ADVANCED BIOFUELS PATHWAYS IN EU: LEGISLATION, STATUS AND GHGs EMISSIONS ACCOUNTING

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Summary and Disclaimer

- The **Joint Research Centre** (JRC) is the Commission's science and knowledge service, and our group is based in Ispra, northern Italy.
- Our group into Unit C.2. provides **scientific policy support** to Commission policy DG's; ENER, CLIMA, MOVE, etc.
- Our work provides bioenergy, biofuels and alternative fuels assessments, including **energy balances and GHG emission accounting**
- We are also collaborating with International agencies and initiatives.

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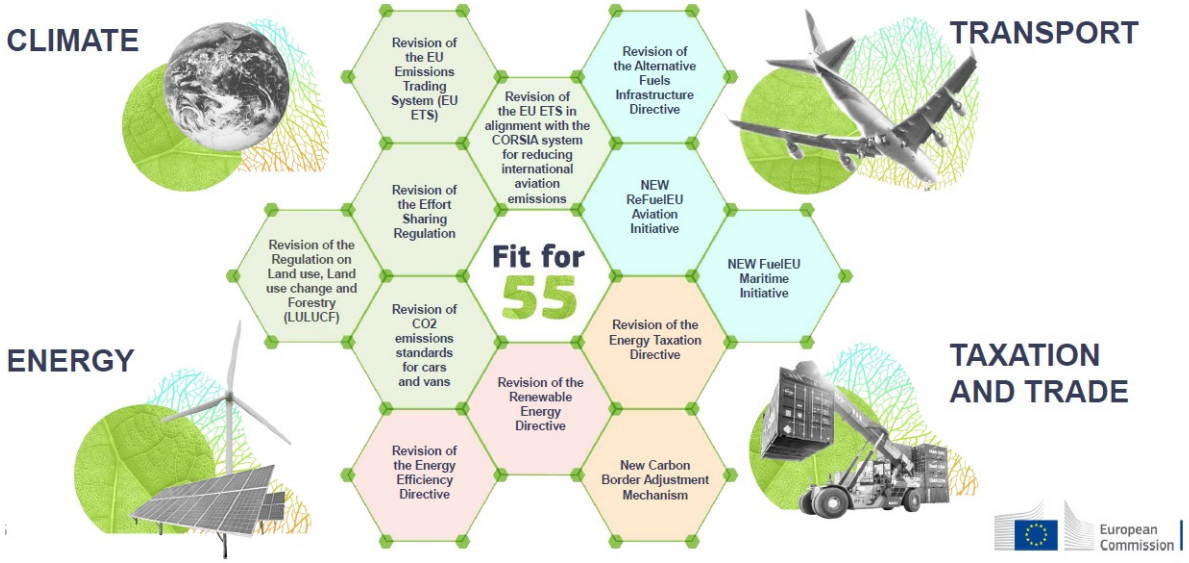
Outline



I. Current EU legislative framework focusing on Advanced Biofuels

II. Sustainability criteria for bioenergy and biofuels

III. RED II GHGs calculation methodology

IV. JECv5 GHGs calculation methodology

V. State of the art of the conversion technologies

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European legislative framework

- **Fit for 55**' package updated the EU's 2030 climate target of at least 55% GHG reduction, according to the **EU Green Deal**' strategy.
- The proposed revision of the **Renewable Energy Directive** 2018/2001 replaces the 14% target for renewable energy in transport with a **13% GHG intensity reduction target for transport for 2030**, compared to the baseline*.
- The comparator of **94 gCO_2e/MJ** for all other transport fuels represents the **GHG intensity of the average liquid fossil fuel mix in the EU**, whereas **183 gCO_2e/MJ** represents the **GHG intensity of fossil-derived electricity.**
- All fuels are required to pass a GHG reduction threshold to be considered eligible. These requirements are **50-65% for biofuels**, depending on date of facility construction, **70% for RFNBOs & RCFs**.

*the baseline shall be calculated by multiplying the amount of energy supplied to the transport sector by the fossil fuel comparator

Advanced biofuels in the RED II

What's an advanced biofuels in EU?

