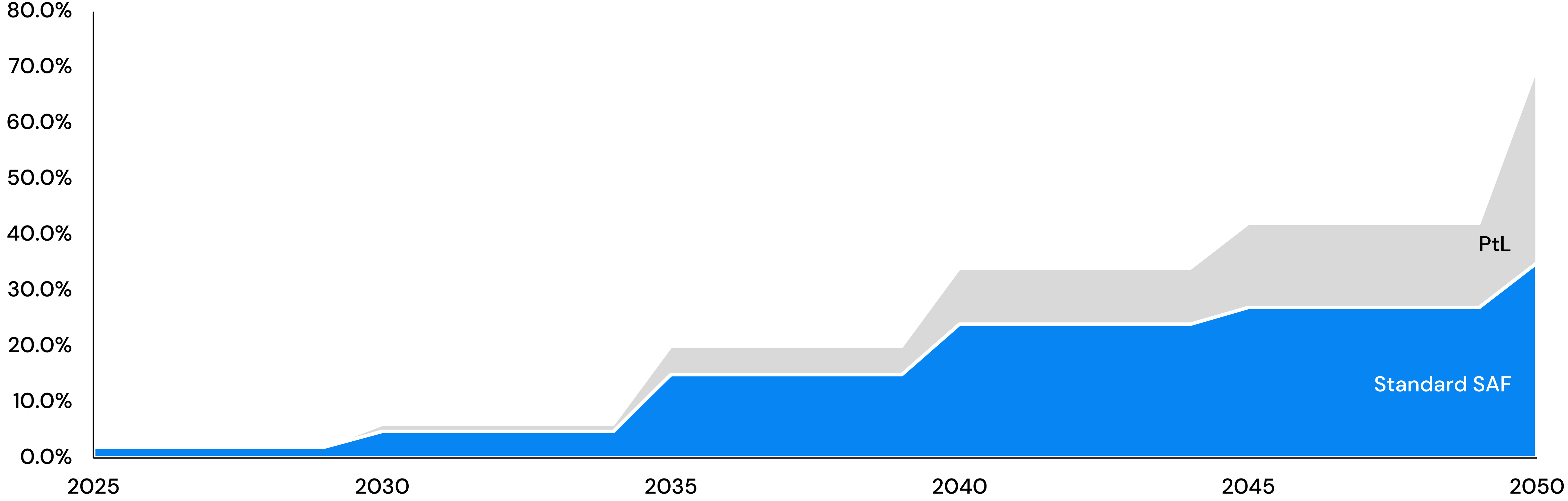




Source: ICF analysis

# The EU ReFuelEU mandates 2% SAF in 2025

**EU SAF Mandate**
SAF blending portion

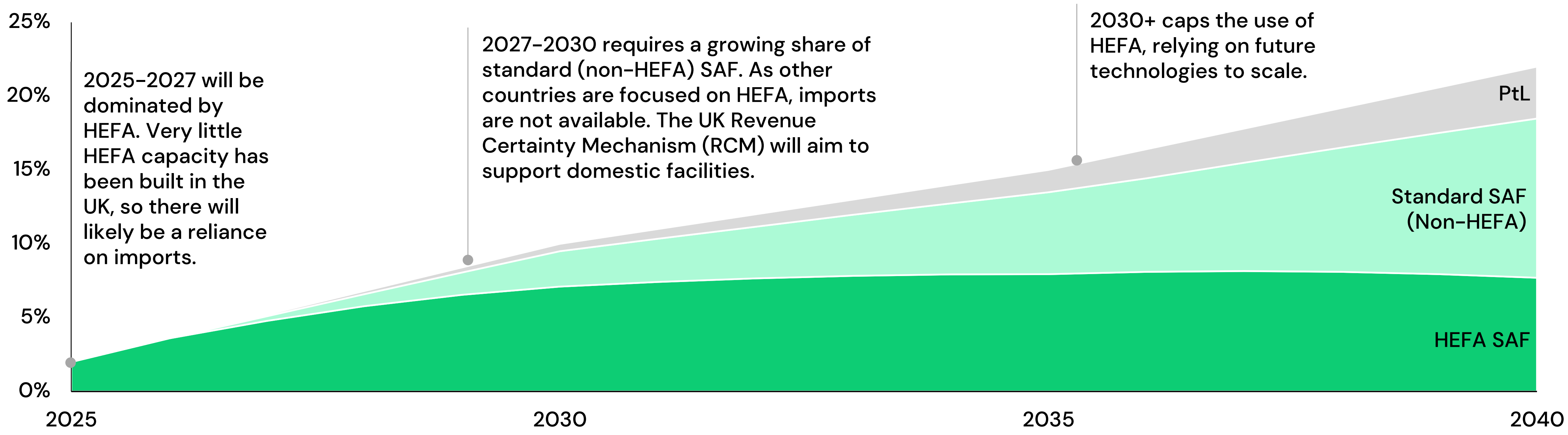



| % of Jet Fuel | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|
| Standard SAF | 2% | 4.8% | 15% | 24% | 27% | 35% |
| PtL SAF | 0% | 1.2% | 5% | 10% | 15% | 35% |

ICF | Department for Transport

# The UK SAF Mandate also requires 2% SAF in 2025

**UK SAF Mandate**
SAF blending portion

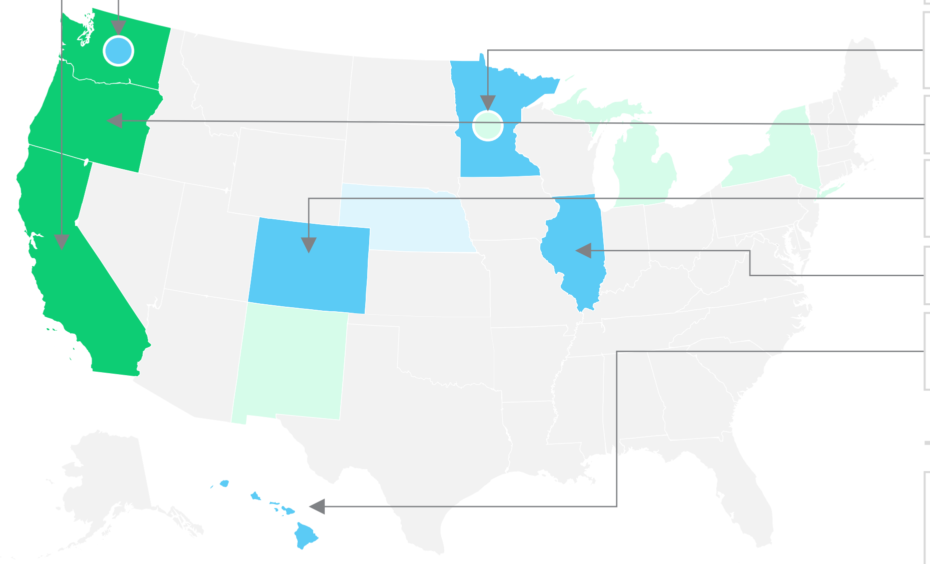



| *% of SAF* | 2025 | 2030 | 2040 |
|---|---|---|---|
| HEFA SAF | 100% | 71% | 35% |
| Standard SAF | 0% | 24% | 49% |
| PtL SAF | 0% | 5% | 16% |

# The US has the highest level of ambition and federal- and state-level incentives

## US SAF Policy Map

● – Tax Incentive ● – Clean Fuel Programme




### State-Level Policy

- California Low Carbon Fuel Standard (LCFS)
- Washington Clean Fuel Standard (CFS)
  Washington SAF Tax Credit
- Minnesota SAF Tax Credit (41A.30) and Sales Tax Use Exemption (297A.71)
- Oregon Clean Fuel Program (CFP)
- Colorado Clean Hydrogen Production Tax Credit (HB23-1281)
- Illinois SAF Purchase Credit (SAFPC)
- Hawaii Renewable Fuels Production Tax Credit (HRS 235-110.32)

### Under Development

- Nebraska SAF Production Tax Credit (LB 937)
- Minnesota (Senate File 2584)
- Michigan (Senate Bill 275)
- New York (Senate Bill S1292)
- New Mexico (House Bill 426)

### Federal Policy

**SAF Grand Challenge:** 3 billion gallons SAF by 2030 and 35 billion gallons by 2050 production target.

**Renewable Fuel Standard:** Annual blending targets for renewable fuels, creating market incentives for SAF production.

**Inflation Reduction Act (IRA):**

- 45Z Clean Fuel Production Tax Credit: $1.00/gallon (2025-2029)
- 45V Clean Hydrogen Production Tax Credit: $3/kg (2023-2033)

**Federal grants and funding:**

- LPO: $2.9B in conditional loan guarantees for two SAF production facilities.
- FAA: $291M through the FAST grant programme.

# Company targets generate additional demand – 50+ airlines have committed to SAF targets of 5% or higher

## 5%

- Air India
- Royal Brunei Airlines
- Bangkok Airways
- Thai
- Singapore Airlines
- Philippine Airlines
- Garuda Indonesia
- EVA Air
- 中華航空 China Airlines
- air astana
- LATAM

