



DIPARTIMENTO DI ENERGIA



# **Synthesis of sustainable fuels: status and perspectives**

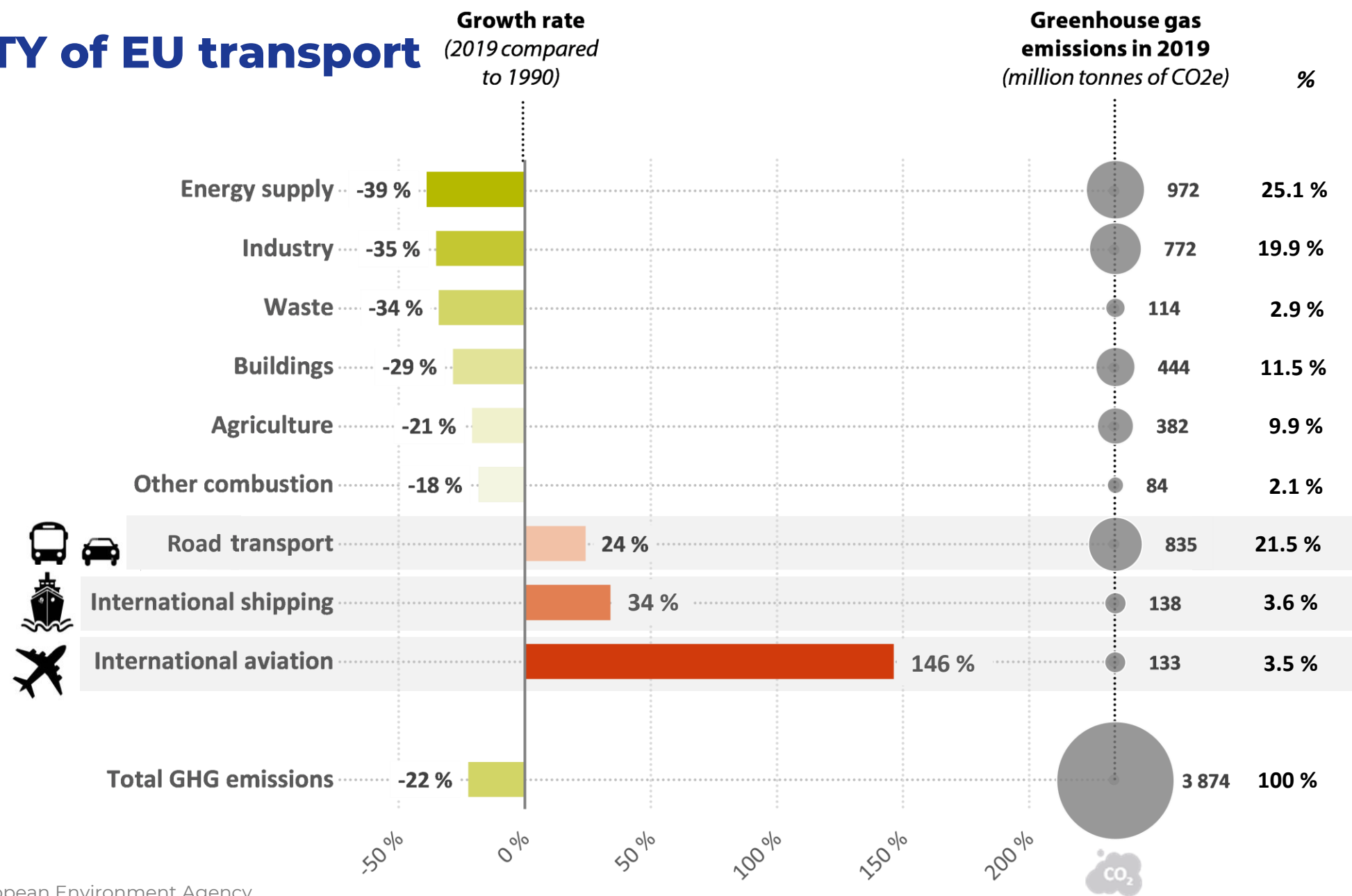
Carlo Giorgio Visconti

“Sustainable fuels (bio-fuels & e-fuels) for CO<sub>2</sub>  
neutral internal combustion engines”

Politecnico di Milano, 19.06.2025

# SUSTAINABILITY of EU transport

Transport not only accounts for ~30% of the EU's total greenhouse gas (GHG) emissions\*, but it is also the fastest-growing source of emissions contributing to climate change.



\*Statista.com, 2023 data  
\*\*Plot readapted from 2022 data of the European Environment Agency

# The urgent need of SUSTAINABLE FUELS (SFs)

**SFs are synthetic fuels that can replace conventional (fossil) fuels (CFs) granting a lower climate impact:**

- by generating **less net greenhouse gas (GHG) emissions** → SFs contribute to limit the **global** warming
- by generating **less combustion byproducts (NO<sub>x</sub>, SO<sub>x</sub>, PM<sub>x</sub>)** → SFs contribute to **local** air quality

