



**Project acronym: BECOOL**

**Project full title: Brazil-EU Cooperation for Development of Advanced Lignocellulosic Biofuels**

**Grant Agreement Number: 744821**

**Project start date: 01.06.2017**

**Deliverable D3.13**

<b>Report on the regulatory framework for advanced biofuel</b>	
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Date:	07/04/2022 (submission due date 31/03/2022)

**Dissemination Level: Public**

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## 1. Introduction

The present deliverable addresses the normative framework surrounding the use of the advanced lignocellulosic biofuels investigated in BECOOL, and the economic, societal, and regulatory implications of their large-scale use (incl. aviation sector). The document is assembled with the aim to support policy-makers and regulators in the development of a scientifically sound normative framework.

More specifically, report D3.13 stands as an update of an earlier BECOOL document (D3.4 - Norms and standards for advanced biofuels) which was released on February 2019.

The document reports on the normative framework covering the period from 2020 on, thus including the RED II and the Fit-for-55 package. As part of the Fit-for-55 package, other relevant initiatives are also briefly touched upon, i.e. the proposed overhaul of the EU-ETS, the REFuel EU aviation, the Fuel EU Maritime.

Finally, a dedicated section covers the aviation-specific measures.

## 2. Definitions

**ADVANCED BIOFUEL:** biofuels produced from feedstocks listed in Part A of Annex IX of the EU ILUC Directive or from feedstocks recognized as wastes in national legislation.

**BIOFUELS:** liquid fuel for transport produced from biomass

**BIOJET FUEL:** a jet fuel derived from biomass

**BIOMASS:** the biodegradable fraction of products, waste and residues from biological origin from agriculture, including vegetal and animal substances, from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin.

**BIOMASS FUELS:** means gaseous and solid fuels produced from biomass

**DROP-IN FUELS:** A fuel that can be used at any blend level with current engine technology and does not require modifications to aircraft engines and fuel systems and ground supply infrastructure.

**EU ETS:** European Union Emission Trading Scheme

**FOOD AND FEED CROPS:** starch-rich crops, sugar crops or oil crops produced on agricultural land as a main crop excluding residues, waste or ligno-cellulosic material and intermediate crops, such as catch crops and cover crops, provided that the use of such intermediate crops does not trigger demand for additional land

**HYDROPROCESSING:** Generic term used to describe a range of refinery processes that use hydrogen, along with an appropriate catalyst, to remove undesired components from refinery streams. The technology is core to a modern petrochemical refinery.

**ILUC:** indirect land-use change, occurs when the increased demand for feedstocks leads to agricultural expansion and the conversion of natural lands.

**LCA:** Life Cycle Assessment accounts the inflows and outflows “from cradle to grave”: this is from the extraction, manufacturing, consumption, recycling to the finale disposal.

**LIGNO-CELLULOSIC MATERIAL:** material composed of lignin, cellulose and hemicellulose, such as biomass sourced from forests, woody energy crops and forest-based industries' residues and wastes

**NON-FOOD CELLULOSIC MATERIAL:** feedstock mainly composed of cellulose and hemicellulose, and having a lower lignin content than ligno-cellulosic material, including food and feed crop residues, cover crops before and after main crops, industrial residues, including from food and feed crops after vegetal oils, sugars, starches and protein have been extracted and material from biowaste.

**RECYCLED CARBON FUELS:** liquid and gaseous fuels that are produced from liquid or solid waste streams of non-renewable origin which are not suitable for material recovery in accordance with Article 4 of Directive 2008/98/EC, or 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

**RED:** Directive 2009/28/EC. The Renewable Energy Directive establishes an overall policy for the production and promotion of energy from renewable sources in the EU. It requires the EU to fulfil at least 20% of its total energy needs with renewables by 2020 – to be achieved through the attainment of individual national targets. All EU countries must also ensure that at least 10% of their transport fuels come from renewable sources by 2020.

**RED II:** Directive (EU) 2018/2001 of the European Parliament and of the Council. Recasts and eventually repeals the previous RED, introducing new targets towards 2030.

**RFNBO:** Renewable Fuel of Non-Biological Origin, means 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

**UCO:** Used Cooking Oil. Also referred to as WVO (waste vegetable oil) and UVO (used vegetable oil), RVO (recycled vegetable oil) and RCO (Recycled Cooking Oil).

### 3. Glossary

ASTM American Society for Testing and Materials

CORSIA Carbon Offsetting and Reduction Scheme for International Aviation

EU ETS European Union Emission Trading System

EUA EU Allowances

EUA A EU Aviation Allowances

FQD Fuel Quality Directive

FRL Fuel Readiness Level

GHG Green House Gas

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ICAO	International Civil Aviation Organization
ILUC	Indirect Land Use Change
LDC	Least Developed Countries
LLDC	Landlocked Developing Countries
LUC	Land Use Change
LULUCF	Land Use, Land-Use Change and Forestry
MS	Member State
MVR	Monitor, Verify and Report
RED	Renewable Energy Directive
RES	Renewable Energy Source
RFNBO	Renewable Fuel of Non-Biological Origin
RTK	Revenue Tonne Kilometres
SAF	Sustainable Aviation Fuel
SIDS	Small Island Developing States
TRL	Technology Readiness Level

## 4. RED II Directive (2018/2001)

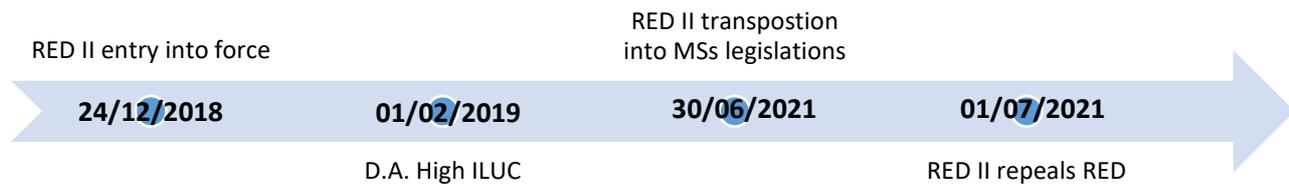


Figure 1: RED II Implementation Timeline

Following the EU Parliament and Council votes (end of November 2018 and beginning of December 2018, respectively) the following main elements are part of the RED II, published on the 21st of December 2019 in the EU Official Journal L328:

- advanced biofuels mandate at 3.5%, with Advanced Biofuels double counted;
- introduction of High ILUC and low ILUC risk concepts;
- extension to RFNBO (Renewable Fuel of Non-Biological Origin) and Recycled Carbon Fuels;
- aviation and maritime counted 1.2 times.

Eligible feedstocks cannot be removed from Annex IX part A (Advanced Biofuels), but it is possible to add other sustainable feedstocks on the list (upon request to EC – procedure still to be defined).

The Directive requires the EC to elaborate delegated acts and implementing acts. Member States are expected to incorporate will have 18 months to incorporate REDII into their national regulations.

Directive 2018/2001 (RED II Directive) entered into force on 24/12/2018 and repeals Directive 2009/28/EC (RED) effective 1 July 2021, as stated by Art. 37; Member States shall enforce the laws, regulations and administrative provisions necessary to comply with Directive 2018/2001 by 30 June 2021 (Art. 36).

### 4.1. Overall Targets and Biofuels contribution to the Transport Sector Target

RED II Directive set two binding targets in Art.3:

- the share of energy from renewable sources in the Union's gross final consumption of energy in 2030 must be at least 32 % by 2030
- the share of renewable energy within the final consumption of energy in the transport sector must be at least 14 % by 2030

Regarding the overall final energy consumption target, from January 1<sup>st</sup>, 2021, the share of energy from renewable sources in each Member State shall not be lower than the baseline shown in Annex I, Part A, that is equal to the 2020 target set in RED Directive. Moreover, the gross final consumption of energy from renewable sources in each Member State will be calculated as the sum of:

- gross final consumption of electricity from renewable sources
- gross final consumption of energy from renewable sources in the heating and cooling sector
- final consumption of energy from renewable sources in the transport sector

For the purposes of the last point, biofuels, biomass fuels and renewable liquid and gaseous transport fuels of non-biological origin (RFNBO) consumed in the transport sector are considered. RFNBO will also be considered for the first point but only for the calculation of total electricity from RES produced in a MS (Art 7).