## 10%

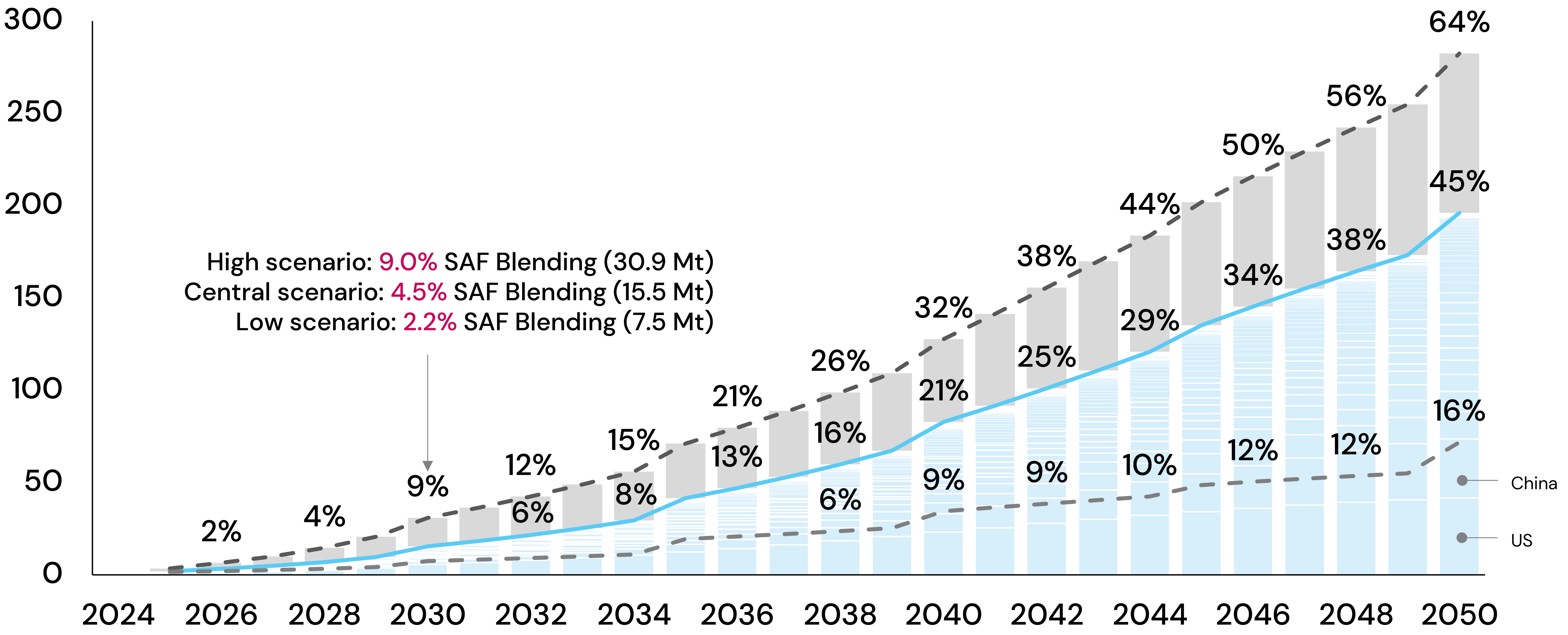
- Aer Lingus
- British Airways
- Iberia
- vueling
- American Airlines
- Cathay Pacific
- SriLankan Airlines
- الملكية الأردنية Royal Jordanian
- Finnair
- Qantas
- Jetstar
- Air France
- KLM
- transavia
- jetBlue
- malaysia airlines
- Southwest
- virgin atlantic
- Delta
- Alaska
- ANA
- Japan Airlines
- Qatar Airways القطرية
- الخطوط الملكية المغربية royal air maroc
- Air New Zealand
- Hawaiian Airlines
- Aeromexico
- Fiji Airways
- Cargojet
- SpiceJet
- IndiGo

## 10%+

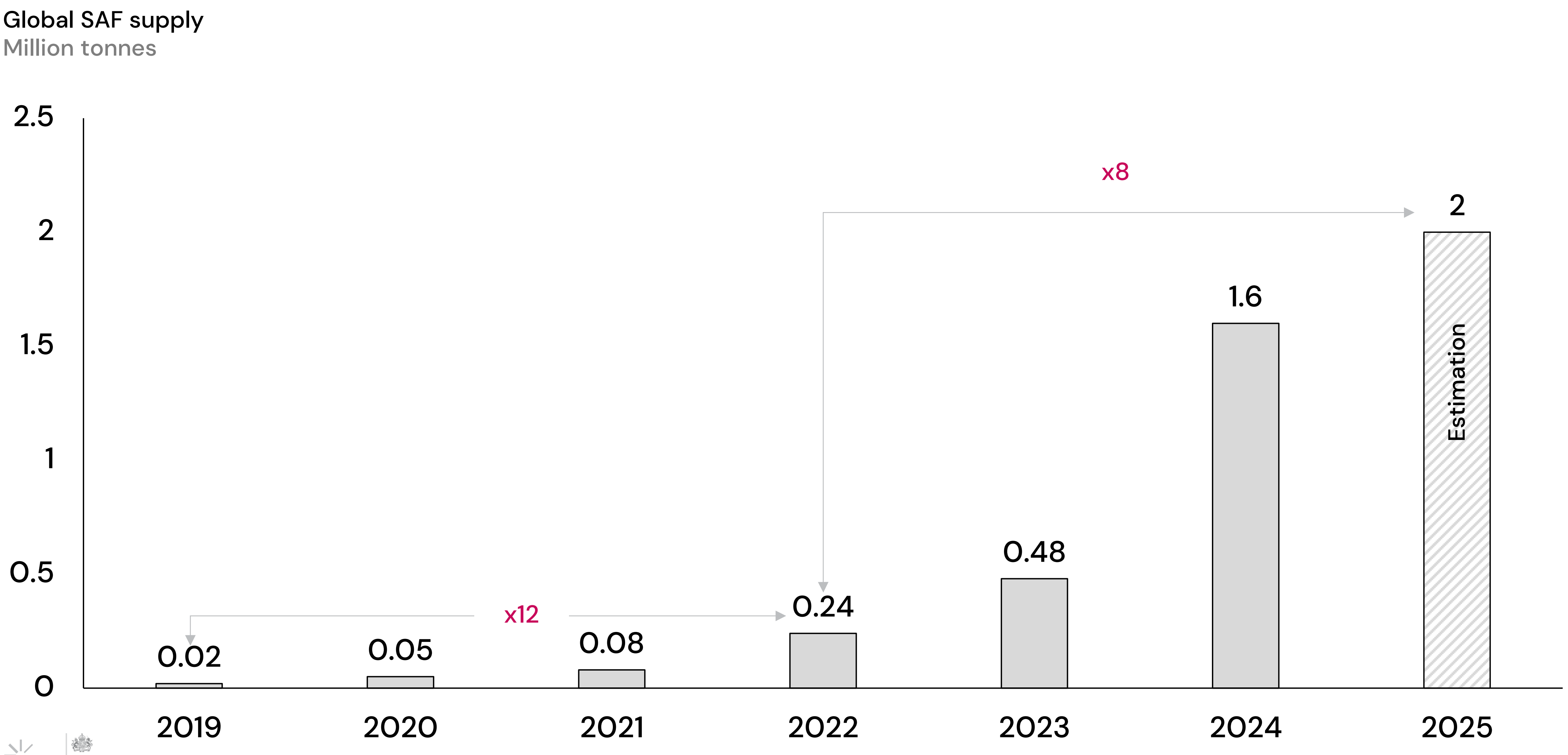
- Ryanair
- SAS
- norwegian
- DHL
- ups
- FedEx

# ICF model regulatory demand based on forecast economics, activity and jet fuel demand, combined with announced SAF regulations and targets

Projected SAF Regulatory Demand, 2024-2050
Million tonnes neat SAF



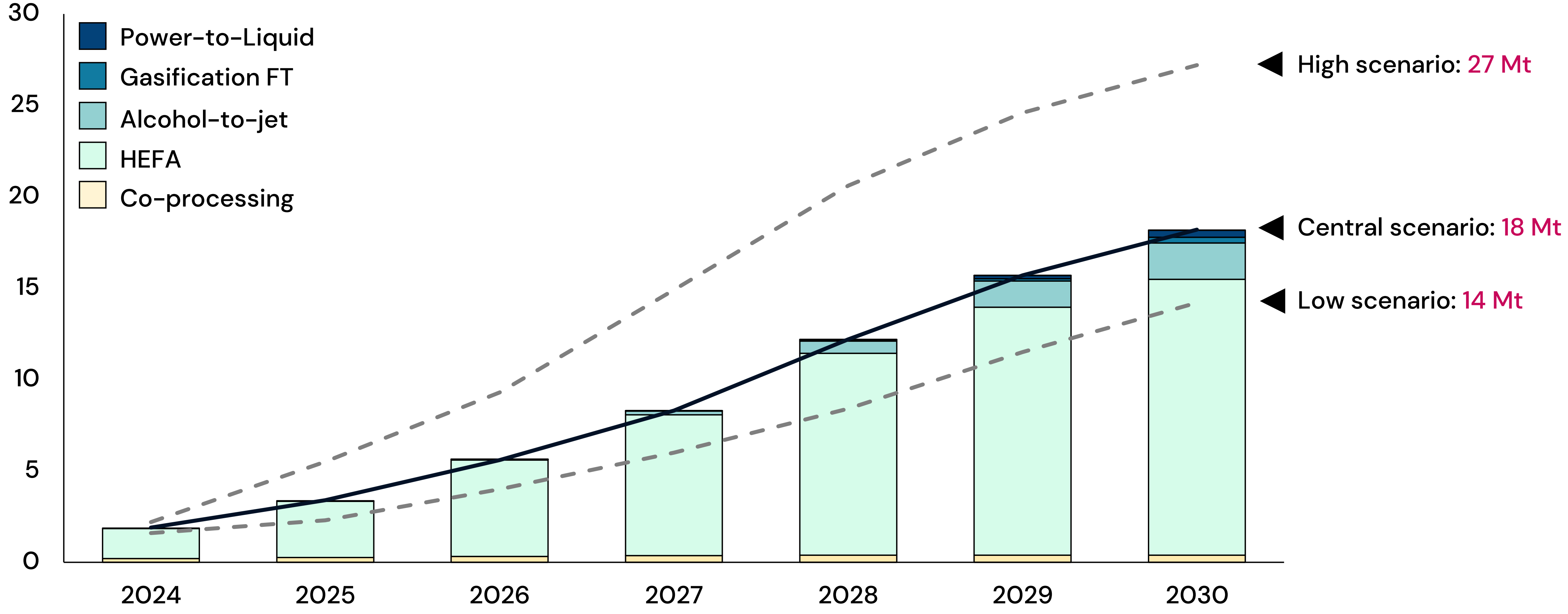
# SAF production has been rapidly scaling over the last few years, but remains only a fraction of global jet fuel consumption




Source: ICF Analysis, IATA

# SAF supply is forecast to rapidly increase as facilities commission – based on tracking over 300 facilities to develop a scenario-based forecast

