SUSTAINABILITY REQUIREMENTS FOR SAF IN EU: GHG EMISSIONS ACCOUNTING WITHIN THE LEGISLATION

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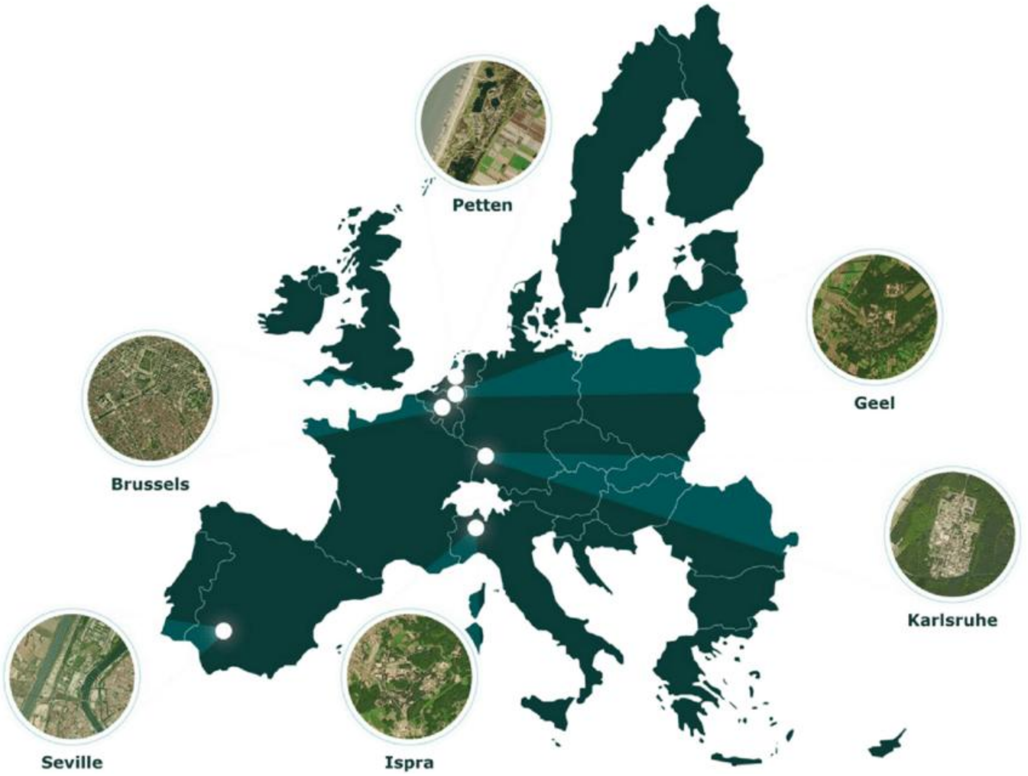
The views expressed here are purely those of the authors and may not, under any circumstances, be regarded as an official position of the European Commission.

EUBCE 2025 parallel event
Aviation Biofuels, Market Outlook and Challenges:
Insights from Cocpit Project
May 11th 2025

About us

- **Joint Research Centre** (JRC) serves as the European Commission's science and knowledge service, offering independent advice to EU policymakers and placing science at the core of European policies.
- Unit C.2 focuses on bioenergy, biofuels and alternative fuels assessments, including calculations for **energy** and **GHG emissions.**
- Unit C.6 performs **energy modelling** to develop scenarios for the implementation of renewable energy technologies.
- **Transparency** is a key value of the JRC, publicly disseminating outcomes and findings through its data hub, scientific papers and international initiatives



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European legislative framework I

- The **European Green Deal** set the path in 2019 to a green transition, towards climate neutrality by 2050.
- EC released in 2021 the **'fit for 55'** package, updating the EU target for GHG emissions reduction at 55% by 2030
- The revision of the Renewable Energy Directive (**RED III**) set a target **of 42.5% RES** by 2030:
  - for transports **14.5% GHG intensity reduction** (compared to the FFC baseline) or binding 29% RES;
  - sub-target of 5.5% for **advanced biofuels/biogas for transport** & **renewable fuels of non-biological origin** (minimum requirement of 1% **RFNBO)**;
  - use of biomass sources that meet the RED sustainability criteria;
  - GHG reduction thresholds as in RED II: **50-65% for biofuels**, depending on date of facility construction, **70% for RFNBO & RCF;**
  - delegated regulations on **RFNBO/RCF – criteria & GHG calculation methodology:** EC approved some voluntary schemes