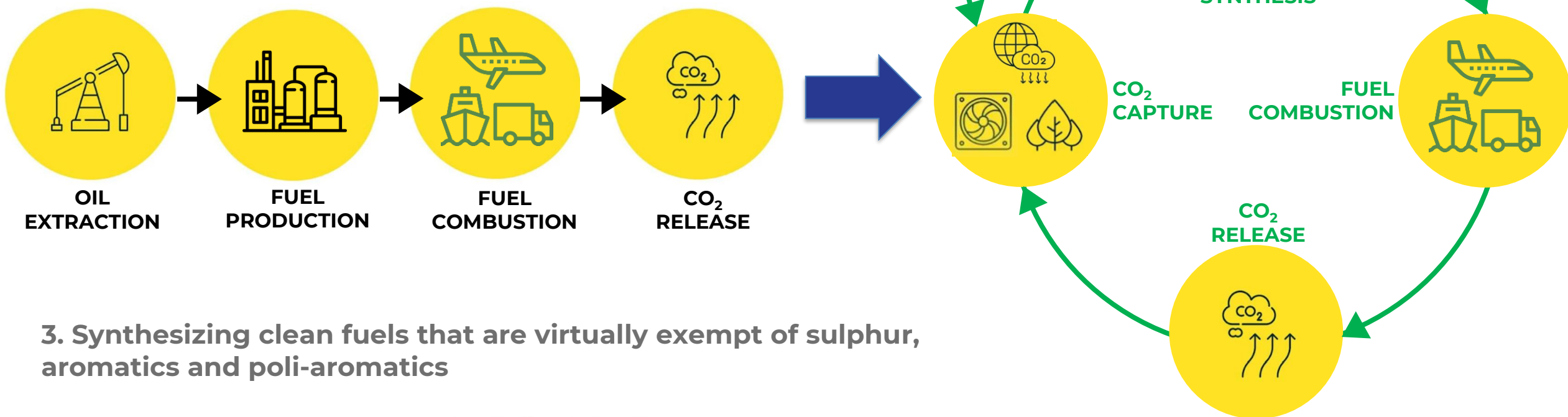
**QTA: how can we synthesize SFs**, supporting the “net-zero GHG emissions by 2050” (climate-neutrality) EU Green Deal goal?

## 1. De-fossilizing the primary source of energy



# The urgent need of SFs / 2

2. Switching from a linear carbon economy to a circular carbon economy (for C-based fuels)



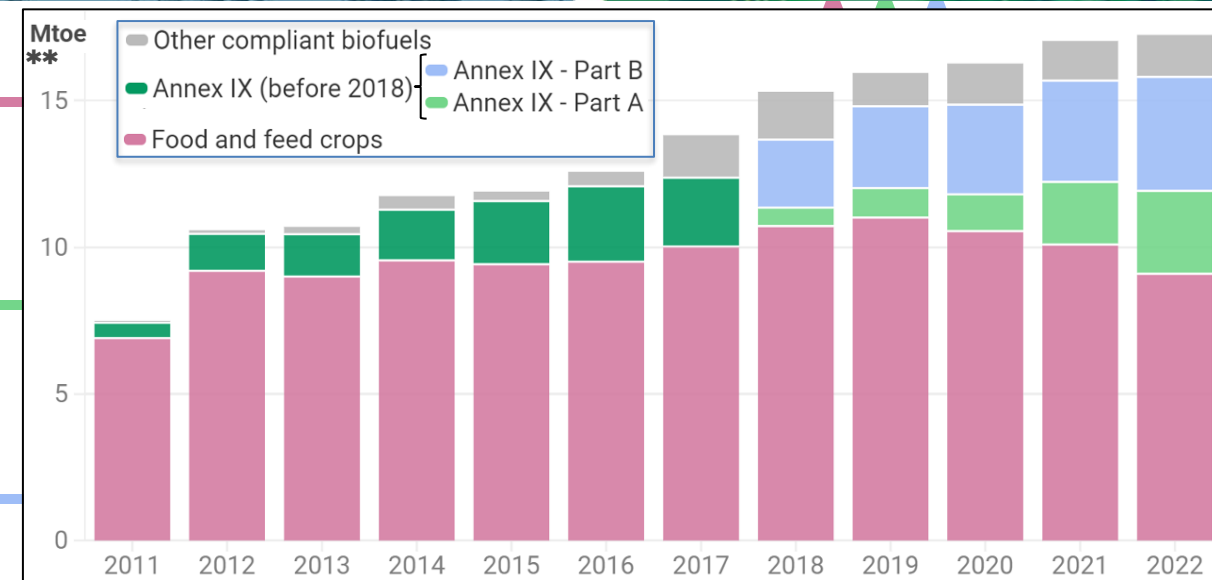
3. Synthesizing clean fuels that are virtually exempt of sulphur, aromatics and poli-aromatics