Projected SAF Supply, 2024-2030
Million tonnes neat SAF



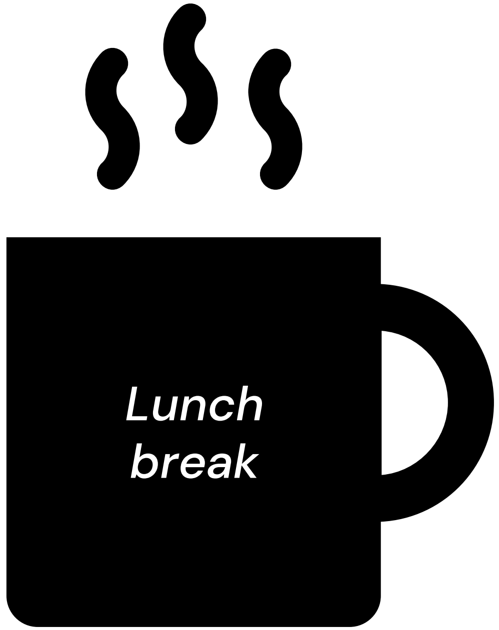

Department for Transport
Source: ICF Analysis

ICF

Department for Transport

*What are the opportunities for your State?*

# Questions?


Lunch
break

# SAF in the southern African context

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

# SAF interest is emerging across the region

**2022**

- Namibia sign EU green H2 project (EUR 2 million)
- WWF study shows South Africa has potential to produce up to 4.5 billion litres of SAF per year

**2023**

- Zimbabwe SAF feasibility study launched under ICAO ACT-SAF
- Zambia requests ICAO and World Bank support to conduct a SAF feasibility study

**2024**

- UK hosts ACT-SAF training for Angola, Tanzania, Equatorial Guinea, Cameroon, Democratic Republic of the Congo and Gabon
- NCAA, in collaboration with EASA, hosted a regional SAF workshop reinforcing ambition to become regional SAF hub

**2025**

- Tanzania hosts SAF training workshop, in partnership with EASA
- Angola plans to host AFRAA-Boeing Sustainability workshop in Dec 2025

**2026**

- 10 SADC states will voluntarily participate in CORSIA

**2050**

- Commitment to net-zero by 2050 across the SADC states

# There's abundant feedstock and industrial opportunity across the region

## *Feedstock Potential*

- Bush Biomass
- Used Cooking Oil (UCO)
- Sugarcane Residues
- Municipal Solid Waste (MSW)
- Biomass from clearing of Invasive Alien Plants (IAPs)
- Animal Fat
- Sun

*Key feedstock for Power-to-Liquid SAFs*

## *Industrial Capabilities*

Across the region there are several fossil-based, and biofuel refineries. The infrastructure is available to support plans to produce SAF.

*Sonangol biofuel refinery in Angola*

*South Africa has multiple operational refineries (Sapref, Enref, Natref)*

*Namibia-Botswana planned joint oil refinery. 60,000-100,000 bpd*

*Mozambique major oil refinery project with Nigeria. 240,000 bpd.*

ICF

- *What actions or initiatives related to SAF have already been taken in your State?*
- *What barriers or enablers are you seeing locally?*
- *What policy options are being considered/relevant to SAF?*

Department for Transport

# Questions?

*15-minute break*

# SAF sustainability, certification and reporting under CORSIA

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Sustainability framework for CORSIA eligible fuels
- CORSIA sustainability certification process and the role of SCS
- Feedstock certification and eligibility
- Traceability and chain of custody
- Reporting of the use of CORSIA Eligible Fuels

# SAF sustainability, certification and reporting under CORSIA

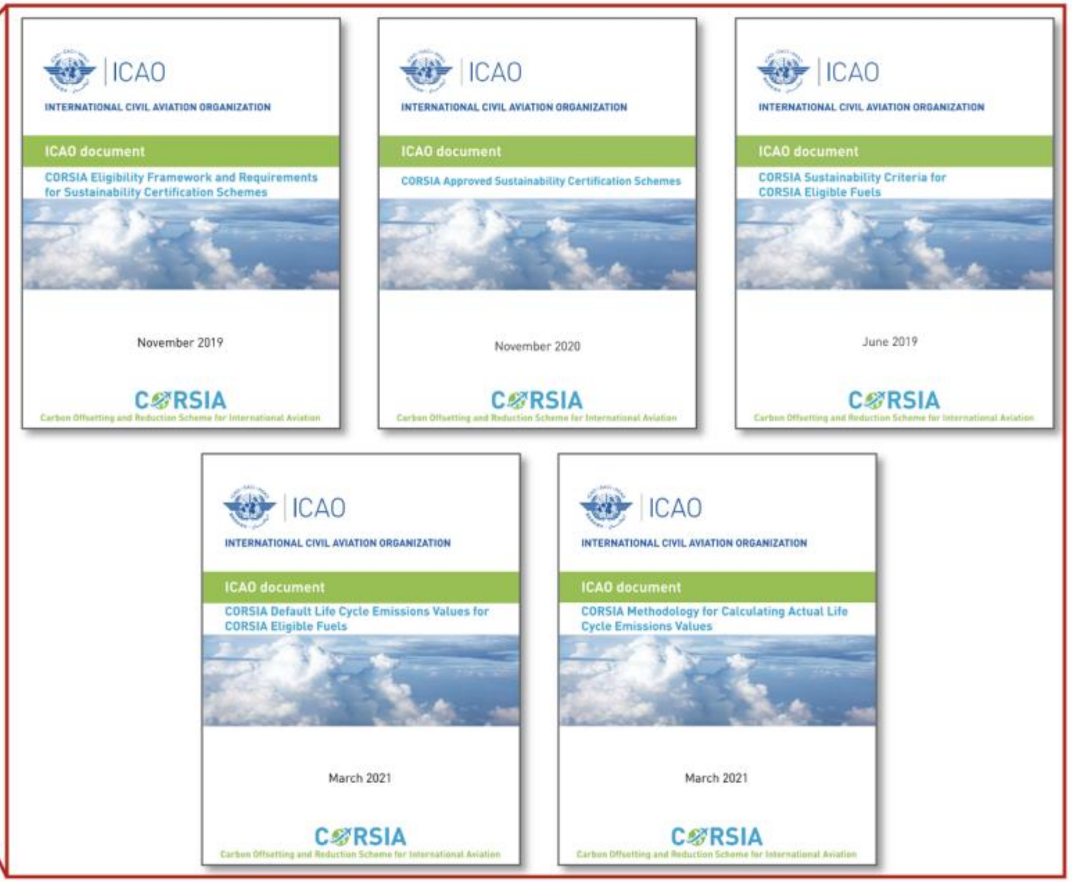
Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Sustainability framework for CORSIA eligible fuels
- CORSIA sustainability certification process and the role of SCS
- Feedstock certification
- Traceability and chain of custody
- Reporting of the use of CORSIA Eligible Fuels

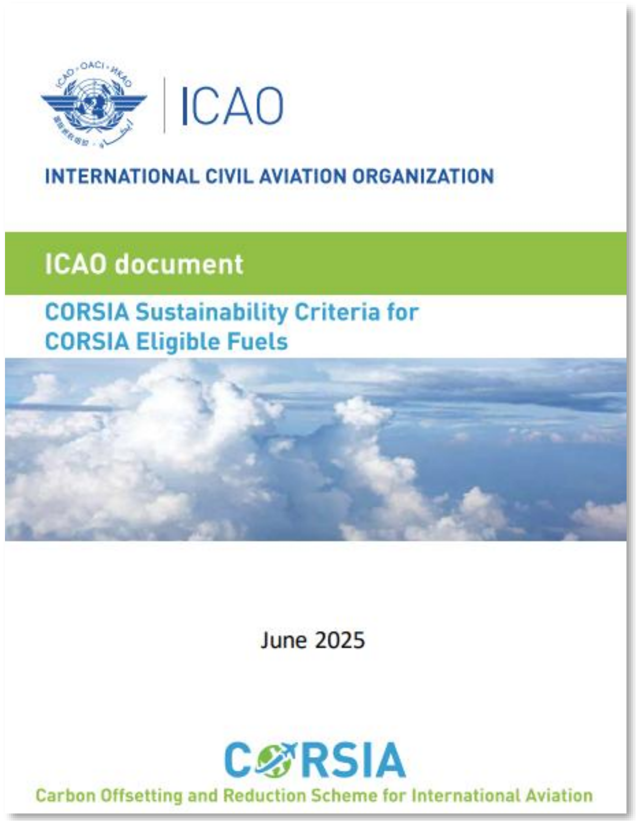
# ICAO has published five key documents that contain all relevant requirements and procedures for CORSIA eligible fuels

| ICAO CORSIA Implementation Elements | ICAO documents |
|---|---|
| CORSIA States for Chapter 3 State Pairs | 1. CORSIA States for Chapter 3 State Pairs |
| ICAO CORSIA $CO_2$ Estimation and Reporting Tool (CERT) | 2. ICAO CORSIA $CO_2$ Estimation and Reporting Tool |
| CORSIA Eligible Fuels | 3. CORSIA Eligibility Framework and Requirements for Sustainability Certification Schemes<br>4. CORSIA Approved Sustainability Certification Schemes<br>5. CORSIA Sustainability Criteria for CORSIA Eligible Fuels<br>6. CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels<br>7. CORSIA Methodology for Calculating Actual Life Cycle Emissions Values |
| CORSIA Eligible Emissions Units | 8. CORSIA Eligible Emissions Units<br>9. CORSIA Emissions Unit Eligibility Criteria |
| CORSIA Central Registry (CCR) | 10. CORSIA Central Registry: Information and Data for the Implementation of CORSIA<br>11. CORSIA Aeroplane Operator to State Attributions<br>12. CORSIA 2020 Emissions<br>13. CORSIA Annual Sector's Growth Factor (SGF)<br>14. CORSIA Central Registry (CCR): Information and Data for Transparency |

The five ICAO CORSIA Implementation Elements listed below are reflected in 14 ICAO documents approved by the ICAO Council for publication. These ICAO documents are directly referenced in Annex 16, Volume IV and are essential for the implementation of the CORSIA.



