COORDINATION OF RENEWABLE FUEL STAKEHOLDER'S STRATEGY IN THE FIELD OF AVIATION

Sustainability and Deployment Strategies for SAF. Communication paper

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Contributing authors	SENASA: Daniel Rivas, Inmaculada Gómez Jiménez ONERA: Philippe Novelli
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TABLE OF CONTENT

PREAMBLE

The European Commission has contracted a team of independent experts to support the activities of the European Advanced Biofuels Flightpath (EABF or "Flightpath") and provide recommendations to the Commission regarding renewable fuels for aviation.

Under the "ESFERA"[1] study, in addition to setting a dedicated Secretariat for the EABF, this team of experts ("the "ESFERA team"[2]) has engaged the study of policy options for the deployment of sustainable alternative fuels (SAF) in aviation. The objective is to provide data and analyses to support the EABF's Core Team (CT) and the European Commission in reaching the EABF targets. The study is to be carried out in close connexion with the EABF and is to engage the CT into the discussion of strategic options, as well as into the provision of inputs based on the expertise of the CT members.

The general approach and steps of the supporting study were presented in the ESFERA Action Plan [1]; they are described in the project proposal. This D1.1.4 report is the deliverable of task 1.1.4, "Preferable deployment strategies" of the project proposal. It is related to task 4, "Analysing the preferable deployment strategies of Axis 1 of the Action Plan, "Investigation and assessment of policy options". It proposes a reference for sustainability criteria and a selection of pathways to be further used in the deployment scenario for which the impact of supporting measures will be assessed. It builds on the more detailed analysis presented in deliverable D2.2.2. “Pathways for alternative fuel production”.

1 INTRODUCTION

The objective of this communication paper is to analyse existing sustainability criteria in order to define a deployment strategy as part of an effort to develop a biojet fuel market in Europe.

Sustainability is a critical component of renewable energy policy, as evidenced by the multiple sustainability-related concerns and debates on current biofuels. These ultimately create uncertainty and heighten the risks for developing alternative fuels.

The objectives of this communication paper are:

- To provide an overview of sustainability criteria that are taken into account in a number of existing policy frameworks for renewable energy;
- To propose a reference for sustainability criteria, which will be used to select eligible pathways for the deployment scenarios later on considered in the assessment of supporting policies for promoting the development of sustainable alternative fuels in the EU aviation;
- To analyse which fuel production pathways comply with the selected reference for sustainability criteria and in particular with the requested greenhouse gas (GHG) emission reductions.

[1] Contract N° ENER/C2/2016-478, invitation to tender: "Coordination of renewable fuel stakeholders' strategy in the field of aviation", March 2016.
[2] The ESFERA team consists of SENASA (coordinator), ONERA, Transport Mobility Leuven (TML) and Wageningen University and Research (WUR)

2 SUSTAINABILITY CRITERIA

Regulatory constraints as well as societal concerns regarding sustainability have significant impacts for the deployment of SAF's value chains, as they are critical for the selection of feedstocks and conversion technologies. Adherence to particular sustainability criteria may have direct consequences on the availability and cost of biofuel, as well as on interactions with other markets - such as world agricultural markets or the road transportation fuel market – with regard to potential competition or benefit from possible economies of scale. Ultimately, all the above-mentioned factors will affect the costs and potential impacts of supporting policies.

Therefore, it is important to define reference sustainability criteria for the ESFERA study. They will be used to select the pathways included in the production scenarios for which supporting measures will be assessed. From this point of view, regulatory frameworks, such as the RED, form a minimum mandatory basis. A question is whether it could make sense to go beyond this basis with additional requirements, in order for example to ensure a stronger resilience with a view to possible future evolutions of regulations or to answer specific societal concerns for producers.

From existing sustainability frameworks, two distinct sustainability approaches have been identified by ESFERA[3]:

1) A **feedstock agnostic approach** based on the compliance with criteria applicable to any type of biomass, or
2) A **feedstock prescriptive approach** based on a list of allowed biomass types combined with sustainability criteria.

