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Stakeholders requirements and market needs

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Abbreviations

TG	Target Group
TAGs	Triacylglycerides
DFBG	Dual Fluidized Bed Gasification
TRL	Technology Readiness Level
FT	Fischer-Tropsch
ETBE	Ethyl Tertiary Butyl Ether
HVO	Hydrotreated Vegetable Oil
HEFA	Hydroprocessed Esters and Fatty Acids
RED	Renewable Energy Directive
FQD	Fuel Quality Directive
FAME	Fatty Acid Methyl Esters
UCO	Used Cooking Oil
MGO	Marine Gas Oil
HFO	Heavy Fuel Oil
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
IMO	International Maritime Organization
ICAO	International Civil Aviation Organization
SAF	Sustainable Aviation Fuel
EU	European Union
R&D	Research & Development

Contents

Executive Summary

Within this document, the identification of the stakeholders has been performed and a series of questionnaires has been developed in order to define their requirements and specifications, emphasizing on the potential benefits that BioSFerA project should bring to the fore.

Seven (7) Target Groups (TG) have been elected to represent the stakeholders core and based on these Target Groups, the appropriate questionnaires have been developed. In particular:

- A – Technology providers
- B – Feedstock suppliers
- C – Refineries
- D – Fuel traders
- E – Final end-users (ship owners/aviation airlines)
- F – Innovation & Research Centers/Institutes
- G – Policy makers

Specifications that need to be met for each of the identified Target Groups have been gathered, starting from the feedstock supply and conversion and ending to the targeted drop-in biofuels for the aviation and maritime sector. Although the integration of the technologies is well recognized as fundamental for the accomplishment of the project's objectives, the understanding of the needs and expectations from main stakeholders (internal & external) can offer a different and more reliable prospective on how to address and review goals and objectives.

Aim of this deliverable is to assess the potential of replicability, marketability and the effectiveness of the functionalities provided as well as to align them with the stakeholders' requirements and specifications in order to ensure a well-oriented project implementation. The received answers are attached in the Annexes.

1. Introduction

1.1. BioSFerA process overview

The BioSFerA concept aims to establish a combined thermochemical - biochemical pathway that starts with the gasification of biogenic residues, continues with the double - stage syngas fermentation and finishes with the hydrotreatment of the resulting bio-based triacylglycerides (TAGs) to produce drop-in biofuels for aviation and maritime transport (Figure 1).

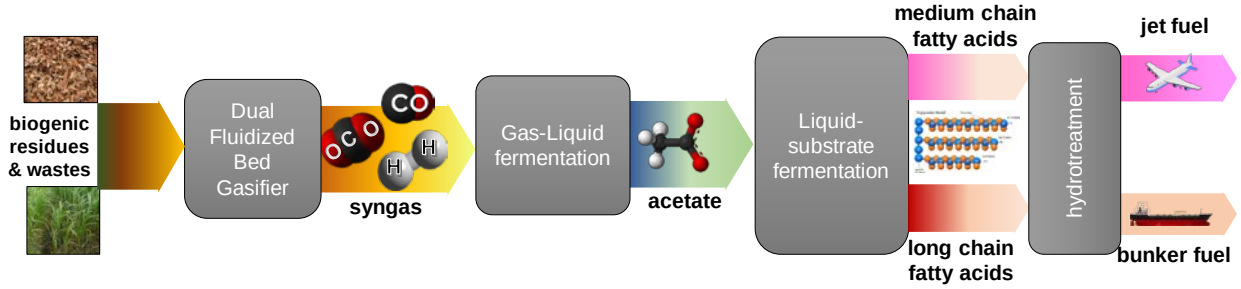


Figure 1. BioSFerA concept at a glance

BioSFerA stakeholders can be described as any party and field that can either affect or be affected by the project realization and implementation. Stakeholders' requirements and specifications, involving the supply chains, the applied technologies as well as the policy framework, must be investigated from the technical and market point of view, as their opinion will affect considerably the aspects at which the project activities will focus on.

1.2. Methodological framework and objectives of the deliverable

The first phase contains the stakeholders identification, aiming to define the BioSFerA 'ecosystem' as a well-oriented community of Target Groups that dominate the whole concept from start to end (Figure 2). In this prospective, understanding the needs and expectations of BioSFerA's stakeholders is of utmost importance. This will be aimed to be performed via dedicated questionnaires that will investigate each Target Group needs and activities, connect them with the BioSFerA concept and assess the framework under which the project will upgrade its maturity in a sustainable and beneficial for the involved factors way.

The core of the project is clearly its consortium, but the elicitation of the stakeholders and the Target Groups definition should be widened. The consortium itself might be able to supervise all the involved technologies and establish a strong concept, but in no case could represent the whole targeted BioSFerA impact. Therefore, the consortium members will be placed in the Target Group that they belong and will be called to answer the corresponding questionnaires, but the questionnaires will be shared also 'externally', in organizations out of the consortium whose activities affect or could potentially be affected by the BioSFerA realization. The analysis that will be performed related to stakeholders requirements &

market needs will be a questionnaires-oriented analysis. Literature data will support the analysis and of course will not be ignored, however main objective of this deliverable is the interaction with the industry and the market itself. Key facts for every identified Target Group will be extracted from the responses .

Aim of this internal/external questionnaires sharing approach and of this deliverable in general, is the formation of a wide and solid data gathering able to express the stakeholders' needs, provide strong directions towards the project, set implementation priorities, reorient the overall BioSFerA objectives and align them with the biggest possible impact indications.

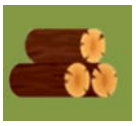
Figure 2. BioSFerA interaction with the relevant stakeholders groups

2. Stakeholders & Market needs

2.1. Identification of Target Groups as Stakeholders of the survey

Aiming to form an appropriate and solid stakeholders body, capable of covering the whole spectrum of the project realization and implementation, the following Target Groups have been selected:

- **Technology providers:**
  As technology providers are defined these parties that will have a technological contribution within the BioSFerA concept. This is a Target Group that will be investigated 'internally' and is represented only by consortium members. The rationale behind this decision is that since BioSFerA aims to introduce and establish a new concept based on the combination of existing technologies, the attention should not be focused on the technologies themselves but on their integration in the same concept. Therefore, BioSFerA project can be assumed as a new technology and on this perspective only consortium members can be seen as technology providers, since investigating separately external gasification providers or fermentation providers under other concepts and technologies is out of scope of this deliverable.



- **Feedstock suppliers:**
  BioSFerA concept is based on the gasification of biogenic residues and therefore it can be characterized as a biomass-based project. One of the major issues associated with the use of any biomass resources is its supply chain management. Regional and seasonal availability of biomass as well as storage problem are key parameters that set up the technological and economic efficiency and environmental sustainability. The feedstock suppliers have been identified as the Target Group which is mainly responsible to plug in the gap between the biomass resource availability and its demand. The feedstock flexibility that is attempted within BiosFerA project along with the prediction of sustainable full-scale scenarios, permits a wide screening around Europe concerning different biomass types and supply chains.

- **Refineries:**
  The bio-based TAGs that will emerge from the double stage syngas fermentation, will subsequently be hydrotreated to obtain the desired jet and bunker fuels. The co-processing (conventional /renewable fuels parallel processing) possibility involving the existing infrastructure, the technical characteristics of the most common aviation and maritime fuels, the potential blending challenges as well as the current legal framework governing the operation of the refineries are aspects that

should surely be taken into consideration when attempting to come up with a new way of producing these kind of fuels. The refining industry, due to its existing distribution system and infrastructure has an important and enduring role to play in the renewable liquid fuels of the future. If a prediction had to be made, the refinery of the future will become a hub where different fuels from different sustainable sources will be processed (co-processed) in a way that complies with the industry specifications.

- **Fuel traders:**

  A more narrowed definition of Fuel traders is utilized within this deliverable, since as fuel traders are assumed companies that sell sustainable fuels only for aviation and maritime application. This Target Group acts as an intermediary between the refineries and the fuel market. In other words, the interest of fuel traders lies in a set of specifications that the produced fuel should surely meet in order to reach the market. This set of specifications might be related with technical parameters (viscosity, density, flash point, etc.), storage facilities and storage properties, or possibly fuel cleaning requirements and costs. Another parameter that has been already mentioned and will surely play a key role in facilitating the introduction of the candidate fuel into the market is its blending ability, meaning its compatibility with the existing fuels and infrastructure in terms of operation and storage.

- **Final end-users:**

  They are the targeted final recipient of the produced fuel, and in the case of BioSFerA project, they are aviation airlines, ship owners and ports/airports. It is maybe the most vulnerable Target Group, since every aspect of the selected fuel must comply with the user demands concerning prices, performance, supply chains, storage ability and existing infrastructure compatibility. As for the latter, some end-users could possibly be willing to proceed to partial retrofitting of their infrastructure either because a new fuel could offer a more favorable balance among the other mentioned demands or because of obligations derived from policies which is another crucial Target Group and is mentioned below.

- **Innovation & Research Centers/Institutes:**

  This is another Target Group that will be investigated only internally, as refers to the Centers/Institutes that are members of the consortium and will take part in the BioSFerA project activities. These Innovation & Research Centers are expected to offer added value regarding process integration, optimization and scale-up standards as well as project dissemination and exploitation. They will prepare the ground and act as a support for the technology providers, targeting to make a breakthrough in their up to now research activities within a highly innovative concept like BioSFerA.

- **Policy makers:**
  Last but not least, this Target Group affects each of the previous mentioned stakeholders as it contains the strategy and the policy which is followed to strengthen biofuel production and establish guidelines for the development of the sector. Biomass utilization, microbes and yeasts involvement, fuel cleaning requirements, blending percentages are all matters that lie in legislative obligations and prohibitions that may also vary from country to country. The current and forthcoming transportation fuel policies, especially in aviation and maritime sector, should be under constant monitoring and act as a 'compass' during the project navigation and orientation. Evolution of current transport policies can be the basis for predictable demand and price cues. In other words, it is emphasized the need of an enabling policy framework with clear legislative signals that will create market incentives and trigger the grow – up of sustainable technologies for alternative fuel production.