European legislative framework II

- **'Net-Zero Industry Act' (NZIA)** aims to support the manufacturing of clean tech in Europe. Provisions include easier permitting for factories, criteria on local content in public procurement and energy auctions. To enable its implementation, EC provided specific policies reporting the eligible technologies.
  - **Delegated Act** amending the list of net-zero technologies and their specific component
  - **Implementing Act** providing for a list of main specific components
- The framework to decarbonize the EU aviation sector is established: **REFuelEU Aviation**
  - Promoting **sustainable aviation fuels (SAF)** – with an obligation for planes to take on sustainable aviation fuels for all flights departing from EU airports; applies to aircraft operators, EU airports and to aviation fuel suppliers.
  - For aviation, a target of 70% of SAFs has been set for 2050 for both fuel suppliers, and to airlines companies to uplift (SAF-blended) aviation fuel at EU airports.
  - **SAF** (i.e. eligible fuels): adv. biofuels, biofuels from Annex IX part B, other non-food, sustainable biofuels (RED)

Total shares in the fuel mix (%)	2025	2030	2035	2040	2045	2050
SAF ramp up:	2	6	20	34	42	70
Of which: sub-mandate on RFNBOs	-	>1.2	5	8	11	28

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Definitions of fuels that can be SAF

Advanced Biofuels are biofuels that are produced from the feedstock listed in Part A of Annex IX
Biofuels from feedstock listed in Part B of Annex IX

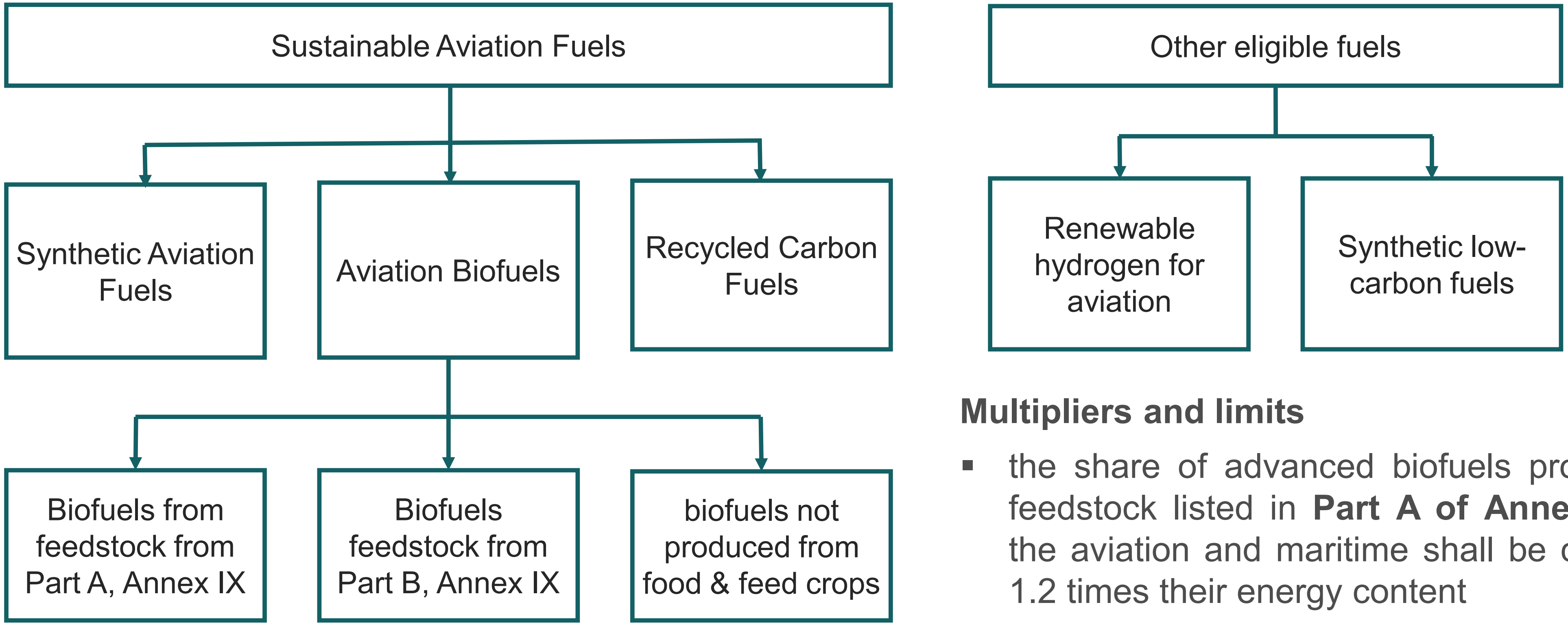
'synthetic aviation fuels' means aviation fuels that are **'renewable fuels of non-biological origin'**, which meet lifecycle emissions savings threshold of 70 % and the methodologies for assessing such lifecycle emissions savings and are certified

