Background: What are SAF and why are they needed?

Background: What are SAF?

- ✓ **SAF definitions**
  - ✓ SAF Sustainability criteria
- ✓ **SAF qualification: How SAF can be produced**
  - ✓ Technology options and approved SAF technology pathways
  - ✓ SAF of non-biological origin
  - ✓ Recycled Carbon Fuels

Background: What are SAF?

- ✓ **SAF definitions**
  - ✓ SAF Sustainability criteria
- ✓ **SAF qualification: How SAF can be produced**
  - ✓ Technology options and approved SAF technology pathways
  - ✓ SAF of non-biological origin
  - ✓ Recycled Carbon Fuels

What are Sustainable Aviation Fuels (SAF)?

- There is **not a single definition** of SAF:

Different policy or regulatory frameworks refer to a non-conventional *drop-in* aviation fuel, alternative to fossil-based jet fuel that reduce life cycle green-house gas (GHG) emissions relative to conventional aviation fuel, and which are compliant with certain sustainability requirements

- **UK SAF mandate**

- **ReFuel EU Aviation**

- **US SAF tax credit**

- **ICAO Annex 16 Vol IV (CORSIA):**
  - *CORSIA sustainable aviation fuel: A **renewable or waste-derived aviation fuel that meets the CORSIA Sustainability Criteria** under this Volume*

What are Sustainable Aviation Fuels (SAF)?

- The **two key requirements** that any SAF should accomplish are:

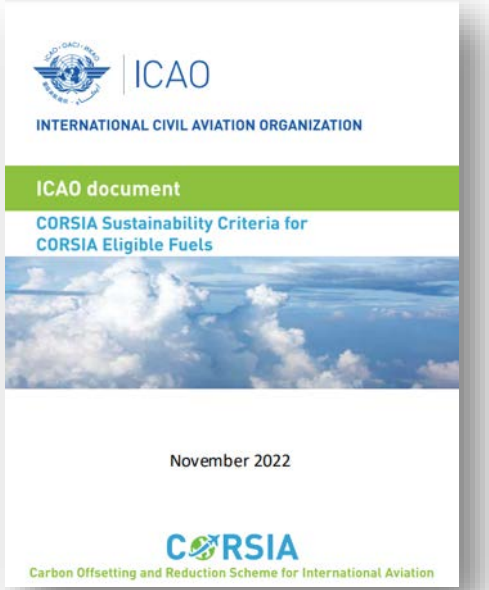
  - **To be SUSTAINABLE:** Need to **fulfil specific sustainability requirements**, including greenhouse gas (GHG) emissions reductions, defined in an explicit policy/regulatory framework or standard.

  - **To be AVIATION FUEL:** Need to meet **equivalent aviation fuel specifications as existing fossil-based ones**, be “drop-in” or miscible thus compatible with existing and going into service civil aircraft fleets.

What are SAF? Sustainable fuels

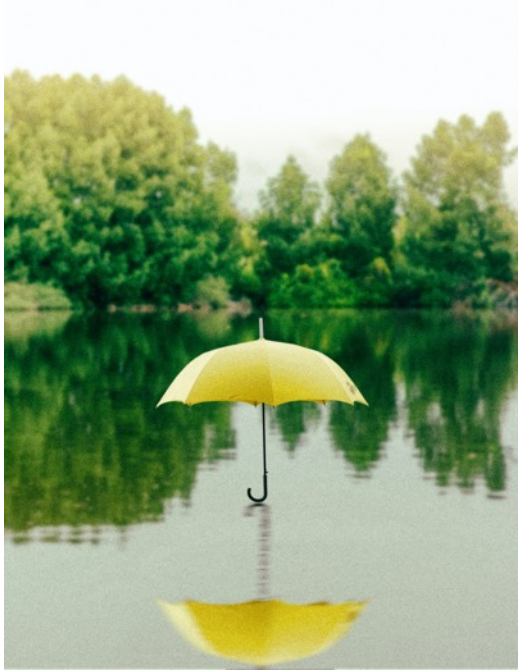
- There can be different requirements worldwide depending on the regulatory or voluntary framework:
  - **ICAO:** The Council endorsed in November 2021 **the FIRST comprehensive GLOBAL sustainability criteria applicable to bioenergy**, including **environmental and socio-economic** criteria
    - ✓ Revised in November 2022
  - **EU RED: Renewable Energy Directive**
  - **Voluntary standards: RSB, ISCC**, etc.

Renewable Energy Directive EU



What are SAF? Sustainable fuels

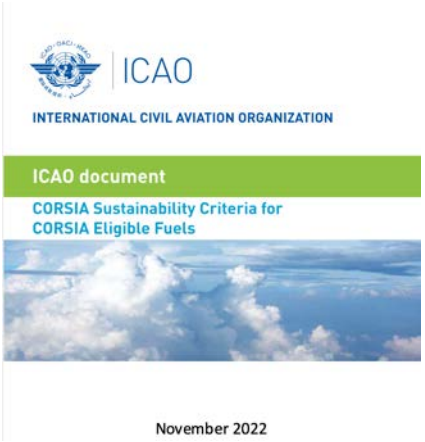
- **ICAO CORSIA** and **EU RED** have a similar approach:
  ***UMBRELLA* STANDARDS**
  - ✓ The **standard/regulation (CORSIA/EU RED)** establishes the criteria to fulfil, for the fuel to be eligible under each respective framework:
    - **Sustainability themes, principles and criteria** (including a minimum GHG emissions savings)
    - **Methodologies to calculate the GHG emissions** savings on a life-cycle basis
  - ✓ Multiple recognised **Sustainability Certification Schemes** can demonstrate compliance with the criteria, using their own approaches, previously assessed and approved by the respective authority