For the calculation of the transport sector target, RFNBO must be considered by MSs, also when they are used as intermediate products for the production of conventional fuels; recycled carbon fuels may be considered.

The contribution of advanced biofuels and biogas (produced from the feedstock listed in Annex IX, Part A) to the transport sector target is set to be at least 0.2 % in 2022, at least 1 % in 2025 and at least 3.5 % in 2030.

The share of biofuels, bioliquids, and biomass fuels produced from food and feed crops and consumed in a MS in the transport sector shall be no more than one percentage point higher than their share in the road and rail transport sectors in 2020, with a cap of 7 % in the road and rail transport sectors energy consumption. Where that share is below 1 %, it may be increased to a maximum of 2 %.

MSs may set a lower limit and may distinguish, for the purposes of sustainability criteria (Art. 29), between different biofuels, bioliquids and biomass fuels produced from food and feed crops, considering best available evidence on their ILUC impact.

For the calculation of both targets for a MS, the share of high ILUC-risk biofuels, bioliquids or biomass fuels produced from food and feed crops shall not exceed the level of consumption registered in that MS in 2019, unless they are certified to be low ILUC risk. Moreover, between December 31<sup>st</sup>, 2023 and December 31<sup>st</sup>, 2030 they have to be phased out completely from the calculation.

The following Table 1 considers all the possible contribution to the transport sector target, considering eventual upper or lower limits, multipliers and other information where provided.

**Table 1: Recap of all possible contributions in term of fuel/feedstock to the transport sector target**

Type of fuel	Percentage Contribution	of Possible Multipliers	Notes
Feedstocks from Annex IX, Part A (Advanced Biofuels)	<ul style="list-style-type: none"> <li>• ≥ 0.2 % in 2022</li> <li>• ≥ 1 % in 2025</li> <li>• ≥ 3.5 % in 2030</li> </ul>	2x	
Feedstocks from Annex IX, Part B	≤ 1.7 %*	2x	*: of the energy content of transport fuels supplied for consumption or use on the market
Food/Feed Biofuels	Feedstock The lower between: <ul style="list-style-type: none"> <li>• ≤ (2020 value + 1%)</li> <li>• ≤ 7%</li> </ul>	no	MSs may set a lower limit and may distinguish between different biofuels, bioliquids and biomass fuels produced from food and feed crops
High ILUC-risk Biofuels	<ul style="list-style-type: none"> <li>• Before 31/21/2023: ≤ (2019 value)</li> <li>• Between 31/21/23 and 31/12/30: go to 0%</li> </ul>	no	

Renewable Electricity (road and Rail)	not set	<ul style="list-style-type: none"> <li>• road:4x</li> <li>• rail: 1.5x</li> </ul>	
Aviation and Maritime Fuels	not set	1.2x	exception of fuels produced from food and feed crops
RFNBO	not set	**	See description in Chapter 4.2
Recycled Carbon Fuels	not set	**	

\*\* : a D.A. establishing a calculation methodology will be issued.

By 1 February 2019, the Commission was due to submit a report on the status of worldwide production expansion of the relevant food and feed crops, as well as to adopt a delegated act setting out the criteria for certification of low ILUC-risk biofuels, bioliquids and biomass fuels and for determining the high ILUC-risk feedstock. Both the report and the delegated act shall be based on the best available scientific data.

By 1 September 2023, the Commission shall review the criteria laid down in the above-mentioned delegated act to amend such criteria, where appropriate, and to include a trajectory to gradually decrease the contribution to the RES share targets of high ILUC-risk biofuels, bioliquids and biomass fuels. In 2023 the Commission is also asked to assess the target obligations, with a view to submitting, a legislative proposal to increase them in the event of:

- substantial costs reductions in the production of renewable energy
- the need to meet the Union's international commitments for decarbonization
- a significant decrease in energy consumption in the Union.

Each MS is also enforced to set an obligation on fuel suppliers, together with an indicative trajectory, to ensure that the share of renewable energy in 2030 will reach the proposed target. Anyway, a degree of flexibility is given to MSs, so that they can exempt different fuel suppliers and different energy carriers, in order to consider, the varying degrees of maturity and the cost of different technologies. Finally, MSs may exempt fuel suppliers supplying fuel in the form of electricity or RFNBO from the requirement to comply with the minimum share of advanced biofuels and biogas produced from the feedstock listed in Part A of Annex IX with respect to those fuels.

#### 4.2. Calculation rules regarding the minimum shares of renewable energy in the transport sector

Art. 27 defines that, for the calculation of the transport sector target, all types of energy from renewable sources, including renewable electricity supplied to the road and rail transport sectors, shall be considered. MSs may also consider recycled carbon fuels; finally, the share of biofuels and biogas produced from the feedstock listed in Annex IX, Part B shall be limited to 1.7 % of the energy content of transport fuels supplied for consumption or use on the market.

For the purposes of demonstrating compliance with the 14% target sector target, a set of energy multiplier have been put into force:

- biofuels and biogas for transport produced from the feedstock listed in Annex IX may be considered to be twice their energy content
- renewable electricity shall be considered to be four times its energy content when supplied to road vehicles and may be considered to be 1.5 times its energy content when supplied to rail transport

- the share of fuels supplied in the aviation and maritime sectors shall be considered to be 1.2 times their energy content, with the exception of fuels produced from food and feed crops.

For the purposes of this paragraph, when electricity is used for the production of RFNBO, either directly or for the production of intermediate products, there are three possibilities to determine the share of renewable energy.

- For electricity that has been taken from the grid:
  - It can be counted as the average share of electricity from RES in the country of production is used, as measured two years before the year in question
  - It can be counted as fully renewable if it is produced exclusively from renewable sources (and it can be demonstrated), ensuring that its renewable properties are claimed only once and only in one end-use sector
- For electricity obtained from direct connection to an installation generating renewable electricity, it may be fully counted as renewable, provided that the installation:
  - comes into operation after, or at the same time as, the installation producing the RFNBO
  - is not connected to the grid or is connected to the grid but evidence can be provided that the electricity concerned has been supplied without taking electricity from the grid.

By December 31<sup>st</sup>, 2021, the Commission shall adopt a delegated act establishing a Union methodology setting out detailed rules by which economic operators are to comply with the requirements laid down in the above-mentioned situation.

### 4.3. Sustainability and GHG emissions saving criteria for biofuels, bioliquids and biomass fuels

Similarly to the 2020 RED and FQD, the RED II defines a series of sustainability and GHG emission criteria that liquid biofuels and bioliquids used in transport must comply with in order to:

- be counted towards the overall RES target
- be counted toward the transport sector RES target and obligations
- to be eligible for financial support by public authorities.

Those criteria, reported below, are laid down in Art. 29, paragraphs 2 to 7 and 10 and shall be applied irrespectively of the geographical origin of the biomass. However, some exemptions and different request in terms of compliance with the set of criteria have been laid down in the Art. 29 and are reported at the end of this chapter.

Par. 2: Biofuels, bioliquids and biomass fuels produced from waste and residues derived from agricultural land shall be taken into account only where operators or national authorities have monitoring or management plans in place in order to address the impacts on soil quality and soil carbon.

Par. 3: Biofuels, bioliquids and biomass fuels from agricultural biomass should comply with the following land criteria and thus not be produced from raw materials originating from High Biodiversity land (as of January 2008), including:

- Primary forests;
- Area designated for nature protection or for the protection of rare and endangered ecosystems or species;

- Highly biodiverse grasslands of more than 1 ha.

Par. 4: Biofuels, bioliquids and biomass fuels from agricultural biomass should comply with the following land criteria and thus not be produced from raw materials originating from High Carbon stock land that changed use after January 2008 from one of the following categories:

- Wetlands;
- Continuously forested land;
- Other forested areas with trees higher than five meters and canopy cover between 10% and 30%.