The BioSFerA 'ecosystem', with the identified Target Groups, is illustrated in Figure 3:

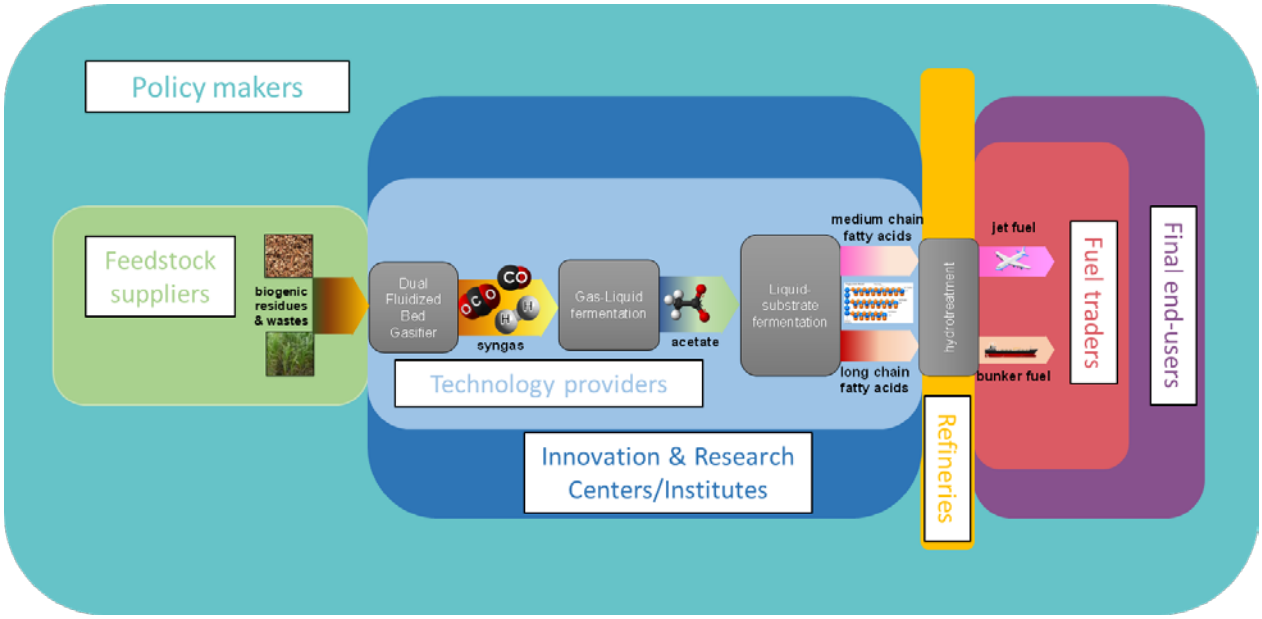


Figure 3. BioSFerA stakeholders and Target Groups community

Concerning the internal placement of the consortium members among the identified stakeholders, VTT, SHI-FW, ENVIPARK & BBEPP were selected to represent the Technology providers and respond to the corresponding questions, KPRT to do the same for the Refineries, GoodFuels for the Fuel traders and finally CERTH, CARTIF, CSIC & NTUA will act on behalf of the Innovation & Research Centers/Institutes Target Group.

2.2. Questionnaires development

The questionnaires aim to define these stakeholders' requirements and specifications that will provide clear hints and guidelines towards the project piloting and realization. Seven (7) questionnaires have been developed, one for each Target Group, and have been shared internally and externally, as described in section 1.2, not only because the consortium members themselves are not enough to cover the whole stakeholders spectrum but also in order to achieve a wide data gathering and maximize the intended impact of this deliverable.

2.2.1. Questionnaire of Technology providers

A – Technology providers Considering the technological and market directions of your organization, please provide the requested information concerning the BioSFerA concept but also the alternative fuels production in general:
1. Which is the technology that is of your main interest within BioSFerA project?
2. Has your provided technology been involved again in biofuels production and, if yes, up to which TRL?
3. Which are the main aspects that you would like to further investigate or improve in your technology?
4. How the BioSFerA project let you focus on these aspects?
Any other issue/comments:

2.2.2. Questionnaire of Feedstock suppliers

B – Feedstock suppliers

Considering the type of your organization and its contribution within BioSFerA project, please provide the requested information concerning your product/s distribution and its characteristics:

1. **In which type of activity would you classify your business?**
   - o Farmer
   - o Transporter
   - o Wood supply industry
   - o Distributor, wholesaler
   - o Other: ……

2. **What type of product do you distribute or you could be able to distribute?**
   - o Cereal bales
   - o Forestry products
   - o Pruning bales
   - o Pruning chips
   - o Pellets
   - o Others: ……

3. **Which type of product are you going to distribute within BioSferA project requirements?**

4. **What type of service do you provide for this product?**
   - o Transport to end user
   - o Transport and storage
   - o Commercialization
   - o Others: ……

5. **Which is the estimated quantity of this product that you are capable of distributing annually (tons/year)?**

6. **Up to which point the seasonality affects your productivity and how you handle this issue?**

7. Could you give an estimation of the average energy content of your distributed products (MJ/ton)?
8. Which is according to your opinion the most important barrier that prevents biomass feedstock price decrease? o cultivation costs o harvesting costs o logistics costs o labor costs o biomass pre-treatment (i.e. drying, pelletizing, torrefaction) investment cost o other …….
Any other issue/comments:

2.2.3. Questionnaire of Refineries

C – Refineries Considering your commercial fuel production experience, please provide the requested information concerning biofuels and their challenges:
1. What type of fuels are the final products of your refineries?
2. Which is your estimated annual production (tons/year) and which are the average energy contents of your final products (MJ/ton)?
3. Is it imposed any obligatory biobased percentage in your final products and, if yes, how much is this percentage?

4. Do you perform co-processing (conventional/renewable fuels parallel processing)? If yes, what kind of renewable fuels are these? If no, would you be interested to this initiative?
5. Which are, according to you, the main challenges from the technical point of view for biofuels establishment? (viscosity, flash point, density etc.)
Any other issue/comments:

2.2.4. Questionnaire of Fuel traders

D – Fuel traders **Considering the type of fuels that you usually trade, please provide the requested information concerning technical and supply requirements:**
1. What type of fuels do you mainly trade for aviation or maritime use?
2. Which are the main specifications that must surely be followed in order an aviation/maritime fuel to reach the market?
3. In the fuels that you trade, are there any cleaning requirements or they can be directed straight to the bunker?

4. If there are fuel cleaning requirements, which is the cleaning cost and up to which grade a clean (drop-in) fuel would enhance your market?
5. How much important is for you the blending ability of the fuels that you trade? o outmost important o very important o medium important o low important o no important at all
Any other issue/comments:

2.2.5. Questionnaire of Final end-users

E – Final end-users (ship owners/aviation airlines) **Considering the type of fuel that you usually use for your activities, please provide the requested information concerning your infrastructure fuel compatibility, fuel standards and performance:**
1. Which is the type of fuel that you usually involve in your infrastructure?
2. Which are the main criteria that lead your fuel selection and define its performance?
3. Which is the annual fuel consumption for your activities?

4. Are you satisfied from the prices and the supply chain of the fuels that you currently use?
5. Do you use fuel blendings and, if yes, which is their typical composition?
6. Which fuel parameter improvement could lead you to investigate alternative options for your fuel?
7. How much negotiable would you be in partial retrofitting of your existing infrastructure due to new fuel requirements?
Any other issue/comments:

2.2.6. Questionnaire of Innovation & Research Centers/Institutes

F – Innovation & Research Centers/Institutes Considering your main Research & Innovation activities, please provide the requested information concerning your ambitions and expectations within BioSFerA project:
1. Which is your main research activities within BioSFerA project?

2. **Have you ever performed similar activities in other biofuel projects and, if yes, up to which TRL?**
3. **Which is your targeted breakthrough/innovation in this kind of activities within BioSFerA project?**
Any other issue/comments:

2.2.7. Questionnaire of Policy makers

G – Policy makers Considering the present and the forthcoming legislative framework, please provide the required information concerning biofuels placement in the energy map:
1. **Which is currently the highest permissible blending ratio (conventional/biofuel) and which are the main obstacles for higher biofuels involvement?**
2. **Which is your prediction concerning the forthcoming transportation fuel policies and how these will affect aviation and maritime sectors?**
3. **How important is the role of liquid biofuels towards the energy transition in aviation and maritime sector?** o outmost important o very important o medium important o low important

o no important at all
4. Which is your current strategy for promoting advanced liquid biofuels? o subsidy/national funds o tax relaxation policies o compulsory blending of renewable and conventional fuels o other….
Any other issue/comments:

3. Data collection & analysis

As it has already been mentioned, the consortium itself in no case could represent all the selected Target Groups and ensure the aimed BioSFerA impact. Therefore, potential stakeholders external contacts from each partner all around Europe have been called to respond to the relative with their activities questionnaires and provide valuable information that will boost the BioSFerA impact and assist in the formation of reliable conclusions.

In total, 21 answered questionnaires, including consortium members and external stakeholders, have been obtained. More specifically, 4 to represent the Technology Providers, 3 to represent the Feedstock suppliers, 4 for the Refineries, 1 for the Fuel traders, 4 for the Final end-users, 4 Innovation & Research Centers/Institutes and 1 for the policy makers. Their spread around Europe is presented in Figure 4.

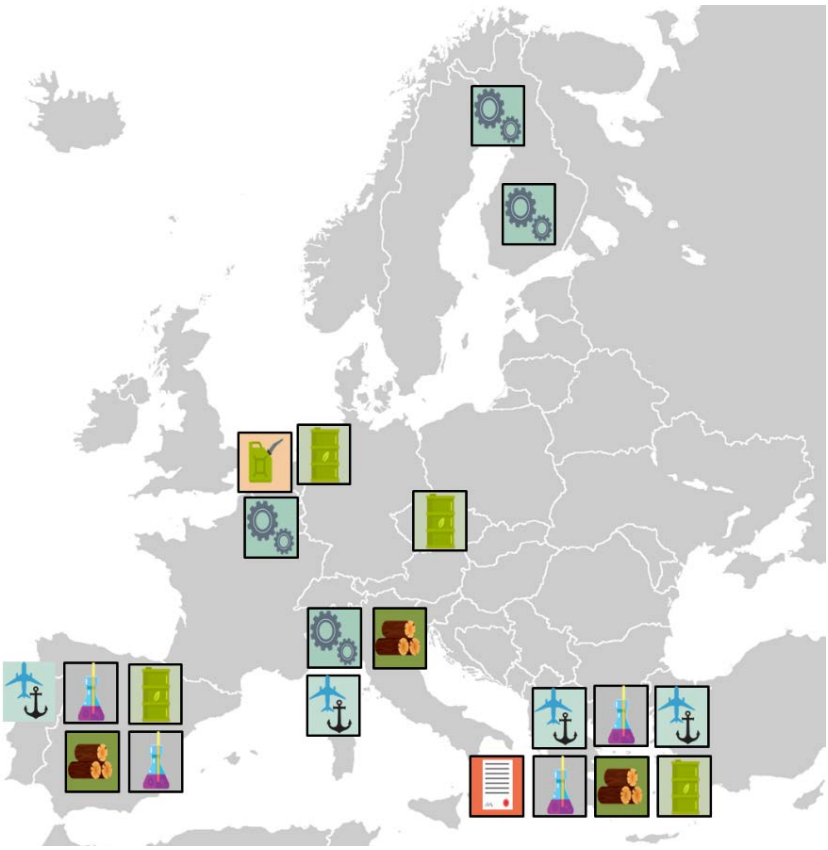


Figure 4. Geographical distribution of the stakeholders representatives

3.1. Technology providers

As described extensively in section 2.1, the TG of Technology providers will be represented only by consortium members that will provide their sub-technology to shape a brand new technology, which aimed to be the BioSFerA concept. The most of the applied sub-technologies have been investigated and have been utilized in various process schemes and TRLs, however the focus must be given on how these sub-technologies will be integrated in a whole new concept and how they will be adapted to the corresponding specifications. Therefore, there was no reason to address the questionnaires also to external providers of these sub-technologies, since they do not have on mind the overview of the new concept.

In particular, VTT will provide the Dual Fluidized Bed Gasification (DFBG) unit and will adjust the syngas conditioning to the syngas fermentation specifications. BBEPP will contribute with the double stage fermentation facilities (i.e anaerobic syngas fermentation to acetate/aerobic acetate fermentation to TAGs) and ENVIPARK will perform the lipids extraction and purification, assisting BBEPP to the selection of the proper TAGs recovery scheme. SHI-FW is a gasifier manufacturer at commercial level and therefore, with its great experience at full-scale, will guide the potential scale-up and measure the applicability of the concept at TRLs > 5. SHI-FW has implemented in the past successfully their gasification technology in a Fischer-Tropsch (FT) based process chain with woody biomass at TRL 7 (12 MWth). Nevertheless, due to

their commercial profile and the high competition that is exists in their activities, SHI-FW selected not to respond in the questions regarding their interests and their aims within BioSFerA project in a public document like the present deliverable.