Picture: Saffu in Unsplash

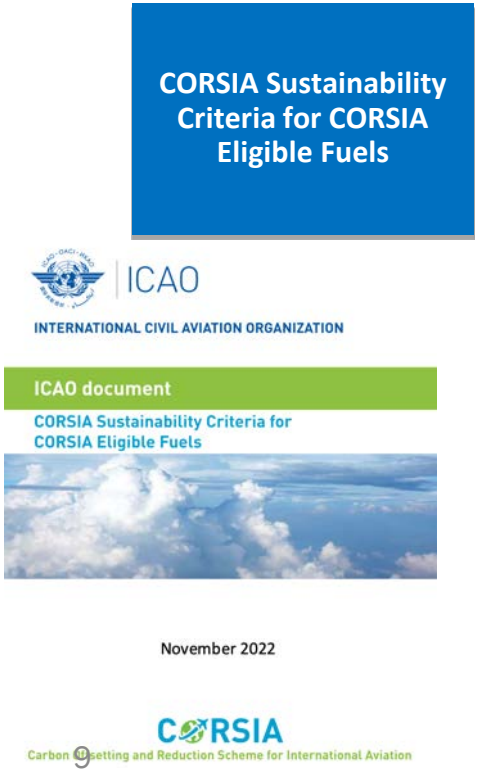
Sustainability Criteria for CORSIA Eligible Fuels

A wide range of criteria ensures **environmental**, **social** and **economic sustainability** of CORSIA eligible fuels



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

Sustainability Criteria for CORSIA Eligible Fuels



Three chapters:

- **Chapter 1:** CORSIA SUSTAINABILITY CRITERIA APPLICABLE FOR BATCHES OF **CORSIA ELIGIBLE FUEL** PRODUCED BY A CERTIFIED FUEL PRODUCER **BEFORE 1 JANUARY 2024**
- **Chapter 2:** CORSIA SUSTAINABILITY CRITERIA APPLICABLE FOR BATCHES OF **CORSIA SUSTAINABLE AVIATION FUEL** PRODUCED BY A CERTIFIED FUEL PRODUCER **ON OR AFTER 1 JANUARY 2024**
- **Chapter 3:** CORSIA SUSTAINABILITY CRITERIA APPLICABLE FOR BATCHES OF **CORSIA LOWER CARBON AVIATION FUEL** PRODUCED BY A CERTIFIED FUEL PRODUCER **ON OR AFTER 1 JANUARY 2024**

Sustainability Criteria for CORSIA Eligible Fuels

Chapter 1: APPLICABLE FOR FUEL PRODUCED **BEFORE 1 JANUARY 2024**

Chapter 1: CORSIA SUSTAINABILITY CRITERIA APPLICABLE FOR BATCHES OF CORSIA ELIGIBLE FUEL PRODUCED BY A CERTIFIED FUEL PRODUCER BEFORE 1 JANUARY 2024

Theme	Principle	Criteria
1. Greenhouse Gases (GHG)	Principle: CORSIA eligible fuel should generate lower carbon emissions on a life cycle basis.	Criterion 1.1: CORSIA eligible fuel will achieve net greenhouse gas emissions reductions of at least 10% compared to the baseline life cycle emissions values for aviation fuel on a life cycle basis.
2. Carbon stock	Principle: CORSIA eligible fuel should not be made from biomass obtained from land with high carbon stock.	Criterion 2.1: CORSIA eligible fuel will not be made from biomass obtained from land converted after 1 January 2008 that was primary forest, wetlands, or peat lands and/or contributes to degradation of the carbon stock in primary forests, wetlands, or peat lands as these lands all have high carbon stocks.
		Criterion 2.2: In the event of land use conversion after 1 January 2008, as defined based on the Intergovernmental Panel on Climate Change (IPCC) land categories, direct land use change (DLUC) emissions will be calculated. If DLUC greenhouse gas emissions exceed the default induced land use change (ILUC) value, the DLUC value will replace the default ILUC value.

Two agreed initial Sustainability Criteria **on CO_2 reduction** for the **CORSIA Pilot Phase** (SAF and LCAF)

- ✓ Net GHG emissions reductions of at least 10% on a life cycle basis
- ✓ No feedstock from deforested areas

Guidance on the application of sustainability criteria

a) Compliance with Themes 1 and 2 is granted on the basis of independent attestation by Sustainability Certification Schemes included in the ICAO document "CORSIA Approved Sustainability Certification Schemes" which is available on the ICAO CORSIA website.
b) A fuel producer can produce batches of CORSIA eligible fuels for 365 calendar days after it has been certified by an SCS for compliance with the CORSIA Sustainability Criteria, after which the fuel producer shall be re-certified for compliance with the sustainability criteria applicable at the time of re-certification.
c) CORSIA Sustainability Criteria for CORSIA Eligible Fuels does not set a precedent for, or prejudge the outcome of negotiations in other fora.

Sustainability Criteria for CORSIA Eligible Fuels

Theme: ENV topic covered by the *standard*

Principle: Agreed requirement for a sustainable production

Criteria: Describe the specific conditions to be met and assessed, to achieve the principles

Guidance: Documentation and information that an SCS can review from a producer, as well as potentially applicable parameters that an SCS can use to demonstrate compliance.

Chapter 1: CORSIA SUSTAINABILITY CRITERIA APPLICABLE FOR BATCHES OF CORSIA ELIGIBLE FUEL PRODUCED BY A CERTIFIED FUEL PRODUCER BEFORE 1 JANUARY 2024

Theme	Principle	Criteria
1. Greenhouse Gases (GHG)	Principle: CORSIA eligible fuel should generate lower carbon emissions on a life cycle basis.	Criterion 1.1: CORSIA eligible fuel will achieve net greenhouse gas emissions reductions of at least 10% compared to the baseline life cycle emissions values for aviation fuel on a life cycle basis.
2. Carbon stock	Principle: CORSIA eligible fuel should not be made from biomass obtained from land with high carbon stock.	Criterion 2.1: CORSIA eligible fuel will not be made from biomass obtained from land converted after 1 January 2008 that was primary forest, wetlands, or peat lands and/or contributes to degradation of the carbon stock in primary forests, wetlands, or peat lands as these lands all have high carbon stocks.
		Criterion 2.2: In the event of land use conversion after 1 January 2008, as defined based on the Intergovernmental Panel on Climate Change (IPCC) land categories, direct land use change (DLUC) emissions will be calculated. If DLUC greenhouse gas emissions exceed the default induced land use change (ILUC) value, the DLUC value will replace the default ILUC value.

