EASA
European Union Aviation Safety Agency

EUROPEAN UNION

Welcome to the 13th webinar of the series on

Sustainability - EU/SEA CCCA CORSIA Project

The webinar will start @ 15h Bangkok/Jakarta/Hanoi Time

16h Singapore/Manila Time

10h Brussels/Cologne Time

1977-2022
EU-ASEAN
45 YEARS OF PARTNERSHIP

Your safety is our mission.

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CORSIA Eligible Fuels:
« SAF Feedstocks and Regulation»

Working for sustainable aviation.
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EU-SEA CCCA CORSIA project

Objective: Support to ASEAN MS in CO2 reduction from International Aviation

Areas of Action:

- ✓ CORSIA Implementation
- ✓ Support to State Action Plan for CO2 Reduction
- ✓ Emission data management systems
- ✓ Climate Change Policies (e.g. SAF)

Some practicalities & moderators

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→ **Q&A** after the speaker
- → Use Q&A section (Slido)
- → Vote up questions

→ **Free chat**, please express yourself live

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#SAF13

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Webinar 13:

SAF Feedstocks and Regulations

An Agency of the European Union

Our key speakers for today!

Dr. Georg Markowz

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CBR Consult & Invest GmbH

Senior Technology Expert

More than 25 years in the chemical industry with focus on process- & technology development for chemical energy conversion for fuels and chemicals production

Consulting Focus @ CBR

- *Technology assessments, feasibility studies and techno-economic analysis on technologies related to renewable liquids and gases, electrical and chemical energy storage, etc.*
- *Expert in green product transformation and in regulatory policies with major focus on renewable fuels, green chemicals, hydrogen, carbon capture & utilization/sequestration, etc.*
- *Focus on renewable fuels process technologies, global feedstock availabilities (biomass, waste, electricity, etc.) and CO2 reduction opportunities (Life-cycle-analysis)*

Education

Engineering Doctorate , RWTH Aachen University, Germany

Graduate Mechanical Engineer, RWTH Aachen University, Germany / Thayer School of Engineering at Dartmouth, USA

Our key speakers for today!

Christoph Behrendt-Rieken

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CBR Consult & Invest GmbH

Managing Partner

More than 15 years experience in the chemical process industry, large production infrastructure projects and technology development with focus on green transition of various industries via ClimateTech related innovation (renewable fuel, green chemistry, sustainability, environmental management systems, environmental certification, etc.)

Consulting Focus @ CBR Consult & Invest GmbH

- *Commercial project development and deal advisory (due diligences, etc.) of green energy, fuel and chemicals investments and production plant projects*
- *Renewable fuel and chemical regulatory, commercial and technology expertise*

Education

- *EMBA -Executive Master of Business Administration-, Kellogg School of Management at Northwestern University / WHU Otto Beisheim School of Management*
- *Diploma -International Business Studies-, University of Paderborn, Germany / École Supérieure de Commerce de Reims, Grande École / NEOMA Business School, France*


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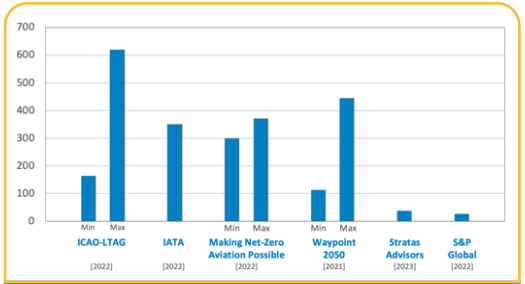
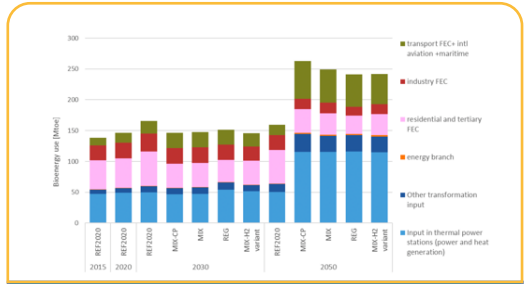
Guiding questions today



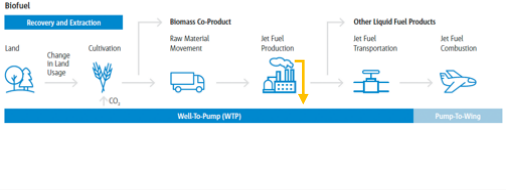
How is feedstock demand linked to the development of **SAF demand**?

1. HEFA
2. Power-to-Liquid
3. Waste-to-Liquid
4. Biomass-to-Liquid
5. Alcohol-to-Jet
6. Hybrid fuels, e.g. PBtL

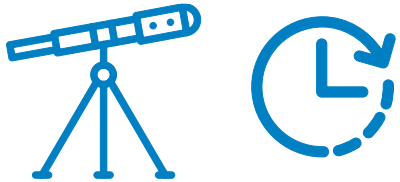
How is feedstock demand linked to the development of **SAF technologies**?



How is feedstock demand linked to the development of **demand from other sectors**?



Why is it important to look at **feedstock energy and carbon feedstock separately**?