The first approach is adopted by voluntary sustainability standards, such as RSB or ISCC, and by ICAO for the CORSIA, whereas the revised RED II is an example of the second approach. The RED II includes a list of "promoted" biomass together with thresholds on emission reductions (**65%** saving for installations operating from 1-01-2021), therefore limiting or excluding the use of feedstocks and pathways that do not comply with both conditions.

Voluntary standards such as RSB or ISCC (and in particular standards following ISEAL guidelines) cover a wide scope of criteria, including impacts on soil, water, air, as well as social criteria[4]. On the contrary, the two major regulatory schemes, RFS and RED, are limited to GHG emission reduction requirements and types of land on which the biomass can be grown (mainly exclusion of lands with high biodiversity and carbon hot spots). This is also currently the case for CORSIA. An additional peculiarity of voluntary standards is that they imply a third party certification of the value chain to demonstrate compliance with sustainability criteria, which is not the case for the RFS 2[5] or the RED II (in the last case, certification is an option), while the choice of certification was also made for CORSIA. Therefore, voluntary standards are especially suited whenever a company wants to implement a more stringent sustainability framework. This is the case, for instance, of SkyNRG for which the implementation of more stringent standards than the RED is a foremost driver within their business model . Another forerunner is LanzaTech (producer of ethanol-based SAF approved by the ASTM D7566) that participated actively in the technical definition of the revised RSB Standard for Advanced Fuels.

Sustainability criteria include "no-go" criteria, such as maximum acceptable emissions of GHG on the life cycle, and criteria that set minimum requirements for biomass production, such as agricultural practices preserving soil quality. An important question for the selection of candidate pathways for the ESFERA study is whether considering a more comprehensive standard is likely to exclude some pathways that would be eligible when considering only regulatory frameworks. Generally, and apart thresholds on GHG emissions reductions, no-go criteria are related to environmental impacts and are not depending on the feedstock per se, but on the location where it is grown and its adaptation to local conditions. As a conclusion, the implementation of a voluntary sustainability certification on top of the CORSIA or RED requirements is not likely to introduce additional absolute limitation on the selection of the

[3] ESFERA Deliverable 2.2.2 pathways for alternative fuel production
[4] It should be pointed out that there are also voluntary standards that were created only with the purpose of demonstrating compliance with the RED. Their scope is limited to RED's criteria as this is the case for example of 2BSvs or the EU RED RSB.
[5] Renewable fuel standards in the US.

pathways. Therefore, a regulatory framework will be used as a reference for sustainability criteria for the ESFERA study.

Considering that, in the near future, alternative fuels used in the EU may be claimed for recognition under two different regulatory frameworks, the RED/EU ETS on the one hand and the CORSIA on the other hand, it was decided for the analysis carried out within ESFERA to **consider contrasting scenarios corresponding to the two respective approaches to sustainability**. In the analysis, a major difference between the two approaches is that RED II does not include ILUC emissions in the life cycle assessment of pathways (LCA) ,since the prescriptive approach for feedstock already excludes feedstock with high ILUC risk, whereas CORSIA includes them but does not preclude any kind of feedstock.

3 COMPLIANCE OF PATHWAYS WITH RED II

A number of potential pathways were selected for review against the REDII framework. These pathways cover the four families of conversion processes, which are today approved for aviation:

- Hydrogenation of vegetable oils and animals fats (HEFA);
- Gasification and Fischer-Tropsch synthesis (FT);
- Fermentation of sugars (including cellulosic sugars), directly to hydrocarbon (SIP) or through alcohols (ATJ).

The associated considered feedstock are listed in Table 1 which analyses their compliance with REDII sustainability requirements[6] and particularly its Annex IX, without considering GHG emissions thresholds at this stage (GHG emissions will be addressed in section 4). It should be noted that all the pathways listed in the table are eligible under CORSIA with regard to non-GHG related sustainability criteria.