**KEY-ROLE OF CATALYSIS**



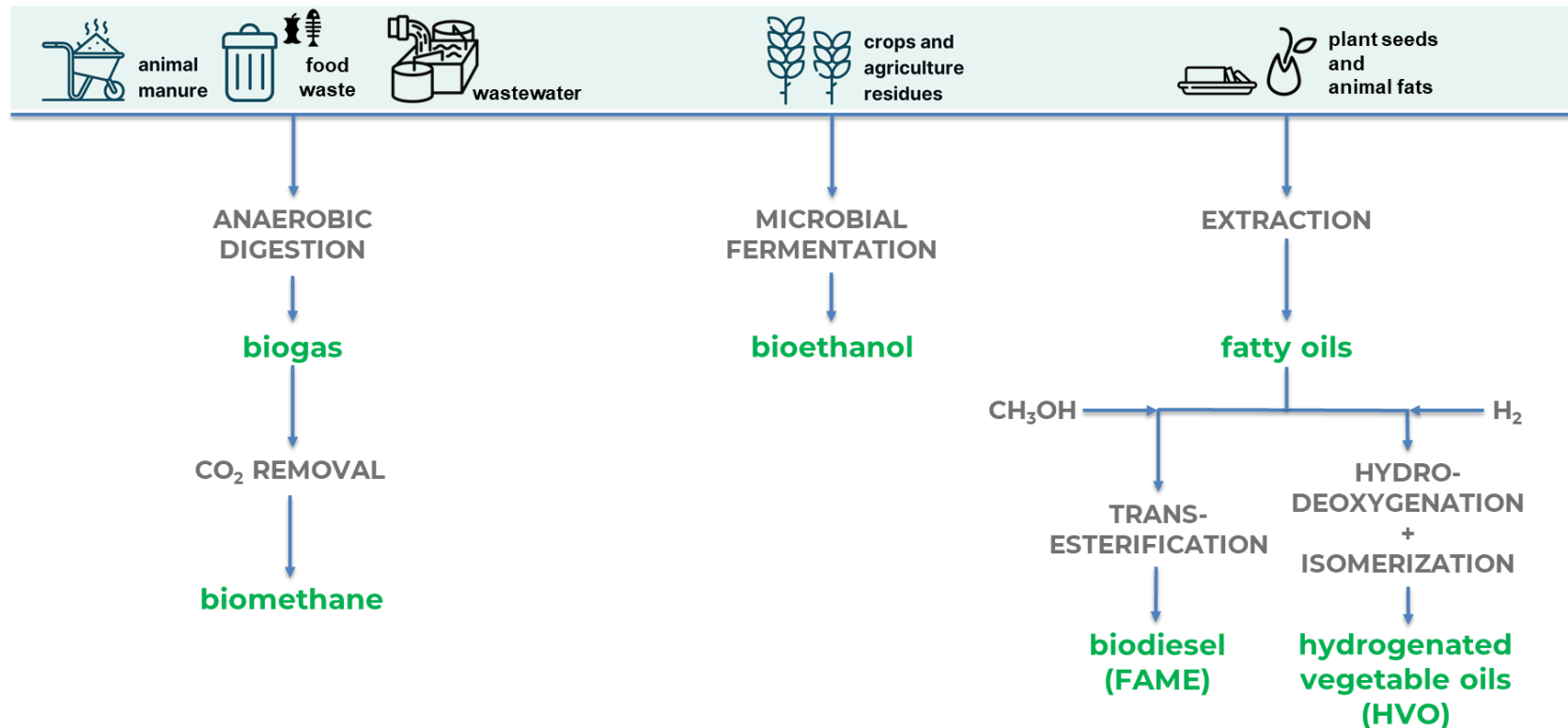
# bio-FUELS: definition, EU classification (REDIII) and production volumes