Guidance on the application of sustainability criteria

a) Compliance with Themes 1 and 2 is granted on the basis of independent attestation by Sustainability Certification Schemes included in the ICAO document "CORSIA Approved Sustainability Certification Schemes" which is available on the ICAO CORSIA website.

b) A fuel producer can produce batches of CORSIA eligible fuels for 365 calendar days after it has been certified by an SCS for compliance with the CORSIA Sustainability Criteria, after which the fuel producer shall be re-certified for compliance with the sustainability criteria applicable at the time of re-certification.

c) CORSIA Sustainability Criteria for CORSIA Eligible Fuels does not set a precedent for, or prejudge the outcome of negotiations in other fora.

Sustainability Criteria for CORSIA Eligible Fuels

Chapter 2: APPLICABLE FOR **SAF** PRODUCED **ON OR AFTER 1 JANUARY 2024**

For **next CORSIA Phases:**

- ✓ 13 themes applicable for SAF with specific criteria (Chapter 2) :
  - ➢ Environmental: GHG, Carbon Stocks, GHG savings permanence, Water; Soil; Air; Conservation; Waste and Chemicals;
  - ➢ Socio-Economic: Human and labor rights; Land use rights and land use; Water use rights; Local and social development; and Food security
- ✓ Same 14 themes for LCAF with specific criteria (Chapter 3)

Theme	Principle	Criteria
1. Greenhouse Gases (GHG)	Principle: CORSIA SAF should generate lower carbon emissions on a life cycle basis.	Criterion 1.1: CORSIA SAF will achieve net greenhouse gas emissions reductions of at least 10% compared to the baseline life cycle emissions values for aviation fuel on a life cycle basis.
2. Carbon stock	Principle: CORSIA SAF should not be made from biomass obtained from land/aquatic systems with high biogenic carbon stock.	Criterion 2.1: CORSIA SAF will not be made from biomass that is either obtained/extracted from land or aquatic ecosystems converted after 1 January 2008 that was primary forest, wetlands, peat lands, coral reefs, kelp forests, seagrass meadows, estuaries, tidal salt marshes or mangrove forests or contributes to degradation of the carbon stock in primary forests, wetlands, peat lands, coral reefs, kelp forests, seagrass meadows, estuaries, tidal salt marshes or mangrove forests as these systems all have high carbon stocks.
		Criterion 2.2: In the event of land use conversion after 1 January 2008, as defined based on the Intergovernmental Panel on Climate Change (IPCC) land categories, direct land use change (DLUC) emissions will be calculated. If DLUC greenhouse gas emissions exceed the default induced land use change (ILUC) value, the DLUC value will replace the default ILUC value.
3. Greenhouse gas Emissions Reduction Permanence	Principle: Emissions reductions attributed to CORSIA SAF should be permanent.	Criterion 3.1: Operational practices will be implemented to monitor, mitigate and compensate any material incidence of non-permanence resulting from carbon capture and sequestration (CCS) activities.
4. Water	Principle: Production of CORSIA SAF should maintain or enhance water quality and availability.	Criterion 4.1: Operational practices will be implemented to maintain or enhance water quality.
		Criterion 4.2: Operational practices will be implemented to use water efficiently and to avoid the depletion of surface or groundwater resources beyond replenishment capacities.
5. Soil	Principle: Production of CORSIA SAF should maintain or enhance soil health.	Criterion 5.1: Agricultural and forestry best management practices for feedstock production or residue collection will be implemented to maintain or enhance soil health, such as physical, chemical and biological conditions.
6. Air	Principle: Production of CORSIA SAF should minimize negative effects on air quality.	Criterion 6.1: Air pollution emissions will be limited.
7. Conservation	Principle: Production of CORSIA SAF should maintain biodiversity, conservation value, and ecosystem services.	Criterion 7.1: CORSIA SAF will not be made from biomass obtained from areas that, due to their biodiversity, conservation value, or ecosystem services, are protected by the State having jurisdiction over that area, unless evidence is provided that shows the activity does not interfere with the protection purposes.
		Criterion 7.2: Low invasive-risk feedstock will be selected for cultivation and appropriate controls will be adopted with the intention of preventing the uncontrolled spread of cultivated alien species and modified microorganisms
		Criterion 7.3: Operational practices will be implemented to avoid adverse effects on areas that, due their biodiversity, conservation value, or ecosystem services, are protected by the State having jurisdiction over that area.
8. Waste and Chemicals	Principle: Production of CORSIA SAF should promote responsible management of waste and use of chemicals.	Criterion 8.1: Operational practices will be implemented to ensure that waste arising from production processes as well as chemicals used are stored, handled, and disposed of responsibly.
		Criterion 8.2: Responsible and science-based operational practices will be implemented to limit or reduce pesticide use.
		Criterion 8.3: Operational practices will be implemented to prevent, minimize, and mitigate any damage from unintentional release of fossil resources, fuel products, and/or other chemicals.
9. Seismic and Vibrational Impacts	Not applicable	Not applicable
10. Human and labour rights	Principle: Production of CORSIA SAF should respect human and labour rights.	Criterion 10.1: CORSIA SAF production will respect human and labour rights.
11. Land use rights and land use	Principle: Production of CORSIA SAF should respect land rights and land use rights including indigenous and/or customary rights.	Criterion 11.1: CORSIA SAF production will respect existing land rights and land use rights including indigenous peoples' rights, both formal and informal.
12. Water use rights	Principle: Production of CORSIA SAF should respect prior formal or customary water use rights.	Criterion 12.1: CORSIA SAF production will respect the existing water use rights of local and indigenous communities.
13. Local and social development	Principle: Production of CORSIA SAF should contribute to social and economic development in regions of poverty.	Criterion 13.1: CORSIA SAF production will strive to, in regions of poverty, improve the socioeconomic conditions of the communities affected by the operation.
14. Food security	Principle: Production of CORSIA SAF should promote food security in food insecure regions.	Criterion 14.1: CORSIA SAF production will, in food insecure regions, strive to enhance the local food security of directly affected stakeholders.

