



ITALIAN NATIONAL AGENCY FOR
NEW TECHNOLOGIES, ENERGY AND
SUSTAINABLE ECONOMIC DEVELOPMENT



TOKYO
GX
WEEK

7th RD20 Conference

Sustainable Aviation Fuels in Italy: opportunities and research challenges faced by ENEA



30th September 2025

TS #1: Synthetic fuels including a wide range of resources, conversion processes and products

Claudia Bassano, Nadia Cerone, Paolo Deiana, Giuseppina Vanga, Rosanna Viscardi



ENEA: Italian National Agency for New Technologies. Energy and Sustainable Economic Development

- 4 Departments: **Energy Technologies and Renewable Energy Sources**. Energy Efficiency. Environment and Sustainability and Fusion and Nuclear Safety
- 9 Research Centers
- 5 Research Laboratories
- a network of territorial offices providing information and consultancy services
- an ENEA-EU Liaison Office in Brussels
- ENEA headquarter in Rome

The 2° Italian R.O.
around 2700 employees



Our mission

Promote the growth and increase the competitiveness of the business sector, public administration. and society at large through **technology development, the transfer of innovation and advanced services**



Our challenge

Today ENEA is called to **contribute to the ecological transition** and **provide solutions** in highly critical sectors:

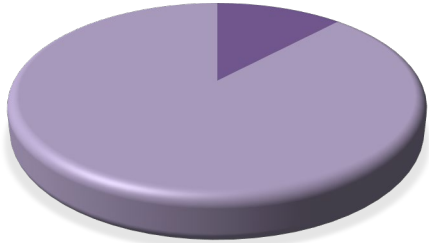
- Energy. from generation to efficient use
- Climate change
- Circular economy
- Eco-friendly technologies to protect the environment. health and ensure safety



ENEA: Areas of activity. expertise and commitment

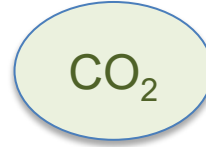


What's the current state of aviation sustainability?



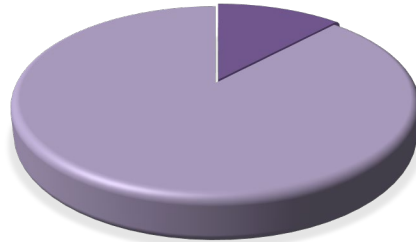
2.05%

The global aviation industry produces around 2.05% of all human-induced CO₂ emissions.



50 grams CO₂/ seat kilometer

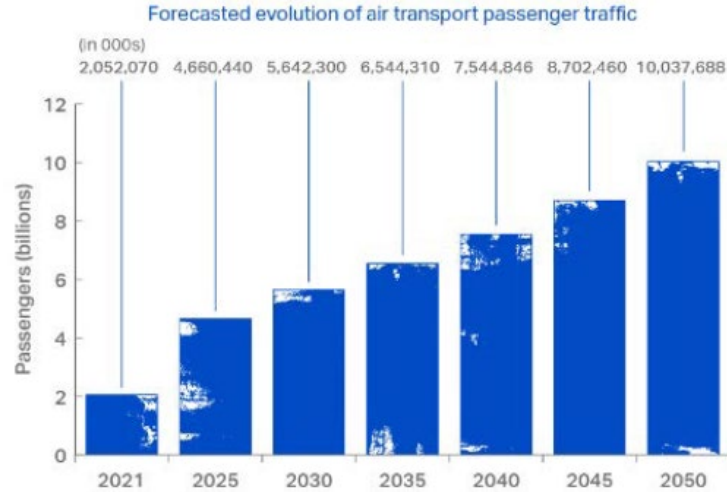
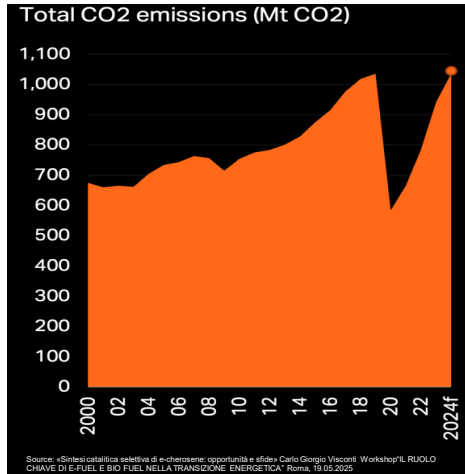
A typical new generation single aisle aircraft coming off the production line today



12%

Aviation is responsible for 12% of CO₂ emissions from all transport sources

Ensuring aviation's sustainability requires more than just efficiency gains!!!!



2025 set to break all records for air travel volume!!!

www.iata.org/flynetzero Net zero carbon 2050 resolution

Efficiency



reduce
emissions
per seat

growing
travel
demand

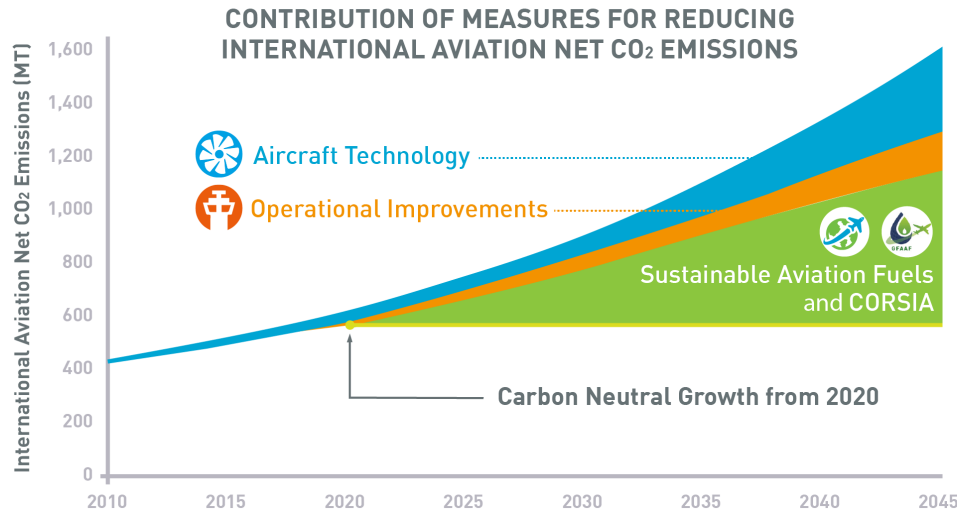


offsets
the
progress

As the effects of the pandemic fade, IATA projects global air travel to reach 5.2 billion passengers in 2025 — an increase of 500 million compared to pre-COVID levels in early 2020.

How can we contribute to making aviation more sustainable?

The ICAO Global Framework for Sustainable Aviation Fuels (SAF) outlines a shared global aspirational vision to cut CO₂ emissions from international aviation by 5% by 2030, relative to a baseline of no cleaner energy use



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ICAO

ENVIRONMENT

41st Assembly (2022), Long-Term Aspirational Goal (LTAG)
net-zero carbon emissions from international aviation by 2050



SAF- Sustainable Aviation Fuels

Sustainable Aviation
Fuels



renewable or waste-derived aviation fuels that meets the CORSIA sustainability criteria. net CO₂ reduction of at least 10% compared to the baseline fossil kerosene (89 gCO₂e/MJ for jet fuel).



ICAO

ENVIRONMENT

CORSIA

CARBON OFFSETTING AND REDUCTION
SCHEME FOR INTERNATIONAL AVIATION

- ✓ SAF refers to drop-in fuels (whit JET A1) made from renewable sources.
- ✓ SAF meet the same technical and safety standards as conventional jet fuel
- ✓ Blending up to 50% SAF with CAF is allowed: “blended SAF” must meet the requirements set out in ASTM D1655 or Defence Standard 91-091
- ✓ SAF can be used with existing aircraft and infrastructure
- ✓ No modifications or additional investments are needed

SAF ?