- According to the Renewable Energy Directive (RED II, 2018/2001), advanced biofuels are biofuels produced from the **feedstock listed in Part A of Annex IX**.
- The list includes many types of lignocellulosic material, animal manure, sewage sludge, and algae, as well as selected other wastes and residues.
- Moreover, the contribution of biofuels produced from the feedstocks defined in Annex IX, part B, including **used cooking oil and category 1 and 2 animal fats**, is **limited to 1.7%**, with an option for MSs to request higher caps depending on national feedstock availability.
- The updated target for the energy share of advanced biofuels is at **2.2%** (lower than the 3.5% in RED II), but it also **excludes the use of multipliers**, thus resulting in a higher energy target for renewable fuels.
- The only multiplier maintained is based on a figure of **1.2x** for advanced biofuels and RFNBOs in **aviation** and **maritime sectors**.

Advanced biofuels for maritime and aviation

- Advanced biofuels can contribute to the targets imposed by **ReFuel EU** and **FuelEU Maritime.**
- For **aviation**, a target of **63% of SAFs** towards 2050 has been set for both fuel suppliers to distribute SAF in increasing amounts over time, and to airlines companies to uplift (SAF-blended) aviation fuel at EU airports.

Total shares in the fuel mix (in %)	2025	2030	2035	2040	2045	2050
SAF ramp up:	2	5	20	32	38	63
Of which: sub-mandate on e-fuels	-	0.7	5	8	11	28

- **Maritime** sector has the target of **75% GHGs reduction intensity** expressed in Well-to-Wake (WTW) - CO_2eqt emissions to account for all the life-cycle emissions (CO_2 , CH_4 , N_2O) of the different fuels and relevant engine technologies.

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Specific rules as regards feedstock origin

- The **share of biofuels and bioliquids and of biomass fuels** produced from **food and feed crops** and consumed in transport shall be no more than 1% higher than the share of such fuels in the final consumption of energy in the transport sector in 2020 in that Member State, with a **maximum of 7 %** of final consumption of energy in the transport sector in that Member State

- The **share of high-ILUC risk biofuels, bioliquids or biomass fuels** produced from food and feed crops shall not exceed the level of consumption of such fuels in that Member State in 2019, unless they are certified to be low-ILUC risk biofuels, bioliquids or biomass fuels. From **31 December 2023 until 31 December 2030** at the latest, that limit **shall gradually decrease to 0 %.**

Source: https://www.theedgemarkets.com/article/eus-indirect-land-use-change-approach-palm-oil-flawed-%E2%80%94-cpopc

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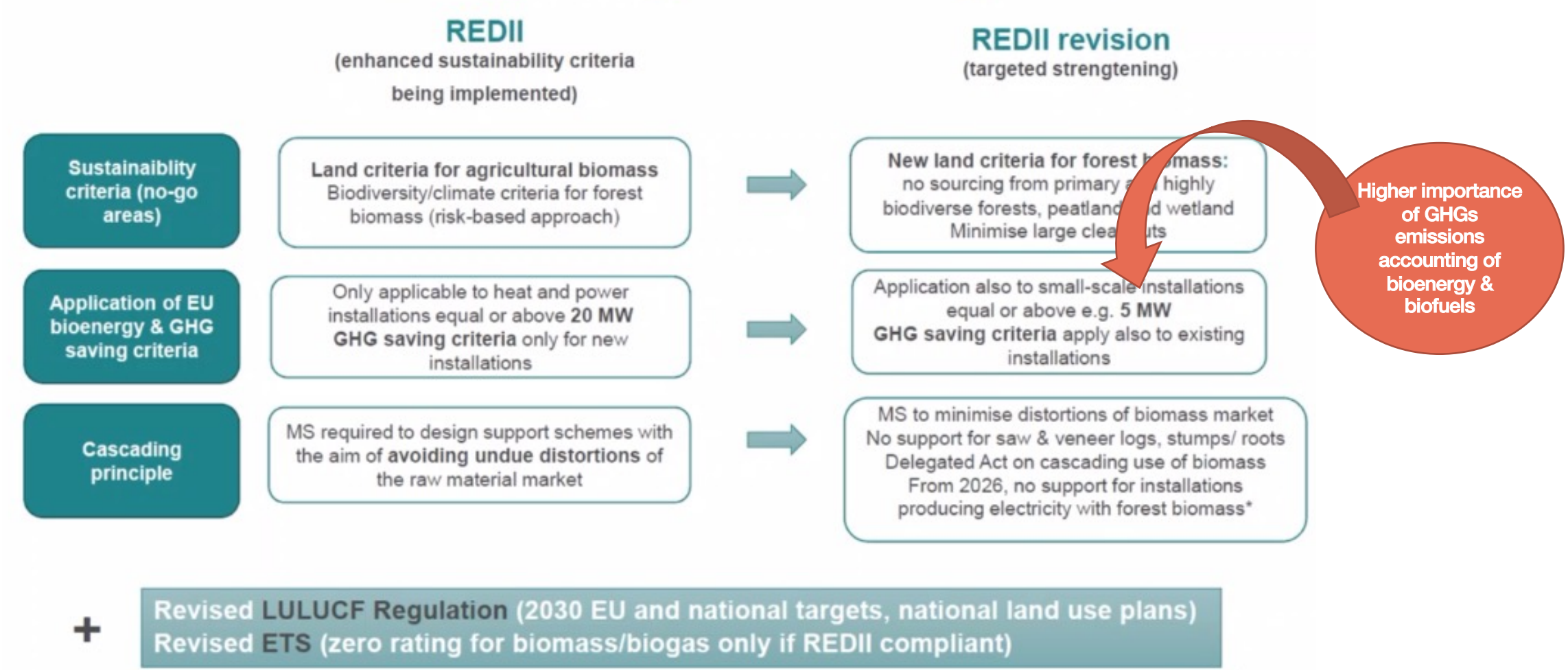
iLUC: a fundamental requirement