# The CORSIA sustainability criteria cover all major themes



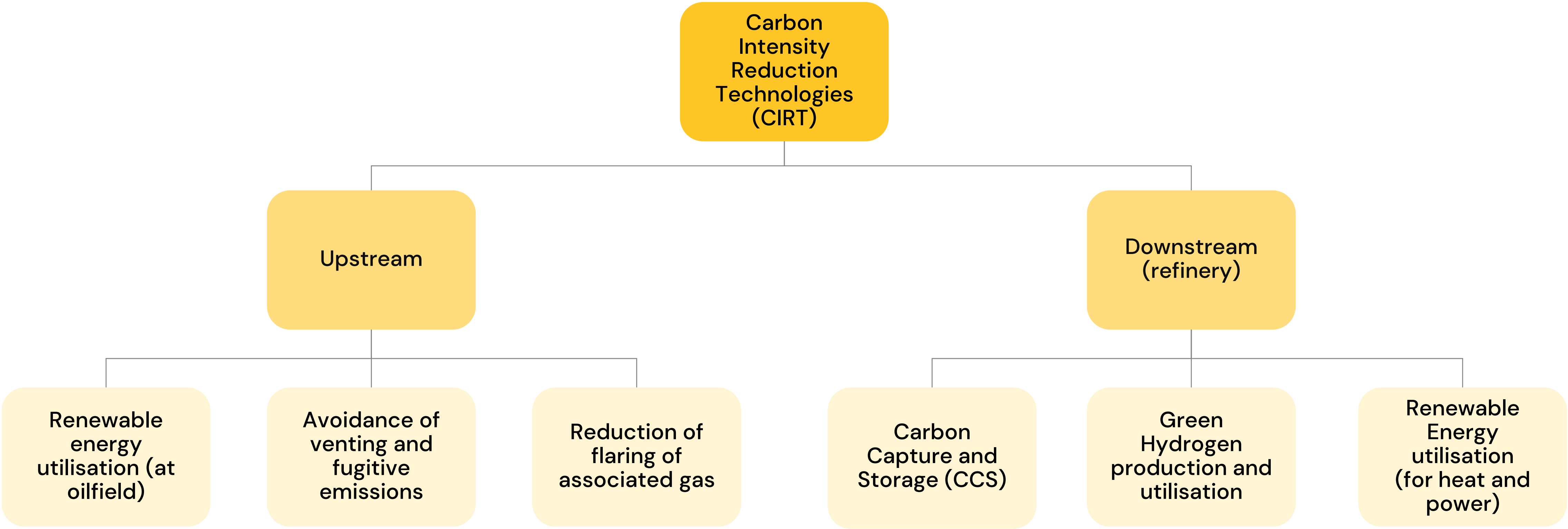

| Sustainability Themes |
|---|
| 1. Greenhouse Gases (GHG) |
| 2. Carbon stock |
| 3. GHG reduction permanence |
| 4. Water |
| 5. Soil |
| 6. Air |
| 7. Conservation |
| 8. Waste and Chemicals |
| 9. Seismic and Vibrational Impacts (only for LCAF) |
| 10. Human and labour rights |
| 11. Land use rights and land use |
| 12. Water use rights |
| 13. Local and social development |
| 14. Food security |

Carbon reduction themes – CORSIA pilot phase, 2021-2023 (themes 1–2)

Environmental and socio-economic Themes for CEF (after CORSIA pilot phase, from 2024) (themes 3–14)

# LCAF qualifies as a CORSIA Eligible Fuel, though unlike SAF, it is fossil-based

According to the ICAO, Lower Carbon Aviation Fuels (LCAF) should provide at least 10% emission reduction compared to CAF.



# SAF sustainability, certification and reporting under CORSIA

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Sustainability framework for CORSIA eligible fuels
- CORSIA sustainability certification process and the role of SCS
- Feedstock certification
- Traceability and chain of custody
- Reporting of the use of CORSIA Eligible Fuels

# Sustainability certification plays a key role in ensuring that SAF lives up to its promise

Sustainability in feedstock production

Traceability of sustainable materials through the supply chain

Verified reduction of life cycle emissions

# SAF value chain (including the feedstock) needs to be certified based on the regional policies and requirements

## CORSIA's sustainability criteria for SAF

ICAO


ICAO

INTERNATIONAL CIVIL AVIATION ORGANIZATION

ICAO document

CORSIA Approved Sustainability Certification Schemes

October 2024

CORSIA

Carbon Offsetting and Reduction Scheme for International Aviation

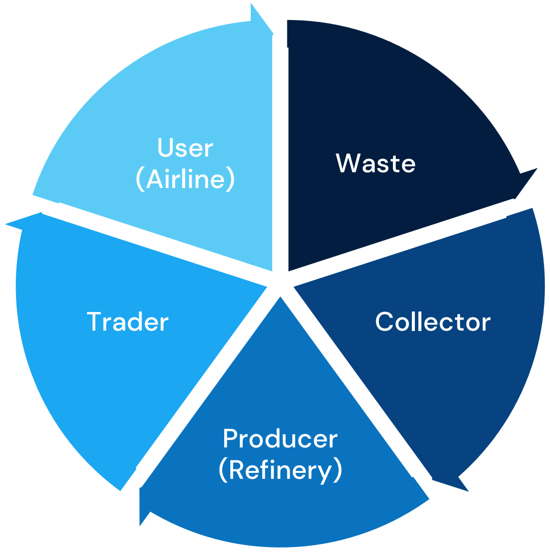
## RSB, ISCC and ClassNK approved by ICAO

ICAO

RSB

ClassNK

ISCC International Sustainability & Carbon Certification

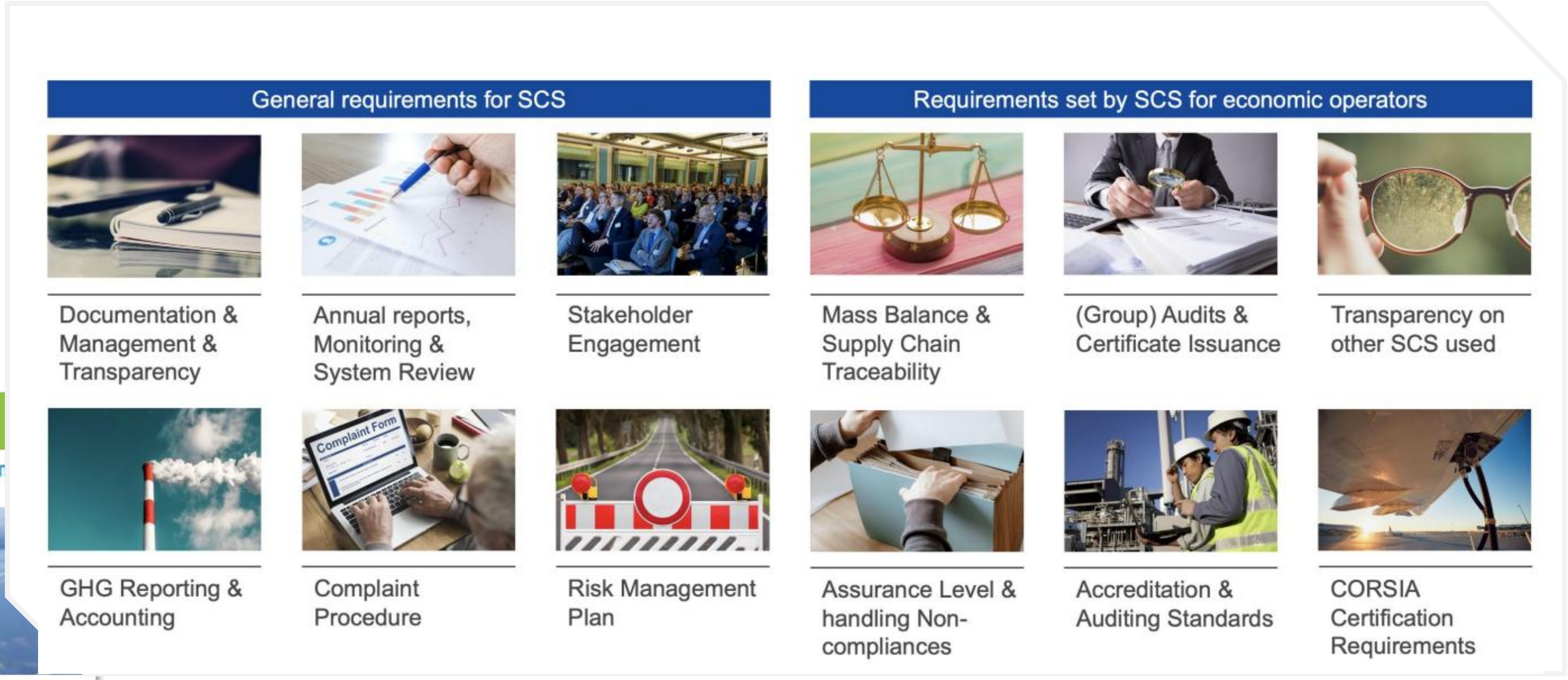



## Stakeholders' criteria sample

ICAO

- Emission Reduction
- Legality
- Human & Labour Rights
- Rural & Social Development
- Local Food Security
- Conservation
- Soil
- Water
- Air Quality
- Use of Technology Inputs and Management of Waste
- Planning, Monitoring & Continuous Improvement
- Land Rights

# CORSIA prescribes a stringent set of criteria that SCS must fulfil to become recognised and certify CORSIA eligible fuels

# The ICAO Council approves sustainability certification schemes (SCS) for certifying CORSIA eligible fuels

Since November 2020, economic operators can demonstrate compliance with the CORSIA Sustainability Criteria for CORSIA eligible fuels by applying the ICAO-approved sustainability certification schemes (SCS)