1 million tonnes SAF in 2024

In 2024, 1 million tonnes (1.3 billion litres) of SAF was used for commercial flights

2x 2023 production

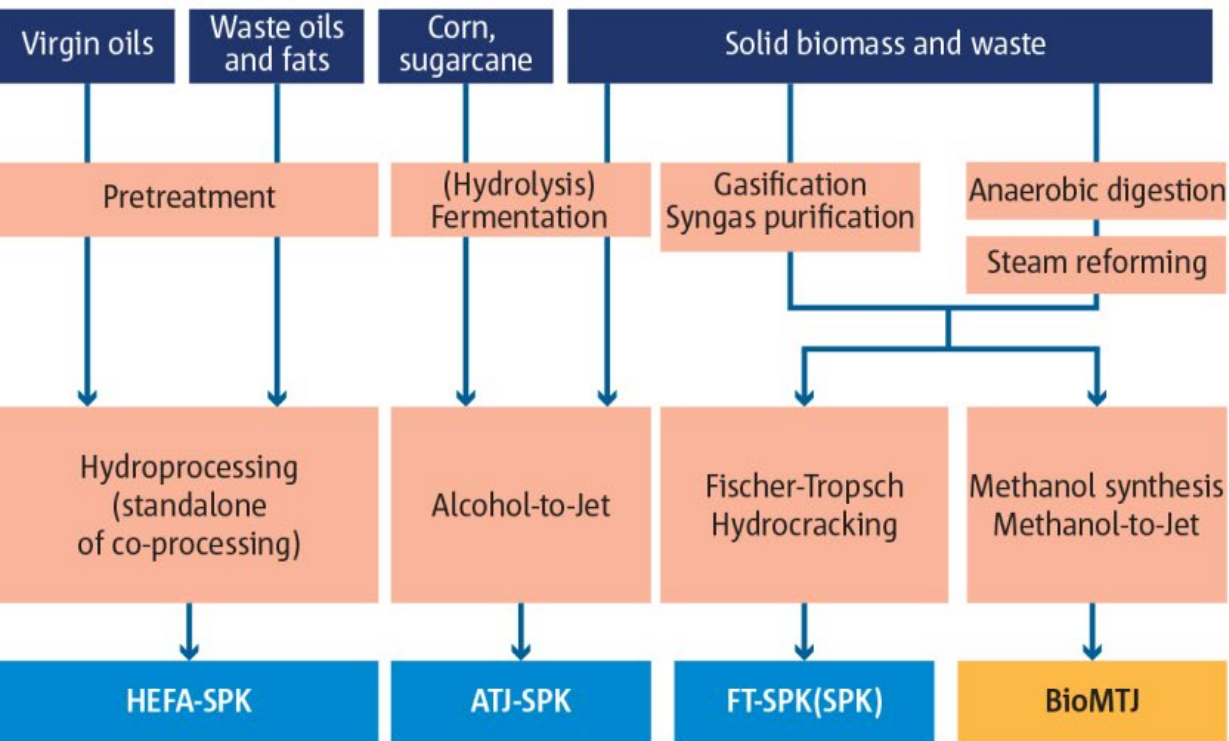
In 2024, SAF production was more than double the 240,000 tonnes produced in 2023.

0.7%

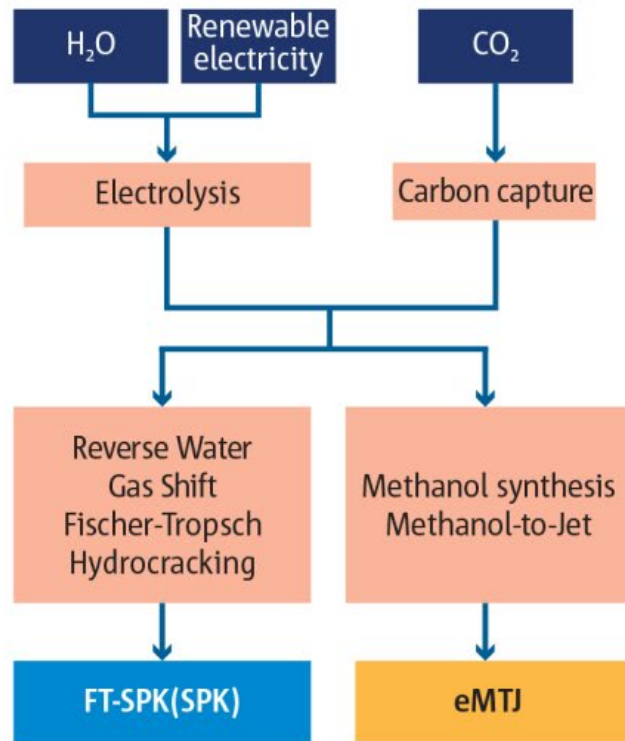
In 2025 SAF accounting for 0.7% of airlines' total fuel consumption



RENEWABLE FUELS



SYNTHETIC FUELS



Feed



Process



Product - ASTM qualified



Product - not ASTM qualified

Production Pathways and Technologies

ASTM

11 synthesis processes approved for the production of drop-in SAF.

11 more are under evaluation.

	HEFA (HYDROPROCESSED ESTERS AND FATTY ACIDS)	ATJ (ALCOHOL-TO-JET)	FT (FISCHER- TROPSCH)	PTL (POWER-TO- LIQUID)
ASTM reference	ASTM D7566 Annex A2 (50% max blend ratio)	ASTM D7566 Annex A5 (50% max blend ratio)	ASTM D7566 Annex A1 (50% max blend ratio)	N.A.
Feedstock	Vegetable oils + H2 Animal fats + H2 Used Cooking Oils + H2	Ethanol and isobutanol from biomass fermentation + H2	Syngas (CO + H2) from biomass gasification	CO2+ (green) H2
Process	Hydrodeoxygenation + hydroprocessing	dehydration + oligomeriz. + hydroprocessing	FT + hydroprocessing	Different routes available
Advantage	Maturity Existing supply chains	Amount of feedstock Cheap feedstock	Unlimited potential via DAC or DOC	
Disadvantage	Amount of feedstock	Collection of feedstock; cost of 2 nd gen. ethanol	Collection of feedstock; high CAPEX	REN consumption / cost
TRL	Commercial (available now!)	Commercial pilot (mid-term solution)	in development (long-term solution)	
GHG reduction	70-85%	82-94%	85-100%	

Dedicated regulations are in place or proposed

ReFuelEU Aviation

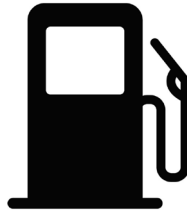


European
Commission

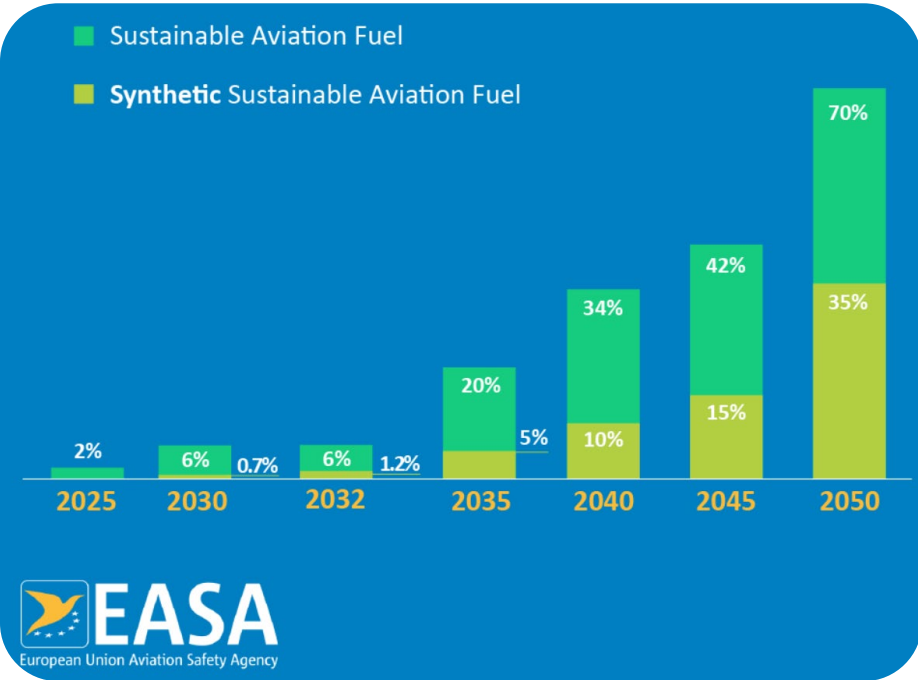


Main European Union policies currently related to the development and adoption of SAF