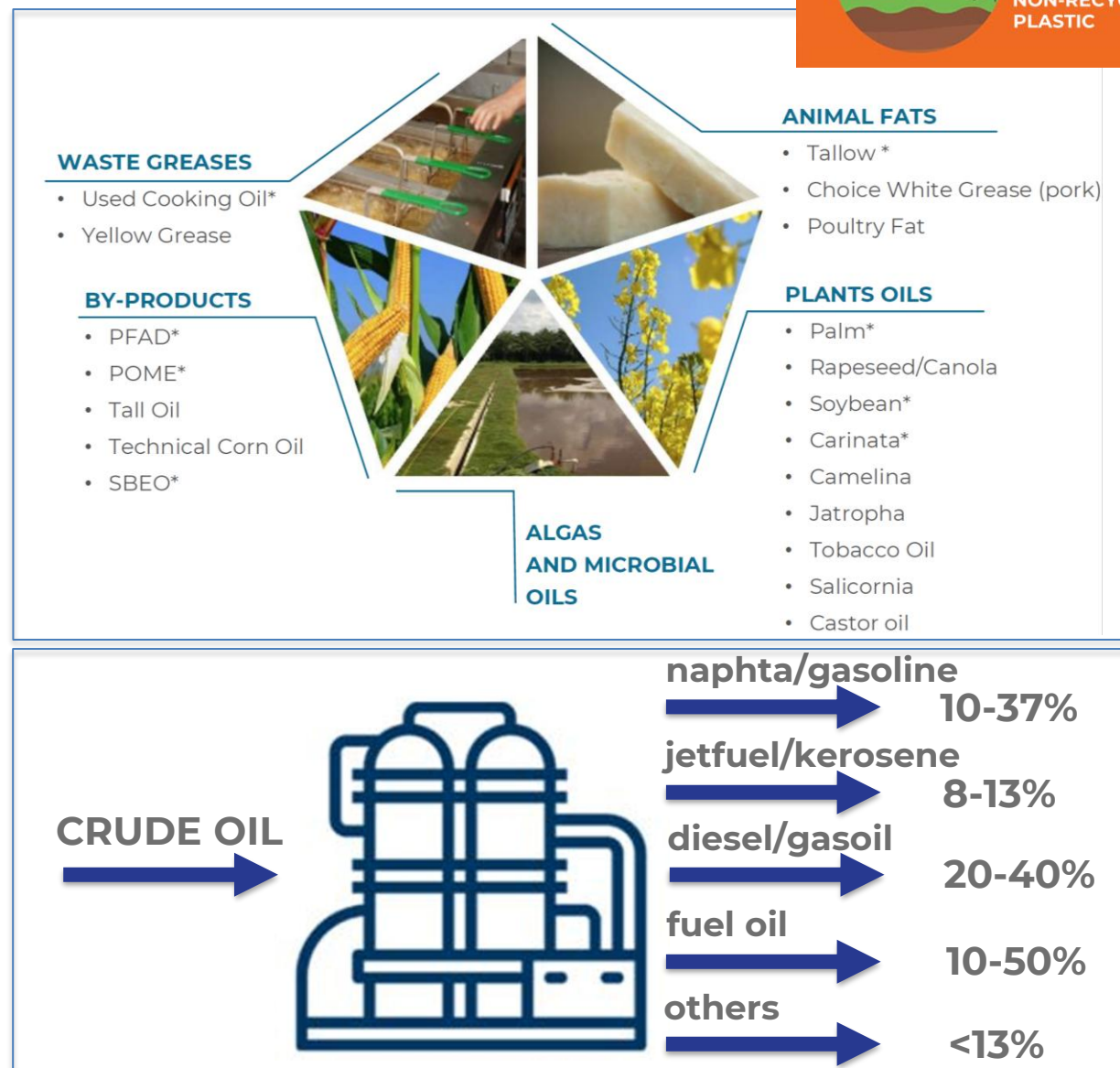
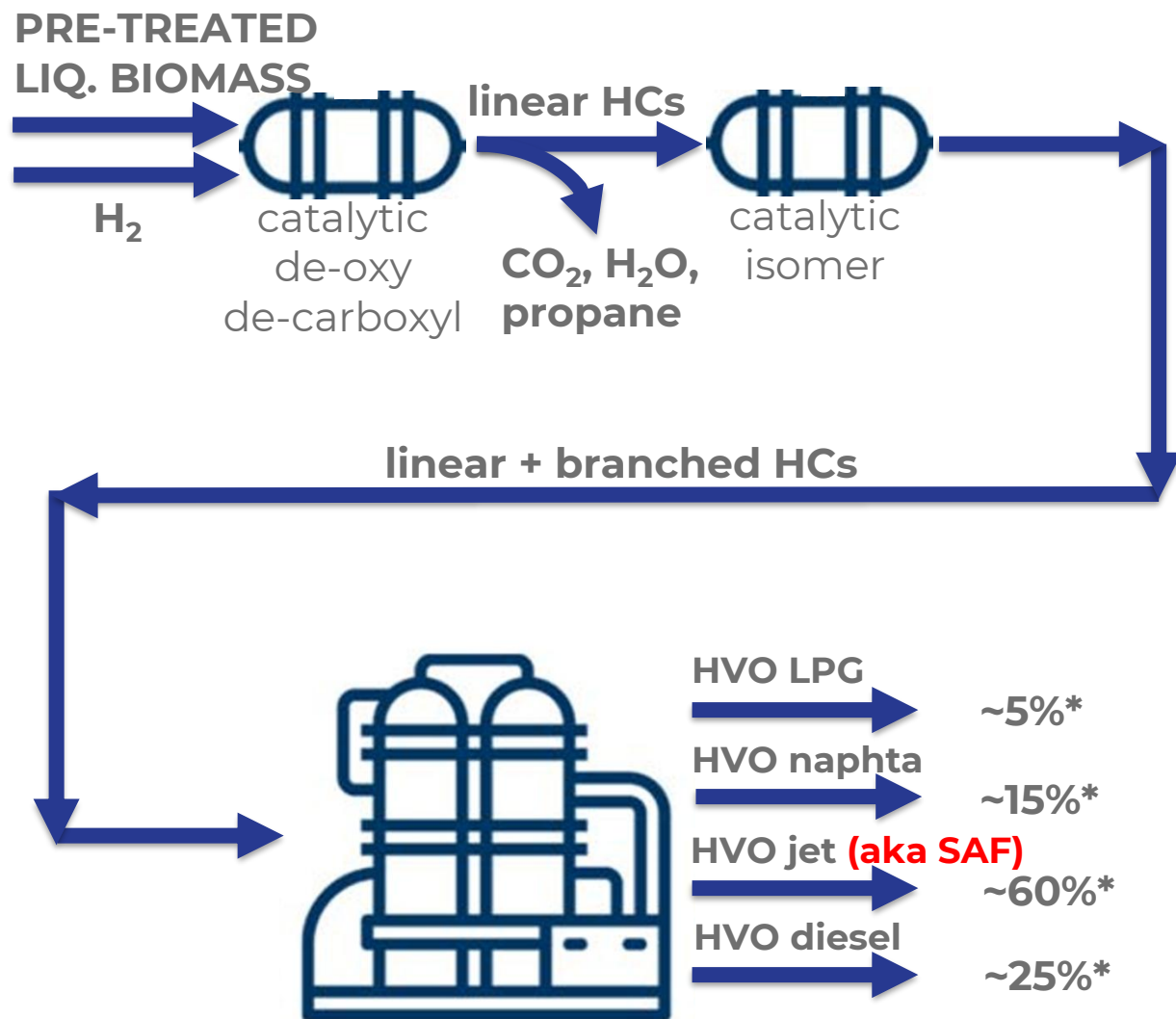
# Main **bio-FUELS** available on the EU market