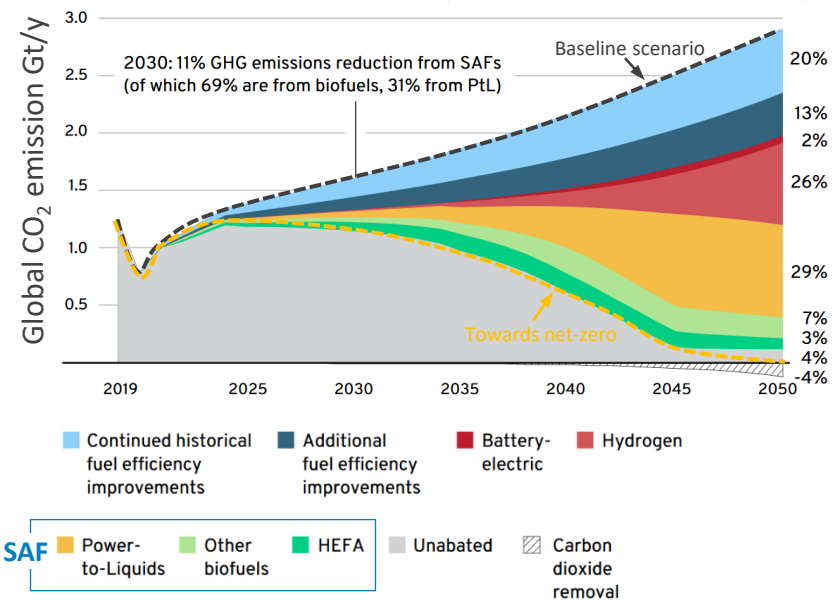
What are **trends to be watched**?

SAF: Sustainable Aviation Fuel; Source: CBR, 2023

Low-carbon substitutes for fossil jet kerosene are critical to decarbonise aviation as hard-to-abate sector.

Slide from Workshop #11
(C. Boscagli, C. Behrendt-Rieken)

Global CO_2 emissions from aviation alone exceeded **1 billion tons** in 2019, accounting for **>2%** of total anthropogenic CO_2 emissions.

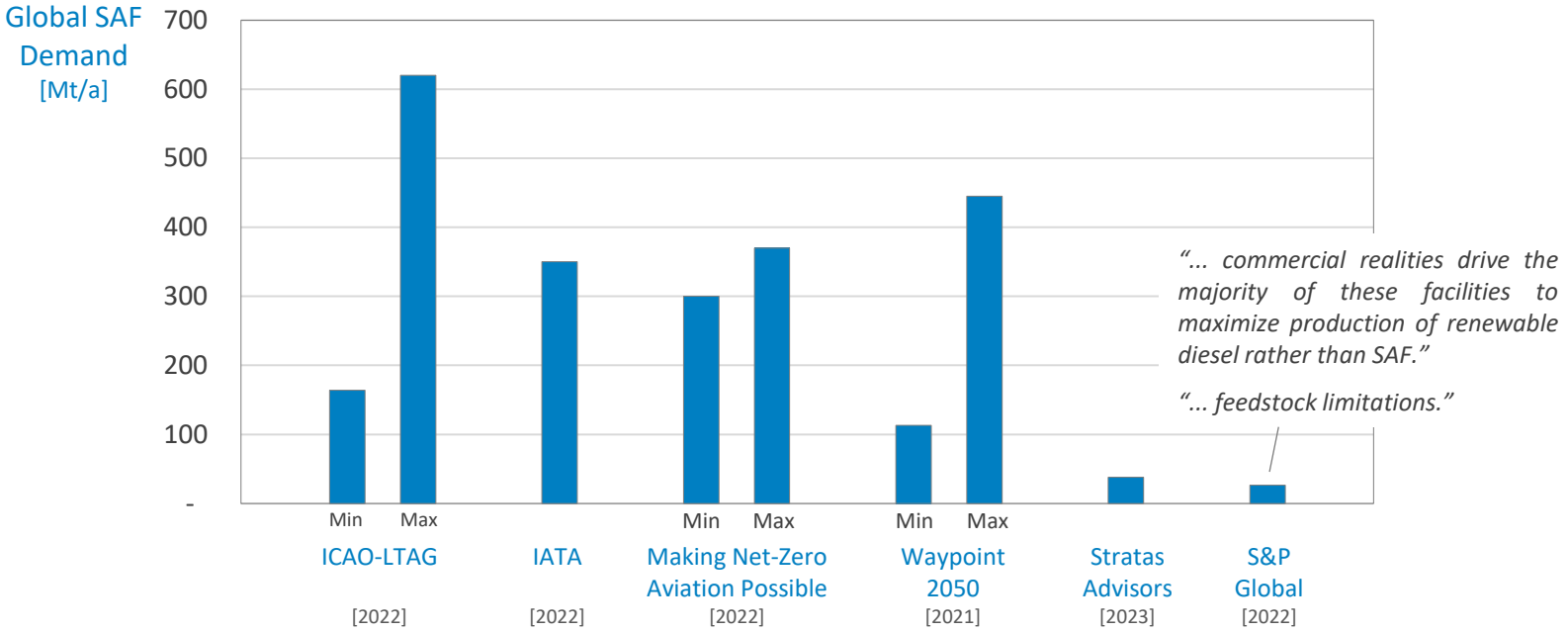


	GHG reduction	Regional flight	Short haul	Medium/ Long haul
Batteries	100%	✓		
H_2 Hydrogen	100%	✓	✓	
Sustainable Aviation Fuel	70-99%	✓	✓	✓

- Global jet-fuel demand in 2019: **~360 million tons.**
- **Batteries and hydrogen are limited** to shorter flights.
- **SAF** shows an intrinsic advantage by having similar properties to jet-fuel, offering a **drop-in compatibility** with the available fleet technology, and being suitable **for long-distance travel.**
- Various studies predict scenarios for 2050, where SAF global demand could be between **300-500 million tons**.