Table 1: Compliance of pathways with the RED II

Conversion	Feedstock	Compliance with RED Annex IX[7]	
		Y/N	Comment
Fischer-Tropsch (FT)	Agricultural residues	Yes	Annex IX Part A e, f, g, k, l, m & n) *Note: Compliance requires that operators or national authorities have monitoring or management plans in place in order to address impacts on soil quality and soil carbon*
	Forestry residues	Yes	Annex IX Part A o) *Note: conditional to additional requirements to minimise risks of using forest biomass derived from unsustainable production*
	Short-rotation woody biomass	Yes	Annex IX Part A q) "other ligno-cellulosic materials"
	Herbaceous energy crops	Yes	Annex IX Part A p) "other non-food cellulosic materials"
	Municipal solid waste (MSW)	Yes	Annex IX Part A b); c) – Biomass fraction only. *Note: EP's amendments add in the recital that avoiding and recycling waste shall be the priority*

[6] There is no objective of comprehensiveness in this list. Feedstock have been selected as they provide a sufficient level of credibility in the short term and cover a large enough scope of types of feedstock for the analysis to be performed.
[7] The reference here is the proposal for RED revision of November 2016.

Hydro-processed Esters and Fatty Acid (HEFA)	Tallow	Yes	Annex IX Part B, limited to category 1 & 2 of animal by-products (exclude by-products that are not intended for consumption for commercial reasons and not for sanitary reasons) *Note: Contribution of Annex IX Part B feedstock to RED target is limited to 1.7% of the energy content of transport fuels*
	Used cooking oil (UCO)	yes	Annex IX Part B *Note: Contribution of Annex IX Part B feedstock to RED target is limited to 1.7% of the energy content of transport fuels*
	Corn oil	No	Inedible corn oil from ethanol and DDGS production Here, a conservative choice is made[8].
	Canola / Rapeseed	No	Not excluded for production of biofuels but limited to a total share of biofuels produced from food and feed crops of 7% of the final consumption of energy in road and rail transport in 2020[9]
	Soybean	No	
	Palm oil	No	
	Camelina	No	
	Palm fatty acid distillates (PFAD)	No	Here, a conservative choice is made[10].
	Tall oil	Yes	Annex IX Part A h)
Synthesized Iso-Parafins (SIP / DSHC) + Alcohol to Jet (ATJ)	Sugarbeet	No	Not excluded for production of biofuels but limited to a total share of biofuels produced from food and feed crops of 7% of the final consumption of energy in road and rail transport in 2020
	Sugarcane	No	
	Corn grain	No	
	Herbaceous energy crops	yes	Annex IX Part A p) "other non-food cellulosic materials"
	Agricultural residues	Yes	Annex IX Part A e, f, g, k, l, m & n) *Note: Compliance requires that operators or national authorities have monitoring or management plans in place in order to address impacts on soil quality and soil carbon*
	Forestry residues	Yes	Annex IX Part A o)

Beyond this analysis, the use of food or feed crops for aviation biofuels production needs to be further questioned. Foremost, there is a clear will in the European policy to cap and even reduce[11] in the long run the contribution of biofuels based on food and feed crops, especially those with the highest risk of indirect land-use change (e.g. palm-based). At the same time, according to the SGAB report, biodiesel and ethanol facilities are currently running respectively at 50% and 70% of their capabilities. Therefore, it could make sense to use the margin on food and feed

[8] Inedible corn oil is not explicitly included in annex IX of the proposal for REDII. It could be considered included in item d) of Annex IX "Biomass fraction of industrial waste not fit for use in the food". We did not include it here because it is a by-product of biofuel production from food-crop.

[9] More precisely, the contribution of biofuels produced from food and feed crops[9] shall be no more than 1 percentage point higher than the contribution from those to the gross final consumption of energy from renewable energy sources in 2020 in that Member State, with a maximum of 7% of gross final consumption in road and rail transport in that Member State.

[10] PFAD are not explicitly included in annex IX of the proposal for REDII. It could be considered included in item d) of Annex IX "Biomass fraction of industrial waste not fit for use in the food". We did not include it here because of existing controversies regarding palm oil (some view the use of PFAD for biofuel as possibly encouraging the production of palm oil).