- The **2019 Commission Delegated Regulation 181** identifies "**high-ILUC risk**" based on land expansion of biofuel, bioliquids or biomass fuels feedstocks into **high-carbon stock areas**.
- Conversely, biofuels, bioliquids or biomass fuels can be certified as "**low-ILUC risk**" if feedstocks used to produce them are: grown on abandoned or severely degraded land; cultivated using duly verifiable measures to increase productivity beyond the increases which would be already achieved in a business-as-usual scenario (additionality); grown by independent smallholders on plots of land smaller than two hectares.
- Upcoming Commission Implementing Regulation on implementing rules for voluntary schemes under RED II (to be adopted soon) will also cover a module on **low-ILUC certification**.

RED II revision: strengthening sustainability



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RED II: GHGs accounting methodology

- **GHG emissions calculation** (as CO_2eq) are available in the **Annex V & VI (part C) in RED II** (developed by JRC).
- Emissions are reported in **gCO_{2eq}/MJ** for each step of the supply chain as disaggregated values.
- The calculation model considers also **savings** and **credits** generated by some cultivation practices and/or initial feedstock (e.g. use of manure)

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr}$$

where

E	=	total emissions from the use of the fuel;
e_{ec}	=	emissions from the extraction or cultivation of raw materials;
e_l	=	annualised emissions from carbon stock changes caused by land-use change;
e_p	=	emissions from processing;
e_{td}	=	emissions from transport and distribution;
e_u	=	emissions from the fuel in use;
e_{sca}	=	emission savings from soil carbon accumulation via improved agricultural management;
e_{ccs}	=	emission savings from CO_2 capture and geological storage; and
e_{ccr}	=	emission savings from CO_2 capture and replacement.

Emissions from the manufacture of machinery and equipment shall not be taken into account.

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RED II: Actual, default and disaggregated values