Sustainability Criteria for CORSIA Eligible Fuels

- **Not all Themes are to be be assessed in the same way:**

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
10. Human and labour rights
11. Land use rights and land use
12. Water use rights
13. Local and social development
14. Food security

Compliance with Themes 1 to 8 is granted on independent attestation by approved Sustainability Certification Schemes (SCS)
and for Themes 4 to 8, also considering the guidance approved by the Council

Compliance with themes 10-12 can be **demonstrated to the SCS by a national attestation from the State in whose territory the SAF is produced**, without further assessment by the SCS

Compliance with 13-14 will be demonstrated by **reporting to the SCS the actions being taken to meet the related criteria,** without further judgement of those actions by the SCS

Sustainability Criteria for CORSIA Eligible Fuels

Chapter 2: APPLICABLE FOR **SAF** PRODUCED **ON OR AFTER 1 JANUARY 2024**

Theme	Principle	Criteria
1. Greenhouse Gases (GHG)	Principle: CORSIA SAF should generate lower carbon emissions on a life cycle basis.	Criterion 1.1: CORSIA SAF will achieve net greenhouse gas emissions reductions of at least 10% compared to the baseline life cycle emissions values for aviation fuel on a life cycle basis.
2. Carbon stock	Principle: CORSIA SAF should not be made from biomass obtained from land/aquatic systems with high biogenic carbon stock.	Criterion 2.1: CORSIA SAF will not be made from biomass that is either obtained/extracted from land or aquatic ecosystems converted after 1 January 2008 that was primary forest, wetlands, peat lands, coral reefs, kelp forests, seagrass meadows, estuaries, tidal salt marshes or mangrove forests or contributes to degradation of the carbon stock in primary forests, wetlands, peat lands, coral reefs, kelp forests, seagrass meadows, estuaries, tidal salt marshes or mangrove forests as these systems all have high carbon stocks.
		Criterion 2.2: In the event of land use conversion after 1 January 2008, as defined based on the Intergovernmental Panel on Climate Change (IPCC) land categories, direct land use change (DLUC) emissions will be calculated. If DLUC greenhouse gas emissions exceed the default induced land use change (ILUC) value, the DLUC value will replace the default ILUC value.
3. Greenhouse gas Emissions Reduction Permanence	Principle: Emissions reductions attributed to CORSIA SAF should be permanent.	Criterion 3.1: Operational practices will be implemented to monitor, mitigate and compensate any material incidence of non-permanence resulting from carbon capture and sequestration (CCS) activities.
4. Water	Principle: Production of CORSIA SAF should maintain or enhance water quality and availability.	Criterion 4.1: Operational practices will be implemented to maintain or enhance water quality.
		Criterion 4.2: Operational practices will be implemented to use water efficiently and to avoid the depletion of surface or groundwater resources beyond replenishment capacities.
5. Soil	Principle: Production of CORSIA SAF should maintain or enhance soil health.	Criterion 5.1: Agricultural and forestry best management practices for feedstock production or residue collection will be implemented to maintain or enhance soil health, such as physical, chemical and biological conditions.
6. Air	Principle: Production of CORSIA SAF should minimize negative effects on air quality.	Criterion 6.1: Air pollution emissions will be limited.
7. Conservation	Principle: Production of CORSIA SAF should maintain biodiversity, conservation value, and ecosystem services.	Criterion 7.1: CORSIA SAF will not be made from biomass obtained from areas that, due to their biodiversity, conservation value, or ecosystem services, are protected by the State having jurisdiction over that area, unless evidence is provided that shows the activity does not interfere with the protection purposes.
		Criterion 7.2: Low invasive-risk feedstock will be selected for cultivation and appropriate controls will be adopted with the intention of preventing the uncontrolled spread of cultivated alien species and modified microorganisms
		Criterion 7.3: Operational practices will be implemented to avoid adverse effects on areas that, due their biodiversity, conservation value, or ecosystem services, are protected by the State having jurisdiction over that area.
8. Waste and Chemicals	Principle: Production of CORSIA SAF should promote responsible management of waste and use of chemicals.	Criterion 8.1: Operational practices will be implemented to ensure that waste arising from production processes as well as chemicals used are stored, handled, and disposed of responsibly.
		Criterion 8.2: Responsible and science-based operational practices will be implemented to limit or reduce pesticide use.
		Criterion 8.3: Operational practices will be implemented to prevent, minimize, and mitigate any damage from unintentional release of fossil resources, fuel products, and/or other chemicals.

Compliance with Themes 1 to 8 is granted on the basis of independent attestation by approved SCS taking into account guidance approved by the Council

Sustainability Criteria for CORSIA Eligible Fuels

Chapter 2: APPLICABLE FOR **SAF** PRODUCED **ON OR AFTER 1 JANUARY 2024**

THEME	PRINCIPLE	CRITERA
9. Seismic and Vibrational Impacts	Not applicable	Not applicable
10. Human and labour rights	Principle: Production of CORSIA SAF should respect human and labour rights.	Criterion 10.1: CORSIA SAF production will respect human and labour rights.
11. Land use rights and land use	Principle: Production of CORSIA SAF should respect land rights and land use rights including indigenous and/or customary rights.	Criterion 11.1: CORSIA SAF production will respect existing land rights and land use rights including indigenous peoples' rights, both formal and informal.
12. Water use rights	Principle: Production of CORSIA SAF should respect prior formal or customary water use rights.	Criterion 12.1: CORSIA SAF production will respect the existing water use rights of local and indigenous communities.
13. Local and social development	Principle: Production of CORSIA SAF should contribute to social and economic development in regions of poverty.	Criterion 13.1: CORSIA SAF production will strive to, in regions of poverty, improve the socioeconomic conditions of the communities affected by the operation.
14. Food security	Principle: Production of CORSIA SAF should promote food security in food insecure regions.	Criterion 14.1: CORSIA SAF production will, in food insecure regions, strive to enhance the local food security of directly affected stakeholders.