- **bio-methane** (CNG replacement)
- **bio-ethanol** (E5, E7, E85 used in gasoline blends, E100)
- **bio-diesel, FAME – Fatty Acid Methyl Esters** (B7, B10 used in gasoil blends)
- **hydrogenated vegetable oil, HVO** (XTL, gasoil engine) - **aka HEFA - Hydroprocessed Esters and Fatty Acids**



# HVO: the family of drop-in bio-fuels with the largest interest



\*source: FuelsEurope. Biorefinery in max. jet mode



# HVO: the major Italian initiatives



1° IT HVOs producer

2° EU HVOs producer (after Neste, FI)

3° **World** HVOs producer (after Neste and Valero + Diamond Green Diesel JV, USA)

**Ecofining™ technology (ENI/UOP patent\*, 2008)**

**Venice** biorefinery (since 2014): **400 kt/y** (→ 600 kt/y with new SMR)

**Gela** biorefinery (since 2019): **700 kt/y**

**Today\*\*:** **1.65 Mt/y HVOs** (palm-oil free, since the end of 2022)

**Livorno** biorefinery (announced): **500 kt/y**

**Target\*\*:** **>3 Mt/y HVOs by 2026** (**>1 Mt/y HVO-jet by 2026**)

**>5 Mt/y HVOs by 2030** (**>2 Mt/y HVO-jet by 2030**)

\*WO2008058664A1

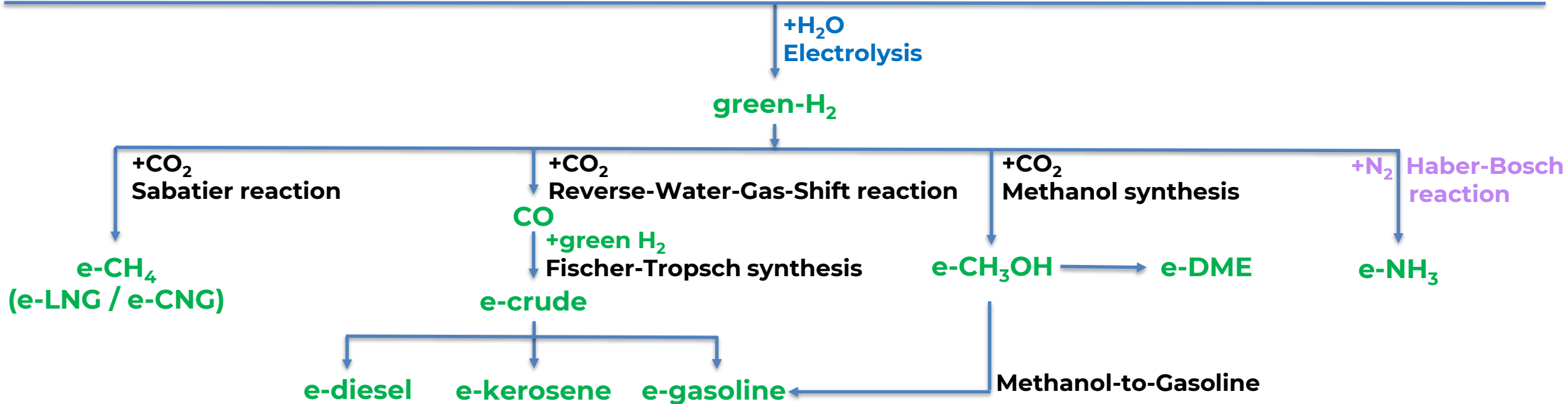
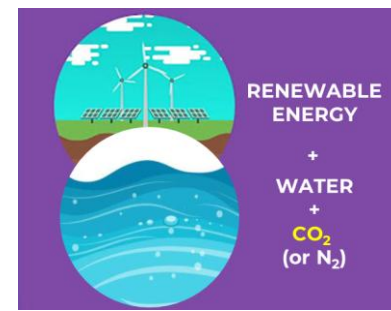
\*\*source: UNEM





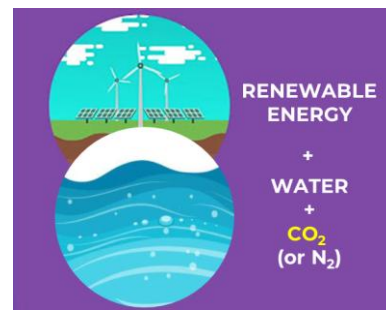
# e-FUELS: definition and main synthesis routes

**Electrofuels (e-fuels)** or Renewable Fuels of Non Biological Origin (**RFNBO**), are **drop-in SFs** synthesized through PTX (Power-to-X) processes from green-H<sub>2</sub> and CO<sub>2</sub> (or N<sub>2</sub>) exploiting appropriate catalysts.