'synthetic low-carbon aviation fuels' - aviation fuels that are of **non-biological origin**, the energy content of which is **derived from non-fossil low-carbon hydrogen**, which meet lifecycle emissions savings threshold of 70% and the methodologies for assessing lifecycle emissions savings

Renewable fuels of non-biological origin (RFNBOs) are '*liquid or gaseous fuels which are used in the transport sector other than biofuels or biogas, the energy content of which is derived from renewable sources other than biomass*' (Art. 2(36)).

RCFs are defined (Art. 2(35)) as '**liquid and gaseous fuels** that are produced from: i) **liquid or solid waste streams of non-renewable origin** which are not suitable for material recovery … or ii) from **waste processing gas and exhaust gas of non-renewable origin** which are produced as an unavoidable and unintentional consequence of the production process in industrial installations.'

Eligible Aviation Fuels



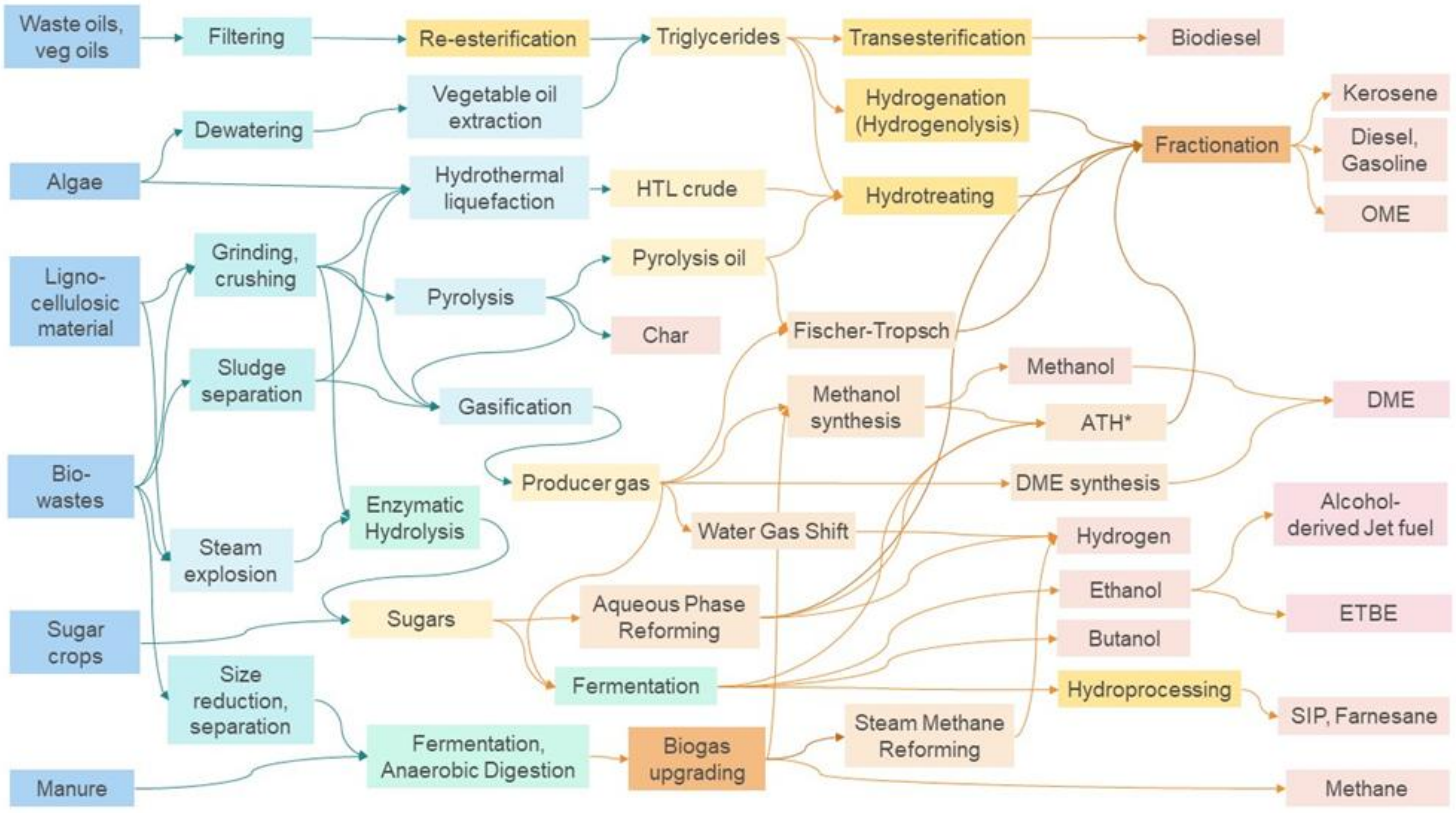
Eligibility Sustainable Aviation Fuels

- sustainability criteria and GHG thresholds established in Directive (EU) 2018/2001 (REDII) and 2023/2413 (REDIII).
- **biofuels produced from food and feed crops are not eligible**