Par. 5: Biofuels, bioliquids and biomass fuels from agricultural biomass should comply with the following land criteria and thus not be produced from raw materials originating from land that was peatland in January 2008.

Par. 6: Biofuels, bioliquids and biomass fuels produced from forest biomass shall meet the following criteria to minimize the risk of using forest biomass derived from unsustainable production:

- The harvesting should take place with legal permits;
- the harvesting level does not exceed the growth rate of the forest;
- and that forest regeneration takes place;
- areas of high conservation value, such as wetlands and peatlands, must be protected;
- the impacts of forest operations on soil and biodiversity should be minimized.

Par. 7: Biofuels, bioliquids and biomass fuels produced from forest biomass shall meet the following land-use, land-use change and forestry (LULUCF) criteria:

- the country of origin of the biomass feedstock must be signatory of the Paris Agreement;
- the country of origin must have submitted a Nationally Determined Contribution to the United Nations Framework Convention on Climate Change (UNFCCC) covering emissions and removals from LULUCF sector and showing emissions do not exceed removals;
- the country of origin has a national system in place for accounting for LULUCF emissions and removals in accordance with the requirements in the Paris agreement.

The criteria defined in par. 7 must be applied either at the country level or at forest sourcing area level.

The Commission will define implementation guidelines for par. 6 and 7 by 31 January 2021, adopting an Implementing Act. Moreover, the Commission shall assess whether the criteria laid down in par. 6 and 7 effectively address LULUCF criteria and shall, if appropriate, submit a legislative proposal to amend those paragraphs for the period after 2030.

Par. 10: The required GHG emission savings for transport biofuels and bioenergy are listed in following Table 2.

**Table 2: GHG savings**

<b>cut-off dates for plants start-up</b>	<b>Transport biofuels, biogas and bioliquids</b>	<b>Transport RFNBO</b>	<b>Recycled Carbon Fuels</b>
Before 5/10/2015	50%	*	*
From 6/10/2015 to 31/12/2020	60%	*	*
From 1/1/2021	65%	70%	#

\*: No mandatory GHG savings threshold until 2021

#: By 1/1/2021, the Commission was due to adopt a delegated act establishing appropriate minimum thresholds for GHG emissions savings of recycled carbon fuels.

Biomass fuels shall fulfil criteria only if used in installations producing electricity, heating and cooling or fuels with a total rated thermal input of:

- 20 MW or more in the case of solid biomass fuels;
- 2 MW or more in the case of gaseous biomass fuels;

Anyway, MSs may apply the sustainability and greenhouse gas emissions saving criteria to installations with lower total rated thermal input.

Biofuels, bioliquids and biomass fuels produced from waste and residues, other than agricultural, aquaculture, fisheries and forestry residues, are required to fulfil only the greenhouse gas emissions saving criteria in order to be considered for the purposes of this chapter. This also apply to waste and residues that are first processed into a product before being further processed into biofuels, bioliquids and biomass fuels.

MSs may establish additional sustainability criteria for biomass fuels; in this case, the Commission shall assess the impact of such criteria on the internal market by December 31<sup>st</sup>, 2026 and, if necessary, define a proposal to ensure harmonization.

#### 4.4. Verification of compliance with sustainability and GHG criteria and calculation of GHG impacts of biofuels

Where biofuels, bioliquids and biomass fuels, or other fuels that are eligible for counting towards the renewable energy share target in transport, MSs shall require economic operators to show that the sustainability and GHG emissions saving criteria have been fulfilled. For those purposes, they shall require economic operators to use a mass balance system which shall ensure that each consignment is counted only once for the purposes of calculating the gross final consumption of energy from renewable sources and shall include information on whether support has been provided for the production of that consignment, and if so, on the type of support scheme.

In order to ensure that compliance with the sustainability and GHG emissions saving criteria as well as with the provisions on low or high direct and indirect LUC-risk biofuels, bioliquids and biomass fuels is verified and in particular to prevent fraud, the Commission shall adopt implementing acts specifying detailed implementing rules, including adequate standards of reliability, transparency and independent auditing and require all voluntary schemes to apply those standards.

GHG emissions saving from the use of biofuel, bioliquids and biomass fuels shall be calculated in one of the following ways:

- by using a default value for GHG saving when it is set, for a specific production pathway, in Part A or B of Annex V (for biofuels and bioliquids) and in Part A of Annex VI (for biomass fuels) and when annualized emissions from carbon stock changes caused by LUC, calculated in accordance with Part B of Annex VI (for biomass fuels) or Part C of Annex V (for biofuels and bioliquids) is equal or lower than zero;
- by using an actual value calculated in accordance with the methodology laid down in Part C of Annex V (for biofuels and bioliquids) and in Part B of Annex VI (for biomass fuels);

- by using a value calculated as the sum of the factors of the formulas referred to in point 1 of Part C of Annex V, where disaggregated default values in Part D or E of Annex V may be used for some factors, and actual values, calculated in accordance with the methodology laid down in Part C of Annex V, are used for all other factors (for biofuels and bioliquids);
- by using a value calculated as the sum of the factors of the formulas referred to in point 1 of Part B of Annex VI, where disaggregated default values in Part C of Annex VI may be used for some factors, and actual values, calculated in accordance with the methodology laid down in Part B of Annex VI, are used for all other factors (for biomass fuels).

Member States may submit to the Commission reports including information on the typical GHG emissions from the cultivation of agricultural raw materials of the areas on their territory, together with a description of the method and data sources used to calculate the level of emissions. In the case of territories outside the Union, equivalent reports drawn up by competent bodies may be submitted to the Commission.

The Commission may, by means of implementing acts, decide that those reports contain accurate data that may be used instead of the disaggregated default values for cultivation laid down in Part D or E of Annex V for biofuels and bioliquids and in Part C of Annex VI for biomass fuels, in the areas included in such reports.

The Commission is empowered to adopt delegated acts to amend, where appropriate, Annexes V and VI by adding or revising the default values or modifying the methodology.

In order to ensure the uniform application of Part C of Annex V and Part B of Annex VI, the Commission may adopt implementing acts setting out detailed technical specifications including definitions, conversion factors, the calculation of annual cultivation emissions or emission savings caused by changes above and below-ground carbon stocks on already cultivated land, the calculation of emission savings from CO<sub>2</sub> capture, CO<sub>2</sub> replacement and CO<sub>2</sub> geological storage.

#### 4.5. Annex V and VI analysis

Annex V is dedicated to biofuels and bioliquids (actual and future technologies, where future technologies are referred to the ones that were not on the market or were on the market only in negligible quantities in 2016) while Annex VI is dedicated to biomass fuels.

Both have a common structure, where in the first part typical and default GHG emissions saving values are defined as percentage values, for several production pathways. The following section is dedicated to the methodology for the calculation of GHG emissions and GHG emissions savings using disaggregated values. The last section contains disaggregated default and typical GHG emissions values for biofuels, bioliquids and biomass fuels.

Focusing on transport fuels, biofuels and bioliquids, GHG emissions from the production and use shall be calculated as follows:

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

where

- E = total emissions from the use of the fuel;
- $e_{ec}$  = emissions from the extraction or cultivation of raw materials;
- $e_l$  = annualized 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<sub>2</sub> capture and geological storage; and
- $e_{ccr}$  = emission savings from CO<sub>2</sub> capture and replacement.

GHG emissions from biofuels, E, shall be expressed in terms of g CO<sub>2</sub>eq/MJ.