GHG: Green House Gas; SAF: Sustainable Aviation Fuel; PtL: Power-to-Liquid; Hydro Treated Esters and Fatty Acids
Source: Mission Possible Partnership, Making net-zero aviation possible, 2022; CBR, 2023

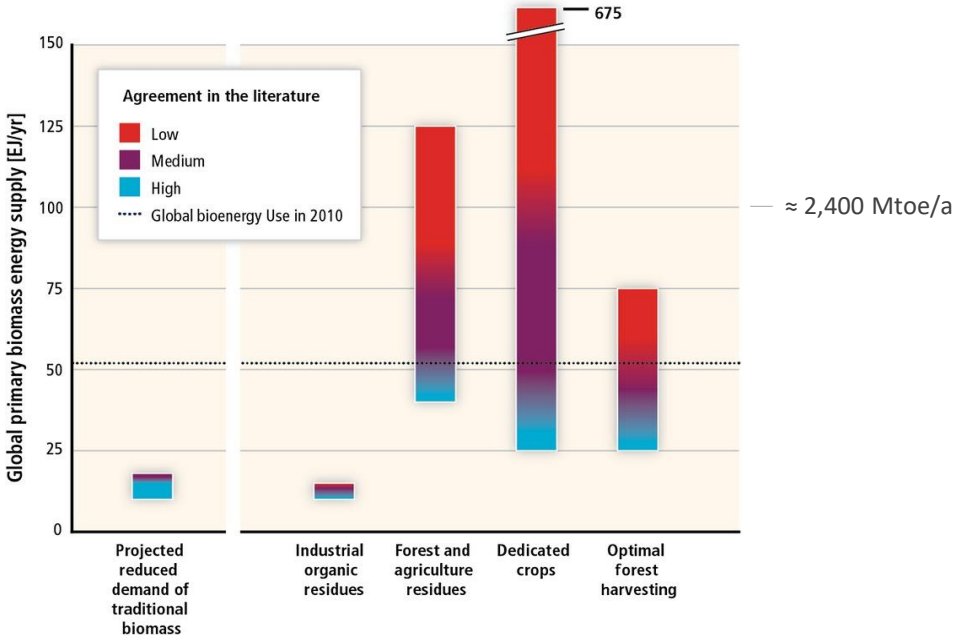
A differentiated look at various studies reveals a broad range of forecasts for SAF demand by 2050 including scenarios for very low demand.



- Significant **uncertainty in forecast** for SAF demand.
- **Many parameters are to be considered** such as overall development of aviation industry, relevance of alternative solutions (e.g., hydrogen and electric aviation) and not the least **availability and costs of feedstock for SAF.**

SAF: Sustainable Aviation Fuel
Source: ICAO, 2022; IATA, 2022; WEF, 2022; ATAG, 2021; Stratas Advisors, 2023; S&P Global, 2022; CBR, 2023

The discussion on biogenic feedstock potentials is in fact quite controversial, even in science.



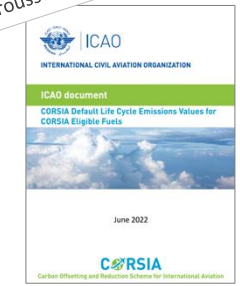
- It is very **difficult** if not impossible, to **achieve a common understanding on available biogenic feedstock potentials** for energy purposes as of today.
- Further impact on feedstock potential results from **what will be recognized by regulation**.

Mtoe: Million ton of oil equivalent
Source: Creutzig et al., 2015; CBR, 2023

The pool of eligible feedstock can vary a lot dependent on the regulatory framework resulting in discrepancies regarding overall feedstock potential.

See also slides from Workshop #12 (Daniel Brousse Rivas)

Example comparison of feedstock pools according to CORSIA vs. ReFuelEU Aviation & Renewable Energy Directive



Minimum GHG saving
- 10 %

Eligible feedstock categories
- Residues
- Waste
- By-Products
- Co-Products
- Main Products
  - Sugarcane, Sugar beet
  - Soybean oil, Rapeseed oil, Palm oil
  - Corn
  - Primary biomass
  - ...