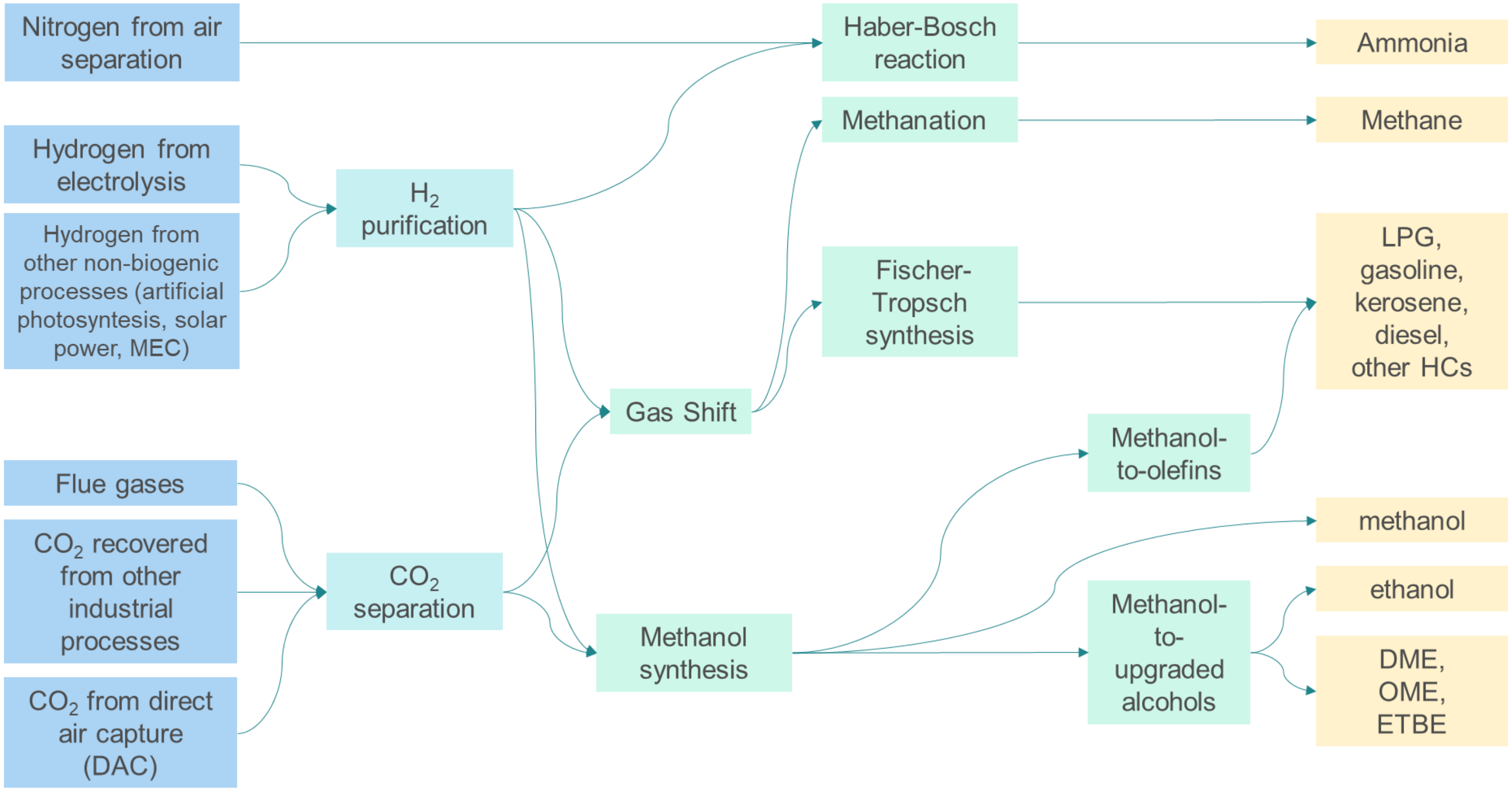
Multipliers and limits

- the share of advanced biofuels produced from the feedstock listed in **Part A of Annex IX** supplied in the aviation and maritime shall be considered to be 1.2 times their energy content
- the share of **renewable fuels of non-biological origin** supplied in the aviation and maritime shall be considered to be 1.5 times their energy content;
- the share of biofuels produced from the feedstock listed in **Part B of Annex IX** in the energy content of fuels and electricity supplied to the transport sector shall be limited to 1.7%;

Advanced biofuels pathways



RFNBO pathways



Fuels
- Hydrocarbons (methane, gasoline, diesel, kerosene)
- Alcohols (methanol, ethanol)
- Ammonia

RFNBO conversion
- Methanation
- Methanolysis
- Fischer-Tropsch reaction
- Haber-Bosch reaction

First conversion step
- Hydrogen
- Carbon dioxide
- Nitrogen

Feedstock
- Renewable energy (to produce electricity and/or heat, excluding the bio-derived ones) and water

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RED GHG accounting: simplified LCA

- LCA based approach adapted to **EU policy requirements**.
- Simplified (WtW), attributional methodology with minor exceptions.
- RED framework targets GHG emissions as grams of CO_2 equivalent (gCO2eq). The climate-impact calculation accounts for emissions of CO2, CH4, and N2O.
- No emissions from combustion, considered Carbon neutral: the CO2 is reabsorbed by biomass growth
- All cultivation emissions are considered, including emissions from the use of synthetic or organic fertilizers
- Emissions from carbon stock changes caused by Land-Use Changes are annualized over a period of 20 years
- Infrastructure and end-of-life emissions (including waste disposal) are not included