Annualized emissions from carbon stock changes caused by land-use change,  $e_l$ , shall be calculated by dividing total emissions equally over 20 years. For the calculation of those emissions, the following rule shall be applied:

$$e_l = (CS_R - CS_A) * 3.664 * \frac{1}{20} * \frac{1}{P} - e_B$$

where

- $e_l$  = annualized greenhouse gas emissions from carbon stock change due to land-use change (measured as g CO<sub>2</sub>eq/MJ). ‘Cropland’ and ‘perennial cropland’<sup>1</sup> shall be regarded as one land use;
- $CS_R$  = the carbon stock per unit area associated with the reference land-use (measured as mass (ton) of carbon per unit area, including both soil and vegetation). The reference land-use shall be the land-use in January 2008 or 20 years before the raw material was obtained, whichever was the latest;
- $CS_A$  = the carbon stock per unit area associated with the actual land-use (measured as mass (ton) of carbon per unit area, including both soil and vegetation). In cases where the carbon stock accumulates over more than one year, the value attributed to  $CS_A$  shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earlier;
- $P$  = the productivity of the crop (measured as biofuel or bioliquid energy per unit area per year);
- $e_B$  = bonus<sup>2</sup> of 29 g CO<sub>2</sub>eq/MJ for biofuel or bioliquid if biomass is obtained from restored degraded land under the following conditions:
  - the land was not in use for agriculture or any other activity in January 2008;
  - is severely degraded land<sup>3</sup>, including such land that was formerly in agricultural use.

The Commission was due to review, by 31 December 2020, guidelines for the calculation of land carbon stocks.

Where a fuel production process produces, in combination, the fuel for which emissions are being calculated and one or more other products (co-products), greenhouse gas emissions shall be divided between the fuel or its intermediate product and the co-products in proportion to their energy content.

<sup>1</sup> Perennial crops are defined as multi-annual crops, the stem of which is usually not annually harvested such as short rotation coppice and oil palm

<sup>2</sup> The bonus of 29 g CO<sub>2</sub>eq/MJ shall apply for a period of up to 20 years from the date of conversion of the land to agricultural use, provided that a steady increase in carbon stocks as well as a sizable reduction in erosion phenomena for severely degraded land are ensured.

<sup>3</sup> a land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded.

In the case of biofuels and bioliquids, all co-products shall be considered for the purposes of that calculation. No emissions shall be allocated to wastes and residues. Co-products that have a negative energy content shall be considered to have an energy content of zero for the purposes of the calculation.

Wastes and residues, including tree tops and branches, straw, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined) and bagasse, shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials irrespectively of whether they are processed to interim products before being transformed into the final product.

For biofuels, for the purposes of the calculation referred to in point 3, the fossil fuel comparator EF(t) shall be 94 g CO<sub>2</sub>eq/MJ.

#### 4.6. Delegated Acts and Implementing Acts

In Table 3 below a brief description of the D.A. and I.A. of interest can be found, together with Article of reference, empowerment deadline and release deadline, where specified.

**Table 3: Deadlines for D.A. and I.A. of interest**

Scope foreseen of legislative act	Type	RED II reference article	Due date	Issued as of 30/03/22
Establishing appropriate minimum thresholds for greenhouse gas emissions savings of recycled carbon fuels through a life-cycle assessment that takes into account the specificities of each fuel.	D.A.	25 (2)	01/01/2021 up to 24/12/2023	-
Setting out the criteria for certification of low indirect land-use change-risk biofuels, bioliquids and biomass fuels and for determining the high indirect land-use change-risk feedstock for which a significant expansion of the production area into land with high-carbon stock is observed	D.A.	26 (2)	01/02/2019 up to 24/12/2023	Commission Delegated Regulation (EU) 2019/807 of 13 March 2019, C/2019/2055
Adapting the energy content of transport fuels, as set out in Annex III, in accordance with scientific and technical progress.	D.A.	27 (1,c)	up to 24/12/2023	-
Establishing a Union methodology setting out detailed rules by which economic operators are to comply with the requirements laid down in the fifth and sixth subparagraphs of this paragraph [ <i>ref to RFNBO</i> ].	D.A.	27 (3)	31/12/2021	-
Specifying the methodology to determine the share of biofuel, and biogas for transport, resulting from biomass being processed with fossil fuels in a common process	D.A.	28 (5)	31/12/2021 up to 24/12/2023	-
Specifying the methodology for assessing GHG emissions savings from RFNBO and from recycled carbon fuels, which shall ensure that credit for avoided emissions is not given for CO <sub>2</sub> the capture of which has already received an emission credit under other provisions of law.	D.A.	28 (5)	31/12/2021 up to 24/12/2023	-
Amend the list of feedstocks set out in Parts A and B of Annex IX by adding, but not removing, feedstock.	D.A.	28 (6)	25/6/2019 and every	-

			two years, up to 24/12/2023	
Further specifying the criteria by which to determine which grassland are to be covered by point (d) of Art 29	I.A.	29 (3)	not specified	-
Establishing the operational guidance on the evidence for demonstrating compliance with the criteria laid down in paragraphs 6 and 7 of Art. 29	I.A.	29 (8)	31/01/2021	-
Specifying detailed implementing rules, including adequate standards of reliability, transparency and independent auditing and require all voluntary schemes to apply those standards in order to ensure the compliance with the sustainability and GHG emissions saving criteria as well as with the provisions on low or high direct and indirect LUC-risk biofuels, bioliquids and biomass fuels.	I.A.	30 (8)	not specified	-
Use data from MSs reports instead of the disaggregated default values for cultivation laid down in Part D or E of Annex V for biofuels and bioliquids and in Part C of Annex VI for biomass fuels, in the areas included in such reports.	I.A.	31 (4)	not specified	-
Amend, where appropriate, Annexes V and VI by adding or revising the default values or modifying the methodology	D.A.	31 (5)	Up to 24/12/2023	-
Setting out detailed technical specifications including definitions, conversion factors, the calculation of annual cultivation emissions or emission savings caused by changes above and below-ground carbon stocks on already cultivated land, the calculation of emission savings from CO2 capture, CO2 replacement and CO2 geological storage	I.A.	31 (6)	not specified	-

## 5. Fit for 55 (COM/2021/550)

The European Council, together with the European Commission, presented the **European Green Deal** on December 2019, as the core EU strategy to fight climate change and achieve climate neutrality (net-zero) by 2050. These targets were made legally binding by the **European Climate Law**, agreed upon in April 2021 and formally adopted in June 2021. The next step was taken on July 2021, when the European Commission published the **“Fit for 55” package**, consisting in a set of policy proposals preparing the implementation of the European Green Deal<sup>4</sup>.

The 'Fit for 55' package, **published on July 2021**, aims to adapt some existing climate and energy legislation to meet the new EU objective of a minimum 55 % reduction in greenhouse gas (GHG) emissions by 2030 (compared to 1990 levels). It consists in **eight revisions** of existing pieces of legislation and in **five new legislation** proposals, as summarized by Figure 2.

<sup>4</sup>European Commission. (2021). *COM(2021) 550 final - “Fit for 55”: delivering the EU’s 2030 Climate Target on the way to climate neutrality*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0550&from=HR>.

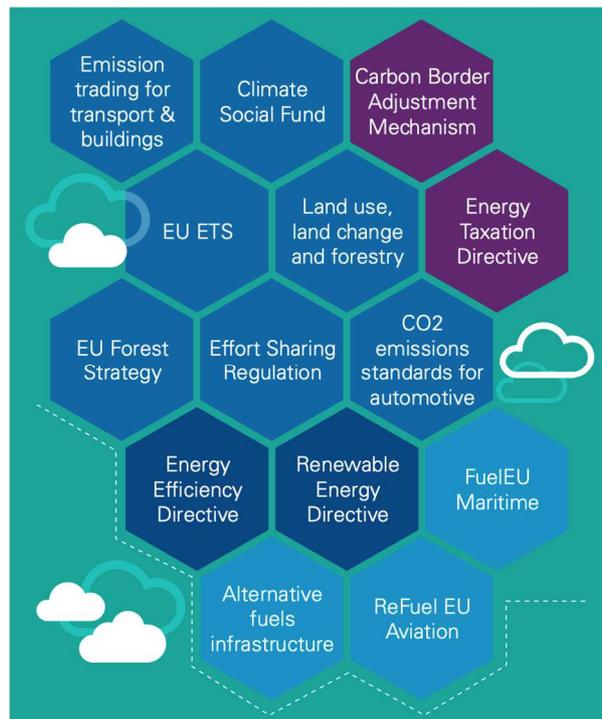


Figure 2: Impacts of proposed "Fit for 55" package on legislation<sup>5</sup>

On **December 2021** the EU Commission published a second suite of proposals<sup>6</sup>, addressing the following topics:

- **building efficiency** rules;
- the **recast of the existing gas market rules** to also cover renewable and low-carbon gases as well as hydrogen;
- the **reduction of methane emissions** from fossil energy produced or consumed in the EU.