The maturity of BioSFerA applied sub-technologies as well as the scale-up that is aimed with their integration in the same concept for pilot tests are presented in Figure 5.

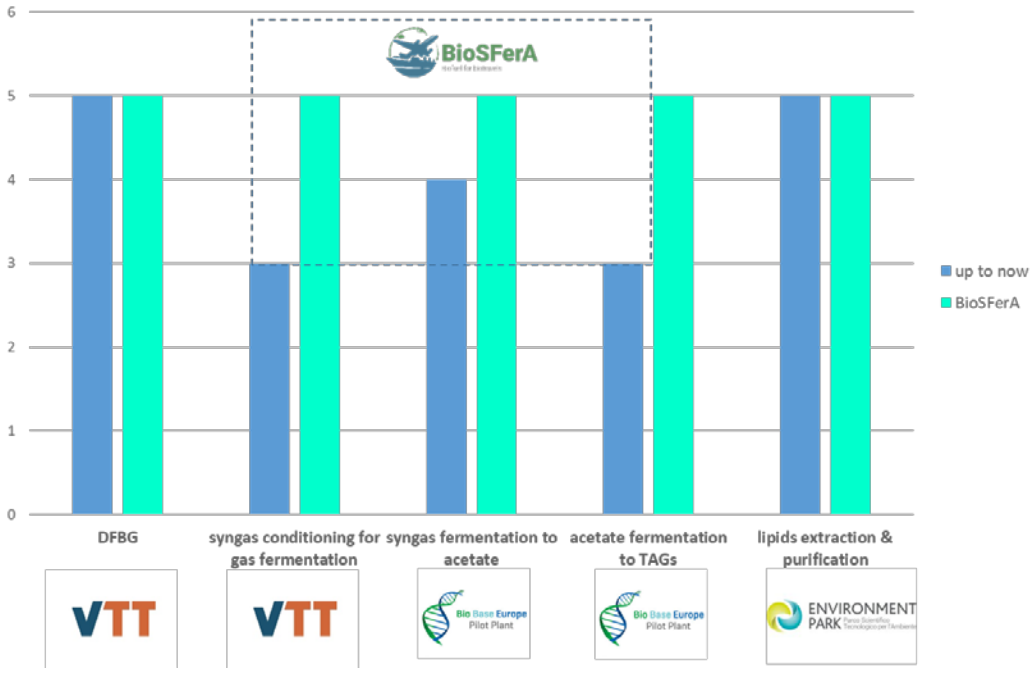


Figure 5. Maturity of BioSFerA applied sub-technologies

The DFBG technology has been involved in FT based process chain at TRL 5, while the syngas conditioning for gas fermentation as well as the double fermentation process have been validated till TRL 3-4. It can be observed, that the Technology providers should focus on the efficient coupling of the thermochemical part with the biological part of the process in TRL 5. This is the major technology challenge of BioSFerA concept, since the standalone sub-technologies have been already tested and utilized in a decent TRL. The Technology providers should take advantage of the Research Centers/Institutes input in order to address a high quality syngas, appropriate syngas conditioning for undistorted gas fermentation, increased acetate and TAGs yields as well as an energy efficient lipids extraction and purification.

Another point of view that was introduced by the respondents concerning BioSFerA value chain, is the high importance of acetate production. Acetate is a valuable product itself and at the same time a versatile building block for other pathways that lead to other valuable products. Therefore, a solid coupling of DFBG with gas fermentation to acetate, which is one of the technological BioSFerA objectives, is of great importance on its own and can be the base for other process schemes that do not end with liquid fuels.

Based on the received answers from Technology providers and the analysis that took place, some key facts are extracted and presented in Table 1.

Table 1. Technology providers key facts

Technology providers – key facts
✓ The main challenge of Technology providers is the integration of the individual technologies in the same process scheme and their adaptations to ensure process efficiency ✓ Thermochemical and biological processes coupling at TRL 5 ✓ BioSFerA value chain till the acetate production (DFBG/ gas conditioning/gas fermentation) is a valuable concept itself

3.2. Feedstock suppliers

Concerning BioSFerA feedstock selection, the strategy that has been adopted is to involve the most promising types of feedstock from each residual biomass category (forestry residues, agricultural residues, biogenic wastes fraction) and from each European region. After the extended feedstock screening and analysis that took place within the deliverable 2.3, the selected types of feedstock were decided to be forestry residues from Finland, cereal straw from Italy, olive prunings from Greece and vineyard prunings from Spain. Some of the mentioned feedstock providers were called to represent the TG of feedstock providers and answer the corresponding questionnaires. In particular, the Italian straw supplier[1], the Spanish vineyard prunings supplier[2] and the Greek olive supplier[3] provided information related to their activities, the seasonality impact as well as their opinion for feedstock price shaping.

Availability and distribution ability of cereal bales, pruning chips and pellets have been quoted. Within BioSFerA concept, it will be attempted the feedstock preparation in a form that is already appropriate to be gasified (e.g. pellets) and to produce reliable and reproducible gasification results. Pelletizing is the most widely used process for the production of high density, solid energy carriers from biomass. The main advantages of the biomass pellets, compared to the raw biomass, are their higher energy density, homogeneous quality, improved storage properties and better applicability for different uses like gasification [1]. The referred feedstock energy content is around 18 MJ/kg (d.b.).

A critical parameter that should be investigated for every developed biogenic feedstock supply chain, is the seasonality of the distributed products. Seasonality can affect the available quantities as well as the quality of the provided feedstock. Sufficient storage for biomass is necessary to accommodate seasonality of production and ensure regular supply to the biomass utilization plant. Pruning is carried out from December to March and then prunings have to remain for a certain time (2-3 months) on the soil to get rid of high moisture content. Moreover, it was mentioned from one respondent that prunings cannot remain at the soil after a certain time since there is the danger of soil infection and soaking from rain. Therefore, feedstock will be available at the right conditions between March and June. Another seasonality derived potential issue that could arise: it is referred for example that olive tree pruning is not performed every year in the same volume and consequently the distributed quantities can be affected. Nevertheless, large biomass providers such as the Spanish and Italian supplier who offer commercialization of their

[1] https://www.gruppoab.com/en/case-history/speranza-cooperative/
[2] http://www.peletsdelamancha.com/en-index.html
[3] https://ktimagolemi.com/

products (e.g. pellets), have found the way (strategic location, network, storage facilities), as expected, to deal with seasonality issues and ensure an annual average productivity accomplishment that can be utilized as a solid base for sustainable biomass supply chains. Finally, pellets selection as the desired type of fuel for BioSFerA concept has taken into consideration except of their qualitative advantages, also their superior storage properties that can remarkably decrease seasonality impact on feedstock supply chains.

The most notable barrier towards extended biomass involvement in energy production is feedstock costs. The low energy density of biomass feeds comes up with remarkably high logistics costs. Moreover, feedstock pre-treatment to increase energy density can be additional expenses to the already existing cultivation, harvesting and labor costs. All these factors burden the final feedstock price and turn it into non-competitive from the market point of view. Indicatively, feedstock costs can represent 40% to 50% of the total cost of biomass-derived electricity produced [2]. Therefore, it was asked from the respondents to express their opinion regarding the impact of these costs and at which grade they regulate the final feedstock price (Figure 6).

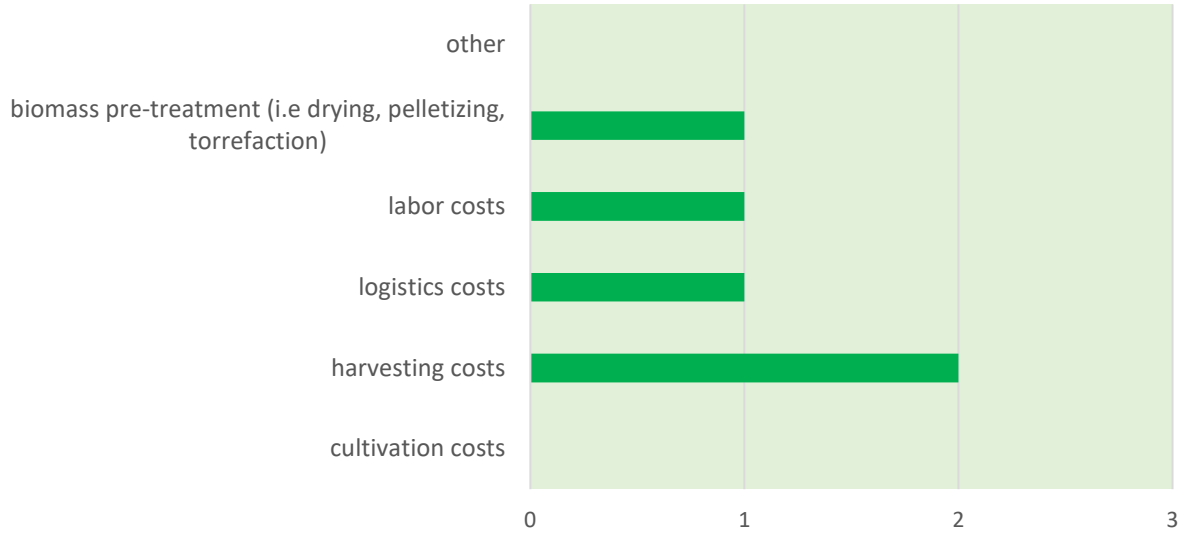


Figure 6. Feedstock price regulators according to the respondents

Harvesting costs have been mentioned two times, while logistics, labor and pre-treatment costs have been quoted also. Of course, the answers of the respondents depend on their activities, meaning that the Italian straw provider as well as the Greek olive provider, that are farmers, focused on the agricultural work and the relative costs while the Spanish supplier that commercializes pellets from vineyard prunings takes into consideration also the pre-treatment costs. The agricultural work related costs (i.e. cultivation, harvesting, labor, etc.) are steady costs while pre-treatment costs are inversely proportional to logistics costs and the balance of the latest two can pave the way for biomass costs reduction and sustainable supply chains. Finally, it has to be mentioned that all the respondents are suppliers derived from agro-industry whereas suppliers from other biogenic residues categories may have different point of view in the same questions or different arisen issues to bring to the fore.

Based on the received answers from Feedstock suppliers and the analysis that took place, some key facts are extracted and presented in Table 2.

Table 2. Feedstock suppliers key facts

Feedstock suppliers – key facts
✓ Within BioSFerA concept, it will be attempted the feedstock preparation in pellet form in order the study to be based on a feedstock with qualitative and storage advantages
✓ Seasonality can affect the available quantities as well as the quality of the provided feedstock. Storage facilities and superior storage properties of feedstock can decrease seasonality impact on supply chains
✓ The main agricultural work costs derive from harvesting, while a balance between pre-treatment and logistics costs would potentially reduce the final feedstock price

3.3. Refineries

The TG of Refineries was represented by global leaders of the refining industry with great experience in the fuels market and international impact. In particular, Kuwait Petroleum International[4], REPSOL[5], Hellenic Petroleum[6] and Unipetrol[7] provided valuable information concerning their activities as well as their opinion towards biofuels involvement and establishment.