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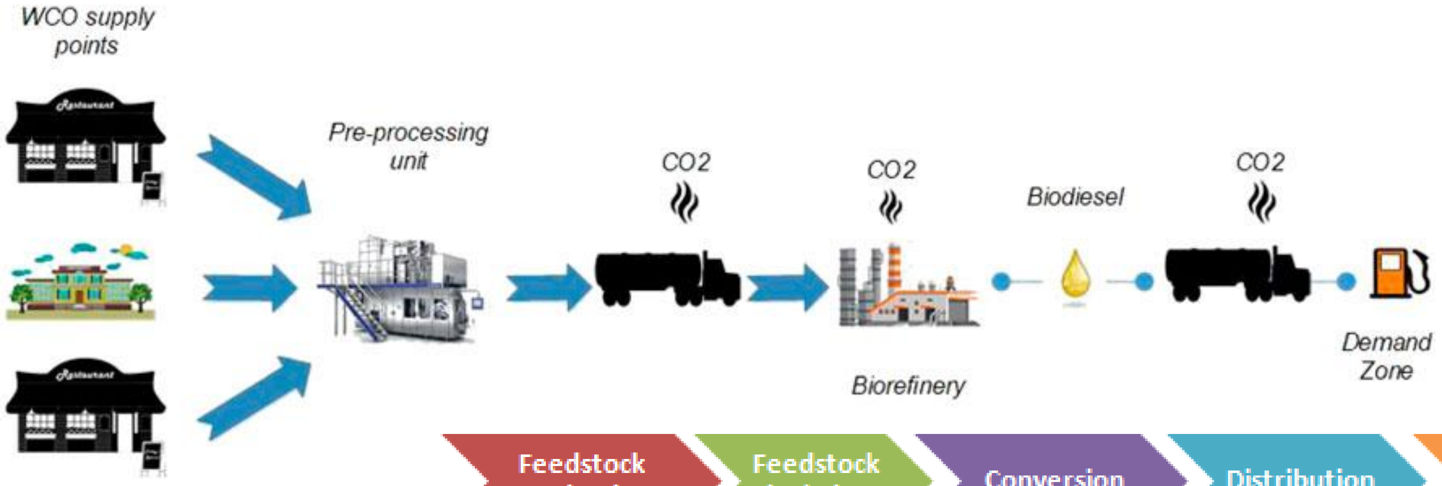
Full value chain evaluation approach



Feedstock production	Feedstock logistics	Conversion	Distribution	End use
• Agricultural crops • Agricultural residues • Energy crops • Forest residues • Wastes	Harvesting and Collection Storage Preprocessing Transportation	**Biochemical conversion** -Acid hydrolysis -Pretreatment and enzymatic hydrolysis -Fermentation **Thermochemical Conversion** -Gasification -Pyrolysis -Hydrothermal depolymerisation **Chemical** - Transesterification	**Transportation-** Truck, Rail, Pipeline **Storage-** Blending terminals **Dispensing-** Dedicated pumps, Blending pumps	• Light duty vehicles • Light duty trucks • Heavy duty trucks • Off road vehicles • Locomotives • Airplanes • Jets • Boats • Ships etc.

Sources: eai.in/ref/ae/bio/biz/biomass, doi.org/10.3389/fenrg.2023.1222787

Methodology for GHG emissions calculations

$$E = e_{ec} + e_{i} + e_{p} + e_{td} + e_{u} - e_{sca} - e_{ccs} - e_{ccr}$$

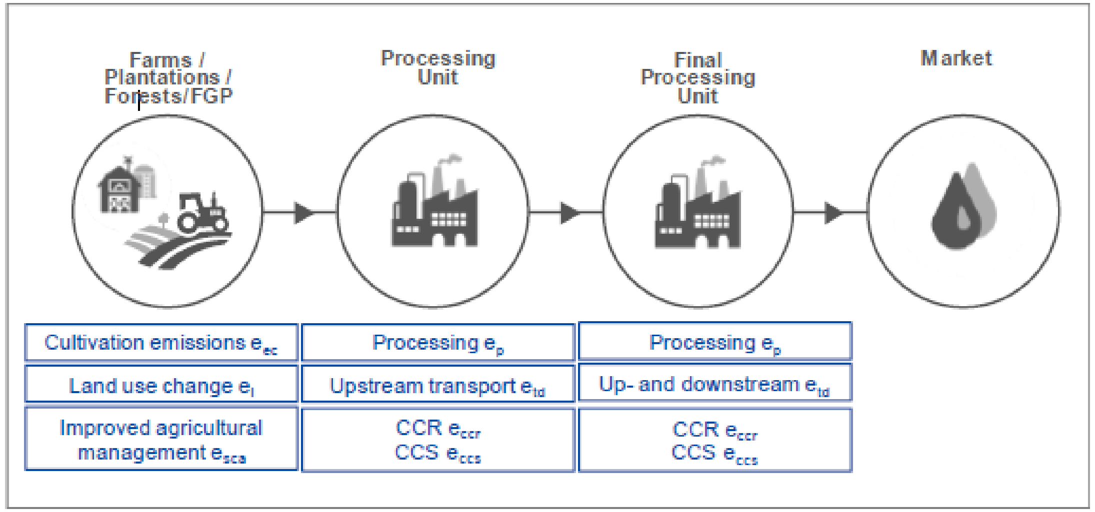
GHG emissions from:

e_{ec} = extraction and cultivation of raw materials
e_{i} = carbon stock changes caused by land-use change
e_{p} = processing
e_{td} = transport and distribution
e_{u} = fuel combustion