The proposals, spanning thousands of pages, would require long negotiations to reach the final versions of the various recasts and new legislation pieces; more than two years are expected for the most difficult ones.

The **updates of existing legislation** are<sup>7</sup>:

- **Revision of the EU Emission Trading System (ETS)**, proposing to increase the overall targets while enlarging the scope of EU carbon trading to cover emissions from shipping, buildings and road transport.
- **Revision of the Effort Sharing Regulation (ESR)**, which applies to sectors not included in the EU ETS and sets binding annual national emissions targets for MS. It proposes an increase in the overall cut of 29 % by 2030 (compared to 2005 levels), moving toward 40 %, with MS targets ranging between 10 and 50 %.
- **Amendment to the Renewable Energy Directive (RED) II**, proposing, among the other measures, an increase in the overall targets for renewables in the energy mix and the removal of double counting for advanced biofuels

<sup>5</sup> <https://home.kpmg/xx/en/home/insights/2021/11/the-european-green-deal-and-fit-for-55.html>

<sup>6</sup> <https://sustainablefutures.linklaters.com/post/102hek4/eu-fit-for-55-the-december-package-has-landed#:~:text=On%202015%20December%202021%2C%20the,greenhouse%20gas%20reduction%20by%202030.>

<sup>7</sup> <https://www.carbonbrief.org/qa-how-fit-for-55-reforms-will-help-eu-meet-its-climate-goals>

- **Amendment to the Energy Efficiency Directive (EED)**, proposing an increase of the existing non-binding goal of keeping energy use 32.5 % below projected levels in 2030 to a new target of 39% reduction.
- **Revision of the Energy Taxation Directive (ETD)**, which sets minimum rates of excise duty on fuel for transport, heat and electricity, and hadn't been updated since 2003. A new structure has been proposed for the directive, by linking tax rates to the energy content and environmental performance of fuels and electricity, with the objective of having the more polluting fuels being taxed with the highest rates.
- **Revision of the Alternative Fuels Infrastructure Directive (AFID)**, aiming to improve adequate recharging and refueling infrastructure for the use of electricity, hydrogen and other alternative fuels.
- **Amendment of the CO<sub>2</sub> emissions standards for cars and vans regulation**, proposing a 55% fleet-wide cut in CO<sub>2</sub> emissions from cars and vans sold in the EU by 2030, to be escalated to a 100% cut by 2035, as reported in Figure 3; the previous targets had been set to a 37.5% cut by 2030, as a comparison.
- **Revision of Land Use, Land Use Change and Forestry (LULUCF) regulation**, proposing a new carbon sink EU target of 310 MtCO<sub>2</sub>eq by 2030.

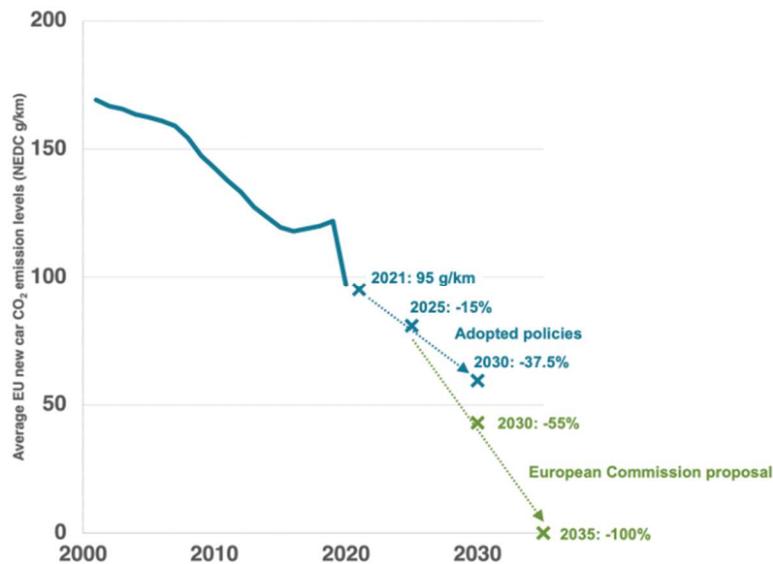


Figure 3: Historical trends (blue) and new proposed future values (green) for average new passenger car CO<sub>2</sub> emission levels in the EU<sup>8</sup>

The proposed new pieces of legislation are:

- **Carbon Border Adjustment Mechanism (CBAM)**, planning to tax certain high-carbon imports, trying to avoid carbon leakage, which occurs when industries subject to a carbon price lose market share to competitors from other jurisdictions, where the carbon price is lower or non-existent.
- **Social Climate Fund**, proposed to help vulnerable households disproportionately affected by higher fossil fuel prices
- **ReFuelEU Aviation**, promoting the use of sustainable fuels for aviation, through increased blending rates into the supplied mix
- **FuelEU Maritime**, similarly promoting the use of sustainable fuels for maritime shipping

<sup>8</sup> <https://theicct.org/the-european-commissions-fitness-program-for-climate-protection-sluggards/>

- **EU forest strategy**, including measures to boost tree-planting, encourage better forest monitoring and increase the use of wood products to replace concrete in construction.

In the followings, the most interesting proposals from the advanced biofuels perspective are reported in more details.

### Amendment to the Renewable Energy Directive (RED) II

The EU is currently obliged to ensure that at least 32 % of its overall energy consumption comes from renewable energy sources (RES) by 2030, as defined by RED II Directive 2018/2001. The proposed amendment for RED II sets a **new EU overall target of a minimum 40 % share** of RES in final energy consumption by 2030, together with new sectoral targets. New 40% overall RES 2030 target, together with a **minimum 55 % reduction in greenhouse gas (GHG) emissions** by 2030 (compared with 1990 levels).

Concerning the transport sector, several changes has been proposed<sup>9</sup>:

- A new **13 % greenhouse gas intensity reduction target**, in replacement for the 14 % sub-target for the share of RES in the transport sector, thus moving from an energy target to an emission reduction one;
- The **removal of multipliers for the Advanced Biofuels sub-target** (the so-called double counting, together with the **increase of the sub-targets** itself: from at least 0.2 % in 2022 to 0.5% in 2025 and 2.2 % in 2030. As a comparison, the previous 2030 sub-target was set at 3.5 % share of the energy used in transport sector, that, considering the double counting measure, was equal to a 1.75 % share in actual energy content;
- Moreover, a **new 2030 sub-target of 2.6 % share** of total transport energy consumption has been introduced **for RFNBOs contribution**. Anyway, RFNBOs would count towards the various RED II targets only if their GHG emissions savings are at least 70 %;
- A **credit mechanism** has been introduced to promote electromobility: it would allow economic operators that supply renewable electricity to electric vehicles via public charging stations to receive credits that they can in turn sell to fuel suppliers, who can use them to satisfy fuel supplier obligations.

Finally, **further rules** have been proposed **on the sourcing of biomass for bioenergy use**, in order to “minimize” the use of “quality roundwood” for energy production (D.A expected on this topic).