- REDIII
- ReFuelEU Aviation
- EU-ETS



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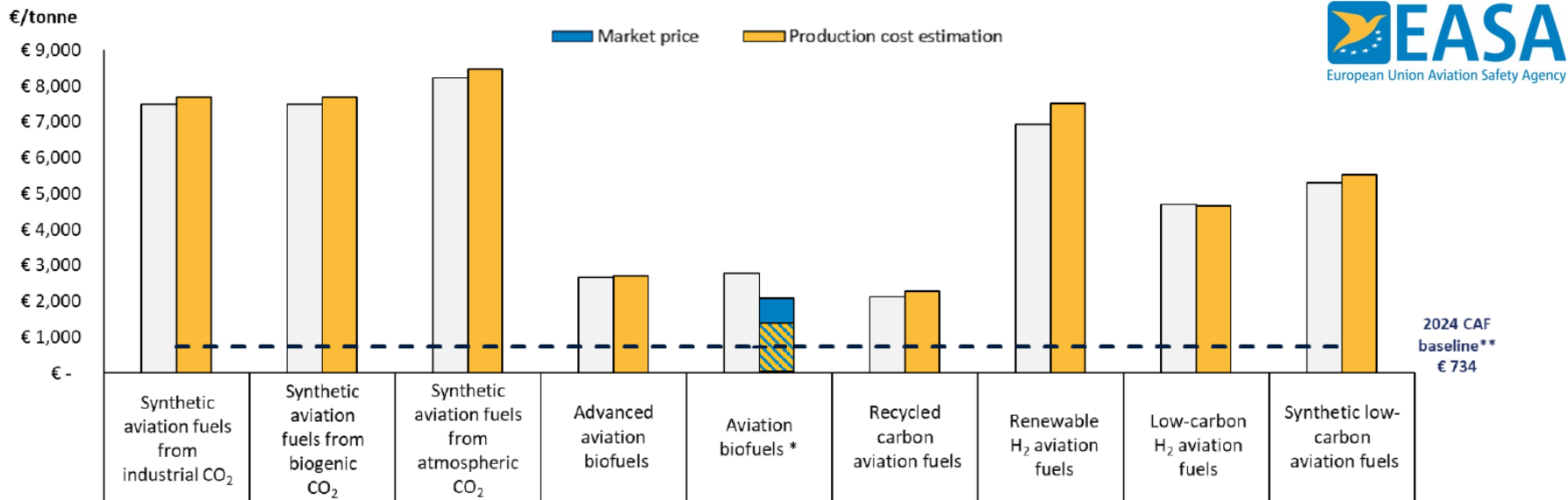
ReFuel EU SAF definition

Article 3(7) of the ReFuelEU Aviation Regulation.
drop-in aviation fuels compliant with the sustainability
criteria of the Renewable Energy Directive (RED).

- ✓ Synthetic aviation fuels from renewable hydrogen and captured carbon and limited to liquid drop-in fuels only
- ✓ Advanced biofuels from waste and residues notably (produced from feedstock listed in Part A of Annex IX. Article 2(34) of RED);
- ✓ Biofuels produced from oils and fats notably (feedstock listed in Part B of Annex IX. Article 2(33) of RED);
- ✓ Recycled carbon aviation fuels Article 2(33) of RED.



SAF production costs



Costs are still high!!!!



EASA 2025 Briefing Note – 2024 Aviation Fuels Reference Prices for ReFuelEU Aviation

SAF Facilities EU Estimates

✈ ICAO Tracker of SAF Facilities reports the total production site capacity existing and announced (SAF + other renewable fuels)

✈ 42 facilities identified in the EU

✈ 2.5 Mt/a (SAF + other renewable fuels) estimated capacity

	Total capacity Mt/y [2025]	SAF Capacity Mt/y [2025]	Facilities [2025]
Producing CORSIA SAF	0.5	0.5	1
In service - producing SAF	2.7	1.0	20
In service - producing other renewable fuels	0.8	0.0	8
Under construction	1.5	0.8	7
Front End Engineering Design	0.5	0.2	6
Total EU	6.0	2.5	42

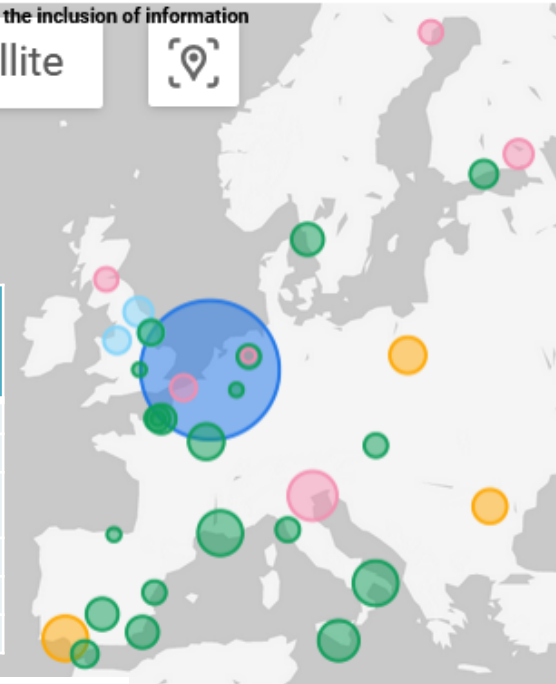
ICAO tracker of SAF facilities

This tracker provides information on facilities (existing and announced) that could produce Sustainable Aviation Fuel (SAF).
Note: capacity numbers refer to total capacity, including SAF and other renewable fuels. ICAO does not guarantee the accuracy of the information.

contact officeenv@icao.int to suggest the inclusion of information

Mappa

Satellite



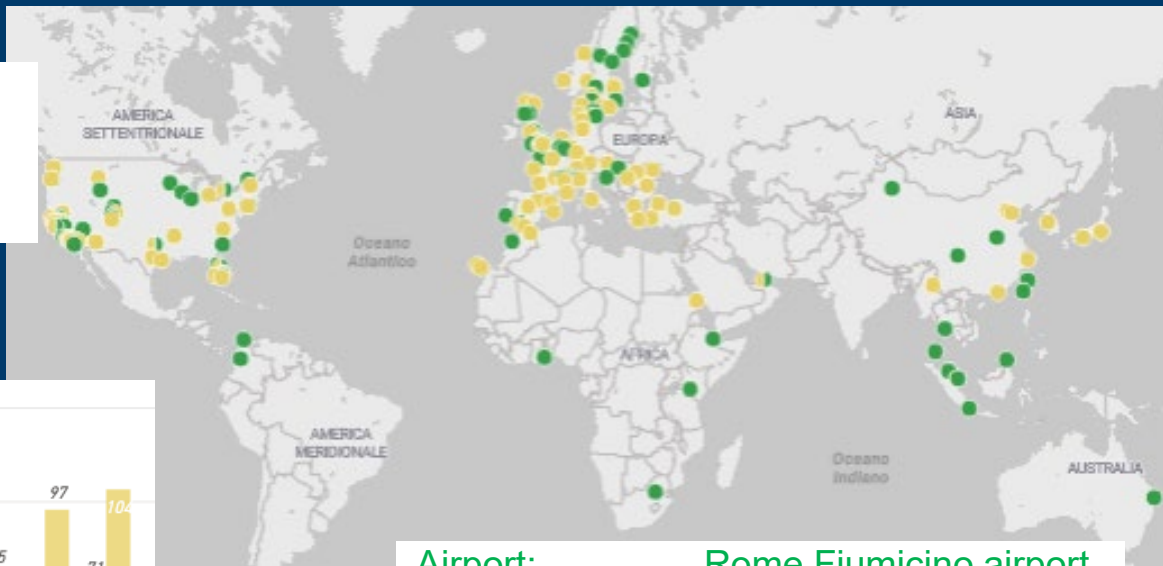
Capacity (ML/year)
0,0 • • • 3.375,0

Facility Status

● 6 - Producing CORSIA SAF ● 4 - In service - producing other renewable fuels ● 3 - Under construction ● 5 - In service - producing SAF
● 2 - Front End Engineering Design (FEED)

Where is SAF available today?

Airport: Milano Linate airport
Status: ongoing deliveries
Member State: Italy
Fuel producer: Eni



Numbers of airports (cumulative by year)