The above mentioned refining companies include in their production activities all the typical fossil-derived liquid fuels (i.e. gasoline, diesel, jet fuel, marine fuel). Regarding commercial biofuels production, Ethyl Tertiary Butyl Ether (ETBE), Hydrotreated Vegetable Oils (HVO) and Hydroprocessed Esters and Fatty Acids (HEFA) have been quoted. ETBE is produced from bioethanol and isobutylene in a catalytic reaction. Isobutylene is currently mainly derived from refining fossil sources. ETBE provides improvements in air quality when blended into conventional gasoline as oxygenate and octane booster, while its bio-based percentage (bioethanol) incorporates renewable energy in gasoline. The EU maximum blending level specification for ETBE is 22% in E10 gasoline and 17.24% mass in E5 (equivalent to 2.7% mass of oxygen). HVO/HEFA, commonly referred to as renewable diesel (HVO) and jet fuel (HEFA), are produced via hydroprocessing of oils and fats. They are straight chain and branched (iso)-paraffinic hydrocarbons that are free of aromatics, oxygen and sulfur and exhibit high cetane numbers. HVO/HEFA offers a number of benefits over Fatty Acid Methyl Esters (FAME/Biodiesel), such as reduced NOx emissions, better storage stability, and better cold flow properties. Hence HVO can typically be used in all diesel engines. HEFA is approved for use as an aviation fuel in blends with conventional jet fuel up to 50% [3].

Concerning the bio-based percentage in the final refinery products, it seems that it is not a refinery's objective itself but rather a fuel trader's matter, and varies from one EU member to another according to the national legislation. In this way is validated also the identification of fuel traders and policy makers as BioSFerA stakeholders and separate TGs. There is one major directive, Renewable Energy Directive (RED)

[4] http://www.q8.com
[5] https://www.repsol.com
[6] https://www.helpe.gr
[7] https://www.unipetrol.cz/

[4], the context of which all the state members adopt. However, each country according to its peculiarities (e.g. size, financial situation, facilities, etc.) differentiates in terms of obligations and long-term goals [5]. Of course, there are European products quality specifications regulated from the Fuel Quality Directive (FQD), that restrict blending potential: e.g. max 10% (bio)ethanol in gasoline, maximum 7% FAME (v/v) in diesel, poor cold properties of some FAME-types and limited blending potential for HVO due to the minimum density.

Another issue that aimed to be investigated via the questionnaires, was the involvement of biomass-derived sources into existing petroleum refineries in terms of co-processing of biomass-derived feedstock with petroleum fraction. Petroleum refineries already have a highly-sophisticated infrastructure to produce fuels and base chemicals and, consequently, would not require additional intensive investments for processing of alternative feedstock [6]. The utilization of conventional vegetable oils as well as used cooking oils (UCOs) was mentioned for the production of HVO, while some of the respondents characterized this information confidential and denied to answer. This could be a proof that co-processing of different renewable feeds with petroleum fraction is a highly active and under development issue for the refining industry. The financial advantages, the potential slight infrastructure modifications as well as the biogenic content compliance with the regulations are factors that surely demand strategic decisions.

Finally, it has been requested from the refineries experts their opinion regarding the main technical challenges towards biofuels increasing involvement and establishment. The answers were divided into two parts: on the one hand they have been mentioned the difficulties of co-processing renewable feeds and on the other hand the main technical specifications of end product biofuels that are in dispute. For the first part (i.e. co-processing), the feedstock contaminants as well as the feedstock costs are a bottleneck for refining industries that are called to involve co-processing in their activities. The contaminants in some renewable feeds and products formed during co-processing pose operational problems in the industrial units and ultimately limit the maximum amount that can be fed to the units for co-processing to 5-7 %. For the second part, which refers to the technical specifications of the end product biofuels, their weak cold properties have been highlighted from every respondent as a major issue especially for potential aviation use. Other critical technical parameters that were mentioned concerning biofuels performance and blending efficiency are the oxidation stability, the polarity and their density/energy density. Biofuels main technical challenges are presented in Figure 7 according to the frequency that each of them quoted from the respondents.

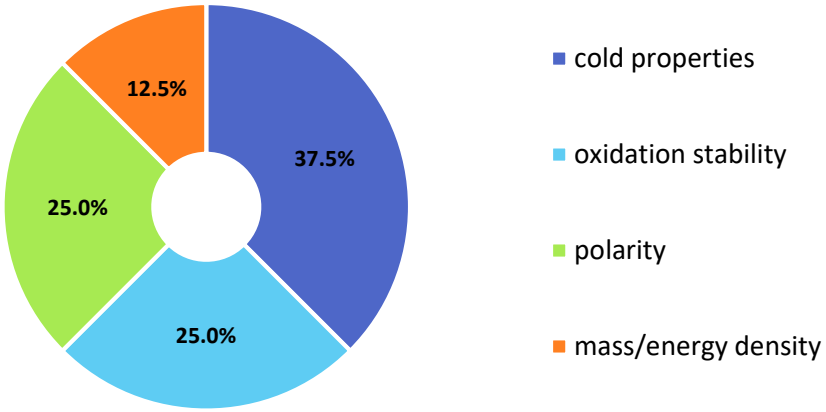


Figure 7. Biofuels main technical challenges according to the respondents

The term cold flow properties mainly refer to cloud point, pour point and cold filtering plugging point (CFPP) of the fuel, which are parameters that describe the flow behaviour of a liquid fuel in low temperature environments. These parameters are very important for the assessment of aviation fuels, since the outdoor temperature during a flight is several decades below zero. During cold conditions, inferior cold flow properties can lead to particles crystallization and blockage of the fuel system. The low-temperature operability of any fuel is a critical parameter that will enable biofuels with superior cold flow properties to extend their blending percentage and therefore their market penetration. The term oxidation stability refers to the tendency of the fuel to degradation by oxidation, while the term polarity refers to fuel affinity for water as this indicates the ability to drain water.

The technical challenges for biofuels establishment are not the same for every sector. There is a big difference in the degree of difficulty for a road/marine biofuel to reach the market compared to an aviation biofuel. In the first case, it is sufficient the final blend complies with the regulations even if the bio-based component itself does not meet all the specifications in order to be used as a drop-in fuel. However, in the case of aviation the blending specifications are by far stricter and it's not enough only the final blending to be compatible with the international standards but the biofuel itself must almost fully comply with the synthetic jet fuel specifications, as indicated in ASTM D7566, and already be a high quality fuel. In other words, for road/marine fuel the performance of the final mixture needs to be qualified, and for jet fuel the full production pathway must be qualified: from feedstock to final product.

Finally, it has to be mentioned that among the answers there was a comment from one respondent that was expressing the mistrust of biofuels characterizing them in general as an ineffective source of energy. In general, it seems that there is a trend in the petroleum industry that is still wary of biofuels and it is quite challenging for them to introduce alternative fuels extensively in their activities. The main reasons for this are the relatively high cost of biofuels, high risks to introduce co-processing and the inability of refiners to recover additional costs as the product markets are very competitive. Not only should the forthcoming fuel policies strengthen and promote biofuels production, but also low-cost technologies, compatible with the existing refineries infrastructure that would encourage renewable feeds and co-

processing, should come to the fore. The trust between biofuels and the refining industry should be built gradually with parallel favorable policies & 'drop-in' technologies.

Based on the received answers from Refineries and the analysis that took place, some key facts are extracted and presented in Table 3.

Table 3. Refineries key facts

Refineries – key facts
✓ ETBE & HVO/HEFA were the quoted biofuels regarding production at commercial scale ✓ The fuel blends and the bio-based percentage in the final products aligned with RED targets for every EU member state. Obligations and long-term goals are adapted to each country's national legislation framework ✓ Regarding co-processing of renewable feeds and petroleum fraction, the utilization of vegetable oils & UCOs has been mentioned for HVO production. Feedstock contaminants as well as feedstock costs are the main challenges. The strategic decision of the most respondents to not provide further information may be a sign that co-processing is a highly active and under development matter for refining industry ✓ Cold flow properties seem to be the major technical challenge for biofuels. Others that were mentioned are oxidation stability, polarity (ability to drain water), density/energy density ✓ Aviation biofuels must comply almost entirely with conventional jet fuel specifications, since the blending regulations for aviation sector are stricter than other transportation. The full production pathway from feedstock to final product must be qualified

3.4. Fuel traders

The sole representative of the Fuel traders was GoodFuels, which is one of the consortium members. As described in section 2.1, Fuel traders are responsible for the transition of the refinery products into the market. Their expertise lies on the recognition of that set of fuel specifications that is able to ensure sustainable market penetration. The bio-based fuels that seem to take part in GoodFuels' activities are HVO, FAME as well as waste residual oils from various industries. Goodfuels is a market leader in sustainable biofuels, especially for marine use. Nevertheless, the main specifications that must be followed in order a biofuel to reach the marine market according to GoodFuels, can be widened up to a point for an aviation biofuel to reach the corresponding market as well. May the requirements in the aviation sector be remarkably stricter and the fuel standards higher as described extensively in section 3.3, however the main challenges, that a candidate alternative fuel will be called to face in order to enter the market, are more or less the same for both aviation & marine and are presented in Figure 8. The main differentiation between marine and aviation biofuels, is the notably higher fuel standards of the latter.

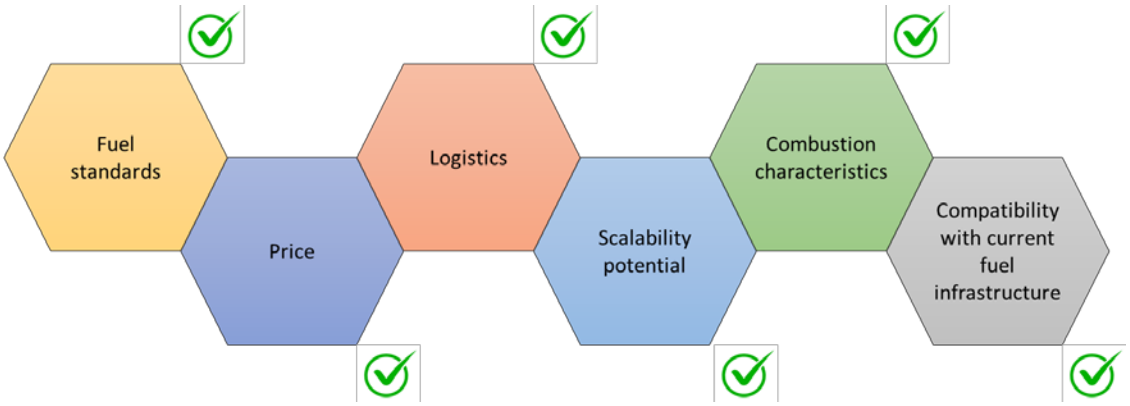


Figure 8. Set of biofuels specifications for a sustainable market penetration

After taking into consideration the answers of the Refineries respondents in section 3.3, the blending ability of the final refineries' products in order to achieve the targeted bio-based percentages in the traded fuels according to the directives and the respective national legislation, is a critical issue not so much for the refineries themselves but mainly for the fuel traders. The characterization of the blending ability of the fuels as 'outmost important', from the side of fuel traders, confirms that claim. The lining up with the RED II sustainability criteria has been mentioned also from the fuel traders, validating the RED II directive as the dominant variable in biofuels involvement and utilization. Finally, it has been underlined the need of biofuels supply chains to be certified by an internationally standard sustainability system (e.g. ISCC or RSB).

Based on the received answers from Fuel traders and the analysis that took place, some key facts are extracted and presented in Table 4.