# e-FUELS available on the EU market

There are NO e-fuels commercially available now, **but the 1<sup>st</sup> industrial plant is now online**



Name: “**ERA ONE**”

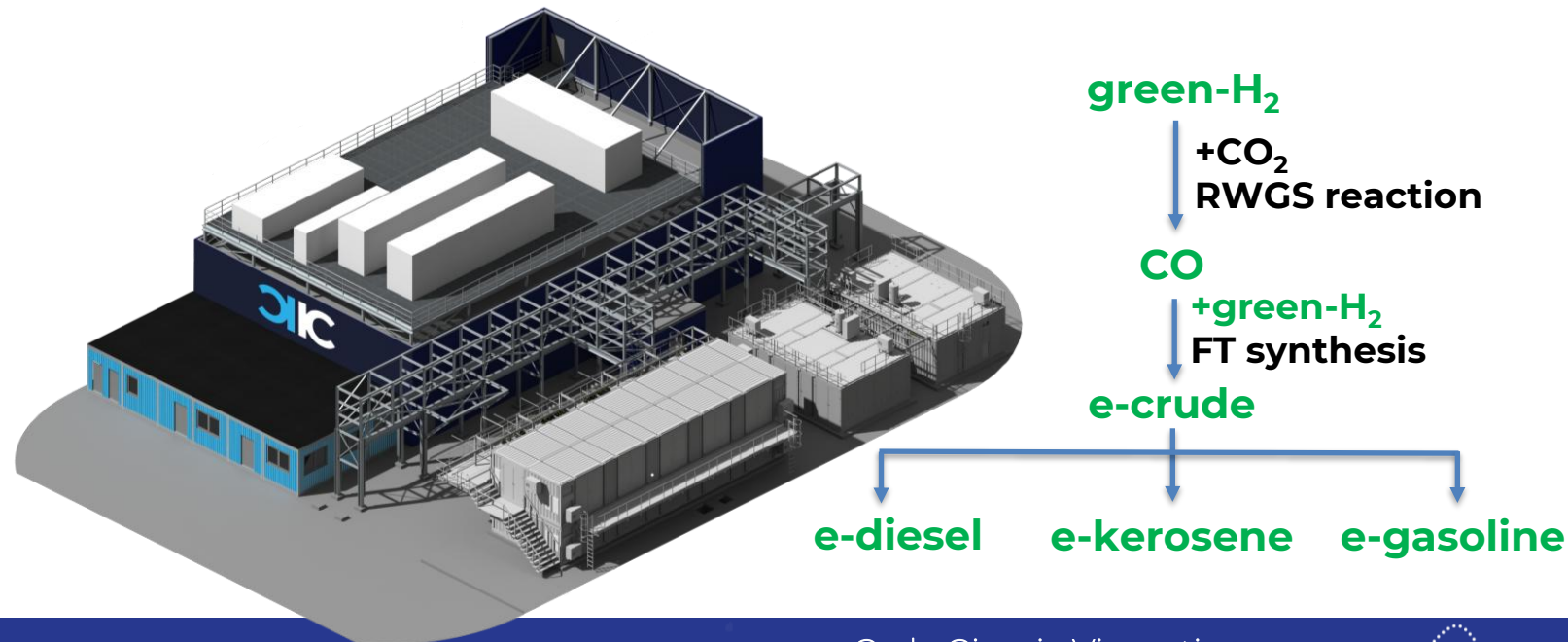
Who: INERATEC (exploiting CLARIANT Ni-catalyst for the RWGS and SASOL Co-catalysts for the FTS)

Where: Industriepark Höchst site, Frankfurt, Germany

When: announced in 2022, under construction from April 2023, start-up **June 3<sup>rd</sup>, 2025**

**INPUT:** 8 kt<sub>CO<sub>2</sub></sub>/y

**OUTPUT:** 2.5 kt<sub>e-crude</sub>/y





# e-FUELS: the largest initiative in Italy (300 t/y e-fuels)



## SARAS S.p.A.: RICONOSCIUTO DAL MASE A SARAS E POLITECNICO DI MILANO UN FINANZIAMENTO PNRR PER LA REALIZZAZIONE DEL PRIMO DIMOSTRATORE DI PRODUZIONE DI COMBUSTIBILE SINTETICO VERDE IN ITALIA.

**Milano 13 dicembre 2023** - Nell'ambito del percorso di evoluzione da "pure refiner" a "sustainable energy player", il Gruppo Saras guarda anche alle opportunità offerte dalle nuove tecnologie in ambito di transizione energetica.

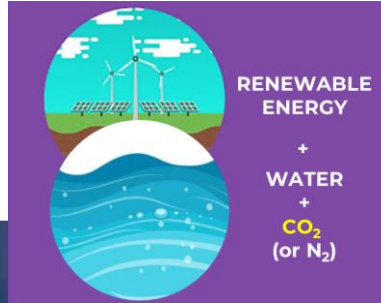
In questo contesto si colloca il recente riconoscimento tra gli investimenti destinati a agevolazioni per l'attuazione del programma "Utilizzo dell'idrogeno in settori hard-to-abate" del Piano Nazionale di Ripresa e Resilienza (PNRR) del progetto per la realizzazione di un dimostratore innovativo per la produzione industriale di circa 300 tonnellate/anno di combustibile sintetico all'interno della raffineria Sarlux a Sarroch (CA), previsto in funzione entro il 2025.