### Revision of the EU Emission Trading System (EU-ETS)

The proposal for the amendment of Directive 2003/87/EC refers to the phase 4 of the EU-ETS, currently ongoing (2021-2030); it combines with two other amending proposals that aim to raise ambition in the aviation sector and to implement CORSIA scheme for international aviation. Summarizing, this proposal aims to **reduce emissions in the covered sectors by 61 % at 2030**, compared to 2005 levels (previously the 2030 target was set at 43 %). In order to reach this target, six main policy choices have been proposed<sup>10</sup>:

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<sup>9</sup> Wilson, A. (2021). BRIEFING EU Legislation in Progress - Revision of the Renewable Energy Directive: Fit for 55 package. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698781/EPRS\\_BRI\(2021\)698781\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/698781/EPRS_BRI(2021)698781_EN.pdf)

<sup>10</sup> Erbach, G., Foukalova, N. (2022). BRIEFING EU Legislation in Progress - Review of the EU ETS. [https://www.europarl.europa.eu/thinktank/en/document/EPRS\\_BRI\(2022\)698890](https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698890)

- The emission allowances cap will be reduced with a **“one-off reduction” of 117m allowances**; moreover, a **steeper annual linear GHG emissions reduction of 4.2%** will be implemented, almost doubling the previous 2.2% Linear Reduction Factor
- The number of free allowances will gradually be reduced, matching with a decreasing emissions cap and the proposed **introduction of a Carbon Border Adjustment Mechanism (CBAM)**, that would aim to provide protection against carbon leakage. CBAM should come into force in 2023, with a first three-year transition phase where only reporting requirements will be in place; in the next ten-years phase spanning across 2026-2035, a progressive ramp-up for payments for emissions will be enforced. Under CBAM, importers would have to buy carbon allowances for direct emissions or prove to have already paid an equivalent carbon price in the importing country.
- The allocation of **free allowances to aircraft operators will start decreasing by 25% per year on 2024**, reaching a **total removal by 2027**. Moreover, **the CORSIA scheme will be implemented** for flights operated by EU companies to, from and outside the European Economic Area, the UK and Switzerland. The Commission will adopt a delegated act defining the methodology for Member States to use when calculating offsetting requirements.
- The **ETS will be extended to cover CO<sub>2</sub> emissions from maritime transport**; it will apply specifically to large ships, above 5 000 gross tonnage. This extension applies to all emissions related to intra-EU voyages, as well as to the 50 % of the emissions related to extra-EU voyages; it will also apply to and all emissions occurring when ships are at berth in an EU port. **This proposed policy will apply starting from 2026**, with a three-years transition phase when only monitoring plans will be required from ship owners (starting from 08/2024).
- The **establishment of a separate new ETS for buildings and road transport**. The regulated entities will be fuel distributors and the regulated activity will be 'release for consumption'; the emissions cap would be started in 2026, gradually and linearly decreasing to achieve a 43 % reduction in emissions in 2030, when compared to 2005 sectorial levels. Since this proposal could have a potentially regressive impact, the commission has also set out **plans for a new social climate fund with a 72 B€ budget deployed for the 2025-2032 period**. It should be roughly equivalent to 25% of the revenues from the new ETS and it should also be match-funded by Member States. They have also to present to the Commission their “social climate plans” by June 2024, describing how such a budget is projected to be spent.
- The **Innovation and Modernisation Funds would be increased with more allowances** coming from both the existing and new EU-ETS systems; Member States would be required to use all the auction revenues for climate and energy-related purposes.

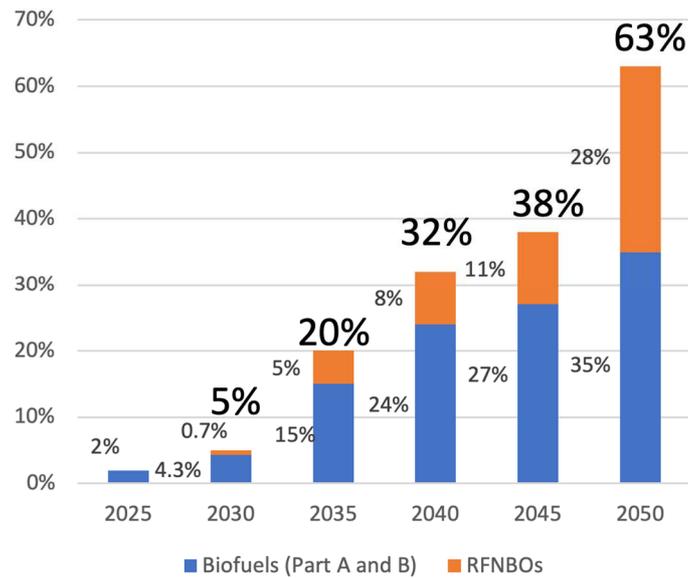
## REFuelEU aviation

The planned **entry into force** of the draft regulation is set **at the beginning of 2023**, introducing **blending mandates & trajectories for Sustainable Aviation Fuels (SAF)**, starting on 2025, as reported in Figure 4.

SAF are defined as either<sup>11</sup>:

- **Synthetic aviation fuels** (Renewable Fuels of Non-Biological Origin, RFNBO), which are fuels made from renewable sources other than biomass, e.g. wind and solar power.
- **Advanced biofuels**, produced from the feedstocks listed in **RED II Annex IX Part A**
- **Biofuels** produced from the feedstocks listed in **RED II Annex IX Part B** (waste oils and fats)

<sup>11</sup> <https://www.easa.europa.eu/light/topics/fit-55-and-refueleu-aviation>



**Figure 4: Proposed trajectories for SAF blending mandates (considering biofuels and RFNBO contributions)**

The mandates are calculated on a **volume basis and not on an energy basis**, as in RED II, and **no caps are set on waste oils and fats contributions**, unlike RED II. **Food- and feed-based biofuels and RCFs are not eligible** to be counted towards these targets.

The targeted minimum SAF share is evaluated at airport level; anyway, a transition period until the end of 2029 is proposed, in which fuel suppliers may consider an average value calculate across all EU airports.

In order to **prevent fuel tankering practices**, an obligation is set on aircraft operators on the yearly quantity of aviation fuel uplifted at a given EU airport, which has to be at least 90 % of the yearly aviation fuel required for flight departing from that airport<sup>12</sup>.

Being this a proposed regulation, it is **directly binding on the obligated parties**; a **non-compliance leads to penalties**, which should be **applied by Member States**.

### Fuel EU Maritime and Energy Taxation Directive

The proposal **fosters the uptake of low-carbon fuels** by introducing limits on carbon intensity of the energy used on board ships, as well as mandates on the use of onshore power supply while harbored in EU ports. The proposal **should come into effect in 2025** and it **applies to all vessels weighting more than 5,000 gross tonnage**. Depending on routes, it applies to<sup>13</sup>:

- All energy used on voyages between EU ports.
- Half of the energy used on voyages between an EU port and a third country.

<sup>12</sup> Soone, J. (2022). *BRIEFING EU Legislation in Progress - ReFuelEU Aviation initiative*. [https://www.europarl.europa.eu/thinktank/en/document/EPRS\\_BRI\(2021\)699466](https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)699466)

<sup>13</sup> Pape, M. (2021). *BRIEFING EU Legislation in Progress - Sustainable maritime fuels*. [https://www.europarl.europa.eu/thinktank/en/document/EPRS\\_BRI\(2021\)698808](https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)698808)

- All energy used on ships at EU ports, with the additional requirement, from 2030 on, that ships must use on-shore power for all energy needs when at berth for more than 2 hours.

The proposed regulation is **directly binding on ship operators** and non-compliance penalties would be established. It introduces GHG intensity reduction requirements; Table 4 reports the proposed timeline from 2025 to 2050 (compared to 2020 levels):

**Table 4: GHG intensity reduction requirements timeline, as introduced by Fuel EU Maritime proposal**

Year	2025	2030	2035	2040	2045	2050
GHG Reduction	- 2%	- 6%	-13 %	- 26%	- 59%	- 75%

The proposal **links with the Alternative Fuels Infrastructure Directive** for what it concerns LNG distribution infrastructure and alternative fuels policies and shore power connection (harbor electricity).