Table 4. Fuel traders key facts

Fuel traders – key facts
✓ The set of biofuels specifications for a sustainable market penetration includes fuel standards, price, logistics, scalability potential, combustion characteristics and compatibility with the current infrastructure
✓ Blending ability of traded biofuels are of outmost importance for Fuel traders
✓ Biofuels supply chains must be certified by a sustainability system (e.g. ISCC, RSB)

3.5. Final end-users

Within BioSFerA project, with the term Final end-users we mainly refer to aviation airlines and ship owners since these are the core of this TG. Nevertheless, organizations & companies that cooperate directly with them and assume the responsibility of fulfilling a part of their obligations should not be excluded. These types of organizations & companies like Marine Classification for the marine sector or airport management companies for the aviation sector, it was aimed to be included in the respondents, since their experience and especially the range of activities they perform, lets them provide valuable and global answers that

derive of a wide spectrum. In particular, the marine sector was represented by DANAOS[8] and ANEK Lines[9], that are ship owners, and Bureau Veritas[10] which is a recognized world Marine classification leader. As for the aviation sector, the sole representative is Aena SME S.A.[11], a leading airport management company, with a network of 46 airports in Spain.

Concerning the main type of fuels that are currently involved in the marine sector, the common marine distillate (i.e. Marine Gas Oil) and residual fuels (i.e. Heavy Fuel Oil) have been quoted as well as their subcategories (e.g Intermediate Fuel Oil, Low Sulfur Fuel Oil, etc). Moreover, the potentials of LNG (Liquefied Natural Gas) and LPG (Liquefied Petroleum Gas) are mentioned. Concerning the main criteria that lead the fuel selection for marine stakeholders, various parameters related to the fuel price, the quality, the regulations as well as the local restrictions seem to play a catalytic role towards the final decision and are presented in Figure 9 according to their frequency of presence in the answers from the respondents.

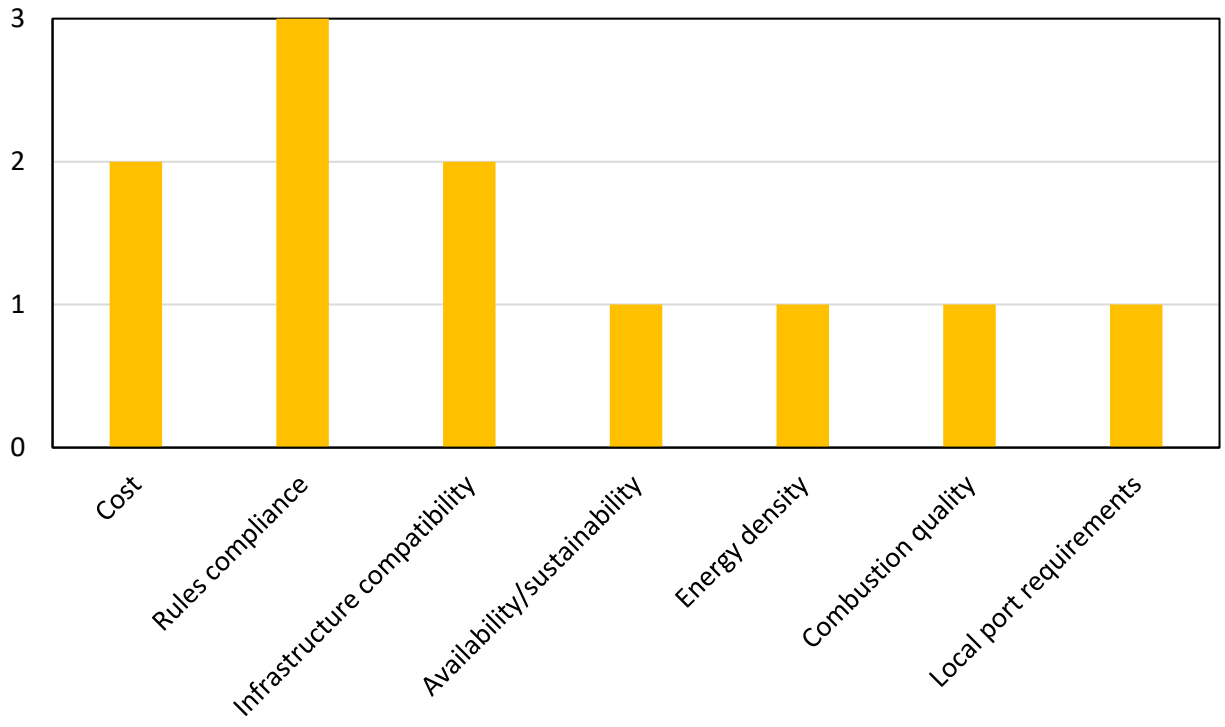


Figure 9. Main criteria for marine fuel selection according to the respondents

The compliance with the rules that governing shipping nowadays, mainly derived from International Maritime Organization (IMO), along with the fuel costs and the fuel compatibility with each company's engines are presented to be the dominant regulators for marine fuel selection. Other parameters that have been mentioned are the availability, the energy density, combustion quality and local port requirements.

[8] https://www.danaos.com/
[9] https://www.anek.gr/
[10] https://group.bureauveritas.com/
[11] http://www.aena.es/en

It can be observed, that marine fuel selection is a matter of different (quantitative, qualitative, legislative, etc.) individual factors and therefore ship owners seem to have a relative 'flexibility' concerning their fuel strategy. On aviation, on the other hand, there are not qualitative factors that allow airlines to choose a fuel strategy or hesitate regarding their infrastructure compatibility. The fuel standards are the same high (Jet-A1) for every aviation fuel and therefore the interest for their selection is limited on the fuel cost, the source of origin, the location of the plant and the compliance with the regulation framework, mainly derived from International Civil Aviation Organization (ICAO). The references from the respondent to the source origin and the plant location for aviation fuels, confirm once again the allegations of Refineries respondents (section 3.3) that for jet fuel the whole production pathway must be qualified and meet strict sustainability criteria, and not only the final product.

Then the respondents, from marine and aviation sector as well, were asked about potential fuel parameter improvements that could lead them to investigate alternative options for their fuel. From the marine sector, the answers included the energy/exergy to price ratio, the compliance with new regulations, the emissions reduction and the fuel stability, while aviation sector mentioned only WtW (Well-to-Wheels) emissions. The term fuel stability is referred to the potential for a fuel to change condition in storage in certain circumstances, depending on its resistance to breakdown. Fuel stored for long periods can become unstable. The mentioned responses for both sectors are gathered and presented according to their rates in Figure 10.

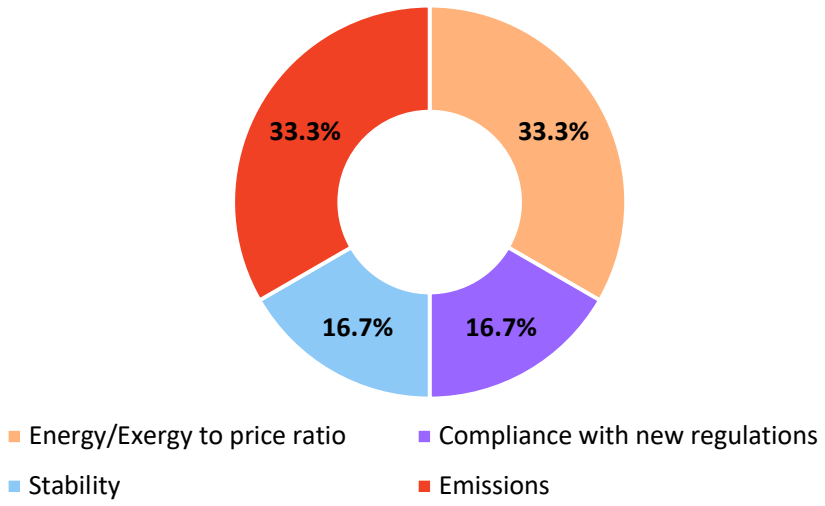


Figure 10. Main fuel improvement potentials according to the respondents

New fuels and therefore new fuel specifications might demand mild retrofitting of the existing infrastructure. Consequently, it is a matter of high importance to investigate up to which grade the end-users stakeholders would be interested or negotiable to partial retrofitting of their infrastructure. It was mentioned the necessity of a holistic assessment (operational, tactical, environmental) as prerequisite, as expected, however all the respondents replied in a remarkably positive mood and seem willing to proceed to modifications in their infrastructure, if the new involved fuels come up with strong benefits and improvements in factors that they recognize as 'weak' in their current fuel selection.

Finally, it is remarked that the limited SAFs (Sustainable Aviation Fuels) production in the EU along with the very high prices that they exhibit compared to conventional Jet-A1, turn aviation biofuels in Europe as non-competitive up to now. In general, after taking into account the input from all the involved Target Groups (Refineries, Fuel traders, Final end-users), there is a common alignment related to the uniqueness of aviation fuels market that highlights aviation biofuels production as a quite challenging and emerging task that should follow strict requirements and high-quality standards all along the value chain.

Based on the received answers from Final end-users and the analysis that took place, some key facts are extracted and presented in Table 5.

Table 5. Final end-users key facts

Final end-users – key facts
✓ For marine fuel selection, compliance with the rules that governing shipping nowadays along with the fuel costs and the fuel compatibility with each company's engines are presented to be the dominant regulators. Other parameters that have been mentioned are the availability, the energy density, combustion quality and local port requirements
✓ For aviation fuel selection, there are not qualitative factors since the fuel standards are the same high (Jet-A1) for every aviation fuel. Therefore, the interest for their selection is limited on the fuel cost, the source of origin, the location of the plant and the compliance with the regulation framework
✓ For potential fuel parameters improvements that could lead to alternative fuel options for their infrastructure, the respondents mentioned the Energy/Exergy to price ratio, the stability, the emission reductions as well as the adaptability to new regulations
✓ The respondents seem willing to proceed to modifications in their infrastructure, if a prerequisite holistic assessment of the new fuels (operational, tactical, environmental) comes up with strong benefits
✓ Biofuels in Europe, especially for aviation, are non-competitive up to now. Aviation biofuels production is a quite challenging task and the market penetration difficult

3.6. Innovation & Research Centers/Institutes

As mentioned also in section 2.1, this TG consists of the Centers/Institutes that are members of the consortium and will take part in the BioSFerA project R&D activities. In particular, CARTIF and CSIC will take charge of the optimization of the double stage syngas fermentation (i.e. syngas to acetate/acetate to TAGs) at lab scale, CARTIF from the operating conditions and stages integration point of view while CSIC, as microbial biotechnology experts, from the engineering of aerobic and anaerobic microorganisms point of view. CERTH will perform the TAGs hydrotreating development at TRL3 and TRL5 validation as concerns the experimental activities, and will carry out simulations of the whole value chain at steady & dynamic level as concerns the modeling activities. Last but not least NTUA is responsible for the social LCA and the social CBA, aiming to reflect the social view on how future benefits and costs should be valued across the whole lifecycle of the presented new jet and marine fuels.

The most of the participating Research Centers/Institutes have previous experience in biofuels projects and have performed tasks similar to those they are required to perform within BioSFerA. CARTIF has been

involved in the fermentation process for producing lactic acid from crude glycerol and bioethanol from cattail biomass, CSIC has experience in modified microorganisms that were used for bioethanol, biodiesel and isobutanol production, while CERTH has carried out waste cooking oil hydrotreating at TRL 5 and has developed process models for advanced biofuels production via different pathways such as Fischer-Tropsch (FT) synthesis, Mixed Alcohol synthesis, hydrolysis/fermentation etc. NTUA, has great experience in previous projects, especially marine fuels, as well as performing to take charge of the kind of tasks that leads in BioSFerA (i.e social LCA & CBA).