Minimum GHG saving
- 70 % for RFNBO-SAF
- 65 % for all other SAF

Eligible feedstock categories
- Residues
- Waste
- By-Products

No “Main Products”, especially no food and feed crops

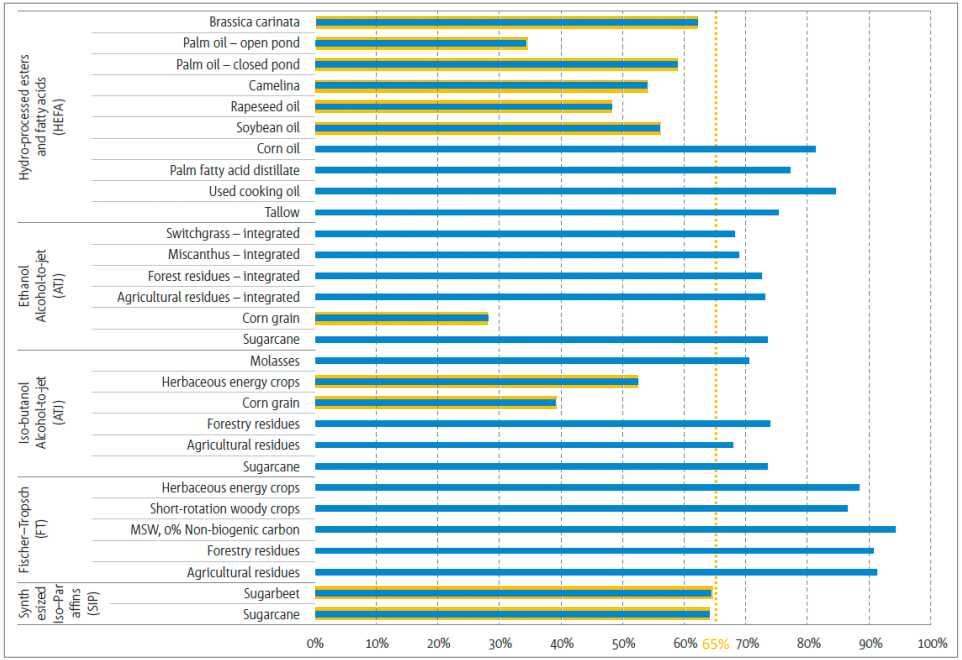
Fuels from waste according to Annex IX/B are capped (1.7 % by energy)

- **Heterogeneous regulation landscape with respect to sustainability criteria** - especially regarding treatment of food and feed crops but also regarding minimum GHG savings - currently results in **highly region-dependent feedstock potential**.

CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation; RFNBO: Renewable Fuels of Non-Biological Origin; GHG: Green House Gas; SAF: Sustainable Aviation Fuel; Source: ICAO, 2022; EC, 2018/2021; CBR, 2023

When comparing the resulting feedstock potentials, it is important to consider associated GHG saving potentials.

LCA emissions reductions for CORSIA eligible SAF pathways and feedstock compared to a fossil fuel reference value (89 g_{CO2e}/MJ)

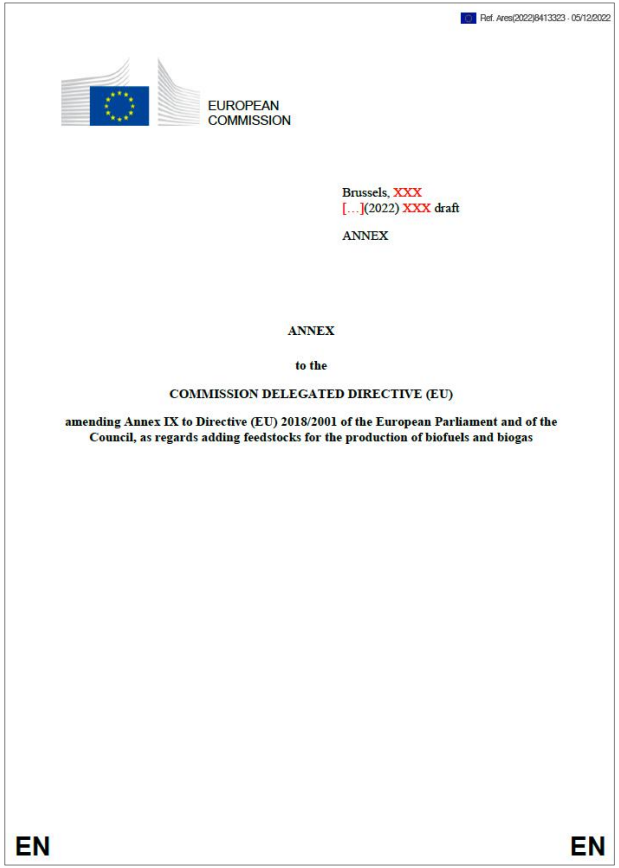


- **Feedstock with high mass potential** (e.g., corn, vegetable oils) in tendency allow for **only moderate specific GHG savings** resulting in respectively **higher need to offset residual emissions** by other means.

CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation; GHG: Green House Gas; LCA: Life Cycle Assessment
Source: EASA, European Aviation Environmental Report, 2022; CBR, 2023

By regular revision and extension of the list of eligible feedstock, the EU seeks to increase the available sustainable feedstock potential.

Draft of Amendment for Annex IX Part A and B for public consultation (Dec 2022)



Ref. Ares(2022)8413323 - 05/12/2022

EUROPEAN COMMISSION

Brussels, XXX
[…](2022) XXX draft

ANNEX

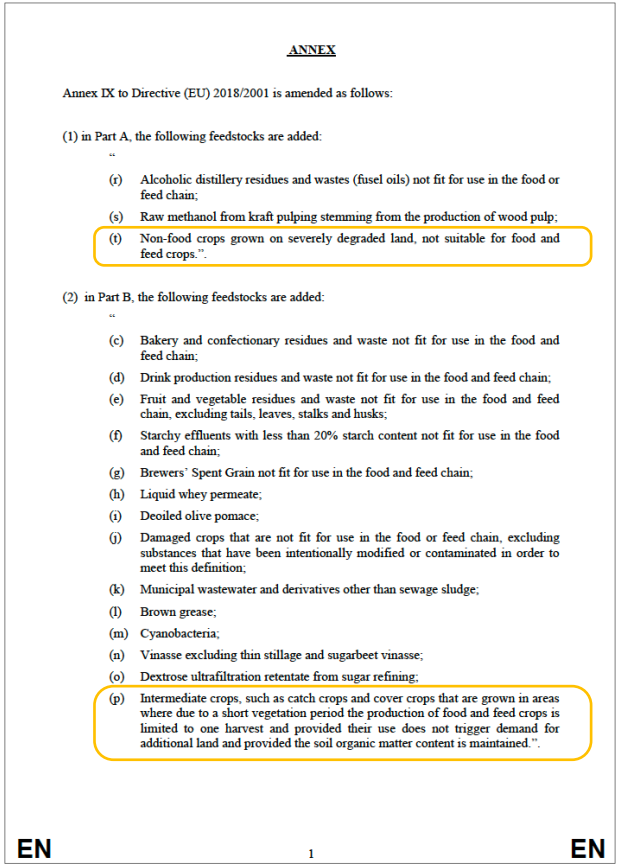
ANNEX

to the

COMMISSION DELEGATED DIRECTIVE (EU)