[11] The initial EC's proposal was planning a decrease of the cap on these fuels from 7% in 2020 to 3.8% in 2030.

crops to saturate first current production capabilities before creating a new industry using these crops. Accordingly, food and feed crops do not seem to represent relevant candidates for aviation fuel production in the European context. It was decided not to include them for the RED II scenarios.

Finally, the list of pathways for the RED baseline scenario reduces to those included in Table 2.

Table 2: final list of pathways for the RED baseline scenario

Conversion	Feedstock	Associated constraints
Fischer-Tropsch (FT)	Agricultural residues	*Possible requirement that measures for soil protection have been taken into account*
	Forestry residues	-
	Short-rotation woody biomass	-
	Herbaceous energy crops	-
	Municipal solid waste (MSW)	Annex IX Part A b); c) – Biomass fraction only.
Hydro-processed Esters and Fatty Acid (HEFA)	Tallow	limited to category 1 & 2 of animal by-products Contribution of Annex IX Part B feedstock to RED target is limited to 1.7% of the energy content of transport fuels
	Used cooking oil (UCO)	Contribution of Annex IX Part B feedstock to RED target is limited to 1.7% of the energy content of transport fuels
	Tall oil	-
Synthesized Iso-Parafins (SIP / DSHC) + Alcohol to Jet (ATJ)	Herbaceous energy crops	-
	Agricultural residues	*Possible requirement that measures for soil protection have been taken into account*
	Forestry residues	-

4 GHG REDUCTION ASSESSMENT FOR SAF

The use of sustainable aviation fuel (SAF) is considered as an essential emission mitigation measure within the aviation industry and actual greenhouse gas (GHG) emission reductions are expected. For this purpose, both the RED and the CORSIA include thresholds on life cycle emissions reductions, but important differences need to be taken into account when assessing the eligibility of a pathway under one or the other framework:

- RED does not include ILUC emissions while the LCA methodology for CORSIA does;
- Minimum emissions reductions shall be 10% under CORSIA and 65% under the RED (for facilities entering in service from January 2021, which is likely to be the case for aviation biofuel production[12]);
- Reference for fossil jet fuel is 94 CO2eq/MJ for the RED II, and 89 CO2eq/MJ for CORSIA.

RED II includes default values applicable when claiming the use of a number of pathways. Unfortunately, none of these pathways is related to aviation fuel. Concurrently, for the implementation of CORSIA, the Alternative Fuel Task

[12] 60% if the installation was already operating from 5-10-2015, **50%** saving if the installation was already operating on or before 5-10-2015

Force (AFTF) of CAEP has been computing default life cycle emissions for aviation biofuels, as well as ILUC emissions values. At time of writing, only part of these values (those already approved by ICAO Council) have been made public. The others are still pending approval and should be made public in the coming months. From our knowledge, these values results from an unprecedented harmonisation effort at international level involving Brazilian, Canadian, European and US teams for proposing defaults life cycle emissions values for the recognition of the use of biofuels under the CORSIA. Moreover, they will gain a regulatory value as being the reference for the implementation of an international system, the CORSIA. Therefore, although these values are not yet public, it was decided to use them as reference value for the ESFERA study.

Accordingly, **¡Error! No se encuentra el origen de la referencia.** provides the default values already approved and ncluded in the SARPs adopted by ICAO Council in June 2018 for the CORSIA. The other values are not given in Table 3**¡Error! No se encuentra el origen de la referencia.**, but the colour code of the box indicates whether the pathway comply with RED and CORSIA minimum emissions reduction thresholds. For information purpose, the table also provides the average of values retrieved from a literature search[13].

Regarding the implementation of the RED, both CAEP values and data found in literature suggest that the GHG emissions of the Fischer-Tropsch pathways are well below 32.9 g CO_2eq/MJ (Table 6). On the other hand, the values for ATJ are much higher, even though produced from the same feedstocks as in the Fischer-Tropsch pathways. They do not necessarily comply with the threshold. HEFA pathways from tallow and UCO have an intermediate position. We did not find data for SIP produced from non-food/feed crops.