Not applicable to SAF

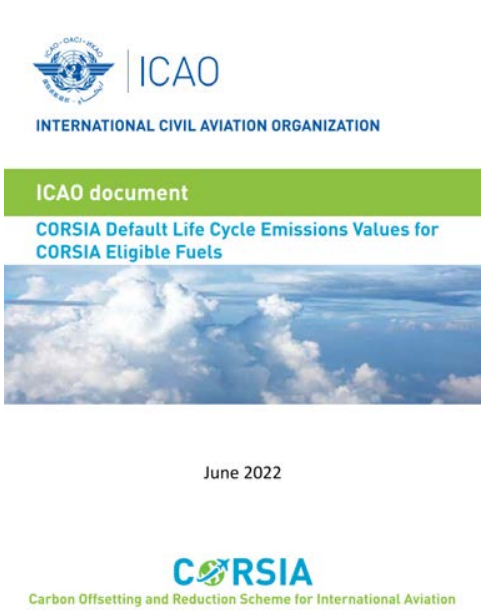
National attestation of compliance is considered sufficient

Compliance is exclusively based on a report of actions, without further judgement of those actions

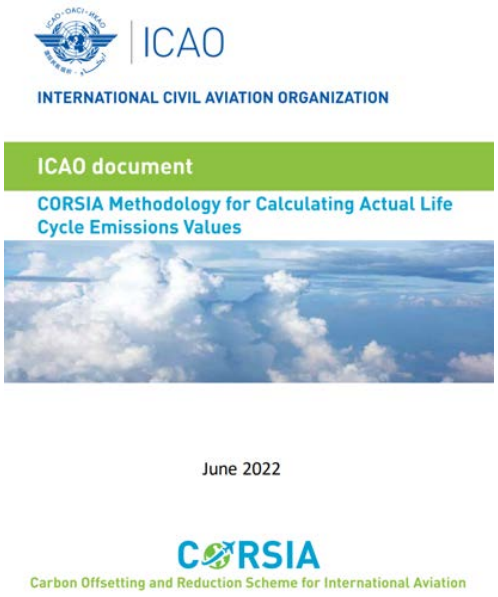
Methodologies to calculate GHG savings

- Economic operators can either:

Use GHG default values calculated by ICAO



Calculate them using an approved methodology



Similar approach as in the EU RED

Methodologies to calculate GHG savings

- Different approach to address indirect/induced land-use change (ILUC):

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_r (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
Brazil	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-20.4	14.0
USA	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-21.4	13.0
Global	Brassica carinata oil	Feedstock is grown as a secondary crop that avoids other crops displacement	34.4	-12.7	21.7
Global	Camelina oil	Feedstock is grown as a secondary crop that avoids other crops displacement	42.0	-13.4	28.6
India	Jatropha oil	Meal used as fertilizer or electricity input	46.9	-24.8	22.1
India	Jatropha oil	Meal used as animal feed after detoxification	46.8	-48.1	-1.3

ICAO estimates through modelling ILUC values

EU RED

Sets limits on high ILUC-risk biofuels, bioliquids and biomass fuels with a significant expansion in land with high carbon stock.

Both introduce exemptions for SAF certified as **low ILUC-risk**

Background: What are SAF?

- ✓ **SAF definitions**
  - ✓ SAF Sustainability criteria
- ✓ **SAF qualification: How SAF can be produced**
  - ✓ Technology options and approved SAF technology pathways
  - ✓ SAF of non-biological origin
  - ✓ Recycled Carbon Fuels