amending Annex IX to Directive (EU) 2018/2001 of the European Parliament and of the Council, as regards adding feedstocks for the production of biofuels and biogas

EN EN



ANNEX

Annex IX to Directive (EU) 2018/2001 is amended as follows:

(1) in Part A, the following feedstocks are added:

"

(r) Alcoholic distillery residues and wastes (fusel oils) not fit for use in the food or feed chain;

(s) Raw methanol from kraft pulping stemming from the production of wood pulp;

(t) Non-food crops grown on severely degraded land, not suitable for food and feed crops.".

(2) in Part B, the following feedstocks are added:

"

(c) Bakery and confectionary residues and waste not fit for use in the food and feed chain;

(d) Drink production residues and waste not fit for use in the food and feed chain;

(e) Fruit and vegetable residues and waste not fit for use in the food and feed chain, excluding tails, leaves, stalks and husks;

(f) Starchy effluents with less than 20% starch content not fit for use in the food and feed chain;

(g) Brewers' Spent Grain not fit for use in the food and feed chain;

(h) Liquid whey permeate;

(i) Deoiled olive pomace;

(j) Damaged crops that are not fit for use in the food or feed chain, excluding substances that have been intentionally modified or contaminated in order to meet this definition;

(k) Municipal wastewater and derivatives other than sewage sludge;

(l) Brown grease;

(m) Cyanobacteria;

(n) Vinasse excluding thin stillage and sugarbeet vinasse;

(o) Dextrose ultrafiltration retentate from sugar refining;

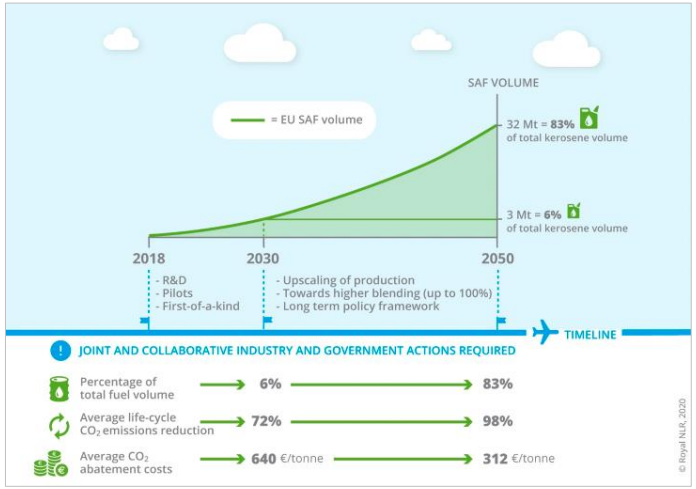
(p) Intermediate crops, such as catch crops and cover crops that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest and provided their use does not trigger demand for additional land and provided the soil organic matter content is maintained.".

EN 1 EN

Source: CBR, 2023

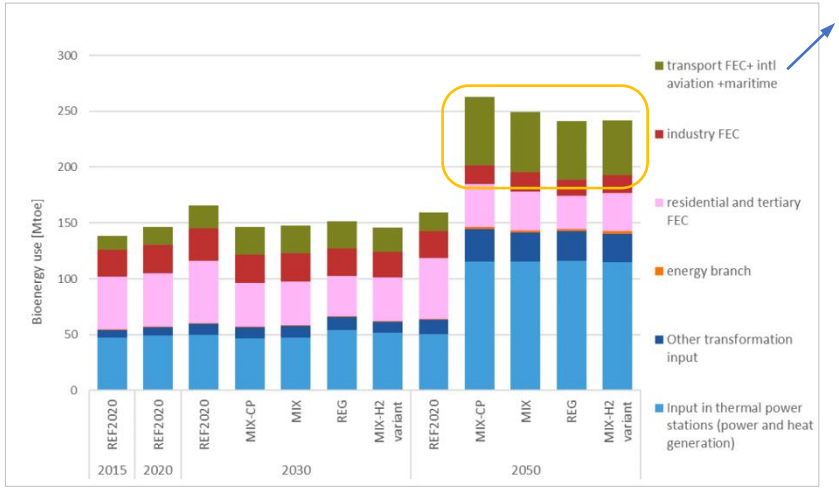
Overall, it is assumed that sufficient sustainable biogenic feedstock for fuel production in hard-to-abate sectors is available by 2050 in the EU.