Regarding the aimed breakthrough in their up to now research activities within BioSFerA, each Research Center focuses on the optimization and progress beyond the state of the art related to their field of activities. CARTIF targets to increased acetate and TAGs yields, CSIC targets to the performance and resistance improvement of the microorganisms, CERTH aims to validate the microbial oil hydrotreatment at TRL5 and perform process simulations of a highly-innovative concept that biological processes are combined with the thermochemical ones and finally NTUA wishes to secure that as much as possible socially valuable resources are used to achieve benefits for all citizens and that the project contributes to social welfare.

The experience of the BioSFerA Research Centers/Institutes regarding experimental and modeling activities that they will perform within the project as well as their targeted breakthrough/innovation matter via these activities, are presented in Figure 11.

Research Centers/ Institutes	Relative Experience (TRL)	Targeted breakthrough/ Innovation within BioSFerA
CARTIF	➢ Optimization of aerobic fermentation process conditions for obtaining lactic acid from crude glycerol (TRL 4) ➢ Optimization of aerobic fermentation process conditions for obtaining bioethanol from cattail biomass (TRL 4)	➢ Testing the use of pressurized bioreactors (5-10 bar) at lab scale to increase the solubility of syngas in water ➢ Increase the acetate yield at 30 g/L (acetate productivity of 0.55 g/L/h) ➢ Reach the high TAG yields that have been previously obtained by other C sources (Y = 0.29-0.34 g/g) ➢ CO/CO2/H2 conversion as well as acetate conversion of 90%
CSIC	modified microorganisms production for bioethanol, biodielel and isobutanol synthesis from lignocellulosic biomass, recycled oils or syngas (TRL 3)	➢ improve the metabolic pathways in different microorganisms ➢ improve the resistance of the microbial strains to inhibitors and toxic byproducts
CERTH	➢ Waste cooking oil hydrotreating (TRL 5) ➢ Simulation studies of biofuels from syngas through FT synthesis and Mixed Alcohol synthesis (TRL 4)	➢ Microbial oil hydrotreating at lab and pilot scale ➢ Biological processes modeling and simulation at steady and dynamic conditions ➢ BioSFerA process system integration

Figure 11. Research Centers/Institutes relative experience and BioSFerA R&D roadmap

Based on the received answers from Innovation & Research Centers/Institutes and the analysis that took place, some key facts are extracted and presented in Table 6.

Table 6. Innovation & Research Centers/Institutes key facts

Innovation & Research Centers/Institutes – key facts
✓ The main research activities include double stage fermentation at lab scale, engineering of microorganisms for performance and resistance improvement, microbial oil hydrotreatment at TRL 5, full-scale process simulations and measurement of BioSFerA project social impact ✓ The optimization of research activities will feed the efficient integration of all technologies ✓ Main challenge is the lack of established knowledge about the novel integration of specific processes like tars formation during gasification, bacteria/yeast fermentation etc. that prevents mathematical formulation of them and optimization.

3.7. Policy makers

The TG of Policy makers was represented by the Hellenic Ministry of Environment & Energy[12]. At this point, the current involvement of biofuels in Greece is limited up to 7% v/v biodiesel in diesel and 3.5% v/v bioethanol in gasoline. These reflect the current national legislative framework regarding biofuels and do not include the aviation and maritime sectors.

The assessment of the Ministry is that the forthcoming transportation fuel policies will need time to be incorporated in the Greek fuel network, however they recognize the very important role of liquid biofuels towards the energy transition in aviation and maritime sector. Yet, there is neither specific strategy for promoting advanced liquid biofuels nor any specific prediction about the fuel policy on blending in these sectors, since the conditions are still immature and the market penetration of SAFs and marine biofuels is still pending. In particular, within the first semester of 2021, Greece is expected to get the new legal framework concerning advanced liquid biofuels and the promotion plan of the relevant new scheme will be developed accordingly.

Based on the received answers from Policy makers and the analysis that took place, some key facts are extracted and presented in Table 7.

Table 7. Policy makers key facts

Policy makers – key facts
✓ Liquid biofuels are very important towards the energy transition in aviation and maritime sector ✓ In Greece, the present legislative framework concerning liquid biofuels does not include aviation & maritime. The assessment of the Ministry is that the forthcoming fuel policies will need time to be incorporated

[12] www.ypeka.gr

4. Conclusions

Within this deliverable, the elicitation of BioSFerA stakeholders took place and it was aimed to define their requirements and specifications. Seven (7) Target Groups have been elected to represent the stakeholders community and the corresponding number of dedicated questionnaires has been developed. In particular, the elected Target Groups are:

- A – Technology providers
- B – Feedstock suppliers
- C – Refineries
- D – Fuel traders
- E – Final end-users (ship owners/aviation airlines)
- F – Innovation & Research Centers/Institutes
- G – Policy makers

Since the consortium itself is not able to represent all the identified BioSFerA stakeholders as well as the whole targeted BioSFerA impact, the questionnaires have been shared also 'externally', in organizations out of the consortium whose activities affect or could potentially be affected by the BioSFerA realization. Aim of this internal/external questionnaires sharing strategy and of this deliverable in general, is the formation of a wide and solid data gathering able to express the stakeholders' needs and scan BioSFerA's impact on the market from start to end.

In total, 21 answered questionnaires, including consortium members and external stakeholders, have been obtained. More specifically, 4 to represent the Technology Providers, 3 to represent the Feedstock suppliers, 4 for the Refineries, 1 for the Fuel traders, 4 for the Final end-users, 4 Innovation & Research Centers/Institutes and 1 for the policy makers. As mentioned also in section 1.2, the analysis that has been performed related to stakeholders requirements & market needs was a questionnaires-oriented analysis. It was preferred to focus on the questionnaires' responses that are more targeted and tailor made to BioSFerA needs than the literature. Of course, literature data will support the analysis, however main objective of this deliverable is the interaction with industry and the market itself. Key facts for every identified Target Group have been extracted from the responses and are presented in Table 8.

Table 8. BioSFerA Target Groups identity

Target Group	Interaction within BioSFerA	Main challenges	Critical aspects
Technology providers	Thermochemical & Biological processes coupling at TRL 5	Integration of the individual technologies in the same process scheme and their adaptations to ensure process efficiency	Value chain till the acetate production is a valuable concept itself
Feedstock suppliers	Feedstock supply	A balance between pre-treatment and logistic costs in order to reduce the final feedstock price	Seasonality impact, storage facilities, agricultural work costs (e.g. harvesting)

Refineries	Hydrotreatment/ Co-processing	For drop-in biofuels: cold-flow properties, oxidation stability, polarity, energy density For co-processing: feedstock contaminants & feedstock prices	Aviation biofuels must comply almost entirely with conventional jet fuel specifications, since the blending regulations for aviation sector are stricter than other transportation
Fuel traders	Traders of drop-in aviation & maritime fuels	Blending ability of traded fuels Supply chains must be certified by a sustainability system (e.g. ISCC, RSB)	Fuel standards, price, logistics, scalability potential, combustion characteristics and compatibility with current infrastructure
Final end-users	Use of end-product	Energy/Exergy to price ratio, fuel stability, emission reductions, adaptability to new regulations	For aviation fuel selection, there are not qualitative factors since the fuel standards are the same high (Jet-A1_ for every aviation fuel Biofuels in Europe, especially for aviation, are non-competitive up to now due to their limited production and high cost
Innovation & Research Centers/Institutes	Feed the efficient integration of all technologies and optimize their performance	Lack of established knowledge about the novel integration of processes that prevents the mathematical formulation of them	Double stage fermentation at lab scale, engineering of microorganisms, microbial oil hydrotreatment, process simulations and social impact
Policy makers	Favourable biofuels policies and promotion	Time needed for the forthcoming fuel policies to be incorporated in each national legislation framework and fuel network	Liquid biofuels are high in the agenda towards energy transition in aviation and maritime sector

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Annexes

A – Technology providers Considering the technological and market directions of your organization, please provide the requested information concerning the BioSFerA concept but also the alternative fuels production in general:
1. Which is the technology that is of your main interest within BioSFerA project? Gasification and synthesis gas conditioning for gas fermentation.
2. Has your provided technology been involved again in biofuels production and, if yes, up to which TRL? Gasification and synthesis gas conditioning is currently at TRL5 in Fischer-Tropsch process chain. Gas fermentation has not been tested in the chain. BIOSFERA process chain is currently at TRL2-3 and the aim is to reach TRL5 during the project.
3. Which are the main aspects that you would like to further investigate or improve in your technology? Optimization of gasification process for the gas fermentation unit.
4. How the BioSFerA project let you focus on these aspects? VTT will integrate BBEPP's gas fermentation unit into the gasification pilot plant. The required modifications are identified and executed during the project.
Any other issue/comments: N/A

A – Technology providers Considering the technological and market directions of your organization, please provide the requested information concerning the BioSFerA concept but also the alternative fuels production in general:

1. Which is the technology that is of your main interest within BioSFerA project? The gas fermentation technology to produce acetate is of great interest to BBEPP. Also the subsequent coupling to produce TAGs is of particular interest. Besides the production of TAGs, we believe acetate is a versatile building block towards many valuable molecules.
2. Has your provided technology been involved again in biofuels production and, if yes, up to which TRL? At BBEPP no other projects are currently ongoing using this technology to produce biofuels. The anaerobic acetate production, however, is also researched in other projects, situated at TRL 3-4.
3. Which are the main aspects that you would like to further investigate or improve in your technology? Two routes are available to improve both the production of both acetate and TAGs. On the one hand strain engineering should allow the availability of improved producing organisms; while in depth process engineering on the other hand is expected to significantly boost yields, titers and productivities. Also, further research in the downstream processing and isolation of TAGs suitable for subsequent conversion to fuels is desirable.
4. How the BioSFerA project let you focus on these aspects? In the BioSFerA project, BBEPP will focus of process engineering to improve both the production of acetate and TAGs, as well as their isolation from the broth. Hence, except for our interest in other processes using the obtained acetate, the BioSFerA project allows us to explore some of our main interests in this field.
Any other issue/comments: N/A

A – Technology providers

Considering the technological and market directions of your organization, please provide the requested information concerning the BioSFerA concept but also the alternative fuels production in general:

1. **Which is the technology that is of your main interest within BioSFerA project?**

- Acetate and yeast production through biochemical processes
- Lipids extraction and purification

2. **Has your provided technology been involved again in biofuels production and, if yes, up to which TRL?**

Our provided technology is the lipids extraction and purification. These technologies have already been involved in biofuel production.
TRL was up to 5

3. **Which are the main aspects that you would like to further investigate or improve in your technology?**

- Yield of lipids extraction
- Energy consumption reduction in lipids extraction and purification
- Level of lipids purity achievement

4. **How the BioSFerA project let you focus on these aspects?**

Biosfera project will focus on all these aspects because a package of test at pilot scale is scheduled in the project and these test will allow to evaluate lipids extraction in relation to Steam explosion process parameters.
Each set of conditions could be evaluated form an energy consumption point of view.
The achievable lipids purity could be also defined by analyzing samples for each performed test.