ICAO

INTERNATIONAL CIVIL AVIATION ORGANIZATION

**ICAO document**

**CORSIA Approved Sustainability Certification Schemes**

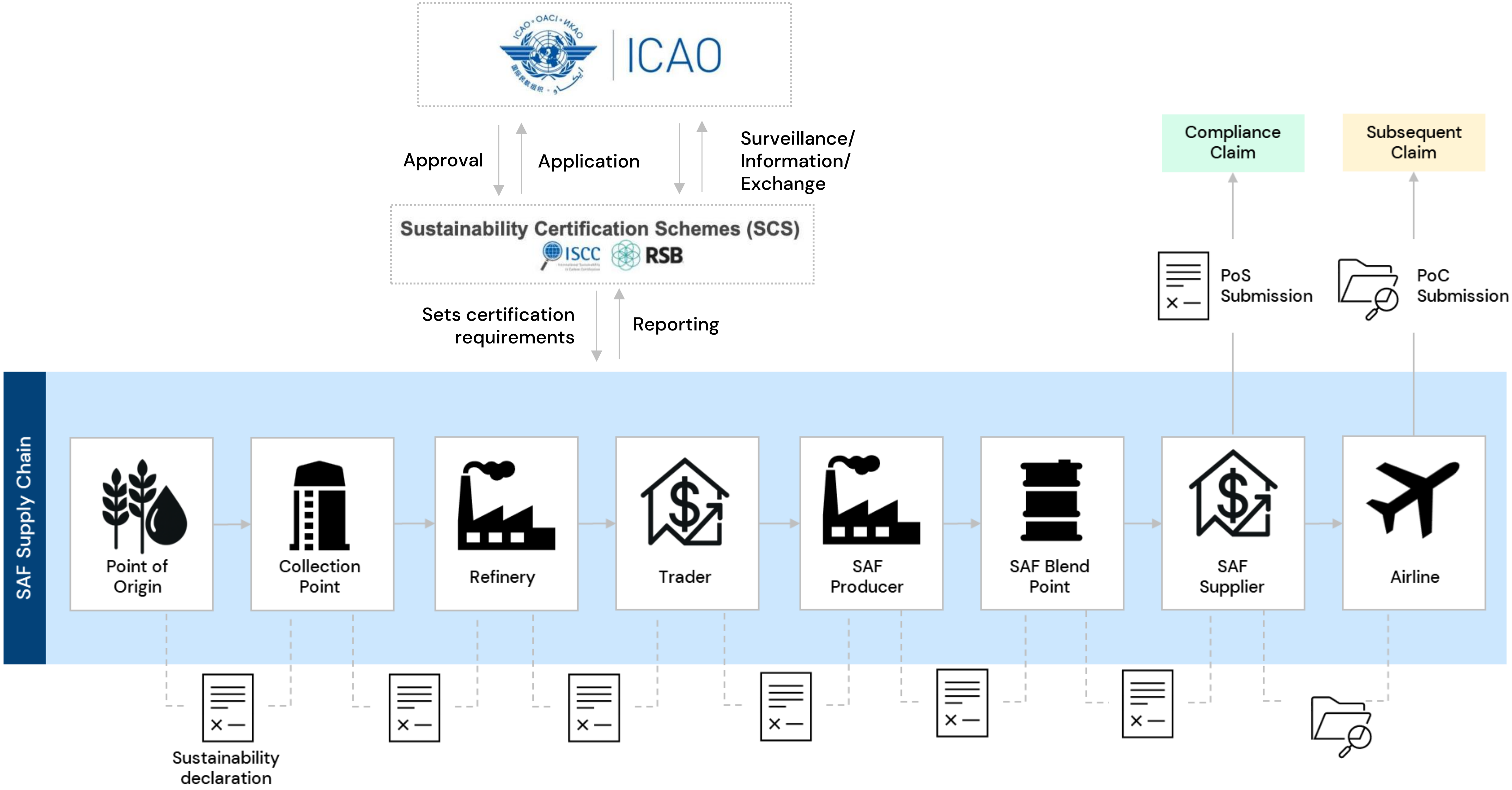
October 2024

CORSIA

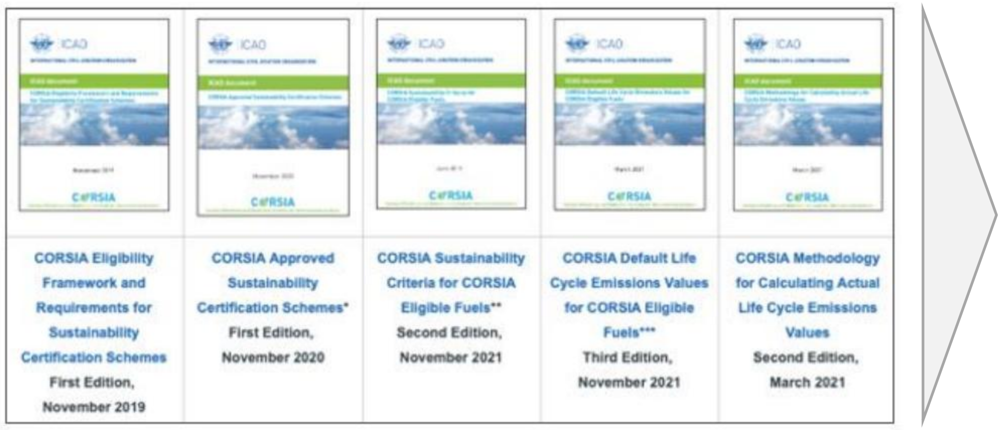
Carbon Offsetting and Reduction Scheme for International Aviation

| Name of the Sustainability Certification Scheme | Date of approval | Website | Scope of approval |
|---|---|---|---|
| International Sustainability and Carbon Certification (ISCC) | 16 Jun. 2023 | https://www.iscc-system.org/about/sustainable-aviation-fuels/corsia/ | Certification of CORSIA Sustainable Aviation Fuels economic operators covered by Chapters 1 and 2 of the ICAO document "CORSIA Sustainability Criteria for CORSIA eligible fuels" |
| Roundtable on Sustainable Biomaterials (RSB) | 16 Jun. 2023 | https://rsb.org/rsb-corsia-certification/ | Certification of CORSIA Sustainable Aviation Fuels economic operators covered by Chapters 1 and 2 of the ICAO document "CORSIA Sustainability Criteria for CORSIA eligible fuels" |
| ClassNK SCS | 28 Oct. 2024 | https://www.classnk.or.jp/hp/en/authentication/scs/index.html | Certification of CORSIA Sustainable Aviation Fuels economic operators covered by Chapter 2 of the ICAO document "CORSIA Sustainability Criteria for CORSIA eligible fuels" |

# The certification 'ecosystem' for CORSIA eligible fuels is complex



# System documents build the basis of SCS




**The system documents:**

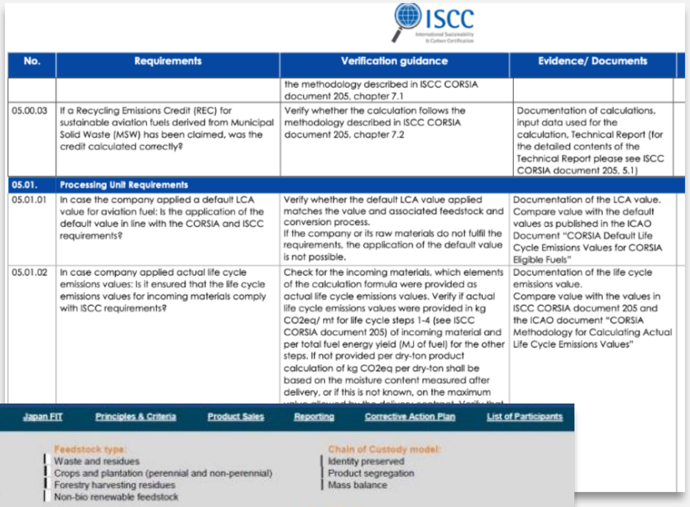
- Translate relevant regulatory requirements into the scheme's requirements and processes 'on the ground'
- Lay down all relevant certification requirements and processes for Certification Bodies and System users (i.e. certified companies)
- Are publicly available on the SCS websites

*Example*

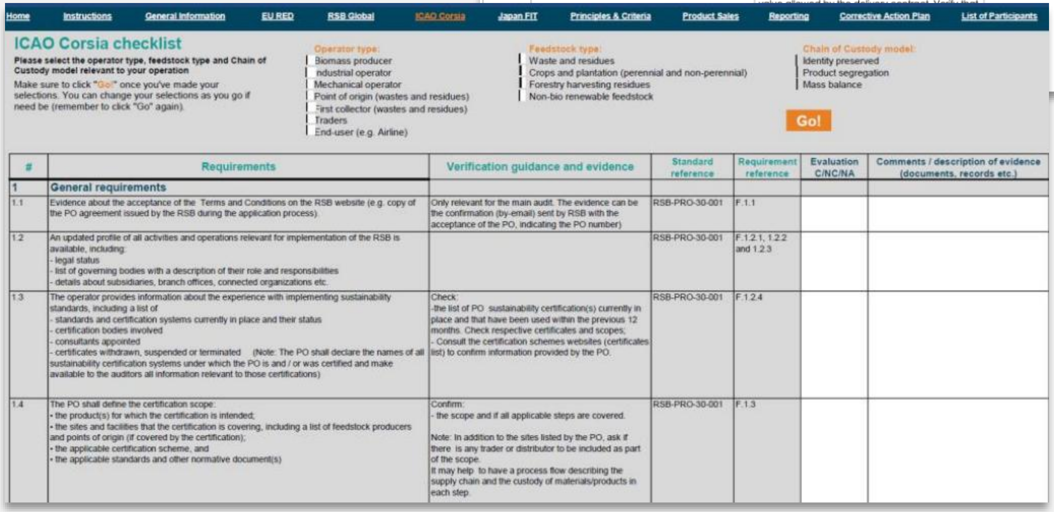
# Auditors verify compliance with the standard's requirements via audit procedures or checklists



*Example*



| No. | Requirements | Verification guidance | Evidence/ Documents |
|---|---|---|---|
| | | the methodology described in ISCC CORSIA document 205, chapter 7.1 | |
| 05.00.03 | If a Recycling Emissions Credit (REC) for sustainable aviation fuels derived from Municipal Solid Waste (MSW) has been claimed, was the credit calculated correctly? | Verify whether the calculation follows the methodology described in ISCC CORSIA document 205, chapter 7.2 | Documentation of calculations, input data used for the calculation, Technical Report (for the detailed contents of the Technical Report please see ISCC CORSIA document 205, 5.1) |
| 05.01. | Processing Unit Requirements | | |
| 05.01.01 | In case the company applied a default LCA value for aviation fuel: Is the application of the default value in line with the CORSIA and ISCC requirements? | Verify whether the default LCA value applied matches the value and associated feedstock and conversion process. If the company or its raw materials do not fulfil the requirements, the application of the default value is not possible. | Documentation of the LCA value. Compare value with the default values as published in the ICAO Document "CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels" |
| 05.01.02 | In case company applied actual life cycle emissions values: Is it ensured that the life cycle emissions values for incoming materials comply with ISCC requirements? | Check for the incoming materials, which elements of the calculation formula were provided as actual life cycle emissions values. Verify if actual life cycle emissions values were provided in kg CO2eq/ mt for life cycle steps 1-4 (see ISCC CORSIA document 205) of incoming material and per total fuel energy yield (MJ of fuel) for the other steps. If not provided per dry-ton product calculation of kg CO2eq per dry-ton shall be based on the moisture content measured after delivery, or if this is not known, on the maximum | Documentation of the life cycle emissions value. Compare value with the values in ISCC CORSIA document 205 and the ICAO document "CORSIA Methodology for Calculating Actual Life Cycle Emissions Values" |



Home | Instructions | General Information | EU RED | RSB Global | ICAO Corsia | Japan FIT | Principles & Criteria | Product Sales | Reporting | Corrective Action Plan | List of Participants

**ICAO Corsia checklist**

**Please select the operator type, feedstock type and Chain of Custody model relevant to your operation**

Make sure to click "Go!" once you've made your selections. You can change your selections as you go if need be (remember to click "Go" again).