About Us Solutions Careers Newsroom

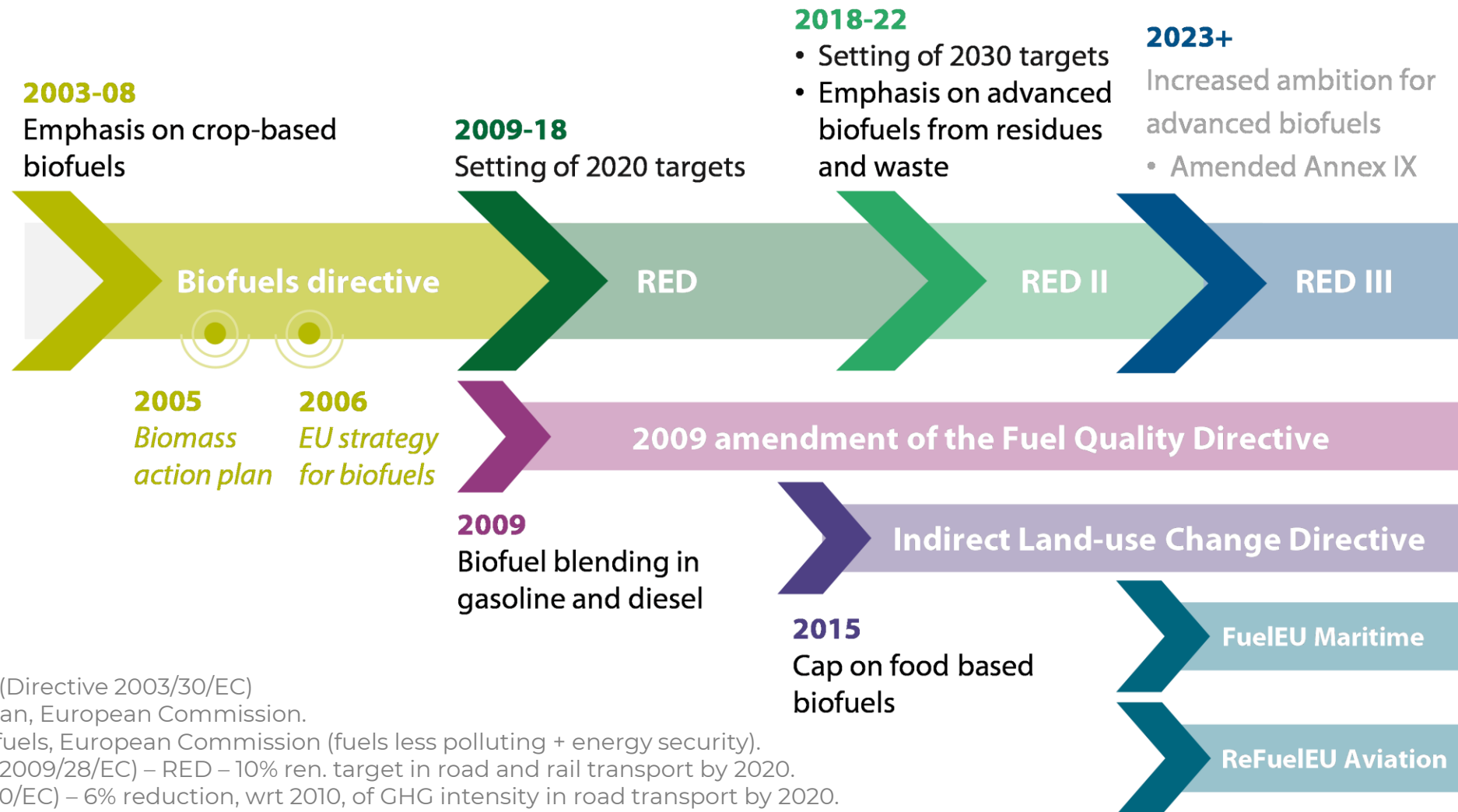
PRESS RELEASE

NEXTCHEM (MAIRE) awarded by Sarlux  
licensing, engineering services, proprietary  
equipment and catalyst supply to integrate its  
NX CPO™ technology in a SAF pilot plant








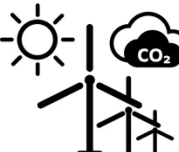

# Over the last 20 years, EU has promoted SFs & set targets for transport



2003: Biofuels and Renewable Fuel Directive (Directive 2003/30/EC)  
 2005: COM(2005) 628 final. Biomass Action Plan, European Commission.  
 2006: COM(2006) 34 final. EU strategy for biofuels, European Commission (fuels less polluting + energy security).  
 2009: Renewable Energy Directive (Directive 2009/28/EC) – RED – 10% ren. target in road and rail transport by 2020.  
 2009: Fuel Quality Directive (Directive 2009/30/EC) – 6% reduction, wrt 2010, of GHG intensity in road transport by 2020.  
 2015: Indirect Land Use Change (ILUC) Directive – 2x on biofuels listed in Annex IX; 7% cap on the contribution of energy from crop-based biofuels in transport.  
 2018: Revised RED (Directive EU/2018/2001) – REDII – 14% ren. target for transport, 3.5% adv. biofuels by 2030; 7% cap on food and feed; 1.7% cap on adv. Part-B, Annex IX.  
 2023: Revised RED (Directive EU/2023/2413) – REDIII – 29% ren. target for transport, 5.5% adv. biofuels + RFNBO (min 1%) by 2030; 7% and 1.7% caps REDII unchanged.