- Operators can use **default values** listed in Annex V and VI (only if Land Use change emissions = 0) to simplify calculation for economic operators
- …or declare their **actual values**
- **Default values** include a “safety” factor of **40% increase** in emissions from processing compared to typical values
- **Disaggregated** default values are also specified in Annex V and VI:
  - cultivation emissions (with or without N_2O); processing emissions; transport and distribution emissions (only if the final product is included), total emissions
  - a combination of default for some production steps + actual for others can be used
- **Last update including JRC calculation is publicly 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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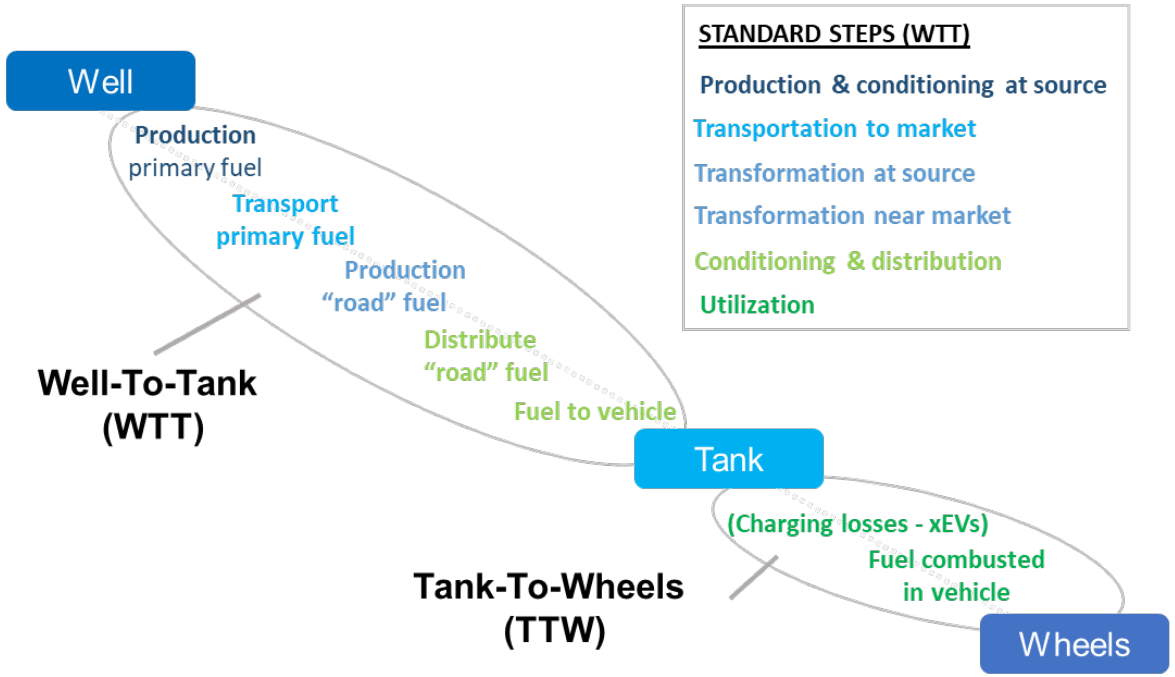
JECv5 - Well-to-Wheel

- *JRC-Eucar-Concawe Well-to-Wheel study version 5 is a long-standing collaboration between the European Commission's Joint Research Centre, EUCAR and Concawe*



Establish

in a **transparent** and **objective** manner a consensual **Well-to-Wheels assessment** of:

- energy use

and

- GHG emissions

for a **wide range** of **automotive fuels** and **powertrains**, relevant to Europe in 2025+

Analysis updated as technologies evolve

Common methodology and data-set

WTT > 250 Resource to fuel pathways
TTW > 60 powertrains solutions

WTW > **1500** potential combinations!

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JECv5 vs REDII: Co-products

A given (fuel) production process may produce multiple products*

* Co-products
Different routes can have very different implications in terms of energy, GHG, or cost
…and it must be realised that economics – rather than energy use or GHG balance – are likely to dictate which routes are the most popular in real life.

RED and RED Recast

- **allocate GHG emissions to biofuels and co-products by energy content** (LHV) **using an ALCA**, i.e.:
  - Emissions are allocated to the main product and on co-products on the basis of their respective energy contents

☑ **Allocation methods simpler to implement**
☒ No accounting of what the by-product substitutes

JEC WTW

- **JEC methodology uses a substitution method (system expansion) since it is a CLCA**, i.e.:
  - All energy and emissions generated by the process are allocated to the main or desired product;
  - The co-product generates an energy and emission credit equal to the energy and emissions saved by not producing what the co-product is most likely to displace.