Operator type:
- Biomass producer
- Industrial operator
- Mechanical operator
- Point of origin (wastes and residues)
- First collector (wastes and residues)
- Traders
- End-user (e.g. Airline)

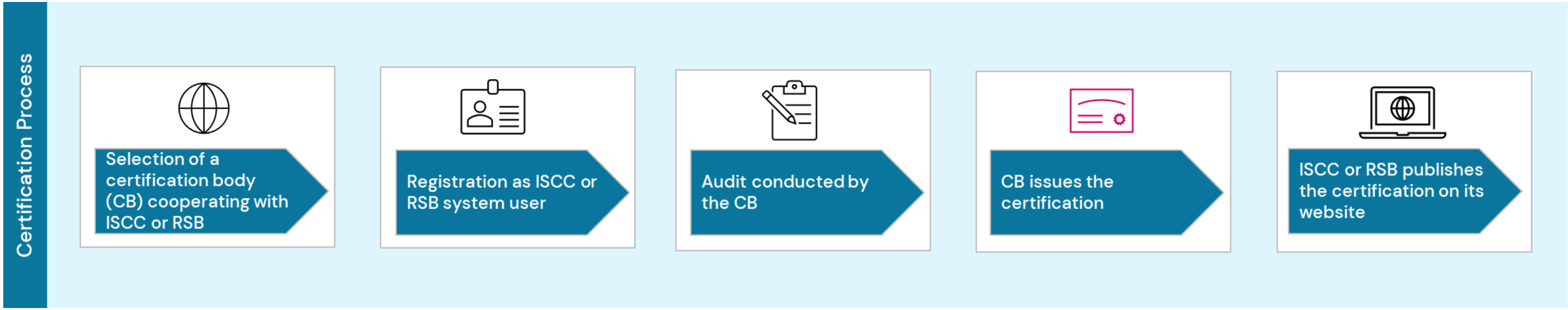
Feedstock type:
- Waste and residues
- Crops and plantation (perennial and non-perennial)
- Forestry harvesting residues
- Non-bio renewable feedstock

Chain of Custody model:
- Identity preserved
- Product segregation
- Mass balance

Go!

| # | Requirements | Verification guidance and evidence | Standard reference | Requirement reference | Evaluation C/NC/NA | Comments / description of evidence (documents, records etc.) |
|---|---|---|---|---|---|---|
| 1 | **General requirements** | | | | | |
| 1.1 | Evidence about the acceptance of the Terms and Conditions on the RSB website (e.g. copy of the PO agreement issued by the RSB during the application process) | Only relevant for the main audit. The evidence can be the confirmation (by-email) sent by RSB with the acceptance of the PO, indicating the PO number) | RSB-PRO-30-001 | F.1.1 | | |
| 1.2 | An updated profile of all activities and operations relevant for implementation of the RSB is available, including:<br>- legal status<br>- list of governing bodies with a description of their role and responsibilities<br>- details about subsidiaries, branch offices, connected organizations etc. | | RSB-PRO-30-001 | F.1.2.1, 1.2.2 and 1.2.3 | | |
| 1.3 | The operator provides information about the experience with implementing sustainability standards, including a list of<br>- standards and certification systems currently in place and their status<br>- certification bodies involved<br>- consultants appointed<br>- certificates withdrawn, suspended or terminated (Note: The PO shall declare the names of all sustainability certification systems under which the PO is and / or was certified and make available to the auditors all information relevant to those certifications) | Check:<br>-the list of PO sustainability certification(s) currently in place and that have been used within the previous 12 months. Check respective certificates and scopes;<br>- Consult the certification schemes websites (certificates list) to confirm information provided by the PO. | RSB-PRO-30-001 | F.1.2.4 | | |
| 1.4 | The PO shall define the certification scope:<br>• the product(s) for which the certification is intended;<br>• the sites and facilities that the certification is covering, including a list of feedstock producers and points of origin (if covered by the certification);<br>• the applicable certification scheme, and<br>• the applicable standards and other normative document(s) | Confirm:<br>- the scope and if all applicable steps are covered.<br><br>Note: In addition to the sites listed by the PO, ask if there is any trader or distributor to be included as part of the scope.<br>It may help to have a process flow describing the supply chain and the custody of materials/products in each step | RSB-PRO-30-001 | F.1.3 | | |

# Overview of the sustainability certification process




ICF | Department for Transport

# SAF sustainability, certification and reporting under CORSIA

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Sustainability framework for CORSIA eligible fuels
- CORSIA sustainability certification process and the role of SCS
- Feedstock certification
- Traceability and chain of custody
- Reporting of the use of CORSIA Eligible Fuels

# SCS cover all types of raw materials that are eligible for certification under CORSIA


ICF | Department for Transport

# Auditors verify whether the feedstock complies with CORSIA sustainability criteria

| | | | |
|---|---|---|---|
| *General Methods* | | *On-site inspection* | *Interviews with personnel* |
| *Crops* | Sustainable crops must comply with CORSIA sustainability criteria | *Remote Sensing Tool* | *Crop Database (e.g. biodiversity databases)* |
| *Wastes* | Sustainable wastes and residues must be genuine wastes and residues | *Plausibility checks (e.g. amount of input virgin oil vs. used cooking oil)* | *Checks to make sure the product was not intentionally contaminated/modified* |

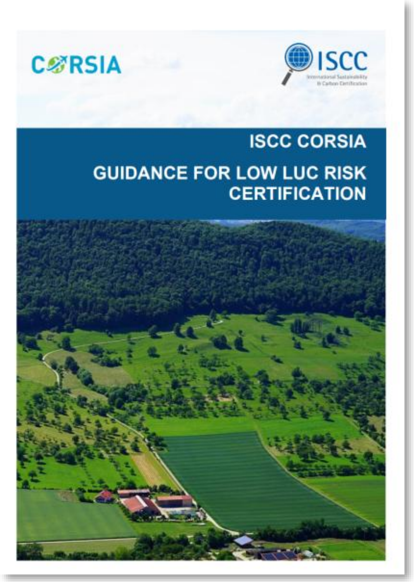
# Feedstocks with low risks for Land Use Change (LUC) can contribute to the overall feedstock basis for SAF production

### *Yield Increase Approach*

Where feedstock producers can increase the amount of available feedstock out of a fixed area of land.

### *Unused Land Approach*

Where previously unused land is used to cultivate sustainable feedstock for SAF production.





### *Feedstocks with Low Risk for Land Use Change*

| | |
|---|---|
| Feedstocks that do not result in the expansion of global agricultural land use for their production | Wastes, residues and by-products (ICAO positive list) |
| Feedstocks that have yields per surface unit significantly higher than terrestrial crops | Feedstocks that were produced by utilizing land use change-risk mitigation (land management practices) |

# SAF sustainability, certification and reporting under CORSIA

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Sustainability framework for CORSIA eligible fuels
- CORSIA sustainability certification process and the role of SCS
- Feedstock certification
- Traceability and chain of custody
- Reporting of the use of CORSIA Eligible Fuels

# What is a 'Chain of Custody'?

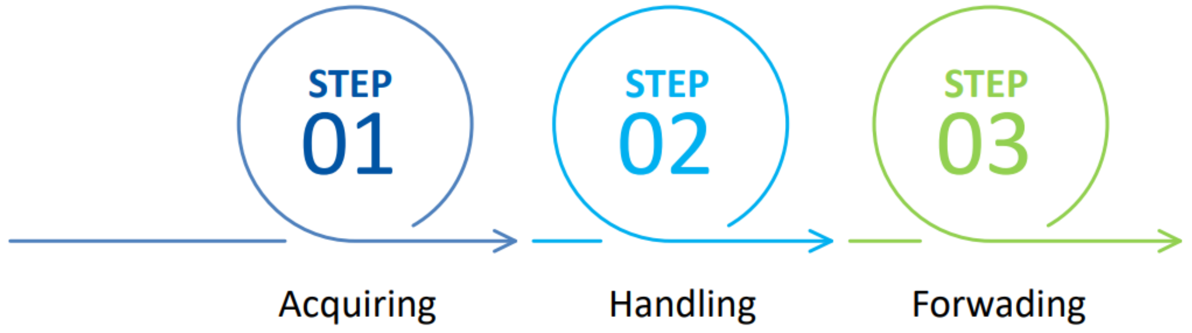
## *'Chain of Custody' definition:*

Process by which inputs and outputs and associated information are transferred, monitored and controlled as they move through each step in the relevant supply chain (Source: ISO/DIS 22095)