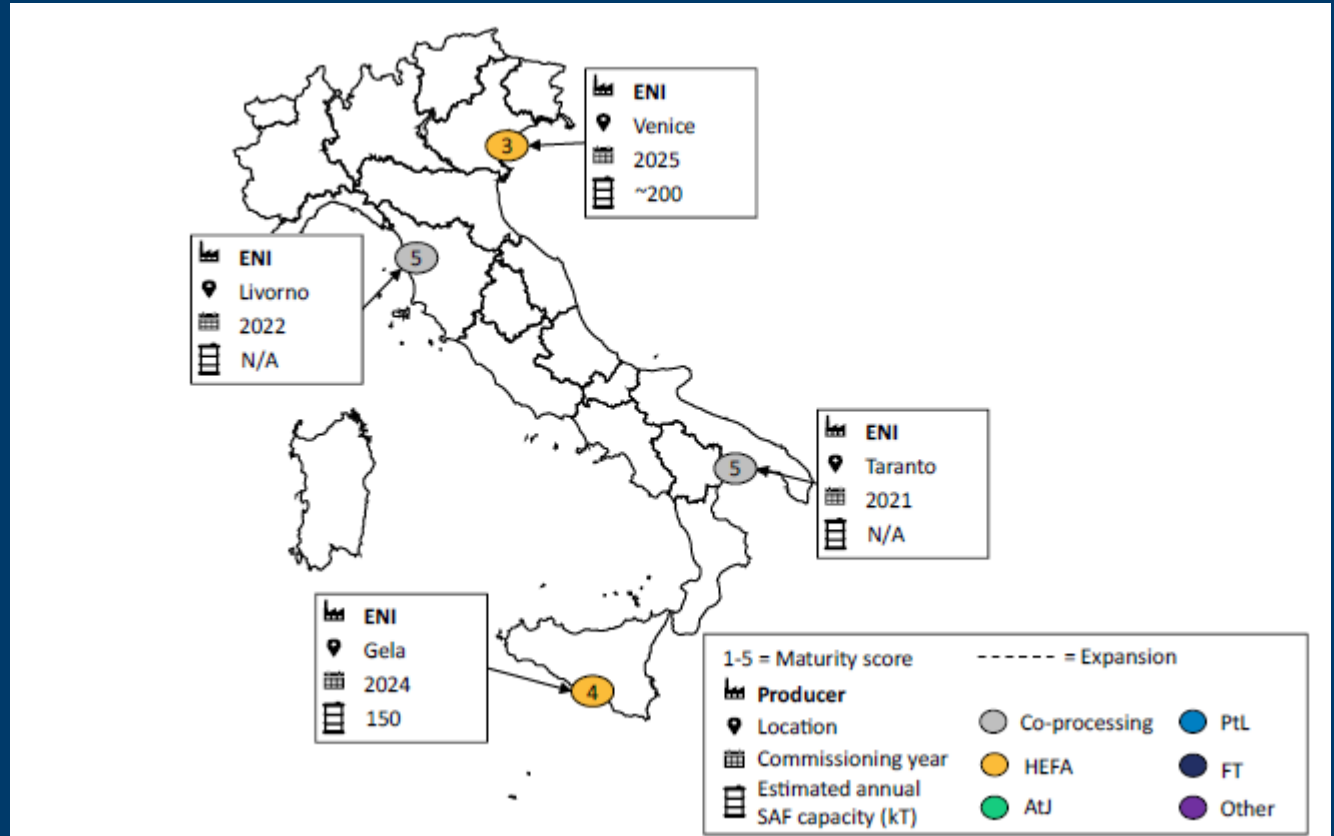
Status: ● Batch delivery ● Ongoing deliveries



Airport: Rome Fiumicino airport
Status: ongoing deliveries
Member State: Italy
Fuel producer: Eni

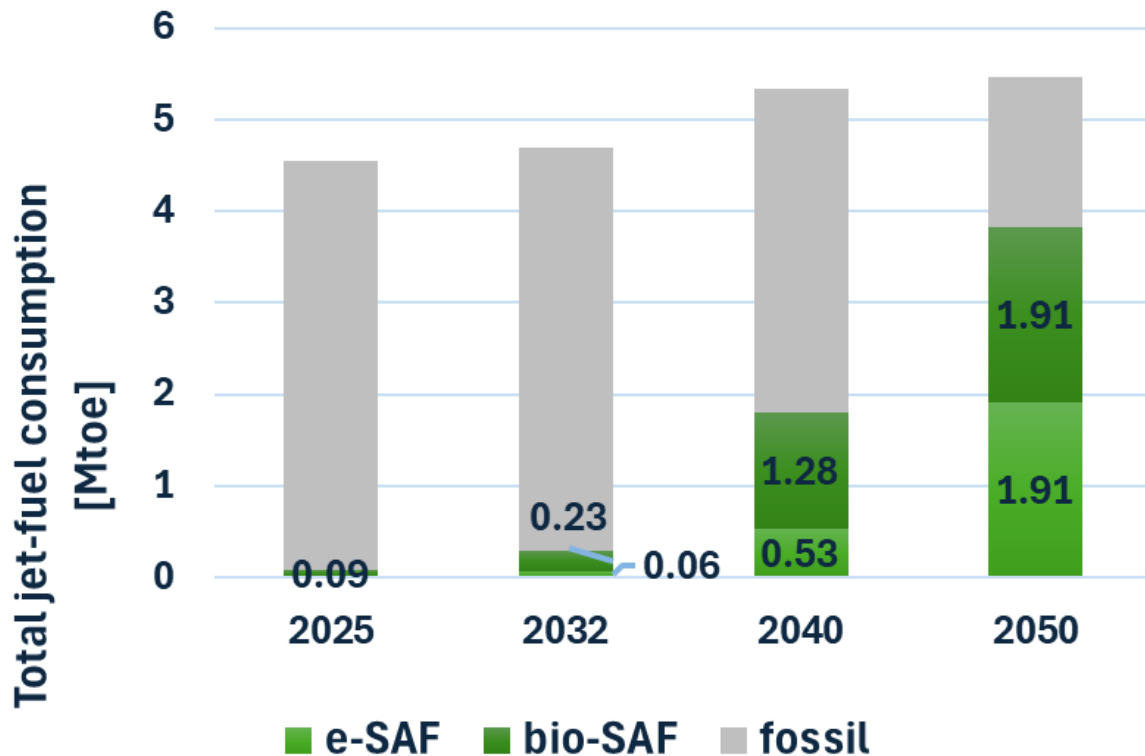
<https://www.icao.int/environmental-protection/SAF-airports>

Operating and announced SAF facilities in Italy



EASA Report – State of the EU SAF Market in 2023

Expected volumes of SAF jet-fuel (Italy)

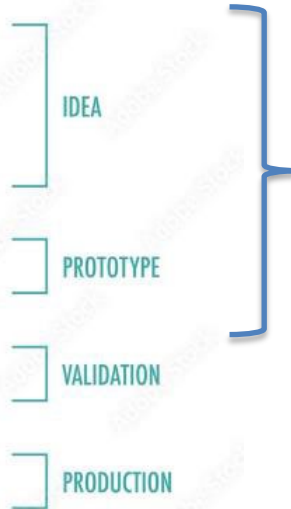


Source: Adapted from Matteo Prussi «L'Italia e la sfida della ReFuel EU Aviation: domanda e produzione attesa di SAF» 2025

ENEA's SAF R&D focus on TRL

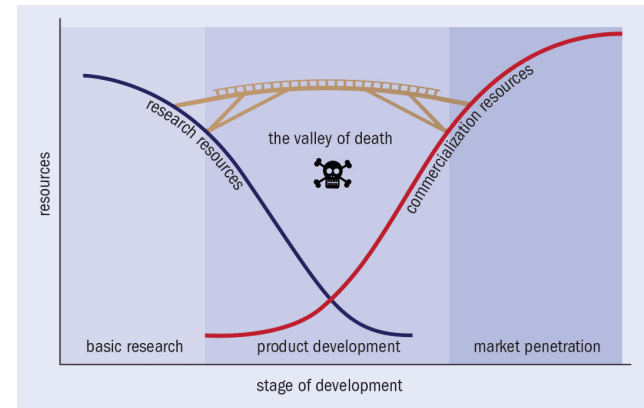
Technology Readiness Level (TRL)

- 0 IDEA**
Unproven concept, no testing has been performed
- 1 BASIC RESEARCH**
You can now describe the need(s) but have no evidence
- 2 TECHNOLOGY FORMULATION**
Concept and application have been formulated
- 3 NEEDS VALIDATION**
You have an initial 'offering, stakeholders like your slideware
- 4 SMALL SCALE PROTOTYPE**
Built in a laboratory environment
- 5 LARGE SCALE PROTOTYPE**
Tested in intended environment
- 6 PROTOTYPE SYSTEM**
Tested in intended environment close to expected performance
- 7 DEMONSTRATION SYSTEM**
Operating in operational environment at pre-commercial scale
- 8 FIRST OF A KIND COMMERCIAL SYSTEM**
All technical processes and systems to support commercial activity are ready
- 9 FULL COMMERCIAL APPLICATION**
Technology on 'general availability' for all customers



ENEA main focus in R&D projects

From lab to pilot scale to support the development of integrated demonstration projects, from FOAK to FEED.