Regarding CORSIA, generally all values from CAEP in Table 8 are below the threshold of 80.1 g CO2eq/MJ and corresponding pathways are eligible for claiming offsets. The eligibility of palm oil depends on the treatment of palm oil mill effluent, whether it is done in open or close ponds (avoiding methane emission). Only ATJ obtained from corn grain through ethanol does not path the threshold.

[13] For more information, the reader is invited to refer to report D.2.2.2, “Pathways for alternative fuels production”.

Table 3: GHG emissions (g CO2eq/MJ) aviation biofuel pathways and corresponding total life cycle GHG emissions

		Core LCA		ILUC		Total LCA
Conversion	**Feedstock**	Average from littérature	*CAEP* Dec 2018	Average from littérature	CAEP	**CAEP** Value
Fischer-Tropsch	Agricultural residues	10,3	7,7		0	7,7
	Forestry residues	9,1	8,3		0	8,3
	Short-rotation woody biomass	9,8	n.d.	8,1	n.d.	
	Herbaceous energy crops	13,9	n.d.	23,6	n.d.	
	Municipal solid waste (MSW) (NBC: non-biogenic carbon content)		NBC*170,5 + 5,2		0	NBC*170,5 + 5,2
Hydro-processed Esters and Fatty Acid	Tallow	29,8	22,5		0	22,5
	Used cooking oil (UCO)	23,7	13,9		0	13,9
	Corn oil		17,2		0	17,2
	Canola / Rapeseed	49,6	n.d;	63,7	n.d.	
	Soybean	38,5	n.d.	66,7	n.d.	
	Palm oil	30,0	n.d.	75,3	n.d.	
	Camelina	37,3	n.d.	n.a	n.a.	n.a.
	Palm fatty acid distillates (PFAD)		20,7	0	0	20,7
	Tall oil					
Synthesized Iso-Parafins (SIP / DSHC)	Sugarbeet		n.d.	11,5	n.d.	
	Sugarcane	47,0	n.d.	19,6	n.d.	
ATJ (Ethanol / Isobutanol)	Sugarcane (iBUOH ATJ)	31,0	n.d.	19,6	n.d.	
	Sugarcane (etaOH ATJ)		n.d.		n.d.	
	Sugar beet			11,5		
	Corn grain (etaOH ATJ)		n.d.		n.d.	
	Corn grain (iBUOH ATJ)	54,0	n.d.	37,5	n.d.	
	Herbaceous energy crops (iBuOH ATJ)		n.d.	23,6	n.d.	
	Agricultural residues (iBUOH ATJ)	35,0	29,3		0	29,3
	Forestry residues (iBUOH ATJ)		23,8		0	23,8

In Table 3:

- In column "Core LCA", green boxes correspond to values that are well below the RED II threshold (<0.8*32.9 g CO_2eq/MJ), red boxes are well above the threshold (>1.2*28.2 g CO_2eq/MJ) and orange boxes are in between;
- In column 'Total LCA", green boxes correspond to the pathways that comply with the CORSIA threshold on emissions reductions.
- N.d. means not disclosed; n.a. means not available

5 SYNTHESIS

From the consideration of existing regulatory frameworks and voluntary sustainability standards, two references for sustainability criteria were chosen for the selection of candidate pathways for the production of alternative fuels for aviation: the RED II regulatory framework and the CORSIA regulatory framework. These two cases are also those considered for the definition of the scenarios for which the assessment of the policy instruments will be carried out within the ESFERA study.

Among the list of possible pathways that were considered for aviation fuel production, the production pathways selected for the RED II scenario are summarised in Table 4, in which both sustainability requirements and GHG emissions thresholds are combined. Those selected for CORSIA are listed in Table 5. It is worth noting that, although production of fuels from food and feed-crop will still be possible in the context of the RED II, the choice was made not to retain such fuels for aviation for the RED scenario.