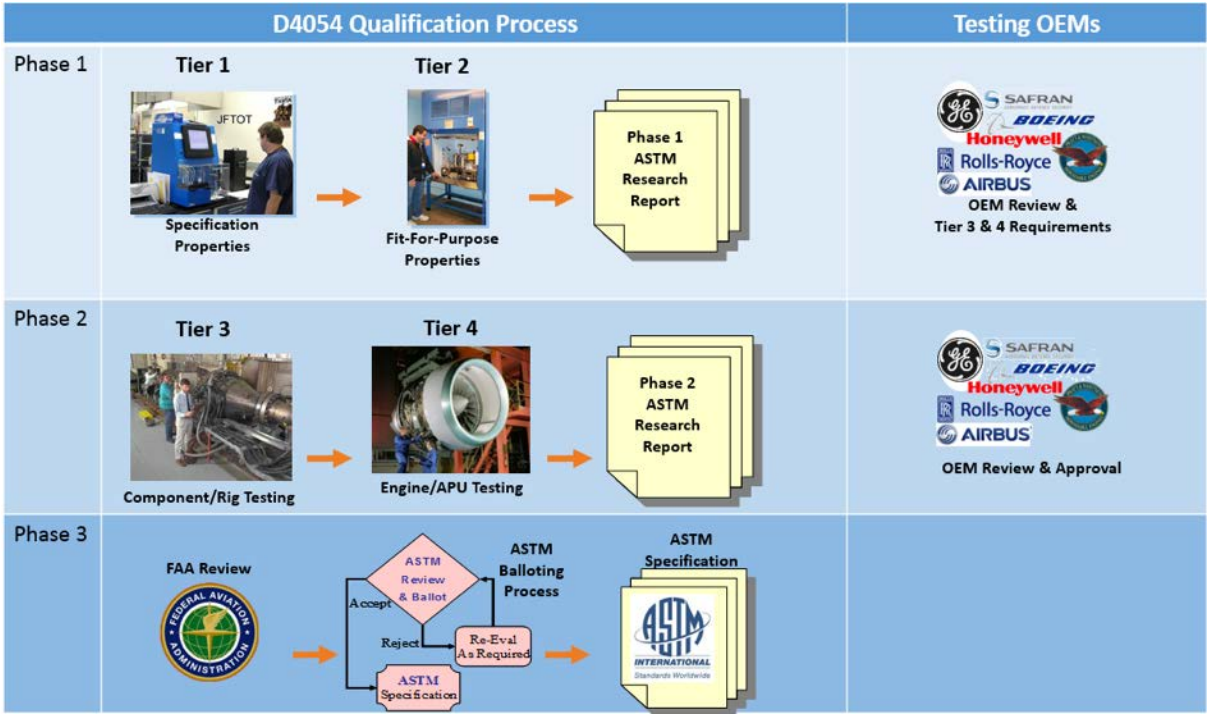
What are SAF? Aviation *drop-in* fuels

- SAF need to **comply with global standards** and have **at least the same level of operational safety requirements as conventional fuels** in order to ensure compatibility with its use on existing and future civil aircraft fleets:
  - **2009:** the American Society for Testing and Materials (ASTM) International, issued the **ASTM D7566** for ***Aviation Turbine Fuel Containing Synthesized Hydrocarbons***
    - ➢ It is **still the standard today for new SAF technologies** > **European standards incorporates those approved by ASTM**
  - The **EU (EASA)** and the **UK** are currently developing **SAF qualification processes** similar to the ASTM one (“Clearing House” concept).

SAF qualification (*clearing house* process)

New SAF production pathways are assessed against the ASTM D4054 Standard Practice and once approved, each pathway is later included within ASTM D7566 Fuel Standard.

Extensive testing is required to ensure the fuel is fit for purpose and performs within expected norms.



Technology options: How SAF can be produced?

- Today **nine technology pathways have been approved** to produce drop-in SAF

BLEND

ASTM INTERNATIONAL

D7566

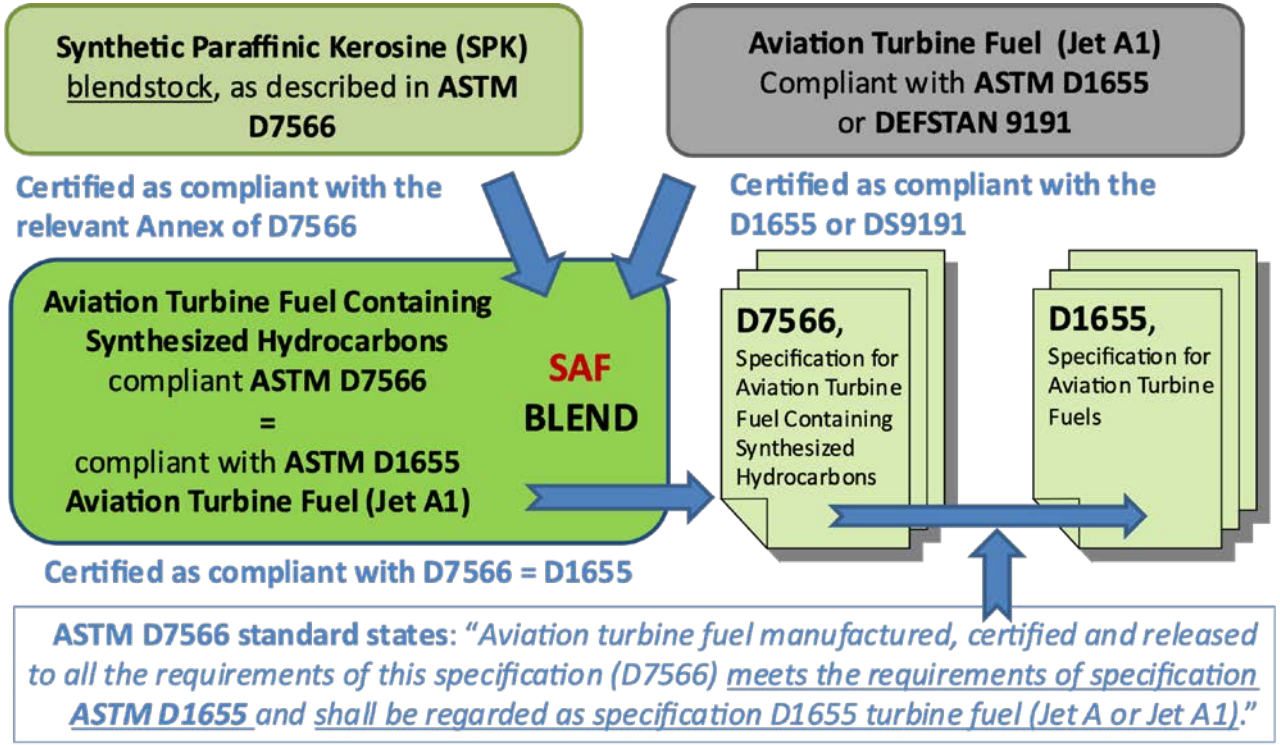
1. Annex A1: **Fischer Tropsch (FT) Synthetic Paraffinic Kerosene** (**FT SPK**), approved in 2009 — Up to **50%**
2. Annex A2: **Hydro-processed Esters and Fatty Acids** (**HEFA SPK**), approved in 2011 — Up to **50%**
3. Annex A3: **Hydro-processed Fermented Sugar** (**HFS-SIP**) approved in 2014 → Up to **10%**
4. Annex A4: **SPK plus aromatics** (**FT-SPK/A**), approved in 2015 — Up to **50%**
5. Annex A5: **Alcohol to Jet** (**ATJ-SPK**), approved in 2016 for isobutanol feedstock and updated in 2018 for ethanol feedstock. — Up to **50%**
6. Annex A6: **Catalytic Hydrothermolysis Synthesized Kerosene** (CH-SK, or CHJ), approved in 2020 — Up to **50%**
7. Annex A7: **Hydroprocessed Hydrocarbons, Esters and Fatty Acids Synthetic Paraffinic Kerosene** (HHC-SPK or HC-HEFA-SPK), approved in 2020 → Up to **10%**

D1655

8. Annex A1: **co-processing** of fats and oils in a conventional refinery, approved in 2018 → Biogenic input **up to 5 vol%** of fossil fraction.
9. Annex A1: **co-processing** of Fischer Tropsch Biocrude, approved in 2020 → Biogenic input **up to 5 vol%** of fossil fraction.