ENEA's SAF R&D focus

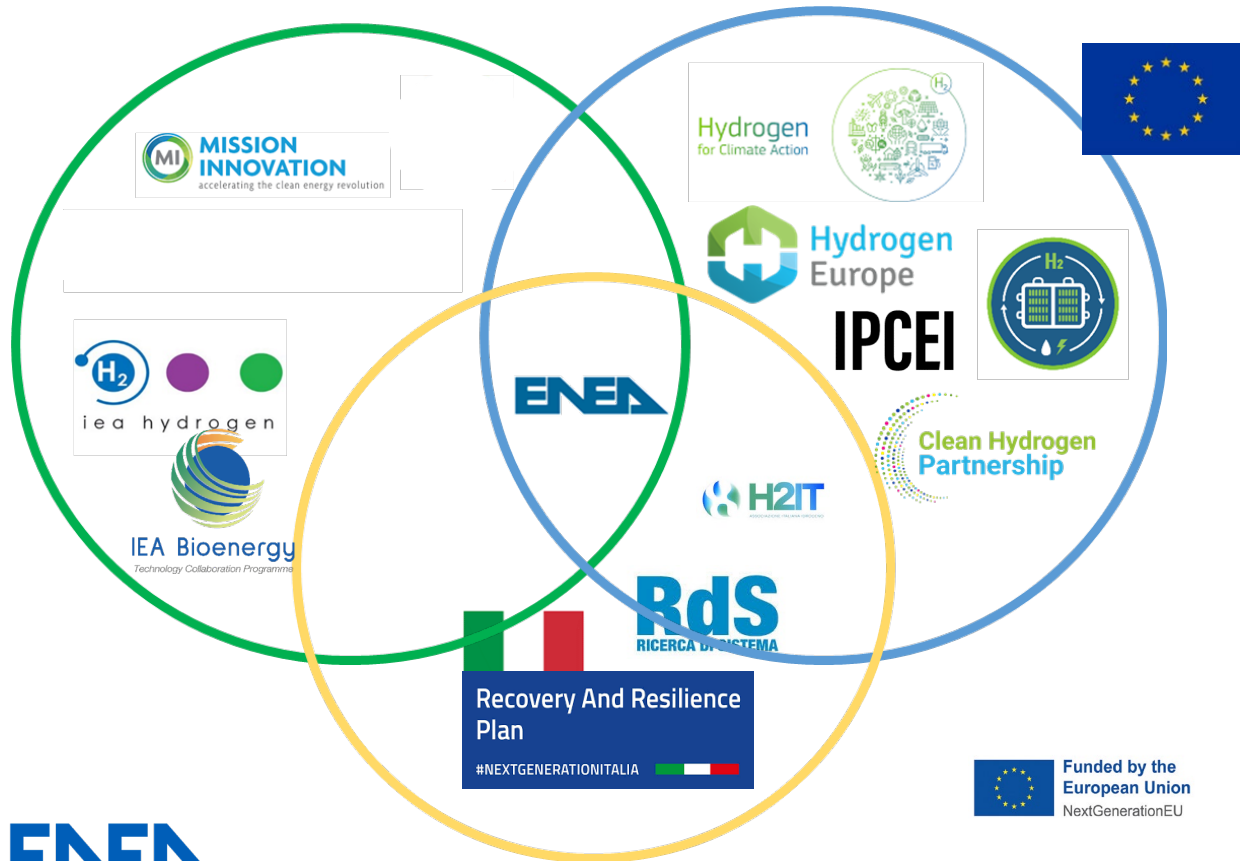
Research is focused **on innovative applications for advanced production processes covering all the value SAF value chain**

- ✈ technical and economic assessments, LCA and social impact;
- ✈ development of prototypes and demonstrators integrated in experimental platforms for the validation of innovative SAF technologies in view of market introduction;
- ✈ development and synthesis of innovative catalytic materials; study of advanced reactor solutions, process engineering and novel plant configurations;
- ✈ experimental work on bench-scale and demonstration-scale;
- ✈ students, researchers and young professionals training
- ✈ technology transfer to public administrations and private companies.



ENEA – R&D Activities on Liquid E-Fuels

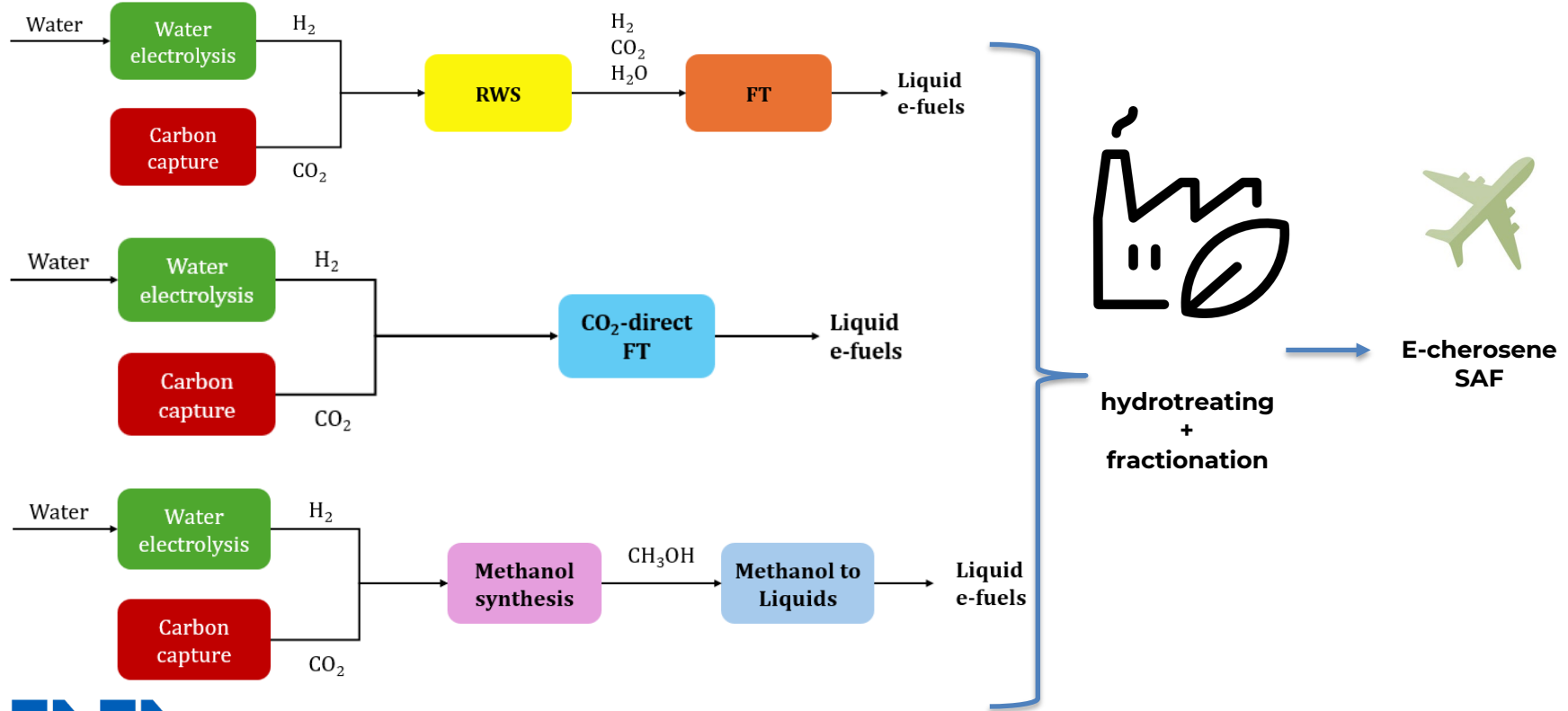
Collaborations National, EU, International



ENEA is the main beneficiary in Recovery and Resilience Plan, coordinating R&D project on H2 Value chain with 110 M€ 2022-2026



SAF production via PTL (PTL-SAF e-cherosene)



ENEA - Current activities and expertise

Green hydrogen production low TRL

– Electrochemical (water-splitting) :

- Materials for polymer electrolyte (PEM & AEM) electrolysis
- Testing and characterization of PEM & AEM cells and short stacks
- High-T and high-p polymer electrolyte (PEM & AEM) electrolysis
- Testing and characterization of Molten Carbonate electrolysis (MCEC)
- Testing and characterization of Solid Oxide Electrolysis (SOEC)
- Integration of electrolyzers with renewable heat & power sources

– Photo-Electrochemical (water-splitting):

- Preliminary investigations on the use of active perovskite materials in progress

– Biotechnologies:

- Microbic electrolysis
- Fermentation of biowastes and CO₂

– Thermochemical Water-Splitting Cycles (TWSC):

- A new TWSC based on a modification of the well-known Sulfur-Iodine cycle patented
- Capability to study two-steps complex metal oxide TWSCs up to 1500° C

– Thermochemical conversion of (bio)wastes:

- Innovative reforming of (bio)methane in electrified reactors
- Cracking of (bio)methane (planned)
- Pyrolysis of solid (bio)wastes with valorization of the solid by-product (biochar)
- Plasma pyrolysis of bio(methane) or CO₂



ENEA - Current activities and expertise

Green hydrogen production medium TRL

Alkaline type electrolyser

H₂ production 4 Nm³/h

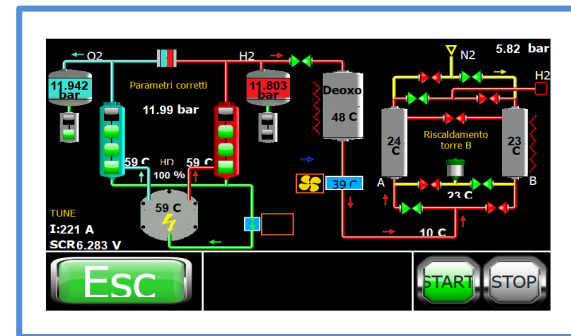
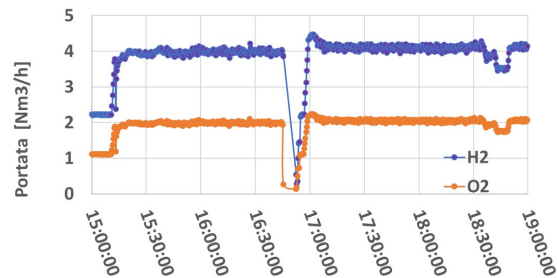
Size 25 kWe

working pressures 12 bar

Deoxo unit H₂ purity 99.9999%

Control panel and remote monitoring

Battery energy storage unit (LiFePO₄ type)