☑ **Closer representation of "real-life": economic choices of stakeholders**
☒ Uncertainty: outcomes dependent on fate of co-products

JEC vs REDII: available conversion pathways

Fuel	Process	Feedstock	RED II	JECv5 WtT
Biodiesel	FAME	Vegetable oils	X	X
	FAME	Waste lipids	X	X
HVO	HEFA	Vegetable oils	X	X
	HEFA	Waste lipids	X	X
Ethanol	1stG	Sugars	X	X
	2ndG	Lignocellulosic biomass	X	X
ETBE	2nd/1stG	Various		X
ED95	2nd/1stG	Various		X
i-butanol	2nd/1stG	Various		X
	2nd/1stG	Various		X
MeOH	FT	Lignocellulosic biomass	X	X
Gasoline	FT	Lignocellulosic biomass	X	X
	Fast pyrolysis + hydrotreating	Lignocellulosic biomass		X
	FT	Black liquor		X
DME	FT	Lignocellulosic biomass	X	X
Diesel	FT	Lignocellulosic biomass	X	X
	Fast pyrolysis + hydrotreating	Lignocellulosic biomass		X
	FT	Black liquor		X
Syn-diesel	Reforming	Electricity		X
OME (ether)	FT	Lignocellulosic biomass		X
Syn-CH4	Reforming	Electricity		X
	Gasification	Lignocellulosic biomass		X
H2	SMR	Biogas		X
	Gas shift	Lignocellulosic biomass		X
CBM	Upgrading	Biogas	X	X
Electricity	CHP	Biogas		X
	Gasif/engine	Wood		X
	Boilers	Wood		X
	-	Renewables (wind)		X

JECv5

☑ Many conversion pathways

☒ Not valid for legislation, not intended as recommendation delivered by JEC' partners to report any conclusions

RED II

☑ Valid for the sustainability criteria

☒ Less number of conversion pathways

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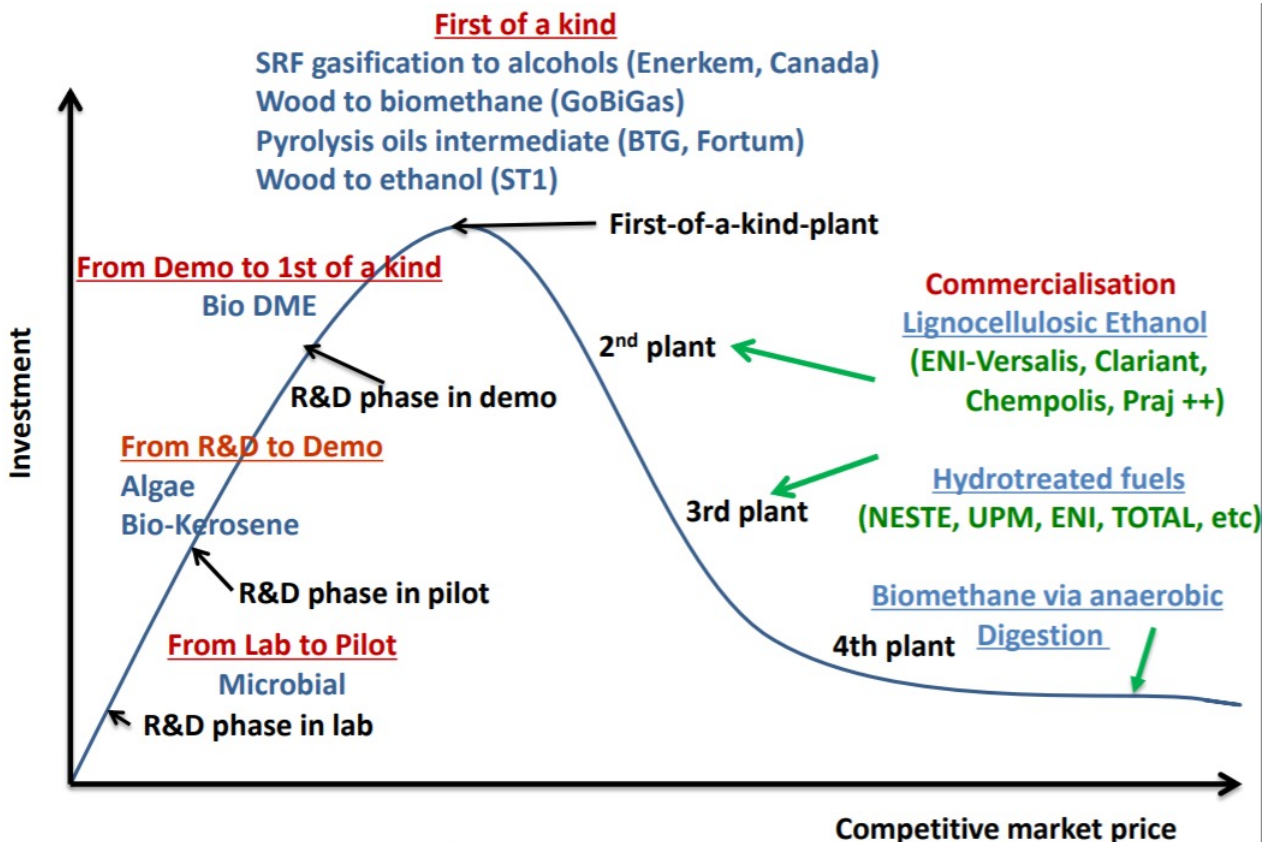
Advanced biofuels: actual TRL