SAF blending and certification as JetA1

The current approved technology options defined in ASTM D7566 require blending with fossil JetA1



SAF blending and certification as JetA1

- Additional pathways are currently in the ASTM certification process

✓ Some will not need blending with fossil

Source: https://www.caafi.org

Current Fuels in the D4054 Qualification Process

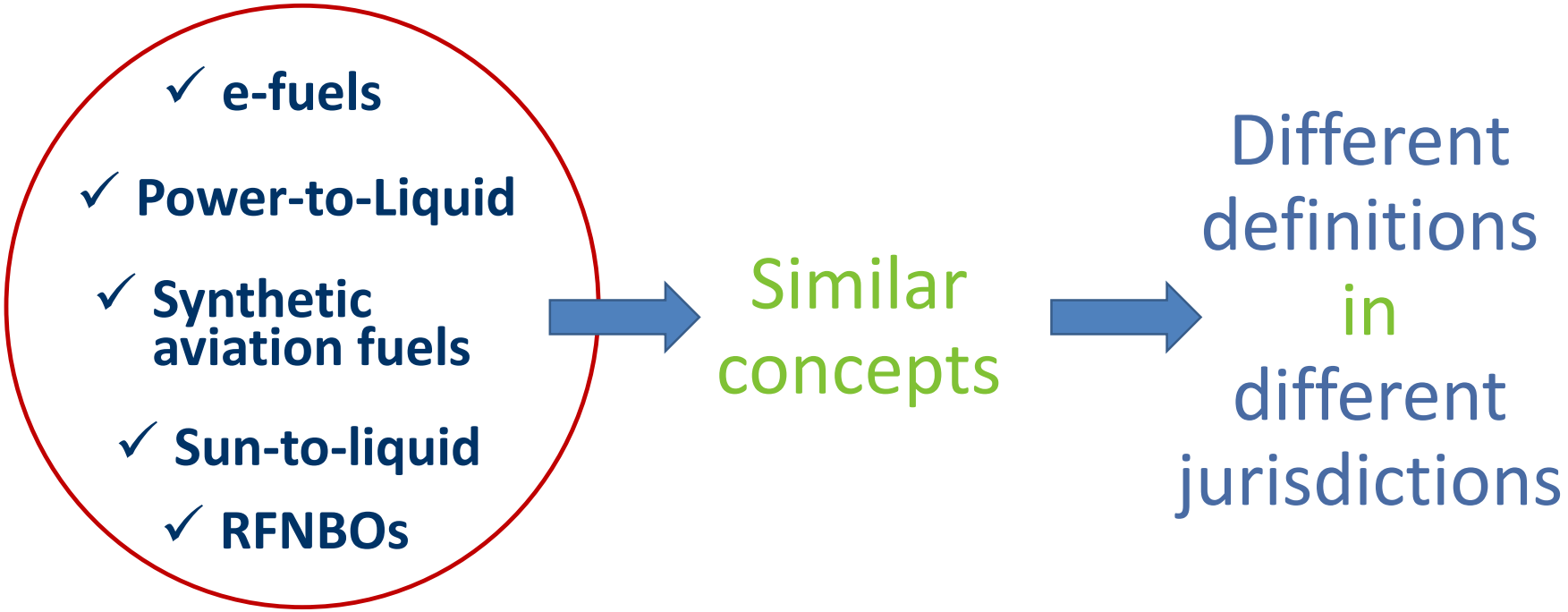
The table below shows the pathways actively pursuing certification at various stages in the process.

ASTM Progress	Pathway	Feedstock	Task Force Lead
ASTM Balloting			
Phase 2 OEM Review			
Phase 2 Testing	Hydro-deoxygenation Synthetic Kerosene (HDO-SK)	Sugars and cellulosics	Virent (inactive)
	Hydro-deoxygenation Synthetic Aromatic Kerosene (HDO-SAK)	Sugars and cellulosics	Virent
Phase 1 OEM Review	High Freeze Point Hydroprocessed Esters and Fatty Acids Synthetic Kerosene (HFP HEFA-SK)	Renewable FOG	Boeing
	Integrated Hydropyrolysis and Hydroconversion (IH^2)	Lignocellulosics	Shell
Phase 1 Research Report			
Phase 1 Testing	Alcohol-to-Jet Synthetic Kerosene with Aromatics (ATJ-SKA)	Sugars and lignocellulosics	Swedish Biofuels, Byogy
	Alcohol-to-Jet (ATJ)	Sugars	Global Bioenergies

Background: What are SAF?

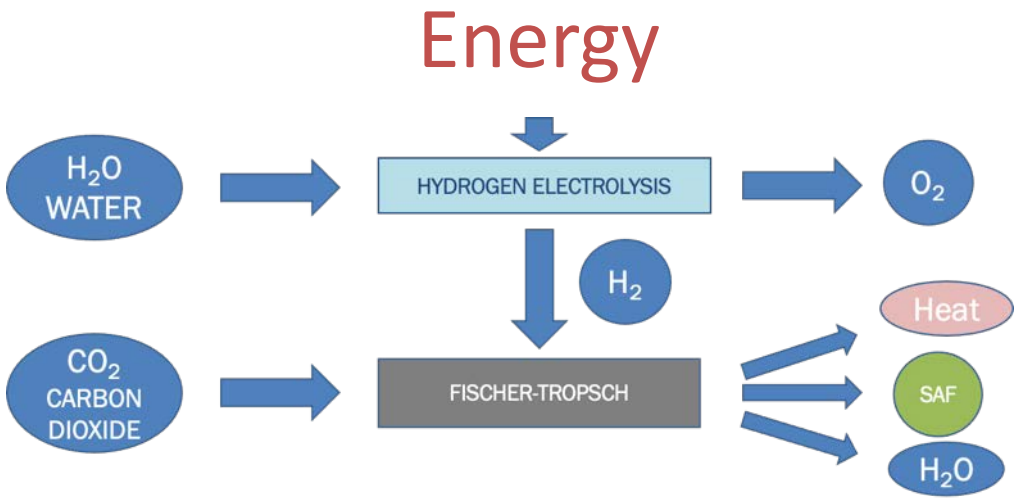
- ✓ **SAF definitions**
  - ✓ SAF Sustainability criteria
- ✓ **SAF qualification: How SAF can be produced**
  - ✓ Technology options and approved SAF technology pathways
  - ✓ SAF of non-biological origin
  - ✓ Recycled Carbon Fuels