GHG emissions savings through:

e_{sca} = soil carbon accumulation via improved farming practices
e_{ccs} = capture and geological storage
e_{ccr} = capture and replacement of CO2

Source: REDcert GmbH 2021 Version EU 05



EU GHG accounting methodology for biofuels

- **GHG emissions calculation** are available in the **Annex V & VI (part C) in RED II** (developed by JRC).
- The calculation model considers also **savings and credits** generated by some cultivation practices and/or initial feedstock (e.g. use of manure)
- Operators can use **default values** listed in Annex V and VI (only if Land Use change emissions = 0) to simplify calculation... or declare their **actual values**
- **Default values** include a “safety” factor of **20/40% increase** in emissions from processing compared to typical values
- **Disaggregated** default values are specified:
  - cultivation (with or without N_2O); processing; transport and distribution, total emissions
  - a combination of default for some production steps + actual for others can be used

JRC’ calculations are available at:

- ANNEX V - http://data.europa.eu/89h/e51f4304-7023-4fca-8900-7d206f89b914
- ANNEX VI - https://data.jrc.ec.europa.eu/dataset/jrc-alf-bio-bioenergy_jrc_annexvi_com2016-767_v1_july17

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RED – Emissions savings

- In the RED II, HG emissions of the fuel (E) are calculated with a life cycle perspective, where the **functional unit is 1 MJ of fuel**. The revised emission factor for the fossil fuel comparator is **94 g CO2-eq./MJ**.