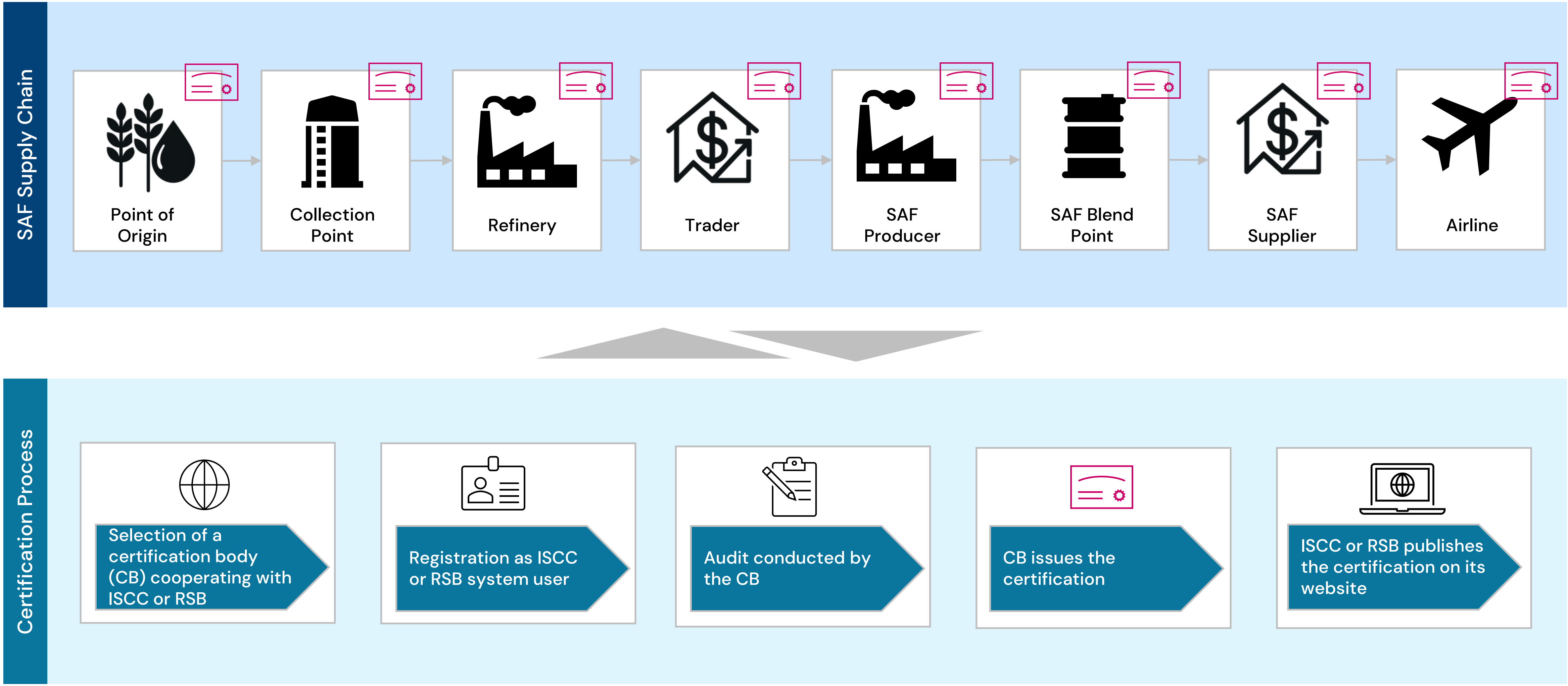
## *'Chain of Custody' system:*

A set of measures designed to implement a Chain of Custody, including documentation of these measures (Source: ISO/DIS 22095)

## *Three steps for tracking materials:*



# Sustainability information (e.g. on life cycle emissions) is forwarded through the supply chain step-by-step



# SAF sustainability, certification and reporting under CORSIA

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

- Sustainability framework for CORSIA eligible fuels
- CORSIA sustainability certification process and the role of SCS
- Feedstock certification
- Traceability and chain of custody
- Reporting of the use of CORSIA Eligible Fuels

# Reporting the use of SAF in CORSIA

1. Intention to use SAF
2. Update of the Emissions Monitoring Plan (EMP) with SAF-related procedures
3. Procurement of SAF
4. Collecting documentation from the fuel supplier
5. Furnishing of the CORSIA Eligible Fuel (CEF) Supplementary Information (SI) template
6. Preparation of the Emissions Report (ER)
7. Third-party verification
8. Submission of the ER, Verification Report, and CEF SI template to the State

# Questions?

# Key takeaways

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

# Key takeaways

- SAF is the most viable near- to mid-term decarbonisation solution for aviation.
- Multiple SAF production pathways exist (HEFA, AtJ, FT, PtL), each with distinct feedstock needs, costs, and technology readiness levels.
- HEFA is currently the only commercially viable pathway, but feedstock limitations will require scaling of AtJ, FT, and PtL technologies.
- Global SAF policy momentum is accelerating, with mandates and incentives in the EU, UK, US, and other regions driving demand.
- SAF production is scaling rapidly, but still represents a small fraction of global jet fuel use, continued investment and collaboration are essential.
- Establishing a domestic SAF industry can provide opportunities for economic growth, employment, and enhanced energy security, while also creating potential for fuel export

# Next steps and available support

Content for this module has been adapted from the ICAO ACT-SAF Series of Training Sessions

# The ACT-SAF Programme consists of 3 steps

**Training**
*2 days in-person*

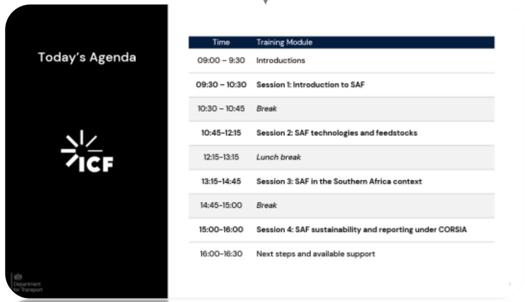
First step in building SAF understanding

**Feasibility Study**
*6 months*

National SAF Roadmap: Feedstock and technology

**Business Implementation**
*6 months*

Bottom up SAF facility design & technoeconomic analysis


Today's Agenda

| Time | Training Module |
|---|---|
| 09:00 – 9:30 | Introductions |
| 09:30 – 10:30 | Session 1: Introduction to SAF |
| 10:30 – 10:45 | Break |
| 10:45–12:15 | Session 2: SAF technologies and feedstocks |
| 12:15–13:15 | Lunch break |
| 13:15–14:45 | Session 3: SAF in the Southern Africa context |
| 14:45–15:00 | Break |
| 15:00–16:00 | Session 4: SAF sustainability and reporting under CORSIA |
| 16:00–16:30 | Next steps and available support |

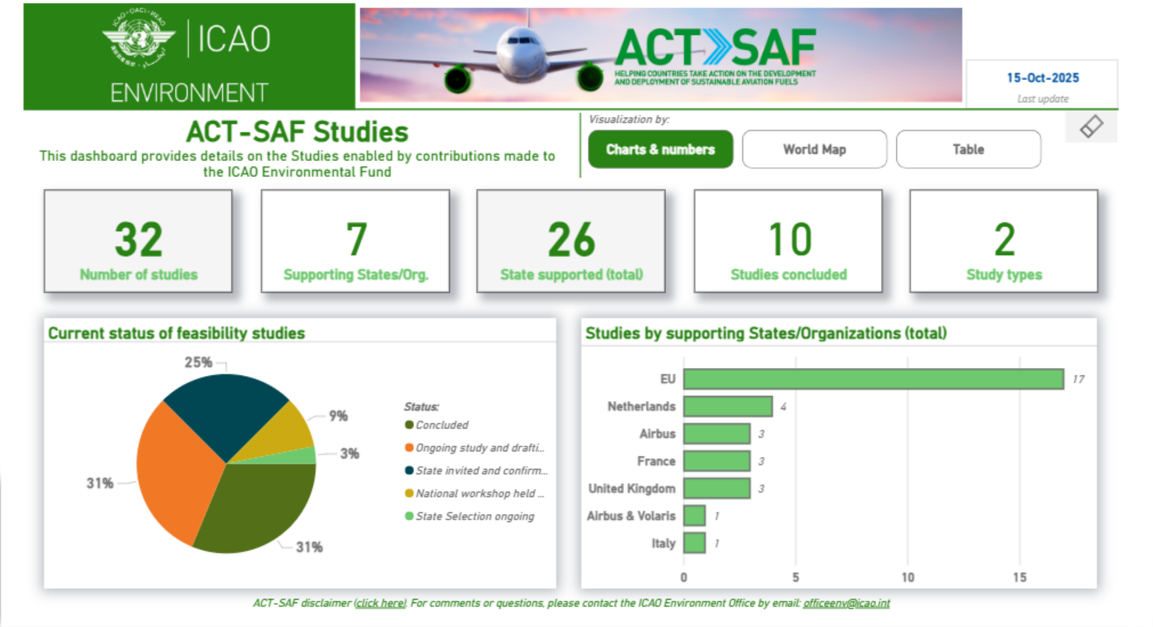

# ICAO ACT-SAF Updates

**The ACT-SAF platform provides the most recent information:**

- List of Partners constantly updated
- ACT-SAF series material available online


### Publicly available on the ICAO website

ACT-SAF: https://www.icao.int/environmental-protection/Pages/act-saf.aspx



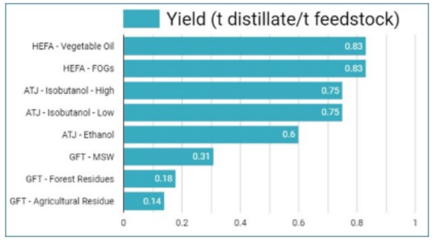
# ICAO ‘Rules of Thumb’ provides order of magnitude estimates on SAF costs, investment needs and production potential

- Provides the impact of feedstock cost, fuel yield, facility scale, total capital investment (TCI) and minimum selling price (MSP) for both the **nth plant and a pioneer plant**

- They can be used to inform policy makers and project developers

**SAF rules of thumb - what does it take to produce SAF?**

The "SAF Rules of Thumb can be utilized to support policy development. They provide order of magnitude estimations related to SAF costs, investment needs and production potential. These "SAF rules of thumb" complete a toolbox of guidance material for use by ICAO Member States together with the "Guidance on potential policies and coordinated approaches for the deployment of SAF".