Table 4: pathways selected for the RED II framework and their GHG emissions (based on values in section 3.1.2)

		Core LCA	
Conversion	**Feedstock**	Average from littérature	*CAEP (dec. 2018)*
Fischer-Tropsch	Agricultural residues	10,3	7,7
	Forestry residues	9,1	8,3
	Short-rotation woody biomass	9,8	
	Herbaceous energy crops	13,9	
	Municipal solid waste (MSW) (NBC: non-biogenic carbon content)		NBC*170,5 + 5,2
Hydro-processed Esters and Fatty Acid	Tallow	29,8	22,5
	Used cooking oil (UCO)	23,7	13,9
ATJ (Ethanol / Isobutanol)	Agricultural residues (iBUOH ATJ)	35,0	29,3
	Forestry residues (iBUOH ATJ)		23,8

Table 5: pathways selected for the CORSIA framework and their GHG emissions

		Core LCA			ILUC		Total LCA
Conversion	**Feedstock**	Average from littérature	*CAEP*		Average from littérature	CAEP	**CAEP**
			Dec 2018				Value
Fischer-Tropsch	Agricultural residues	10,3	7,7			0	7,7
	Forestry residues	9,1	8,3			0	8,3
	Short-rotation woody biomass	9,8	n.d.		8,1	n.d.	
	Herbaceous energy crops	13,9	n.d.		23,6	n.d.	
	Municipal solid waste (MSW) (NBC: non-biogenic carbon content)		NBC*170,5 + 5,2			0	NBC*170,5 + 5,2
Hydro-processed Esters and Fatty Acid	Tallow	29,8	22,5			0	22,5
	Used cooking oil (UCO)	23,7	13,9			0	13,9
	Corn oil		17,2			0	17,2
	Canola / Rapeseed	49,6	n.d;		63,7	n.d.	
	Soybean	38,5	n.d.		66,7	n.d.	
	Palm oil	30,0	n.d.		75,3	n.d.	
	Camelina	37,3	n.d.		n.a	n.a.	n.a.
	Palm fatty acid distillates (PFAD)		20,7		0	0	20,7
Synthesized Iso-Parafins (SIP / DSHC)	Sugarbeet		n.d.		11,5	n.d.	
	Sugarcane	47,0	n.d.		19,6	n.d.	
ATJ (Ethanol / Isobutanol)	Sugarcane (iBUOH ATJ)	31,0	n.d.		19,6	n.d.	
	Sugarcane (etaOH ATJ)		n.d.			n.d.	
	Corn grain (iBUOH ATJ)	54,0	n.d.		37,5	n.d.	
	Herbaceous energy crops (iBuOH ATJ)		n.d.		23,6	n.d.	
	Agricultural residues (iBUOH ATJ)	35,0	29,3			0	29,3
	Forestry residues (iBUOH ATJ)		23,8			0	23,8

For CAEP values, n.d. means not disclosed (i.e. values not already made public by ICAO. n.a. means not available.

6 REFERENCES

[1] ESFERA report D1.0.1 – Action Plan – April 2017

[2] ESFERA report D2.2.2 - Pathways for alternative fuels production – January 2019.

ANNEX I

As a first step in the analysis a review was made of various policy frameworks that are defined in the EU and outside the EU that are relevant in the context of alternative fuels for aviation. These policy frameworks consist of:

- Current EU policy:

  Renewable Energy Directive (RED), Renewable Energy Directive Revision (RED II), European Emission Trading System (ETS phase III (2013-2020) and proposal for phase IV (2021-2030)), Fuel Quality Directive (FQD), Common Agricultural Policy (CAP), Land use, land use-change and forestry (LULUCF) regulation

- "Clean Energy for All Europeans" proposals, with particular attention for the Proposal for a revised Renewable Energy Directive

- National policies in a selection of EU Member States: Belgium, Germany (Federal Emission Protection Act (BImSchG)), Spain, France (Law for the energy transition and Multi-year Energy Planning), the Netherlands (Energy agreement), the UK

- International policies:

  - ICAO: Carbon offsetting and Reduction Scheme for International Aviation (CORSIA)

  - US: Renewable Fuel Standard (Federal level), Low Carbon Fuel Standard (State of California)

  - Australia: Biofuels Act 2007 (New South Wales)