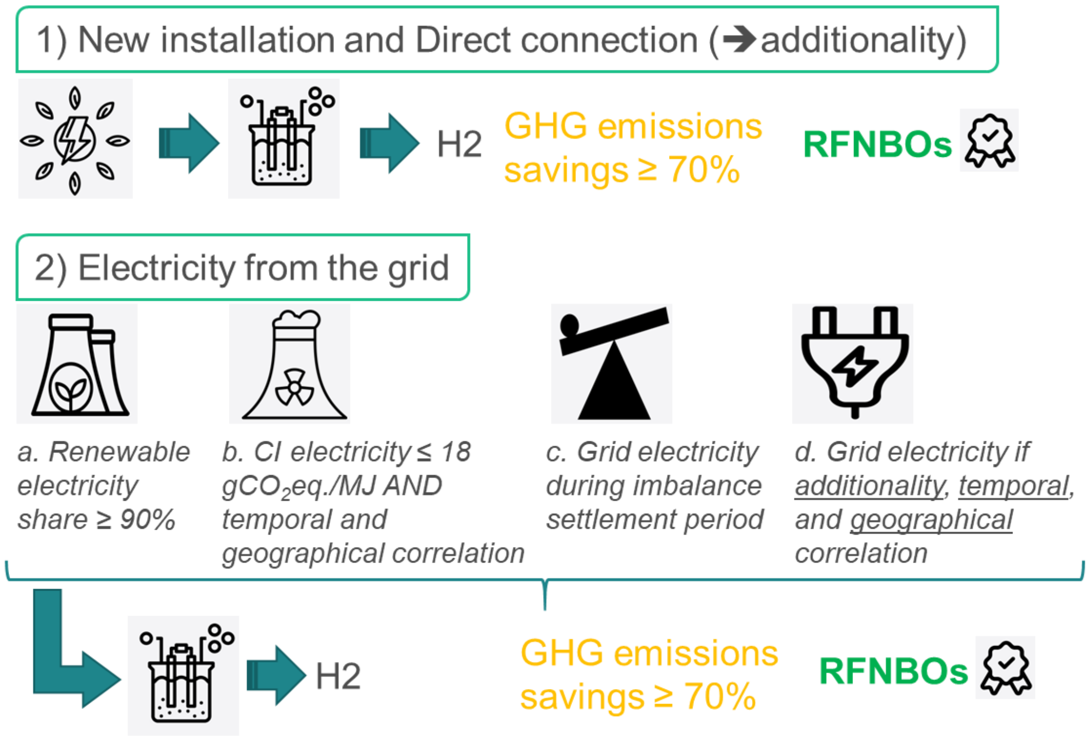
Formula for calculation of GHG savings

$$\text{GHG saving potential}[\%] = \frac{GHG\ emission\ fossil\ reference - GHG\ emission\ biofuel}{GHG\ emission\ fossil\ reference} * 100$$

Methodology for GHG emissions of RFNBO

$$E = e_{i} + e_{p} + e_{td} + e_{u} - e_{ccs}$$

- E = total emissions from the use of the fuel (gCO2eq/ MJ fuel)
- $e_{i} = e_{i\ elastic} + e_{i\ rigid} - e_{ex\text{-}use}$: emissions from supply of inputs (gCO_{2eq}/ MJ fuel)
  - $e_{i\ elastic}$ = emissions from elastic inputs (gCO_{2eq} / MJ fuel)
  - $e_{i\ rigid}$ = emissions from rigid inputs (gCO_{2eq} / MJ fuel)
  - $e_{ex\text{-}use}$ = emissions from inputs’ existing use or fate (gCO_{2eq} / MJ fuel)
- e_{p} = emissions from processing (gCO_{2eq}/ MJ fuel)
- e_{td} = emissions from transport and distribution (gCO_{2eq}/ MJ fuel)
- e u = emissions from combusting the fuel in its end-use (gCO_{2eq}/ MJ fuel)
- e_{ccs} = emissions savings from CCS (gCO_{2eq} / MJ fuel)



Three underlying principles

Additionality

Hydrogen production should add to the deployment of renewable energy

Temporal correlation

Renewable hydrogen should be produced when renewable electricity is available

Geographical location

Renewable hydrogen should be produced where renewable electricity is available.

Technology state of the art and market analysis

Support to Clean Energy Technology Observatory (CETO)

Reports on:

- Advanced biofuels
- Batteries
- Bioenergy
- Carbon Capture Utilisation and Storage
- Concentrated Solar Power and Heat
- Geothermal heat and power
- Heat Pumps
- Hydropower & Pumped Hydropower Storage
- Novel Electricity and Heat Storage
- Ocean energy
- Photovoltaics
- Renewable Fuels of Non-Biological Origin
- Renewable Hydrogen