**Summary Table 1 - Feedstock Information**

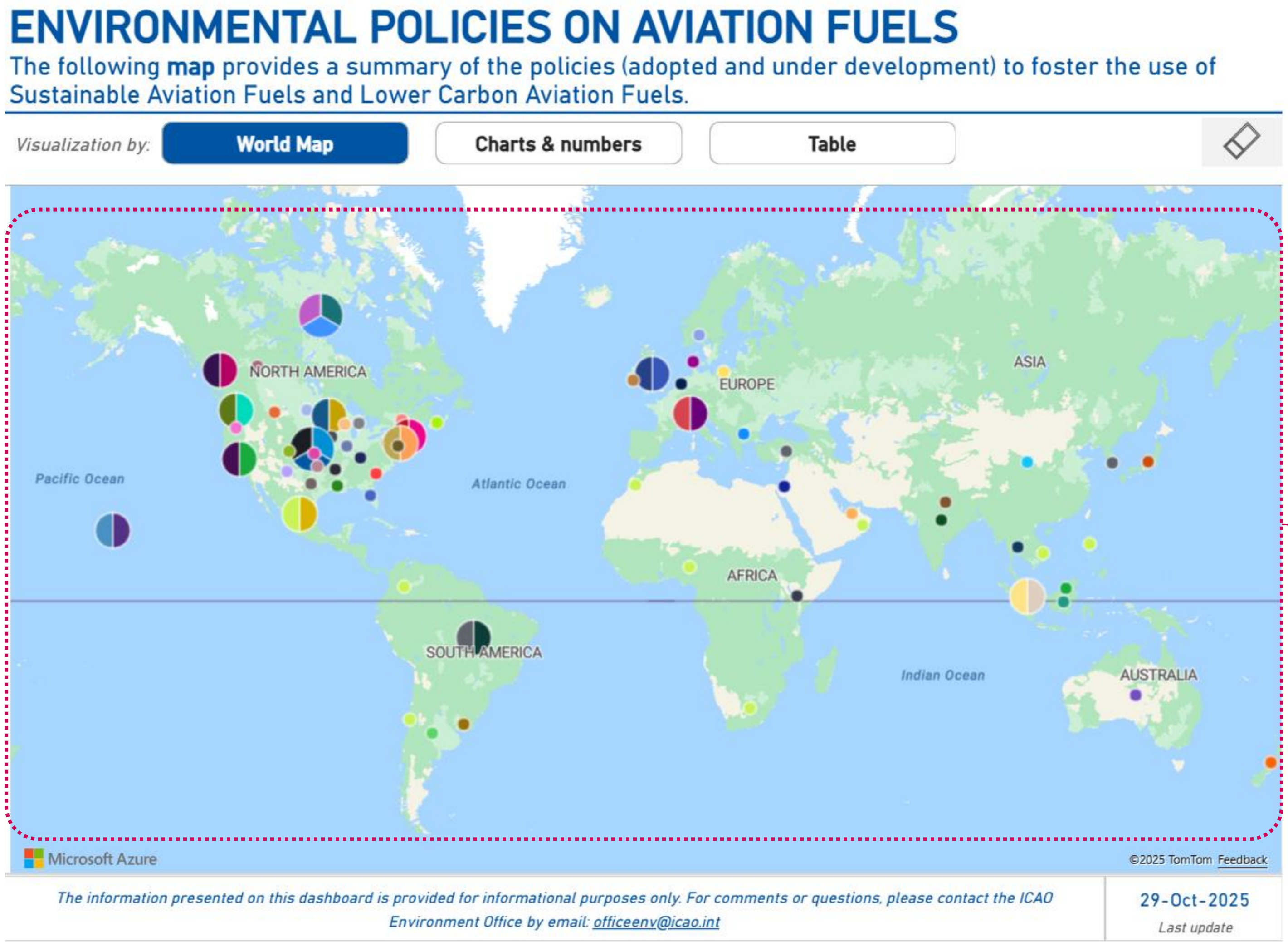
Technology, feedstock type and price, yield, total annual distillate scale, annual SAF production for both $n^{th}$ and pioneer facilities.

| Processing Technology | Feedstock | Yield (ton distillate/ton feedstock) | Feedstock Price | Total Capacity (million L/year) | | SAF production (million L/year) | |
|---|---|---|---|---|---|---|---|
| | | | | $n^{th}$ | pioneer | $n^{th}$ | pioneer |
| FT* | MSW | 0.31 | $30/ton | 500 | 100 | 200 | 40 |
| FT* | forest residues | 0.18 | $125/ton | 400 | 100 | 160 | 40 |
| FT* | agricultural residues | 0.14 | $110/ton | 300 | 100 | 120 | 40 |
| ATJ | ethanol | 0.60 | $0.41/L | 1000 | 100 | 700 | 70 |
| ATJ | isobutanol-low | 0.75 | $0.89/L | 1000 | 100 | 700 | 70 |
| ATJ | isobutanol-high | 0.75 | $1.20/L | 1000 | 100 | 700 | 70 |
| HEFA | FOGs | 0.83 | $580/ton | 1000 | - | 550 | - |
| HEFA | soybean oil*** | 0.83 | $809/ton | 1000 | - | 550 | - |
| FT | $CO_2$ from Direct Air Capture (DAC) , $H_2$ | 0.24 | $300/t, $6/kg | 1000 | - | 200 | - |
| FT | waste $CO_2$, $H_2$ | 0.24 | $300/t, $6/kg | 1000 | - | 200 | - |
| Pyrolysis** | forest residues | 0.23 | $125/ton | 400 | 100 | 180 | 40 |
| Pyrolysis** | agricultural residues | 0.21 | $110/ton | 400 | 100 | 180 | 40 |

**Publicly available on the ICAO website**

SAF rules of thumb: https://www.icao.int/environmental-protection/Pages/SAF_RULESOFTHUMB.aspx

# ICAO SAF Policies tracker documents all the policies in development by member States




| Date | Jurisdiction | Policy Title | Policy Description | Status | Source (weblink) |
|---|---|---|---|---|---|
| 22-Oct-2025 | Singapore | SAF Bill | Singapore tables Bill for sustainable aviation fuel levy, fund and central procurement | under development | |
| 03-Oct-2025 | Mexico | Biofuels law | The Regulations of the Biofuels Law, published in the Official Gazette of the Federation on October 3, 2025, explicitly support and regulate the deployment and use of the SAF | adopted | |
| 05-Sep-2025 | Israel | 2025 Regulatory Plan | Government's 2025 Regulatory Plan lists a forthcoming rule to "set minimum percentages of sustainable jet fuel (SAF) out of total jet fuel" under the Motor Vehicles (Engines & Fuel) Law, 1960 — i.e., a blending mandate under development (not yet enacted) | under development | |
| 04-Sep-2025 | Mexico | SAF Roadmap | Mexico has an enabling national quality standard for SAF (bioturbosina) and an active, government-led process to build a National SAF Roadmap and domestic production goals, but no SAF blending mandate or specific federal tax-credit/subsidy is in force | under development | |
| 01-Sep-2025 | Oman | SAF Roadmap | Signals national intent & planning: Official communications show Oman planning SAF deployment and production, including a sector roadmap and CAA–MEM collaboration to introduce SAF at Omani airports and build local supply. | under development | |
| 21-Aug-2025 | Ireland | Sustainable Aviation Fuel Policy Roadmap | Ireland will enable SAF through four pathways: (1) Market certainty, (2) Collaboration, (3) Supporting uptake, (4) Supporting production. It frames near-term actions that build on EU measures (e.g., ReFuelEU Aviation) and will guide future national measures. A Sustainable Aviation Fuel Task Force (set up Dec 2023) informed the roadmap | adopted | |
| 01-Aug-2025 | United States | Sales & Use Tax Exemption — Renewable Feedstock Refinery | Exempts materials used to construct/expand or make environmental upgrades to a renewable feedstock refinery (defined to include facilities producing jet fuel from renewable biomass by deoxygenation, ≥5,000 bbl/day). It isn't SAF-only, but it does cover jet fuel from renewable biomass, which can include SAF produced via HEFA/other eligible routes. | adopted | |
| 22-Jul-2025 | Canada | Clean Fuels Fund (CFF) | Up to C$1.5B to de-risk, build, expand or retrofit clean-fuel production (explicitly includes SAF) and enabling infrastructure | adopted | |
| | | | market-enabling measures. The Sept 2025 workshop (government-hosted) explicitly set out to identify opportunities and barriers and to build a national plan for SAF deployment in Morocco; MAP's coverage confirms the government's lead role | | |
| 13-Jul-2025 | New Zealand | Fuel Security Plan | Draft Fuel Security Plan (consultation) noting SAF as only viable long-haul alternative and continued engagement | under development | |
| 01-Jul-2025 | United States | Low Carbon Fuel Standard (LCFS) | California's LCFS lets Alternative Jet Fuel (SAF) participate as an opt-in fuel; suppliers can generate LCFS credits when SAF displaces fossil jet fuel in California, provided they register and meet pathway/reporting requirements. | adopted | |
| 30-Jun-2025 | Türkiye | SAF mandate | Establishes the national framework for SAF standards, mandatory use, and promotion to reduce GHG from international flights. Applies to flights departing Türkiye to countries listed in a CORSIA document and to aircraft with MTOW > 5,700 kg. Annual requirement: Each year, by the end of Q3, SHGM publishes the minimum per-litre emissions-reduction value to be achieved via SAF use for the upcoming year. Fuel suppliers must supply at least the sector quantity they offered the prior year and meet/enable that reduction, and airlines must consume the corresponding amount on applicable flights. Airlines must uplift at least 90% of the jet fuel they are required to use in Türkiye for those flights | adopted | |
| 26-Jun-2025 | United States | SAF tax credit/SAF Incentive Program Act | Per-gallon credit: $1.50/gal for SAF produced or blended in Michigan and sold to a purchaser certifying use in an aircraft departing a Michigan airport; +$0.02/gal for each additional 1% lifecycle GHG reduction above 50%, capped at $2.00/gal; refundable if credit exceeds tax liability | adopted | |
| 26-Jun-2025 | United States | Study on potential refining, transportation, and use of SAF | An Oklahoma House interim study proposal for 2025 to examine opportunities and needs around SAF production (refining), logistics/transport, and in-state use. It's part of the formal interim study process used to scope issues and inform future legislation; inclusion on the official list indicates it's under consideration in the current interim cycle | under development | |
| 17-Jun-2025 | European Union | | Under the scheme, the EU will provide up to €6 per liter for e-fuels and €0.50 per liter for | under | |

*Across 36 states, 83 SAF policies have been adopted or are under development*

*Thank you for your time today!*

*Please provide your feedback below:*

https://forms.office.com/r/6LbvUWXFNx?origin=lprLink

Department for Transport

# Questions?

**Alina Viehweber**
Sustainable Aviation Manager
Alina.Viehweber@icf.com

**Kelly Gibson**
Sustainable Aviation Consultant
Kelly.Gibson@icf.com

icf.com

linkedin.com/company/icf-international/
twitter.com/icf
https://www.facebook.com/ThisIsICF/

**About ICF**

ICF (NASDAQ:ICFI) is a global consulting and digital services company with over 9,000 full- and part-time employees, but we are not your typical consultants. At ICF, business analysts and policy specialists work together with digital strategists, data scientists and creatives. We combine unmatched industry expertise with cutting-edge engagement capabilities to help organizations solve their most complex challenges. Since 1969, public and private sector clients have worked with ICF to navigate change and shape the future.