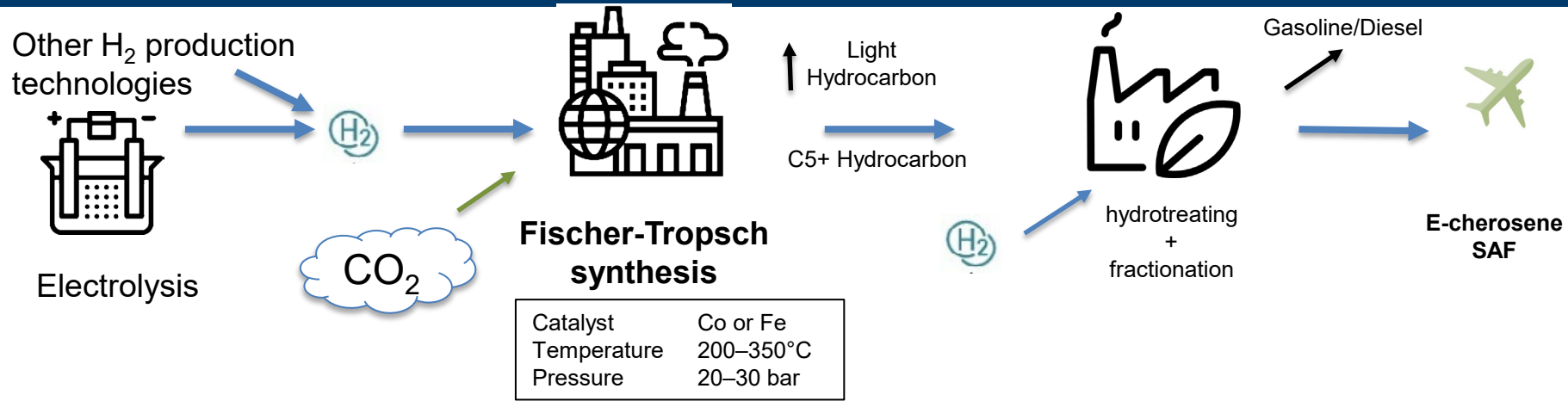
Study Power To Gas process evaluating the dynamic environment start up, shut-down, stand-by e idle condition

Electrical characterization of the power supply/conversion system



ENEA SAF production via PtL

e-cherosene via Fischer Tropsch synthesis



Experimental test:
e-cherosene production

Fischer-Tropsch synthesis

Direct CO₂ hydrogenation



e-cherosene via Fischer Tropsch synthesis

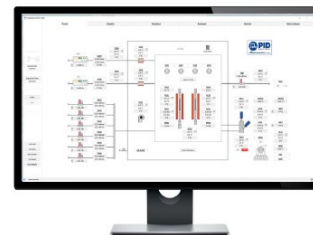
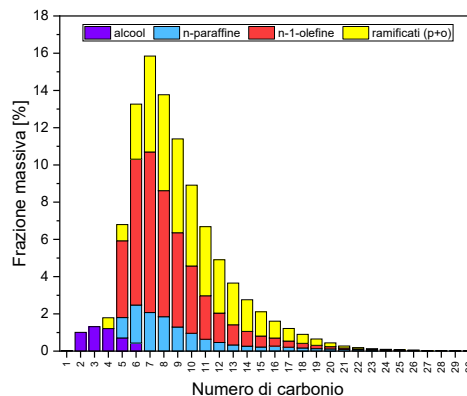
laboratory plant- low TRL



Funded by the
European Union

NextGenerationEU

Flow reactor bench scale
evaluation of innovative
bifunctional catalysts
performance (Fe based)

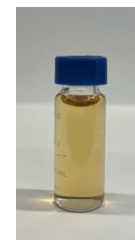
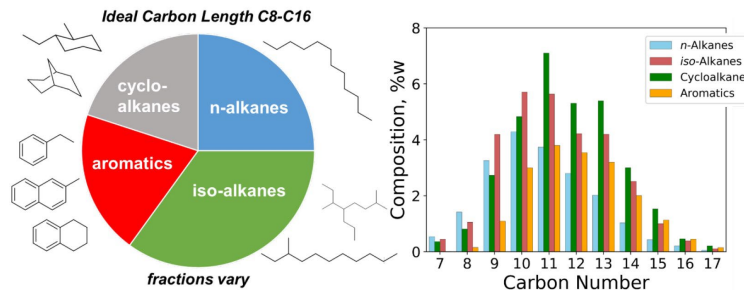


POLITECNICO
MILANO 1863

DIPARTIMENTO DI ENERGIA



Test results using Fe based catalyst →
higher C8-C16 content typical of
kerosene



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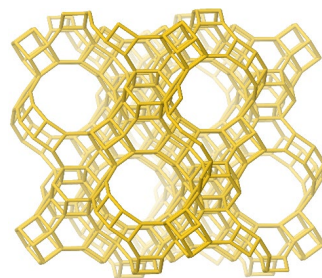
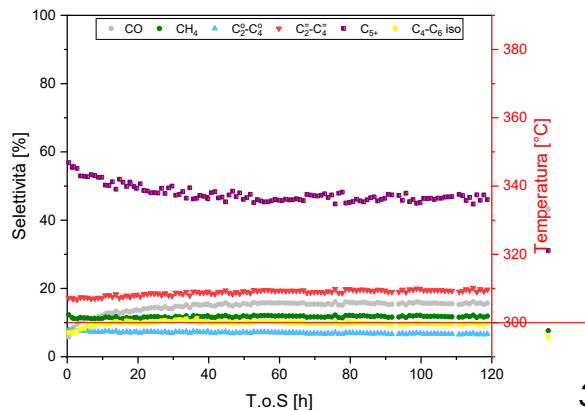
e-cherosene via Fischer Tropsch synthesis

laboratory plant- low TRL

Verso del gas

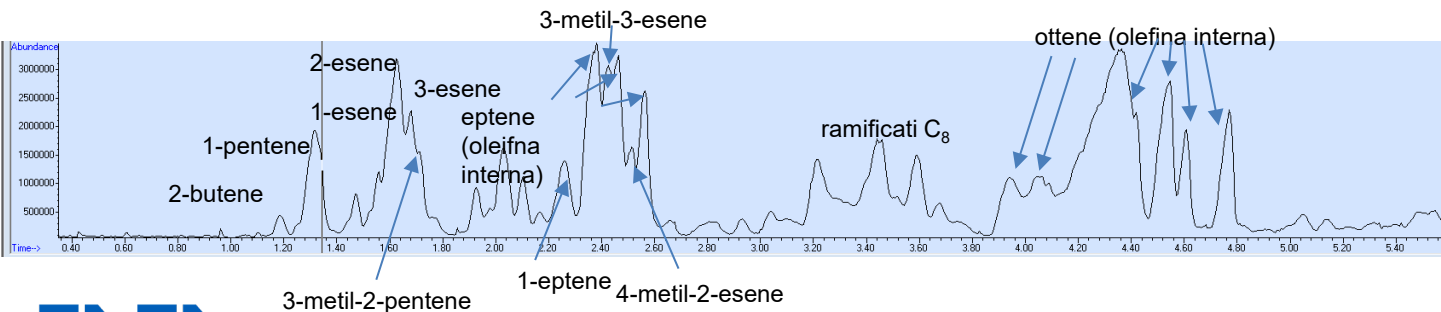
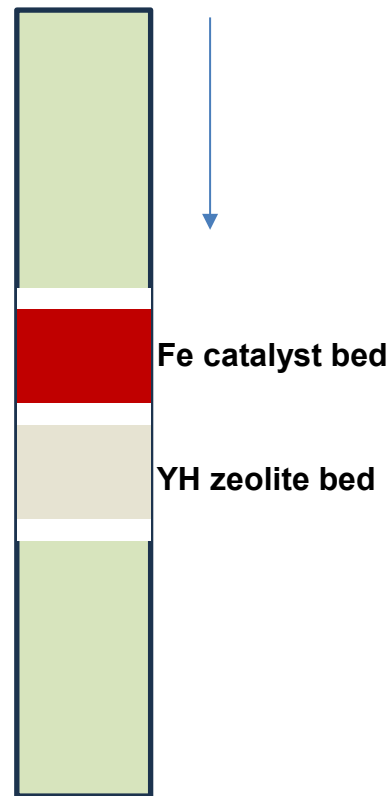
DOUBLE CATALYTIC BED:

1. Fe catalyst bed for CO_2 hydrogenation
2. YH zeolite bed (at the end of the Fe bed) for wax cracking



3D structure of faujasite

GAS PHASE - Marked presence of isomers - zeolite activity



e-kerosene via Fischer Tropsch synthesis

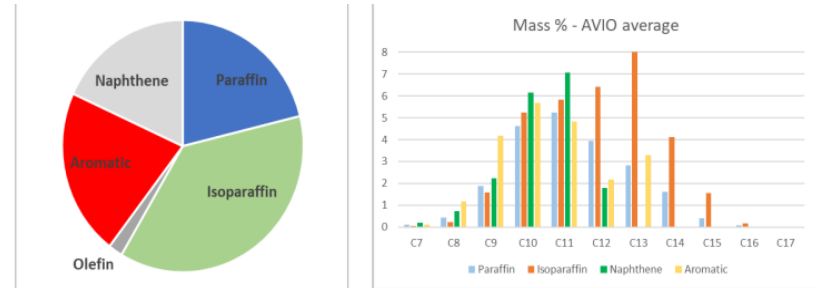
Fraction characterization and AST compliance

Objective: To develop a method capable of separating and characterizing small quantities of e-kerosene fraction of a synthetic crude oil obtained in a FT process and verifying compliance with international standards.



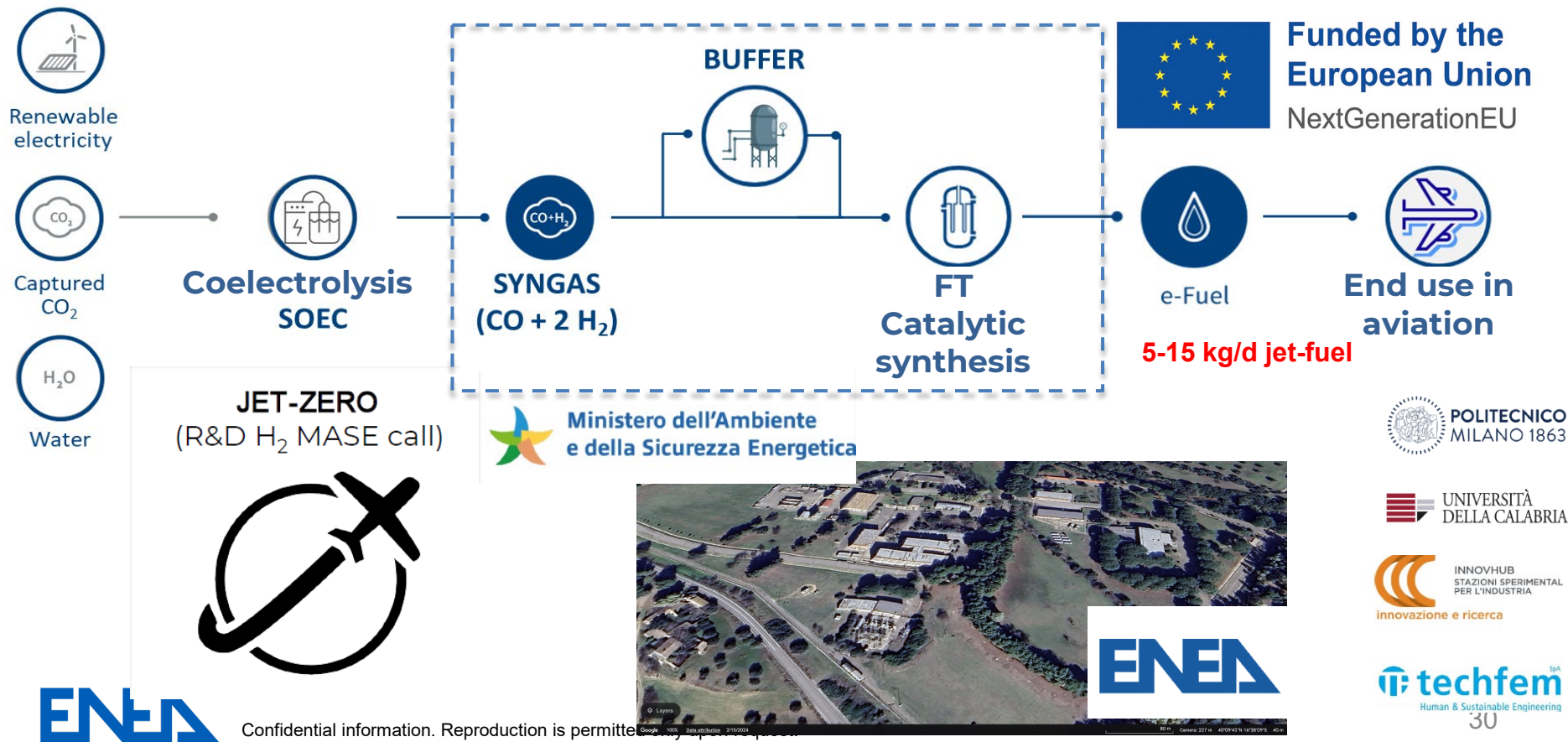
Activities: Characterization of fossil jet fuel using ASTM standards and GC-VUV (Gas Chromatography–Vacuum Ultraviolet Spectroscopy) / GCxGC techniques to identify the hydrocarbon families present (it is important to differentiate between isomers) based on the number of carbon atoms then comparing the results with the literature.

10 fossil jet fuel samples analyzed by GC-VUV

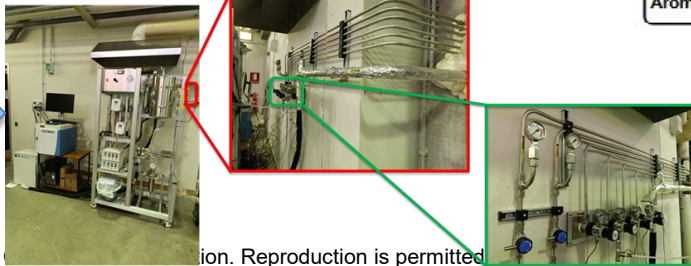
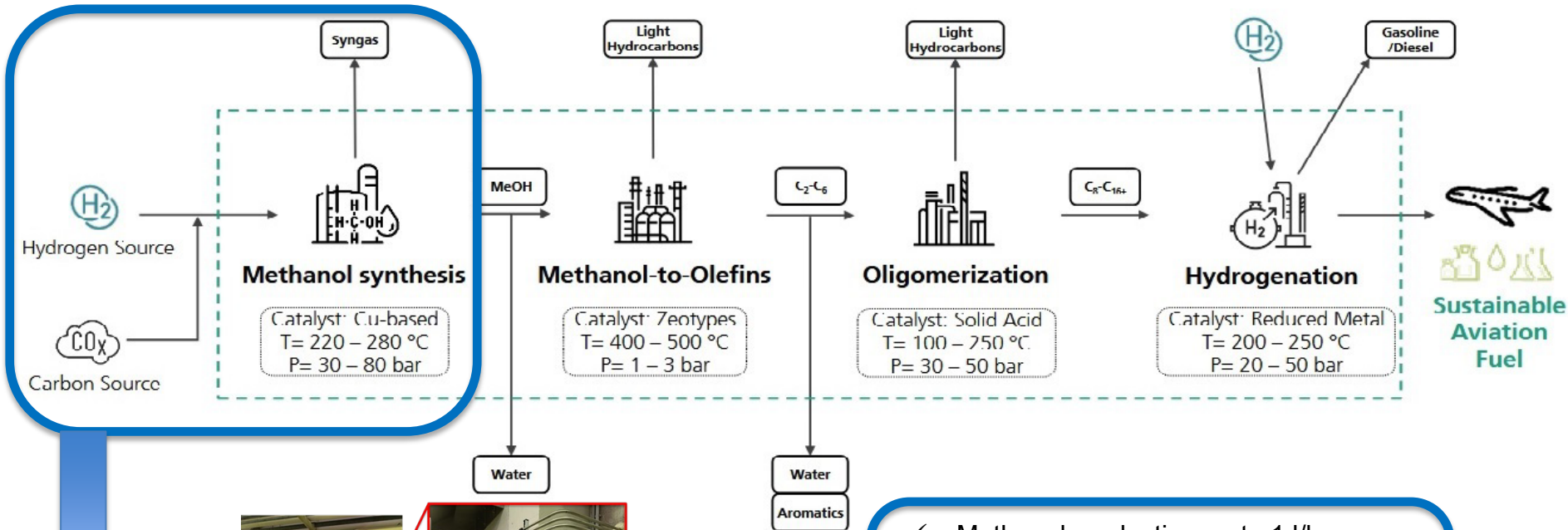


e-cherosene via Fischer Tropsch synthesis

pilot plant - medium TRL (kg/d)