Any other issue/comments:
N/A

B – Feedstock suppliers

Considering the type of your organization and its contribution within BioSFerA project, please provide the requested information concerning your product/s distribution and its characteristics:

1. **In which type of activity would you classify your business?**
   - Farmer : X
   - Transporter
   - Wood supply industry
   - Distributor, wholesaler

o Other: …….
2. What type of product do you distribute or you could be able to distribute? o Cereal bales: X o Forestry products o Pruning bales o Pruning chips o Pellets o Others: …….
3. Which type of product are you going to distribute within BioSferA project requirements? STRAW
4. What type of service do you provide for this product? o Transport to end user o Transport and storage o Commercialization o Others: X Straw collection and transport to the local project partner
5. Which is the estimated quantity of this product that you are capable of distributing annually (tons/year)? 100 hectares grown for forage, corn, wheat and triticale
6. Up to which point the seasonality affects your productivity and how you handle this issue? The seasonal rhythm of crops is followed and dried crops are stored
7. Could you give an estimation of the average energy content of your distributed products (MJ/ton)? Not available data
8. Which is according to your opinion the most important barrier that prevents biomass feedstock price decrease? o cultivation costs o harvesting costs o logistics costs o labor costs: X o biomass pre-treatment (i.e. drying, pelletizing, torrefaction) investment cost

o other …….
Any other issue/comments: **None**

B – Feedstock suppliers Considering the type of your organization and its contribution within BioSFerA project, please provide the requested information concerning your product/s distribution and its characteristics:
1. In which type of activity would you classify your business? ✓ Farmer o Transporter o Wood supply industry o Distributor, wholesaler o Other:
2. What type of product do you distribute or you could be able to distribute? o Cereal bales o Forestry products o Pruning bales ✓ Pruning chips o Pellets o Others: …….
3. Which type of product are you going to distribute within BioSferA project requirements? The main product that we are going to distribute within BioSFerA project is olive tree prunings.
4. What type of service do you provide for this product? o Transport to end user ✓ Transport and storage o Commercialization o Others: ……
5. Which is the estimated quantity of this product that you are capable of distributing annually (tons/year)? An initial goal is to manage mobilize around 1000 ton/year of olive tree prunings from the wide area.

6. Up to which point the seasonality affects your productivity and how you handle this issue? Unfortunately, the seasonality affects the productivity in the wide area since pruning is carried out from December till March, but prunings cannot remain at the soil after a certain time since there is a danger of soil infection. Moreover, olive tree pruning is not performed every year in the same volume which affects the final quantities of the olive tree prunings.
7. Could you give an estimation of the average energy content of your distributed products (MJ/ton)? For the olive tree prunings the low heating value is 17,700 MJ/ton (d.b.) or 14,200 MJ/ton (a.r.).
8. Which is according to your opinion the most important barrier that prevents biomass feedstock price decrease? o cultivation costs ✓ harvesting costs o logistics costs o labor costs o biomass pre-treatment (i.e. drying, pelletizing, torrefaction) investment cost o other …….
Any other issue/comments:

B – Feedstock suppliers Considering the type of your organization and its contribution within BioSFerA project, please provide the requested information concerning your product/s distribution and its characteristics:
1. In which type of activity would you classify your business? o Farmer o Transporter o Wood supply industry o Distributor, wholesaler ✓ Other: Wood chip and pellet production from vineyard prunings

2. What type of product do you distribute or you could be able to distribute?

- o Cereal bales
- o Forestry products
- o Pruning bales
- ✓ Pruning chips
- ✓ Pellets
- o Others: …….

3. Which type of product are you going to distribute within BioSferA project requirements?

The biomass that is used in this company are prunings that are collected from vineyards in a 30 km radius around the town of Socuéllamos.

4. What type of service do you provide for this product?

- o Transport to end user
- o Transport and storage
- ✓ Commercialization
- o Others: …….

5. Which is the estimated quantity of this product that you are capable of distributing annually (tons/year)?

This vineyard pruning wood pelleting plant is the largest of its kind in the world, with a production capacity of 20,000 tons per year.

6. Up to which point the seasonality affects your productivity and how you handle this issue?

Usually pruning is carried out from December to March but prunings have to remain between 2 and 3 months on the soil to lose enough moisture content. In this way, it is expected that this feedstock will be available at the right conditions between March and June. Based on our estimations there are around 320,000 t_{fm}/year (moisture content: 30%, after 60-90 days left on the field) of vineyards pruning that could be potentially valorized in an area of 30,000 ha, enough to cover our productivity needs.

7. Could you give an estimation of the average energy content of your distributed products (MJ/ton)?

The quality requirements for the final produced pellets and chips are:

- Pellets: Low Heating Value of 16,700 – 18,000 MJ/ton

8. Which is according to your opinion the most important barrier that prevents biomass feedstock price decrease?

- o cultivation costs
- ✓ harvesting costs
- ✓ logistics costs
- o labor costs
- ✓ biomass pre-treatment (i.e. drying, pelletizing, torrefaction) investment cost
- o other …….

Any other issue/comments:

C – Refineries Considering your commercial fuel production experience, please provide the requested information concerning biofuels and their challenges:
1. What type of fuels are the final products of your refineries? o Propylene/LPG o Gasolines (ETBE, Mogas/LCN/Naphtha) o JP1 (Jet fuel) o Diesel/Gasoil o Heavy Fuel Oil (own use, power)
2. Which is your estimated annual production (tons/year) and which are the average energy contents of your final products (MJ/ton)? o Average yearly production: 421000 barrels/day ~ 10 million tons/year o Crude source = 42000 [MJ/ton] o LPG(Butane/Propane/LPG MIX) = 45000- 48000 [MJ/ton] o Gasoline/Jet fuel/Gasoil = 43000-47000 [MJ/ton] o Heavy Fuel Oil : ~40000 [MJ/ton]
3. Is it imposed any obligatory biobased percentage in your final products and, if yes, how much is this percentage? o The products at the refinery itself do not have to contain bio-components by law. In other words a refinery has no obligations. o There's one leading directive → the "Renewable Energy Directive" that states that 14% of energy in transport must be renewable by 2030. You can do it with BEV, FCEV, biodiesel, ethanol, biomethane….. The obligation is for the supplier of the product to the market, and is different for each member state. The obligation is changing every year. Examples ▪ In Italy bioethanol is not allowed, but a large focus on biomethane ▪ In Sweden blendpercentages go up to 30% ▪ In the NL you can cover your obligation with tickets, so blending is not obligatory…..
4. Do you perform co-processing (conventional/renewable fuels parallel processing)? If yes, what kind of renewable fuels are these? If no, would you be interested to this initiative? Confidential

5. Which are, according to you, the main challenges from the technical point of view for biofuels establishment? (viscosity, flash point, density etc.)

Everything depends on the type of biofuel.

- FAME:
  - Cold properties, oxygen content and oxidation stability give the main quality issues.
  - The quality of FAME largely depends on the used feedstock. It is either stable (but freezes to soon) or unstable (but then is has good cold properties)
  - The "Fuel Quality Directive" puts a limit on the addition of FAME to EN590 diesel to 7%. This is the so-called "blend wall". Since the RED requires much higher blend percentages, we need other type of products like HVO (which is much more expensive).
  - Energy density of FAME is lower → higher consumption
  - Density of FAME is higher than diesel, so watch out when blending!
  - Oxygen content is high, so the product is polar and keeps water in the product. This makes FAME unsuitable for aviation! On top water pick-up leads to increased microbial contamination of diesel

- HVO:
  - There are not many challenges for HVO, because it is a perfect fuel in use.
  - The density is rather low, what limits the use to about max; 30% in EN590 diesel.This is the main challenge for HVO.
  - Due to low density, the fuel-consumption/L is also higher than conventional diesel. HVO has no other technical disadvantages. It is paraffinic. That is perfect! HVO can be used for aviation.

- Ethanol:
  - The main challenge with ethanol is that addition of ethanol has impact on the quality of EN228 gasoline. Especially the effect on the vapour pressure, but the issue is solved by the introduction BOB-gasoline
  - Ethanol is polar, so tends to attract water. Therefore, it is added to the product as late as possible in the supply chain
  - Not all cars are compatible with E10 (= blend of 10% ethanol in gasoline), so a protection grade is needed

Any other issue/comments:

Road vs. Air → Biofuel for road transport is easier, because "just" the final blend of biofuel + conventional fuel must comply with EN590 or EN228. It is "just" a blend component. But when you make biofuel for aviation then the 100% biofuel must comply to almost 99% of the final jetfuel specification, so the quality of the biofuel must already be excellent. This is driven by risk-analysis!

C – Refineries Considering your commercial fuel production experience, please provide the requested information concerning biofuels and their challenges:
1. What type of fuels are the final products of your refineries? Gasoline, diesel, jet fuel, IMO fuel oil, high sulfur fuel oil, gasoil, LPG, naphtha
2. Which is your estimated annual production (tons/year) and which are the average energy contents of your final products (MJ/ton)? 16,5 Mt/y
3. Is it imposed any obligatory biobased percentage in your final products and, if yes, how much is this percentage? 7% v/v biodiesel in diesel 1% v/v bioethanol in gasoline
4. Do you perform co-processing (conventional/renewable fuels parallel processing)? If yes, what kind of renewable fuels are these? If no, would you be interested to this initiative? Confidential
5. Which are, according to you, the main challenges from the technical point of view for biofuels establishment? (viscosity, flash point, density etc.) Cloud point and CFPP
Any other issue/comments:

C – Refineries

Considering your commercial fuel production experience, please provide the requested information concerning biofuels and their challenges:
1. What type of fuels are the final products of your refineries? Gasoline Jet Diesel LSFO HSFO
2. Which is your estimated annual production (tons/year) and which are the average energy contents of your final products (MJ/ton)? Gasoline 1 600 000 ton Jet 200 000 ton Disel 3 500 000 ton LSFO 80 000 ton HSFO 60 000 ton
3. Is it imposed any obligatory biobased percentage in your final products and, if yes, how much is this percentage? Yes, there is volumetric mandate 4,1 % vol. of BioEtOH in Gasoline 6,0 % vol. of biodiesel in Diesael Plus there is manmdate to reduce 6% og GHG emission along FQD directive
4. Do you perform co-processing (conventional/renewable fuels parallel processing)? If yes, what kind of renewable fuels are these? If no, would you be interested to this initiative? No
5. Which are, according to you, the main challenges from the technical point of view for biofuels establishment? (viscosity, flash point, density etc.) Oxygenation stability, affinity to water
Any other issue/comments: Biofuels are ineffective/idle source of energy.

C – Refineries Considering your commercial fuel production experience, please provide the requested information concerning biofuels and their challenges:

1. What type of fuels are the final products of your refineries? We produce the whole range of liquid fuels: gasoline, diesel, marine and jet fuel. Regarding biofuels, we produce ETBE and HVO.
2. Which is your estimated annual production (tons/year) and which are the average energy contents of your final products (MJ/ton)? Confidential
3. Is it imposed any obligatory biobased percentage in your final products and, if yes, how much is this percentage? We meet the percentages of the Renewable Energy Directive (RED II) as transposed to our National Legislation.
4. Do you perform co-processing (conventional/renewable fuels parallel processing)? If yes, what kind of renewable fuels are these? If no, would you be interested to this initiative? Yes, we co-process conventional vegetable oils and used cooking oils (UCOs) in our assets, for the production of hydrogenated vegetal oil (HVO).
5. Which are, according to you, the main challenges from the technical point of view for biofuels establishment? (viscosity, flash point, density etc.) Currently, the major challenge for us is the production of biofuels by co-processing renewable feedstocks. The presence of contaminants in these feedstocks pose operational problems in the industrial units and ultimately limit the maximum amount that can be fed to the units for co-processing. Another challenge is the cost of the feedstock. Regarding properties: in general, biofuels produced from vegetal oils have poor cold properties, which represent a difficulty, especially for the case of biojet fuel, which specification is stricter.
Any other issue/comments: N/A

D – Fuel traders Considering the type of fuels that you usually trade, please provide the requested information concerning technical and supply requirements:
1. What type of fuels do you mainly trade for aviation or maritime use? ➢ HVO ➢ FAME ➢ Waste residual oils from various industries

2. Which are the main specifications that must surely be followed in order an aviation/maritime fuel to reach the market?