It also **links to the Energy Taxation Directive**, which proposes to link taxation rates to environmental performance of the fuels, for what it concerns<sup>14</sup>:

- The use of heavy oil in the maritime industry, which will no longer be fully exempt from energy taxation for intra-EU voyages in the EU
- The use of ammonia and advanced biofuels in shipping, that would be exempted to encourage the use of sustainable alternative fuels
- The taxation levels for marine gas oil (MGO), diesel oil (MDO), heavy fuel oil (HFO) and non-sustainable biofuels, that will be set at 0.9 €/GJ
- The taxation levels for LPG, LNG and non-sustainable biomethane, that will be set at 0.6 €/GJ during a 10-years transitional period and then to 0.9 €/GJ
- The taxation levels for Sustainable biofuels, that will be set at 0.45 €/GJ
- The taxation levels for RFNBO, that will be set at 0.15 €/GJ

## 6. Aviation-specific measures



**Figure 5: Aviation sector, market-based measures timeline**

<sup>14</sup> Kostova Karaboytcheva, M. (2022). BRIEFING EU Legislation in Progress - Revision of the Energy Taxation Directive: Fit for 55 package. [https://www.europarl.europa.eu/thinktank/en/document/EPRS\\_BRI\(2022\)698883](https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698883); (in Italian language) <https://www.rivistaenergia.it/2022/03/fit-for-55-quali-rotte-di-transizione-per-lo-shipping/>

Along with legislative measures, market-based measures such as EU ETS and ICAO CORSIA are being put into operation. Emissions trading systems (such as EU ETS) and offsetting schemes (such as CORSIA) both address aviation emissions but differ in their functioning. ETSs generally work towards economy-wide emission reduction targets, while offsetting schemes also compensate for emissions by reductions in other sectors but without an associated cap<sup>15</sup>.

### 6.1. EU-Emission Trading System

The EU-ETS is the EU's key tool for reducing, in a cost-effective manner, greenhouse gas emissions from the power and heat, industry and aviation sectors. Set up in 2005, it is world's first major carbon market and still remains the biggest one.

The system covers, for CO<sub>2</sub> emissions, the following sectors:

- power and heat generation
- energy-intensive industry sectors including oil refineries, steel works and production of iron, aluminum, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals
- commercial Aviation (since 2008)

The EU ETS use the 'cap and trade' principle: a cap is set on the total amount of certain GHG that can be emitted by installations covered by the system. The cap is reduced over time in order to drive total emissions to reduction. Within the cap, companies receive or buy emission allowances, tradable with one another as needed. If a company reduces its emissions, it can keep the spare allowances to cover its future needs, or else sell them to another company that is short of allowances. Finally, a limited amount of international credits from emission-saving projects around the world can be bought by companies. After each year a company must surrender enough allowances to cover all its emissions, otherwise fines are imposed.

For the aviation sector, the initial scope of the EU ETS covered all flights arriving at, and departing from, airports in the European Economic Area; from 2013, however, flights to and from airports in non-European Economic Area countries have been excluded until the end of 2023. This exclusion was made to facilitate negotiation of a global market-based measure for international aviation emissions at the International Civil Aviation Organization (ICAO). As a consequence, at present only flights between airports located in the European Economic Area are included in the EU ETS.

EU ETS has gone under several different period, current phase is the 3<sup>rd</sup>, covering 2013-2020 period. The cap for aviation activities for the current phase of the ETS was set to 95% of 2004-2006 aviation emissions.

Since 2013, the amount of annual EU Aviation Allowances (EUAAAs) issued is around 37.5 Mt (1 EUAA or EUA equals 1 ton of CO<sub>2</sub>). The EUAAAs cover emissions under the EU ETS cap for aviation. About 15% of these allowances are auctioned, while 85% are allocated for free. For CO<sub>2</sub> emissions exceeding the EU ETS aviation cap, aircraft operators must purchase EU Allowances from the stationary sectors; on the contrary, stationary installations are not permitted to use aviation allowances for compliance. In addition, aircraft operators could use international credits for up to 15% of their verified emissions in 2012. Since 2013, each aircraft operator

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<sup>15</sup> European Aviation Environmental Report 2019 - EASA - ISBN 978-92-9210-214-2

is entitled to use international credits up to a maximum of 1.5% of its verified emissions during the current phase, in addition to any residual entitlement from 2012.

In 2017, 677 operators, which included more than 200 non-European carriers, operated under the scope of the system. EU ETS carbon prices varied between €4 and €6 per ton of CO<sub>2</sub> during the 2013-2017 period. For 2017, it is estimated that these EUA-related costs represent about 0.3% of total operating costs for aircraft operators on flights within the scope of the EU ETS.

For the 4<sup>th</sup> phase of the EU ETS, from 2021 to 2030, the system is expected to undergo a major overhaul, that will also affect the aviation sector. The linear reduction factor of 2.2% per year will also be applied to the aviation cap. Emission reductions will have to be exclusively domestic; therefore, only EU Aviation Allowances (EUAs) and EU Allowances (EUAs) will be eligible for compliance.

The 2017 revision to the EU ETS Directive includes a mandate from the European Parliament and the Council to the Commission to consider ways for CORSIA to be implemented in the EU through a revision of the Directive, consistent with the EU 2030 climate objectives.

## 6.2. ICAO Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)

In October 2016, the 39th General Assembly of ICAO Contracting adopted Resolution A39-3, aiming to introduce a global market-based measure in order to offset international aviation's CO<sub>2</sub> emissions above 2020 levels through international credits, namely the 'Carbon Offsetting and Reduction Scheme for International Aviation' (CORSIA)<sup>16</sup>. In June 2018, the ICAO Council approved the associated Standards and Recommended Practices (SARPs). Work is continuing on the additional rules on eligible fuels and emission units that can be used to comply with CORSIA offsetting requirements.

CORSIA first action has been the definition of a CO<sub>2</sub> emission baseline, to be used as a reference after 2020. In order to do so, all operators with international flights producing annual CO<sub>2</sub> emissions greater than 10,000 ton from airplanes with a maximum take-off mass greater than 5,700 kg have been required to monitor, verify and report their CO<sub>2</sub> emissions during 2019 and 2020. Due to the unexpected COVID pandemic, the baseline has been limited to the 2019 values. The average yearly CO<sub>2</sub> emissions reported during that period represents the baseline, against which the aviation operator will be required to offset its international CO<sub>2</sub> emissions.

76 States have officially notified ICAO that they intend to voluntarily participate in the pilot and first phase of CORSIA, representing approximately 76% of international aviation activity in terms of Revenue Tonne Kilometres (RTKs). The first deadline for intention notification was set to 30 June 2020.

CORSIA comprises of three implementation phases:

- the pilot phase (2021-2023)
- a first phase (2024-2026)
- a second phase (2027-2035).

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<sup>16</sup> Maniatis, Kyriakos, et al. Sub Group on Advanced Biofuels - Sustainable Transport Forum. 2017

During the pilot phase and first phase, offsetting requirements will only be applicable to flights between States that have volunteered to participate. The second phase will apply to all ICAO Member States within the agreed applicability scope, complying with some requirements:

- individual share of international aviation activities in RTKs over 0.5% of total RTKs in year 2018
- being part of the list of States that account for 90% of total RTKs when sorted starting from the highest amount of individual RTKs
- not being part of Least Developed Countries (LDCs), Small Island Developing States (SIDS) and Landlocked Developing Countries (LLDCs).

Each international flight within the scope of CORSIA is attributed to an airplane operator; each airplane operator is attributed to a State to which it must submit an Emissions Monitoring Plan. Airplane operators monitor, verify and report (MVR) their fuel use according to the approved plan; their annual emissions offsetting requirements are calculated by the State (see Figure 6).

Emissions monitoring applies to all flights, including those not subject to offsetting requirements. Offsetting requirements are calculated considering the growth of the aviation sector and that of an individual airplane operator<sup>17</sup>.

Airplane operators meet their offsetting requirements on a 3-year compliance period basis by purchasing and cancelling CORSIA eligible emissions units. Airplane operators can reduce their offsetting requirements by using CORSIA eligible fuels that meet CORSIA sustainability criteria.