- Solar Fuels (direct)
- Wind (offshore and onshore)

2024 versions are available online!

Technology Development	Value Chain	Market analysis
Technology Readiness Level	Turnover	Global&EU market leaders
Capacity & production	Gross value added	Trade
Costs	Sustainability	Resource efficiency and dependency
Public R&I funding	Role of EU companies	
Private R&I funding	Employment	
Patenting trends	Energy intensity & productivity	
Bibliometric Trends	EU Production	

+ EU R&I Impact & Trends

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Takeaway messages

- **SAF** are pivotal in the **EU's decarbonization efforts**, with **advanced biofuels** playing a critical role in transitioning to a sustainable energy future.
- **Europe's leadership** in RFNBO technology is supported by policy and industrial capabilities, but large-scale deployment faces challenges like high costs and infrastructure needs (slower market uptake compared to biofuels).
- Need for **sustainable** (value chain-tailored) **biomass management** to ensure feedstock availability without compromising environmental integrity.
- Biomass production, biofuels processes and bioenergy gradually introduce **biogenic CO_2 recovery** to further decarbonize the EU economy, offering the opportunity to produce RFNBO as well.
- **Co-producing high added values co-products** (e.g. biochar) or **alternative crops management systems** can be an opportunity to introduce further GHG emissions reduction/incentives within the supply chain.
- Need for **continued investments** and **policy support** to scale up biofuels production capacity (e.g. NZIA, Innovation Fund, CRCF, ETS, etc.).

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Thank you!

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