- Fuel standards
- Price
- Logistics
- Scalability potential
- Combustion characteristics/fit for use
- Compatible with current fuel infrastructure

3. In the fuels that you trade, are there any cleaning requirements or they can be directed straight to the bunker?

- The fuels we currently deliver are drop-in fuels, which means no adjustments or cleanings are required to bunker them

4. If there are fuel cleaning requirements, which is the cleaning cost and up to which grade a clean (drop-in) fuel would enhance your market?

- N.a.

5. How much important is for you the blending ability of the fuels that you trade?

- **outmost important**
- very important
- medium important
- low important
- no important at all

Any other issue/comments:

- Feedstock used for the fuel should meet RED II sustainability criteria
- Supply chain should be certified by a sustainability system (e.g. ISCC or RSB)

E – Final end-users (ship owners/aviation airlines)

Considering the type of fuel that you usually use for your activities, please provide the requested information concerning your infrastructure fuel compatibility, fuel standards and performance:

1. Which is the type of fuel that you usually involve in your infrastructure?

Several types of Marine Gas Oil (IFO, LSFO, VLSFO, ULSFO, MGO, MDO)

2. Which are the main criteria that lead your fuel selection and define its performance? • Price • Rules compliance
3. Which is the annual fuel consumption for your activities? Given that a vessel consumes approximately 40 ton/day, for 300 and for the whole fleet (60 vessels), our annual consumption is around 720k tons
4. Are you satisfied from the prices and the supply chain of the fuels that you currently use? As far as it concerned the price, you can never be fully satisfied, although the same principal does not apply on the supply chain.
5. Do you use fuel blendings and, if yes, which is their typical composition? This is forbidden.
6. Which fuel parameter improvement could lead you to investigate alternative options for your fuel? In order to be compliant with new rules and in case that there is improvement in exergy/ price ratio.
7. How much negotiable would you be in partial retrofitting of your existing infrastructure due to new fuel requirements? This decision will be made based on multicritiria life cycle analysis of different alternatives. Operational, tactical, environmental and strategic attributes should be identified and assessed.
Any other issue/comments:

E – Final end-users (ship owners/aviation airlines) **Considering the type of fuel that you usually use for your activities, please provide the requested information concerning your infrastructure fuel compatibility, fuel standards and performance:**
1. Which is the type of fuel that you usually involve in your infrastructure? Bunker fuels (Heavy Fuel Oil 0.5 Sulphur Content and Marine Gasoil).
2. Which are the main criteria that lead your fuel selection and define its performance? Our engine maker's requirements and IMO, local port, or other pertinent regulation.
3. Which is the annual fuel consumption for your activities? Non-disclosed.
4. Are you satisfied from the prices and the supply chain of the fuels that you currently use? Yes.
5. Do you use fuel blendings and, if yes, which is their typical composition? No.
6. Which fuel parameter improvement could lead you to investigate alternative options for your fuel? Emissions, cost and energy content.
7. How much negotiable would you be in partial retrofitting of your existing infrastructure due to new fuel requirements? We would consider it depending on cost, classification, flag, and operational requirements.
Any other issue/comments: -

E – Final end-users (ship owners/aviation airlines) Considering the type of fuel that you usually use for your activities, please provide the requested information concerning your infrastructure fuel compatibility, fuel standards and performance:
1. Which is the type of fuel that you usually involve in your infrastructure? HFO – MGO – LNG - LPG

2. Which are the main criteria that lead your fuel selection and define its performance? Availability – Sustainability – Energy density – Cost – Bunkering Infrastructure – Combustion Quality
3. Which is the annual fuel consumption for your activities? N/A
4. Are you satisfied from the prices and the supply chain of the fuels that you currently use? Heavily affected by the law of supply and demand as well as geopolitics
5. Do you use fuel blendings and, if yes, which is their typical composition? Yes, blending is an option at varying percentages
6. Which fuel parameter improvement could lead you to investigate alternative options for your fuel? Stability
7. How much negotiable would you be in partial retrofitting of your existing infrastructure due to new fuel requirements? 100%
Any other issue/comments: No

E – Final end-users (ship owners/aviation airlines) **Considering the type of fuel that you usually use for your activities, please provide the requested information concerning your infrastructure fuel compatibility, fuel standards and performance:**
1. Which is the type of fuel that you usually involve in your infrastructure? **JET-A1 Aviation fuel**
2. Which are the main criteria that lead your fuel selection and define its performance? **Nowadays, regulation framework, availability, fuel cost (quality is the same), the source of origin, and the location of the plant.**
3. Which is the annual fuel consumption for your activities? **8.362.417.045 liters of JET-A1 (2018 all airlines JET-A1 consumption operated in 46 airports from Aena's net in Spain)**
4. Are you satisfied from the prices and the supply chain of the fuels that you currently use? **Yes**
5. Do you use fuel blendings and, if yes, which is their typical composition? **Not by the moment**
6. Which fuel parameter improvement could lead you to investigate alternative options for your fuel **WtW emissions**

7. **How much negotiable would you be in partial retrofitting of your existing infrastructure due to new fuel requirements?** **Very much negotiable**
Any other issue/comments: **The main problem is that nowadays there is almost no SAF production in the UE and the price of the little SAF that is produced in the UE is too high compared to conventional JETA-1**

F – Innovation & Research Centers/Institutes Considering your main Research & Innovation activities, please provide the requested information concerning your ambitions and expectations within BioSFerA project:
1. **Which is your main research activities within BioSFerA project?** -Optimization of syngas fermentation process for acetate production (1st stage) at lab scale. -Optimization of acetate fermentation process parameters for C14 and C16-18 TAGs production (2nd stage) at lab scale.
2. **Have you ever performed similar activities in other biofuel projects and, if yes, up to which TRL?** -Optimization of aerobic fermentation process conditions for obtaining lactic acid from crude glycerol (TRL 4) (FP7, VALOR-PLUS) -Optimization of aerobic fermentation process conditions for obtaining bioethanol from cattail biomass (TRL 4) (LIFE BIOMASS C+)
3. **Which is your targeted breakthrough/innovation in this kind of activities within BioSFerA project?** -Testing the use of pressurized bioreactors at laboratory scale (5-10 bars) to increase of the solubility of syngas in water and increase the acetate yield at 30 g/L (acetate productivity of 0.55 g/L/h) and the CO/CO2/H2 conversion at 90%.

-Achieve an efficient utilization of low-strength acetic acid with oleaginous microorganisms. The objective is to reach the high TAG yields that have been previously obtained with other C sources (Y=0.29-0.34 g/g) and an acetate conversion of at least 90%.
Any other issue/comments:

F – Innovation & Research Centers/Institutes Considering your main Research & Innovation activities, please provide the requested information concerning your ambitions and expectations within BioSFerA project:
1. Which is your main research activities within BioSFerA project? At CIB-CSIC we are devoted to the microbial biotechnology, particularly the engineering of bacteria and yeast for the production of value-added chemicals (i.e. biofuels) from unexpensive feedstocks, contributing in addition to solve environmental issues. Our tasks within BioSFerA are related to the selection and optimization of bacterial strains for the production of acetate from syngas, and the selection and optimization of yeast strain for the production of triglycerides from acetate. In the frame of this project we will have the opportunity to engineer and optimize the fermentation of aerobic and anaerobic microorganisms for the production of biofuels.
2. Have you ever performed similar activities in other biofuel projects and, if yes, up to which TRL? We have experience in the production of modified microorganisms and enzymes for the production of bioethanol, biodiesel, isobutanol, etc. Using lignocellulosic biomass, recycled oils or syngas as feedstocks. We perform experiments at lab scale (TRL 3).
3. Which is your targeted breakthrough/innovation in this kind of activities within BioSFerA project? We aim to improve the metabolic pathways in different microorganisms to optimize the production of biofuels, as well as to improve the utilization of the different feedstocks and the resistance of the microbial strains to inhibitors and toxic byproducts. In addition, we are interested in the fermentation process development at lab scale.
Any other issue/comments:

F – Innovation & Research Centers/Institutes

Considering your main Research & Innovation activities, please provide the requested information concerning your ambitions and expectations within BioSFerA project:

1. **Which is your main research activities within BioSFerA project?**

In the context of BIOSFerA, NTUA is the partner responsible for the social LCA and the social CBA. More specifically, the input, output and external effects of the project will be valued at their social opportunity costs, and the return will be calculated as a proper measure of the project's contribution to social welfare.

2. **Have you ever performed similar activities in other biofuel projects and, if yes, up to which TRL?**

No

3. **Which is your targeted breakthrough/innovation in this kind of activities within BioSFerA project?**

The objective of NTUA's activities is to reflect the social view on how future benefits and costs should be valued across the whole lifecycle of the new jet and marine fuels. The analysis of NTUA will measure any social and environmental externalities, as it will be conducted from the point of view of society, not just the project owner. The examination of such indicators will indicate if the new fuels will use too many socially valuable resources to achieve benefits for all citizens.

Any other issue/comments:

No

F – Innovation & Research Centers/Institutes

Considering your main Research & Innovation activities, please provide the requested information concerning your ambitions and expectations within BioSFerA project:

1. **Which is your main research activities within BioSFerA project?**

- stakeholders' requirements and market needs analysis.
- feedstock selection and characterization
- TRL3 TAG hydrotreating development and TRL5 validation.

- 3D model development of the gasification process
- development of the full chain process model
- dynamic process simulations and plant control.
- techno-economic and environmental assessment.

2. Have you ever performed similar activities in other biofuel projects and, if yes, up to which TRL?

- Waste Cooking Oil hydrotreating (TRL5),
- biofuels from syngas through FT synthesis (simulation study – TRL4)
- biofuels from syngas through Mixed Alcohol Synthesis (simulation study – TRL4)

3. Which is your targeted breakthrough/innovation in this kind of activities within BioSFerA project?

- Microbial oil hydrotreating at lab and pilot scale
- Biological processes modeling and simulation at steady and dynamic conditions
- BioSFerA process system integration

Any other issue/comments:

G – Policy makers

Considering the present and the forthcoming legislative framework, please provide the required information concerning biofuels placement in the energy map:

5. Which is currently the highest permissible blending ratio (conventional/biofuel) and which are the main obstacles for higher biofuels involvement?

-7%v/v biodiesel (flat rate)
-3.5%v/v bioethanol (flat rate)
There is no specific obstacle for increasing the blending ratio, it is a matter of political decision.

6. Which is your prediction concerning the forthcoming transportation fuel policies and how these will affect aviation and maritime sectors?

The blending policy in the biofuels with the aforementioned v/v blending ratio concerns the transportation sector excluding the aviation and maritime. The forthcoming transportation fuel policies will need time to be in-cooperated in the greek system. Furthermore, there is no specific prediction about the fuel policy on blending in these subsectors (i.e. aviation and maritime).

7. How important is the role of liquid biofuels towards the energy transition in aviation and maritime sector?

- o outmost important
- o **very important**
- o medium important
- o low important
- o no important at all

8. Which is your current strategy for promoting advanced liquid biofuels?

- o subsidy/national funds
- o tax relaxation policies
- o compulsory blending of renewable and conventional fuels
- o **other:** *at the moment there is no specific strategy for promoting advanced liquid biofuels)*

Any other issue/comments:

By, either the end of 2020, or the first semester of 2021 (the latest), Greece will have the new legal framework concerning the advanced liquid biofuels. The promotion plan of the relevant new scheme will be decided at that period.