SAF demand in the EU



SAF demand by 2050
about 32 Mt/a

Biomass waste use in the EU in various scenarios



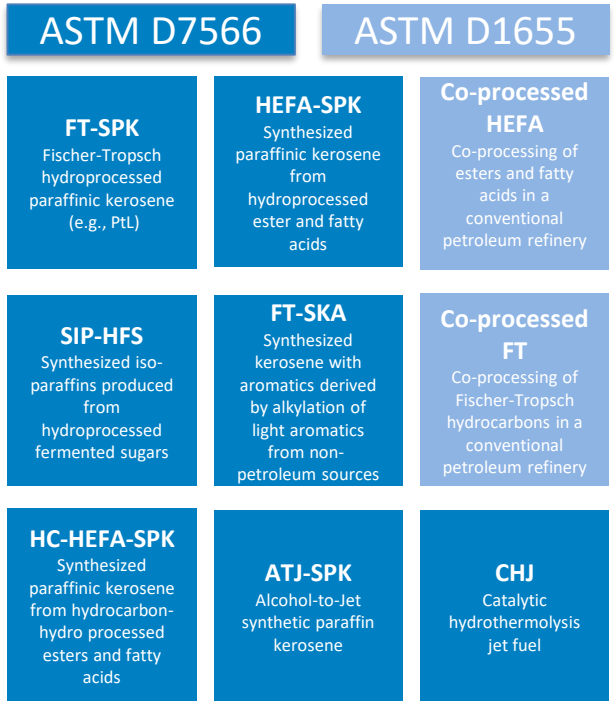
Watch for demand from road transport sector!

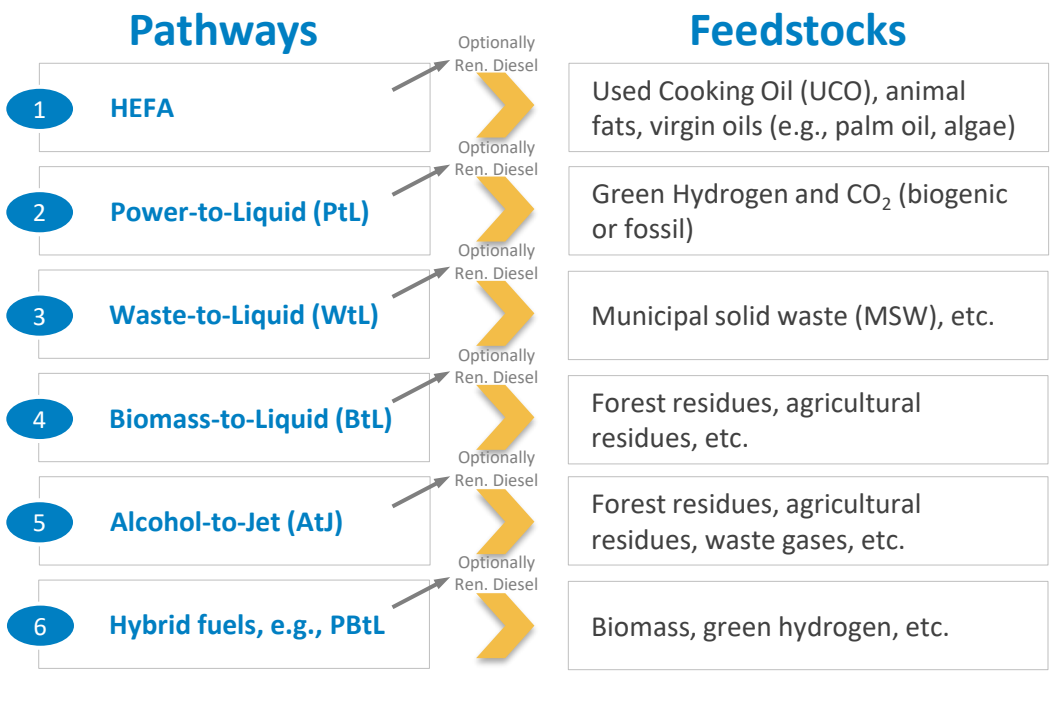
Biofuel supply (aviation & maritime) by 2050
about 50 Mt/a

- Despite high sustainability requirements in the EU, key stakeholders expect that **feedstock supply will be sufficient to enable high level of SAF penetration by 2050** (note that RFNBO shall also contribute to the SAF mix by 2050)

SAF: Sustainable Aviation Fuel; RFNBO: Renewable Fuels of Non-Biological Origin
Source: Destination 2050, A4E, ACI-EUROPE, ASD, CANSO, ERA, 2021; Impact Assessment, SWD(2021) 621 final, 2021; CBR, 2023