- **HVO/HEFA** is a technology at full commercial scale (**TRL 9**). Many oil companies are already producing drop-in gasoline and diesel in the market, as well as SAFs.
- **Co-processing** of biogenic material in the existing oil refineries is already adopted, but it can rapidly grow much more (a delegated act implementing the recast REDII' regulation is due by 2024)
- **FT-derived fuels** from lignocellulosic material (including organic residues and waste streams) are currently at demo-level (**TRL 7-8**) with some companies (EU, US) commissioning new plants.
- **2nd Generation Ethanol** is currently produced at industrial scale by some companies in EU, Brazil and US (**TRL 8-9**).
- **E-fuels** technologies are rapidly growing (**TRL 6-7**), in particular H_2 produced from renewable electricity (as a RNFBO).
- **Renewable Carbon Fuels (RCFs)** technologies are still at pilot-scale (**TRL 7**), but many ongoing initiatives (e.g. IF, Horizon2020 demo-projects) will increment their production soon.

Advanced biofuels: mountain of death

❑ is a method to represent the **industrial status of innovative technologies.**



- The most critical moment corresponds to the **large-scale demonstration/First Of A Kind (FOAK).**
- **Positioning** not only depends on the technological status, but also on the distance to the possibility of developing large scale production, as necessary in the transport fuel fields.
- Achieving **fuel cost-competitiveness** is still a challenge, which requires both supporting fundings and further developments over the entire value chain (from biomass / feedstock supply to conversion and use).

Source: https://ec.europa.eu/info/sites/default/files/2_kyriakos_maniatis.pdf

https://doi.org/10.1051/e3sconf/202123808002

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Conclusions

- **EC** is accelerating the **EU climate and environmental legislation** and supports the development of the market for **advanced biofuels.**
- **Fit- for-55** updated the **RED II regulation** with **new targets for advanced biofuels** (including an updated sustainability criteria as GHGs thresholds, iLUC regulation...) and RCFs/RFNBOs**.**
- **RED II** default values and **JECv5** offer an overview and guidelines of the current GHGs emissions of advanced biofuels.
- Advanced biofuels can be a **sustainable solution for not electrifiable transport needs**, and the GHGs reductions can be significant.
- In particular, **aviation** and **maritime** still maintained a multiplier 1.2x to achieve the production targets towards 2030.

Take home messages

- Conversion technologies at high TRL such as **HVO** and **co-processing** can cover large fuels demand but have some limits as the feedstock origin and/or the hydrogen supply.
- Other technologies as biomass **FT-gasification** and **2G Ethanol** are promising technologies, but still limited due to undeveloped non-food biomass value chains and short-term policies on biomass sustainability.
- **E-fuels** and **RCFs** can play a significant role in the upcoming years, but still limited for the absence of a “carbon”-based market.
- The analysis of the conversion technologies based on the **mountain of death’** approach showed that **first-of-a-kind plants** have **limited market uptake** compared to **established technologies** based on **existing biomass value chains** producing **drop-in fuels** (e.g. advanced biomethane).

Keep in touch

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Thank you

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