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<sup>17</sup> <https://www.icao.int/environmental-protection/CORSIA/Pages/default.aspx>

## CORSIA ROUTE-BASED APPROACH

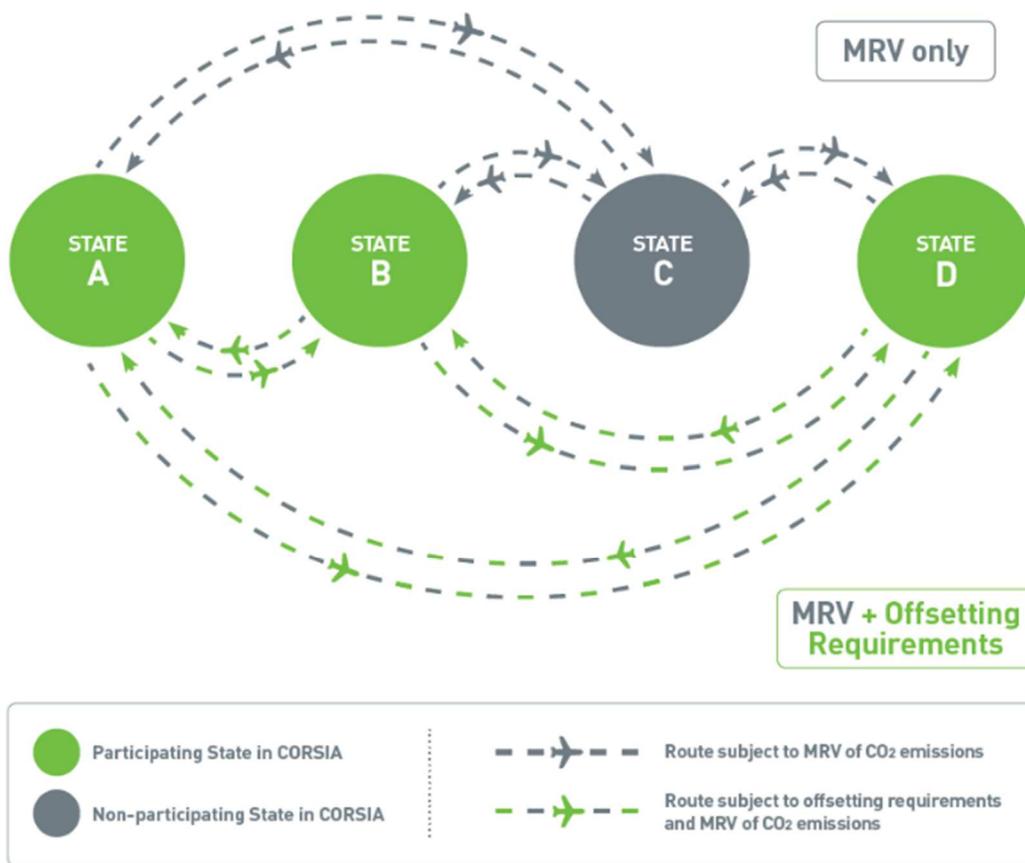


Figure 6: Explanation of CORSIA MRV and offsetting requirements (taken from ICAO website)

## 7. Standards

### 7.1. Aviation

In commercial aviation the JET-A1 (i.e. the conventional fossil aviation fuel) is regulated by several specifications and recommended practices for its use.

Among these:

- ASTM D1655 “Standard Specification for Aviation Turbine Fuel” (US and international)
- UK Defence Standard 91-91 “Turbine Fuel, Aviation Kerosene Type, Jet A-1” (UK and international)
- Joint Inspection Group (JIG) Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS, or “joint checklist” – international)
- GOST 10227 TS-1 (Russia and CIS)
- Number 3 Jet Fuel (China)
- Others, produced by organizations (engine manufacturers, pipeline operators, etc.) wishing to define fuel to their own requirements

This list contains very similar specification since they essentially describe the same product. For instance, ASTM D1655 and Def Stan 91-91 have nearly identical requirements for Jet A-1 with just an exception in acidity level, and a parameter related to naphthalene content.

ASTM D1655, in particular is the main standard for conventional jet fuel and it has been modified numerous times since it was first released to reflect changes in quality requirements associated with engine and aircraft modifications and new materials. In 2009, ASTM International approved D7566 Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons, the first specification describing a jet fuel not derived from petroleum crude. New renewable fuels must be certified and approved by D7566, which defines the composition and properties of renewable aviation fuels. In order to proceed with the certification process, ASTM D4054 standard is a guidance for a new fuel or additive approval process that includes the prerequisite testing and required interactions with the engine and airframe manufacturers, standards organizations and airworthiness agencies such as the FAA and EASA. In particular the ASTM D7566 norm allows for blending up a defined quantity of renewable jet fuel in the standard Jet A-1, already reported in chapter 8.1.

## 8. Annexes

### 8.1. ASTM-Approved Production Pathways

The American Society for Testing and Materials (ASTM) International has developed standards to approve new bio-based aviation fuels, and as of October 2021, 9 conversion processes have been approved for SAF production<sup>18</sup>, up from the 6 approved at the time of release of report D3.4, February 2019, which are reported in Table 5.

**Table 5: ASTM D7566-approved pathways for SAF production<sup>18</sup>**

ASTM reference	Conversion process	Abbreviation	Possible Feedstocks	Blending ratio by volume	Commercialization proposals / Projects
ASTM D7566 Annex 1	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene	FT	Coal, natural gas, biomass	50%	Fulcrum Bioenergy, Red Rock Biofuels, SG Preston, Kaidi, Sasol, Shell, Syntroleum
ASTM D7566 Annex 2	Synthesized paraffinic kerosene from hydroprocessed esters and fatty acids	HEFA	Bio-oils, animal fat, recycled oils	50%	World Energy, Honeywell UOP, Neste Oil, Dynamic Fuels, EERC
ASTM D7566 Annex 3	Synthesized iso-paraffins from hydroprocessed fermented sugars	SIP	Biomass used for sugar production	10%	Amyris, Total

<sup>18</sup> ICAO, <https://www.icao.int/environmental-protection/GFAAF/Pages/Conversion-processes.aspx>, accessed on 14/03/2022

ASTM D7566 Annex 4	Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources	FT-SKA	Coal, natural gas, biomass	50%	Sasol
ASTM D7566 Annex 5	Alcohol to jet synthetic paraffinic kerosene	ATJ-SPK	Biomass from ethanol or isobutanol production	50%	Gevo, Cobalt, Honeywell UOP, Lanzatech, Swedish Biofuels, Byogy
ASTM D7566 Annex 6	Catalytic hydrothermolysis jet fuel	CHJ	Triglycerides such as soybean oil, jatropha oil, camelina oil, carinata oil, and tung oil	50%	Applied Research Associates (ARA)
ASTM D7566 Annex 7	Synthesized paraffinic kerosene from hydrocarbon-hydroprocessed esters and fatty acids	HC-HEFA-SPK	Algae	10%	IHI Corporation
ASTM D1655 Annex A1	FOG Co-processing		Fats, oils, and greases (FOG) from petroleum refining	5%	
ASTM D1655 Annex A1	FT Co-processing		Fischer-Tropsch (FT) biocrude as an allowable feedstock for petroleum co-processing	5%	Fulcrum

Additional pathways are currently in the ASTM certification process.

Alongside the technology readiness, the commercial development of a certain fuel could be different due to various other drivers (e.g. certification issues, costs issues). To better clarify the progress of a specific fuel production pathway towards full commercialization, the US Commercial Aviation Alternative Fuels Initiative has developed the Fuel Readiness Level (FRL) system, which has been endorsed by ICAO.

Process		Technology Readiness Level (TRL)	Fuel Readiness Level (FRL)
Fischer-Tropsch Synthetic Paraffinic Kerosene	<i>FT-SPK</i>	6-8	7
Fischer-Tropsch Synthetic Paraffinic Kerosene with Aromatics	<i>FT-SPK/A</i>	6-7	7
Hydroprocessed Fatty Acid Esters and Free Fatty Acid	<i>HEFA</i>	9	9
Hydroprocessing of Fermented Sugars - Synthetic Iso-Paraffinic kerosene	<i>HFS-SIP</i>	7-8	5-7
Alcohol-to-Jet Synthetic Paraffinic Kerosene	<i>ATJ-SPK</i>	6-7	7
Co-processing biocrude up to 5% by volume of lipidic feedstock in petroleum refinery processes	<i>Co-processing</i>	7-8	6-7

Figure 7: TRL and FRL of ASTM certified production pathway for use in commercial flights<sup>19</sup>

<sup>19</sup> EASA. European Aviation Environmental Report 2019.