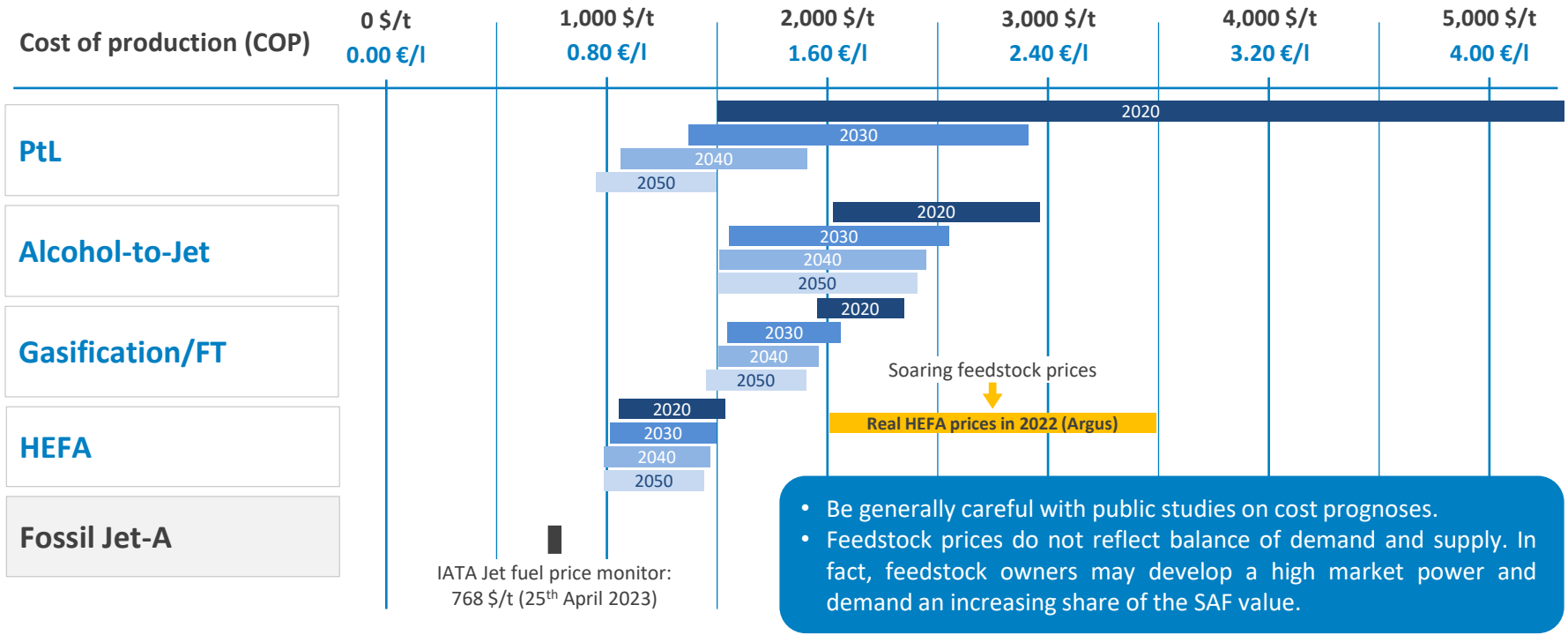
Value of feedstock and respective demand also depend on available technologies. Nine ASTM certified SAF types, six main pathways and a variety of feedstocks are available for SAF production.





ASTM: American Society for Testing and Materials; SAF: Sustainable Aviation Fuel; UCO: Used Cooking Oil; HEFA: Hydro Treated Esters and Fatty Acids; FT: Fischer-Tropsch; SPK: Synthetic Paraffinic Kerosene; MSW: Municipal Solid Waste; PBtL: Power-and-Biomass-to-Liquid; PtL: Power-to-Liquid; AtJ: Alcohol-to-Jet; Source: ICAO; CBR, 2023

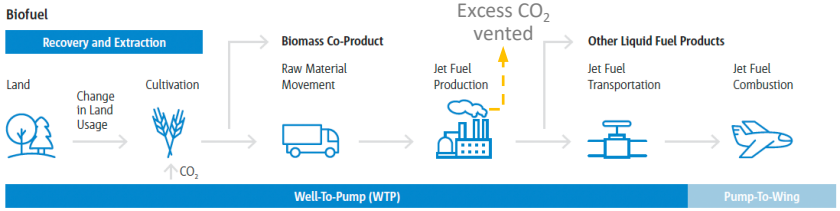
Demand for feedstock and hence costs will be linked to production technology competitiveness.



PtL: Power-to-Liquid; HEFA: Hydro Treated Esters and Fatty Acids; FT: Fischer-Tropsch; COP: Cost of production; SAF: Sustainable Aviation Fuel; Source: WEF; CBR, 2022
Remark: Currently no SAF market price exists due to single project-specific offtake agreements reflecting the immature SAF market, here project-based cost of production ranges for different SAF pathways and SAF project locations; exchange rate: 1 EUR/1.07 USD

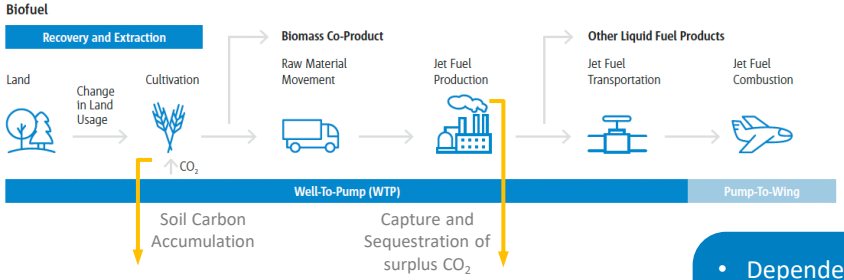
A high impact on feedstock value might result dependent on whether a quantity of SAF is targeted or the respective GHG saving.