SAF of non-biological origin



SAF of non-biological origin

- ✓ Uses **CO_2 as feedstock**
- ✓ Needs a **large amount of energy** to be produced
- ✓ Allows **different sources of energies to be stored in liquid fuels** (Power-to-Liquid or electro-fuels, Sun-to-liquid, etc.)



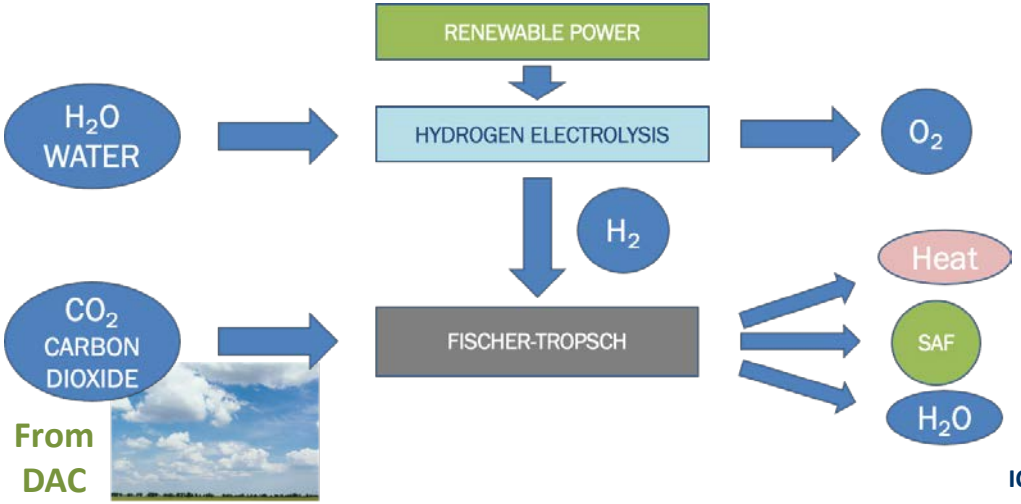
SAF of non-biological origin

- Can be:
  - **SUSTAINABLE and RENEWABLE:** are made from renewable sources other than biomass. These can be of solar, wind, geothermal and hydropower origin, and used as feedstock H_2O and CO_2, from direct air capture (DAC).
  - **SUSTAINABLE but NOT RENEWABLE:** power can be of non-renewable origin or CO_2 could be sourced from industrial gases (recycled carbon fuels).

SAF of non-biological origin

➢ Examples of **SUSTAINABLE** and **RENEWABLE**:

- **E-fuels / PtL** using CO_2 from **direct air capture** :



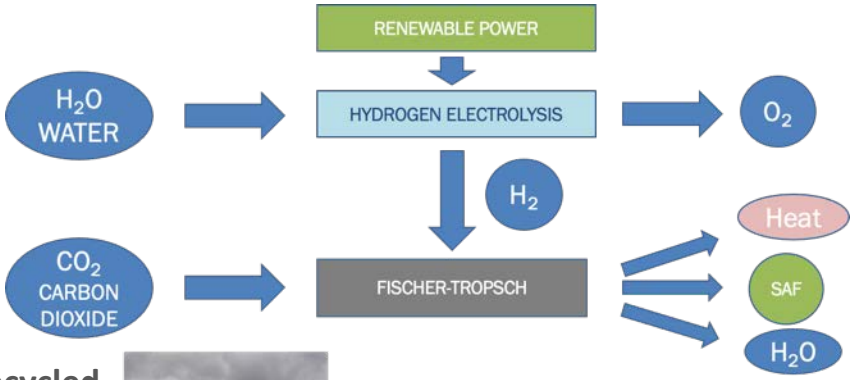
- **Sun-to-Liquid** technology, using concentrated solar radiation to drive a thermochemical process

Photo: ©ARTTIC 2019

SAF of non-biological origin

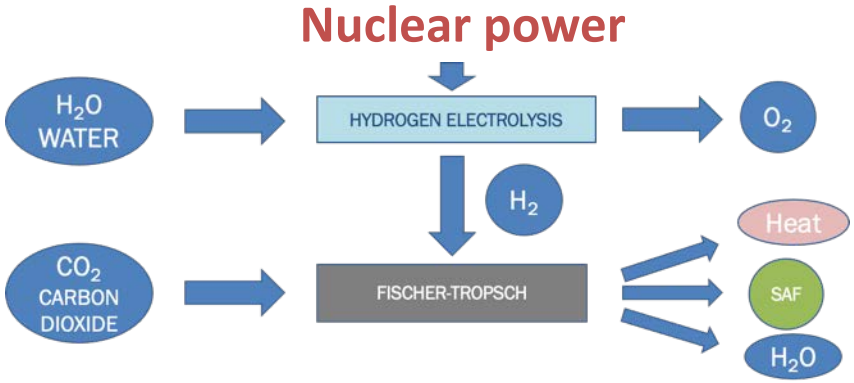
- Examples of **SUSTAINABLE** but **NOT RENEWABLE:**

  - **E-fuels / PtL** using CO_2 from industrial gases



Recycled Carbon

  - **E-fuels / PtL** using nuclear power



SAF of non-biological origin

- Key challenges
  - ✓ High use of Power: Competition with other uses
  - ✓ The technology is not yet mature: No commercial production yet
  - ✓ High production costs

Thank you for your attention!

For more information

www.ecac-ceac.org

@ecacceac