# Current EU targets (and constraints) for 2030

**REDIII → 29% RES-T (or -14.5% GHG wrt 2010); Adv. bio-fuels + RFNBO > 5.5% (of which RFNBO > 1%)**

	 <b>Food and feed crops</b>	 <b>Advanced biofuels</b> (Part A of Annex IX)	 <b>Mature biofuels</b> (Part B of Annex IX)	 <b>efuels (RFNBO)</b> (Part A of Annex IX)
2030-target	7 % max. 	x 2	1.7 % max. x 2	x 2

7 % max.

value capped at 2020 level, but not more than 7 % of final consumption of energy in transport

x 2

value counted twice of its energy content

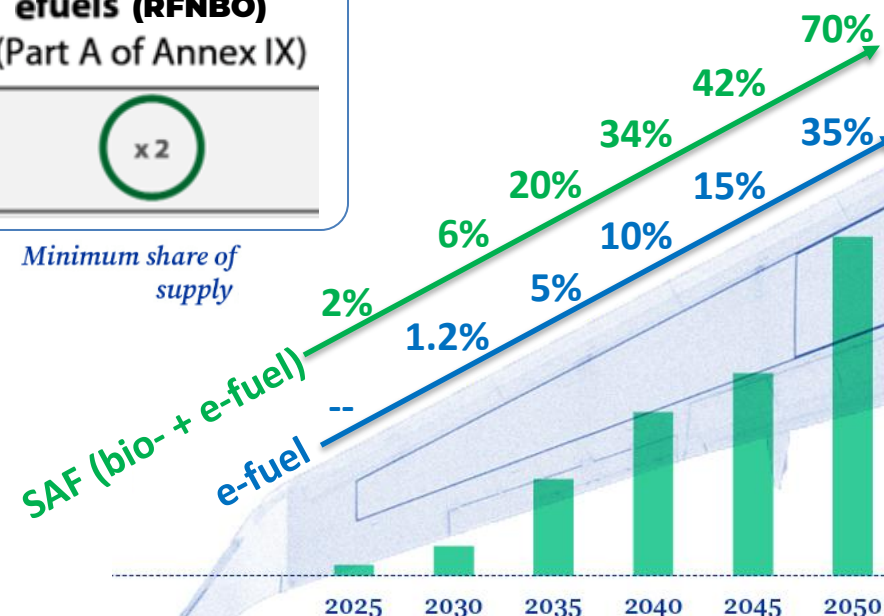


no high-ILUC crops counted for target

1.7 % max.

value capped at the level of 1.7 % of final consumption of energy in transport

Minimum share of supply



**ReFuelEU Aviation → Adv. bio-fuels + RFNBO > 6% (of which RFNBO > 1.2%)**

**FuelEU Maritime → -6% GHG wrt 2020 baseline; RFNBO 1% by 2031 or 2% by 2034**

2015: Indirect Land Use Change (ILUC) Directive – 2x on biofuels listed in Annex IX; 7% cap on the contribution of energy from crop-based biofuels in transport.

2018: Revised RED(Directive EU/2018/2001) – REDII – 14% ren. target for transport, 3.5% adv. biofuels by 2030; 7% cap on food and feed; 1.7% cap on adv. Part-B, Annex IX.

2023: Revised RED (Directive EU/2023/2413) – REDIII – 29% ren. target for transport, 5.5% adv. biofuels + RFNBO (min 1%) by 2030; 7% and 1.7% caps REDII unchanged.

# Why should we invest in SFs?

- SFs are commercially available, usable for all types of transportation and applicable to the existing vehicle fleet  
→ **immediate environmental benefits**
- SFs enhance the value of existing infrastructure in Italy (13 refineries - including 2 biorefineries; 21'000+ fuel stations)<sup>1</sup> and in EU (85 refineries - including 8 biorefineries; 137'000+ fuel stations)<sup>2</sup>  
→ **transition possible with limited capital intensity**
- SFs enable the long-term development of ICEs, in which the national/EU components supply chain is strategic  
→ **preserves EU competitiveness in the value chains linked to fuels and automotive**
- SFs allow to develop fully domestic/EU supply chains, without reliance on components or raw materials controlled by a few countries  
→ **preserves the energy security of Europe**
- SFs allow the redeployment of the 150'000 people currently employed in the EU traditional fuel supply chain  
→ **preserves quality jobs and social coherence**
- **SFs are a unique solution to defossilize aviation and maritime sectors and are not in competition with transport electrification for road transport!**

<sup>1</sup>source: [www.unem.it/il-downstream-petrolifero/](http://www.unem.it/il-downstream-petrolifero/)

<sup>2</sup>source: [www.concawe.eu/refineries-map/](http://www.concawe.eu/refineries-map/)



# CONTACTS



**POLITECNICO  
MILANO 1863**

DIPARTIMENTO DI ENERGIA

Campus Bovisa  
via Lambruschini 4A, 20156 Milano  
[www.energia.polimi.it](http://www.energia.polimi.it)  
[www.polimi.it](http://www.polimi.it)



**LCCP**  
LABORATORY  
OF CATALYSIS  
AND CATALYTIC  
PROCESSES



**Prof. Carlo Giorgio Visconti**

[linkedin.com/in/carlogiorgiovisconti](https://www.linkedin.com/in/carlogiorgiovisconti)