Value of SAF according to
fuel quantity
(e.g., ReFuelEU Aviation)



Costs of GHG savings from
Fuel Production
500-1,000 $/$t_{CO2,Prod.}$

Value of SAF according to
GHG saving
(e.g., CORSIA, US IRA, SBTi)



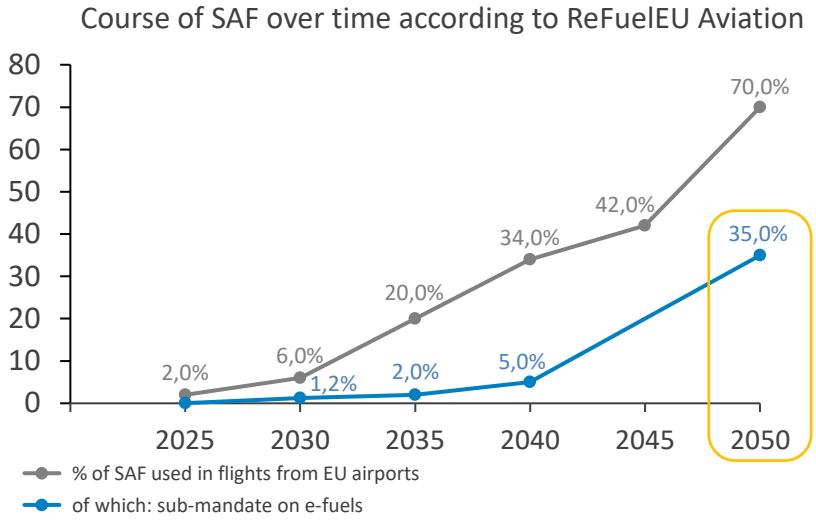
Costs of GHG savings from
Fuel Production
500-1,000 $/$t_{CO2,Prod.}$

Costs of GHG savings costs from
Capture and Sequestration
150-250 $/$t_{CO2,Sequestred}$

- Dependent on the amount of surplus CO_2, a significant reduction in average GHG savings can be realised.
- Hence, biogenic carbon feedstock (which typically provides excess of carbon) becomes more valuable.

SAF: Sustainable Aviation Fuel; GHG: Green House Gas; CORSIA: Carbon Offsetting and Reduction Scheme for International Aviation; US IRA: US Inflation Reduction Act; SBTi: Science-Based Target initiative; Source: EASA, 2022; CBR, 2023

In view of the attractive potential from CCS, sustainable carbon (biogenic or from DAC) for PtL could become a scarce resource.



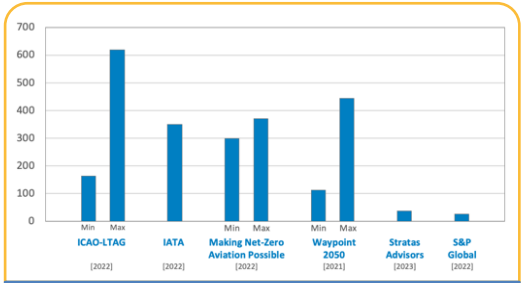
e-SAF demand by 2050 about 14 Mt/a

Demand for biogenic CO_2 or CO_2 from DAC by 2050 about 42 Mt/a

- Under regimes and frameworks valuing GHG savings, CO_2 from (biogenic) point sources could become a limiting resource, forcing e-SAF producers to source CO_2 from air.
- As CO_2 from DAC is much costlier compared to CO_2 from biogenic point sources, cost levels for e-SAF could stay higher than prognosed by many studies so far.

CCS: Carbon Capture and Sequestration; DAC: Direct Air Capture; PtL: Power-to-Liquid; SAF: Sustainable Aviation Fuel
Source: EC, 2023; CBR, 2023

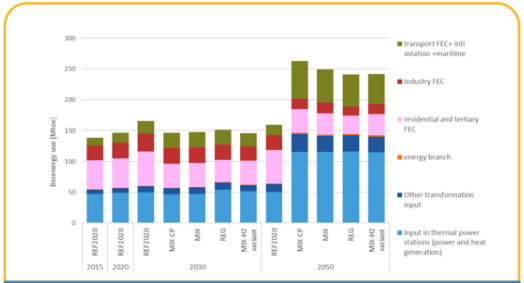
Key messages



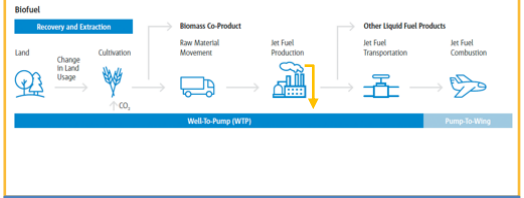
Development of SAF and hence feedstock demand depends on several parameters and is uncertain.

1. HEFA
2. Power-to-Liquid
3. Waste-to-Liquid
4. Biomass-to-Liquid
5. Alcohol-to-Jet
6. Hybrid fuels, e.g. PBtL

As of today, no clear preferred feedstock can be anticipated from current technology portfolio.



It seems to be possible to serve also high SAF demands under high sustainability standards. Yet, watch out for feedstock competition.



The option for CCS provides a competitive edge for biomass and waste-based fuels and could render RFNBO costlier.

Novel sustainable feedstock

Updates in Regulation

SAF Technology Developments

Demand for renewable feedstock in Chemical Industry

BECCS

Hydrogen, Batteries

…

Demand for Diesel in road and marine transport

Various interlinked trends need to be watched in parallel. The SAF world continues to be complex. Regulatory framework is key.

SAF: Sustainable Aviation Fuel; CCS: Carbon Capture and Sequestration; RFNBO: Renewable Fuels of Non-Biological Origin; BECCS: Bio Energy with Carbon Capture and Sequestration; Source: CBR, 2023

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European Union Aviation Safety Agency

Thanks for joining!

Stay tuned for additional sessions planned for the coming weeks & months!

Please let us know your subject of interest

e.g.
- sustainability certification
- adaption of refineries to SAF
- any other

15h Bangkok / Jakarta / Hanoi Time
16h Singapore / Manila Time
10h Brussels / Cologne Time

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European Union Aviation Safety Agency

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Shared ambitions


Shared challenges


Shared opportunities

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