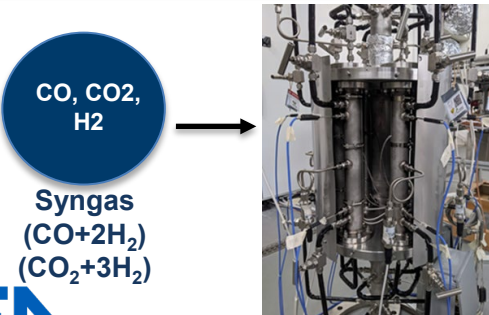
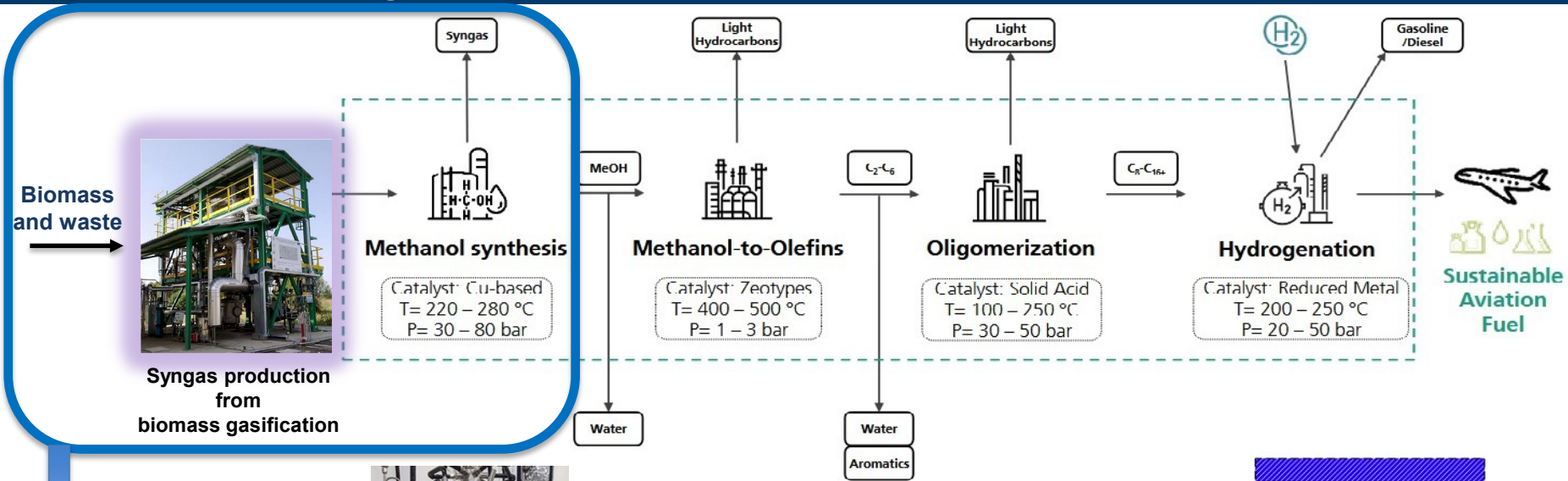


SAF production via PtL methanol synthesis low TRL



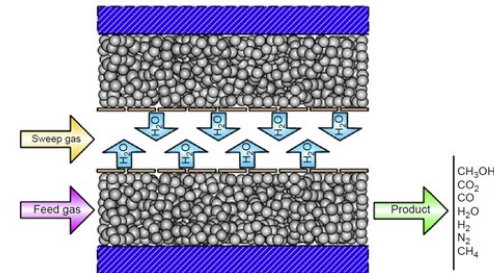
- ✓ Methanol production up to 1 l/h
- ✓ Working pressures 1-100 bar
- ✓ Working temperatures 20-550 °C
- ✓ Control panel and remote monitoring
- ✓ Catalyst development and screening
- ✓ Process modelling

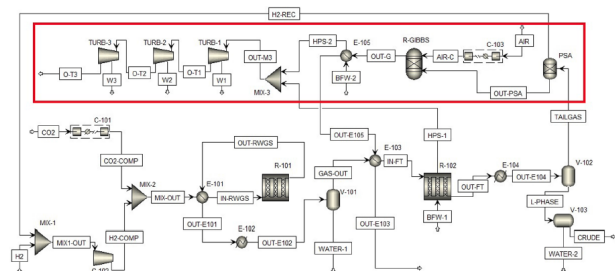
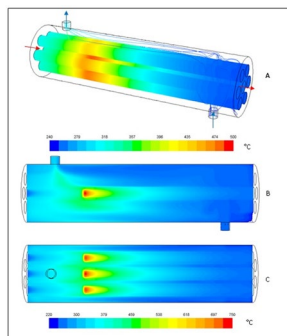
SAF production via PtL methanol synthesis medium TRL



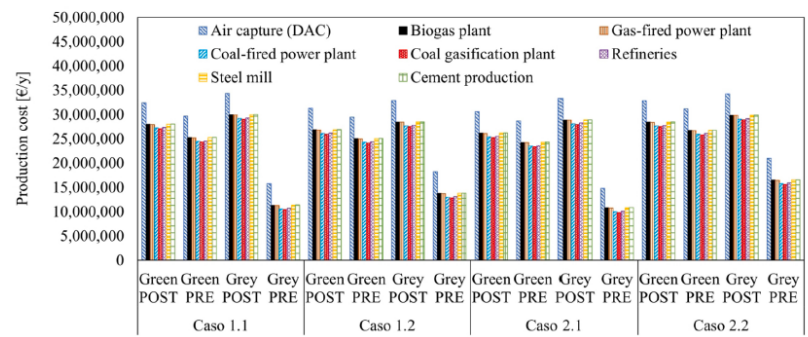
Catalytic membrane reactor for the methanol synthesis composed by:

- Six zeolite membranes stable under reaction conditions (180–220 °C, 30–40 bar) and selective for water permeation
- Multitubular reactor feed by 0.2 Nm³/h of syngas with a core composed of six alumina tubes coated with zeolite synthesized and deposited on their surface.

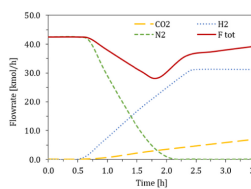




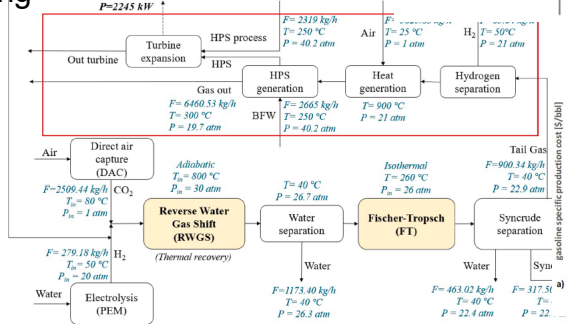
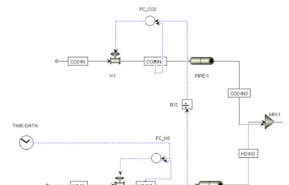
Process modelling



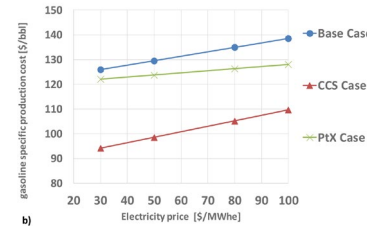
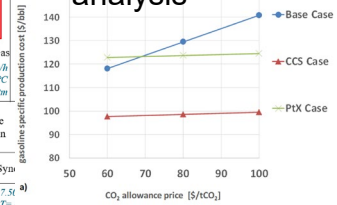
Component and reactor model



Dynamic modelling



Levelized cost of production and economic analysis



SAF-technical and economic assessments





Training and workshop



Take-home messages



✈ Sustainable Aviation Fuel are essential to reducing the aviation sector's carbon footprint.

✈ Several challenges are limiting large-scale adoption:



High production costs

Limited availability of feedstock

Competition with other sectors for resources

Regulatory and certification hurdles

Need for dedicated infrastructure development

✈ HEFA-SAF are available now: it is the only near-term large-scale decarbonization option for the aviation.

Take-home messages



- ✈ Expanding the feedstock base and diversifying conversion technologies requires sustained investment in research and development.
- ✈ A streamlined and harmonized regulatory environment is essential to reduce complexity and provide certainty for investors.
- ✈ Public funding continues to play a crucial role in enabling the large-scale deployment and rapid scale-up of SAF technologies.
- ✈ More SAF will come, with larger market potential !!!!!

**We are working making SAFs
ready for takeoff.**





Thank you for
your kind attention
Claudia Bassano

claudia.bassano@enea.it



1101 0110 1100
0101 0010 1101
0001 0110 1110
1101 0010 1101
1111 1010 0000

