Highlighting biofuels production from syngas fermentation

Setting the course for sustainable aviation and marine fuels

Aviation and marine transport have a direct effect on global greenhouse gas emissions and air quality. The BioSferA project aims to mitigate this impact through the development of innovative and high performing biofuels.

That is why the project aims to develop a cost-effective production method of sustainable aviation and maritime fuels, by combining different technologies.

The project started in 2020 and will be completed by 2024. Despite the COVID-19 restrictions and after one year since the beginning of the project, the project's first results have been achieved.

This technical scheme in Figure 1 shows the full concept of BioSFerA. Biogenic residue and waste will be converted in two industrial fermentation steps after being gasified.

The first fermentation step will convert syngas, obtained from gasification, into acetate. This will be fed to the second fermenter where microorganisms will convert the acetate to microbial lipids. Microbial lipids are molecules similar to vegetable oils or animal fat, and can be further treated by hydrotreatment in a process similar to hydrotreated vegetable oil (HVO) production.

Conversion by means of industrial fermentation requires less energy than conventional thermochemical processes. This has a significant impact on the energy efficiency and carbon footprint of the conversion technology; a double target is reached. First of all, the feedstock has a low carbon footprint because it is derived from waste or residue (annex IX of Renewable Energy Directive), and, secondly, the conversion to final product requires less energy input.

Industrial fermentation is possible at a large scale and is less dependent on climate conditions. Moreover, the conversion can be executed close to the feedstock, which will have a significant impact on the total emission calculation of BioSferA product.

Finally, the BioSFerA project will undertake a full value chain evaluation that will result in a final analysis to define a pathway for the market introduction of the project concept.

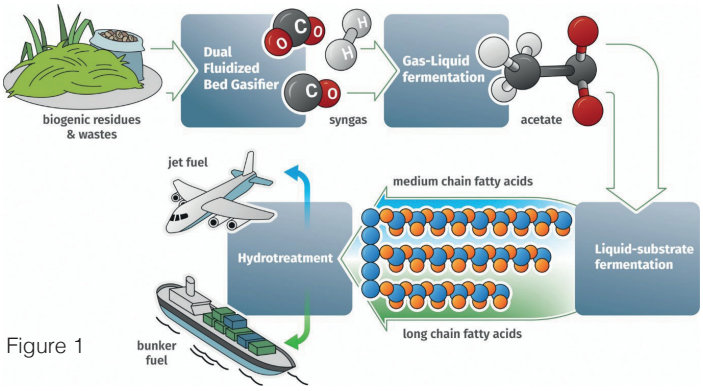


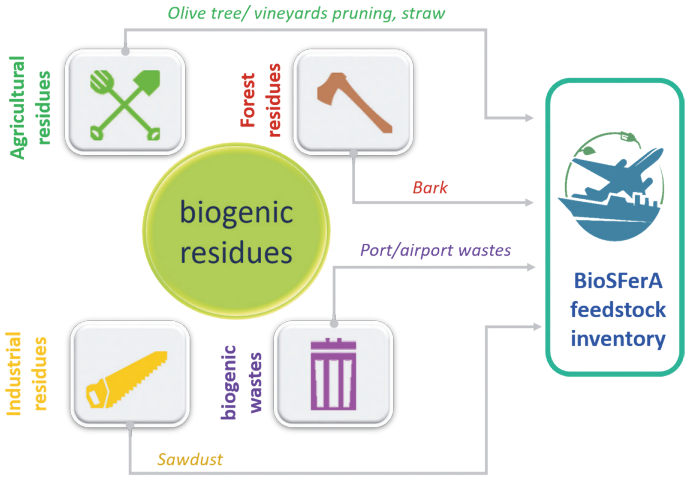
Figure 1

Some crosscutting evaluations carried out on all tested and validated processes will complete the results of the project from an economic, environmental, and social point of view. This full value chain approach, from waste to fuel, is also reflected in the multidisciplinary consortium of companies spread all over Europe as seen in Figure 2.

BioSferA's first results achieved

Firstly, thanks to the Dual Fluidised Bed Gasification technology developed by the Technical Research Centre of Finland, the process can be driven by flexible feedstocks, using a broad and variable portfolio of biogenic residues which may be lower quality carbon sources compared to the sugar-, starch- and oil plants used for conventional liquid biofuels, but nevertheless do not come into conflict with food production and tend to avoid land use restrictions.

In this light, the feedstock selection was based on the fulfilment of three main prerequisites: availability/sustainability (i.e. capacities for large scale applications), favourable technical



characteristics for good performance at the integrated BioSFerA system, and market competitiveness.

The selected feedstock inventory includes agricultural (prunings, straw), forestry (logging) and industrial (wood) residues as well as biogenic wastes from airports and ports.

Based on this selection, bench-scale gasification tests have been completed for the most of the selected feedstocks. VTT gasified five pelleted types of feedstocks, including forest residue, bark, straw, sunflower, and olive pruning. The gasification tests confirmed that all the feedstock types could be used in the forthcoming pilot phase. Research also revealed that tar reforming is a prerequisite of syngas fermentation due to the significant presence of inhibiting components.

Secondly, the Centre for Research and Technology Hellas (CERTH) carried out an assessment of the potential to replicate the BioSFerA concept across Europe at commercial scale. This assessment included specific case studies in four European countries – Greece, Italy, Spain, and Finland.

In each country, the consortium selected a location suitable to host a production plant with a 200 MWth capacity. Critical parameters for the selected regions were the average feedstock cost and the suitable feedstock type.

Even when calculating with the most conservative assumptions, it is possible to obtain biogenic waste feedstock at a maximum cost of €10/MWh. Moreover, together with the technology providers in the consortium, CERTH described a preliminary overall value chain for BioSFerA. Process models were developed and various simulations with altering operational parameters were performed.

The overall process can be separated in three distinct parts: the thermochemical, the biotechnological and the thermocatalytic part. Preliminary heat and mass balances were calculated and evaluated:

The Energetic Fuel Efficiency (EFE) – the energy content of the final liquid fuels – is measured at 31-37%, whereas the carbon utilisation – the carbon content of the final liquid fuels – has been calculated equal to 22-27%. These values are expected to improve through process optimisation in later stages.

In parallel, the syngas fermentation to acetate has proceeded and five acetogenic strains in eight different media have been examined.

Clostridia proliferate easily in YTF (fructose) medium and Moorella in TSB (Tryptic Soy Broth) medium. HCN, typically present in syngas from biogenic waste showed the highest consumption of CO and H_2, while M. thermoacetica had the best performance in terms of microbial growth and acetate concentration.

Genes have been selected to decrease or knock out ethanol production. Currently the Spanish National Research Council and the Bio Based Europe Pilot Plant are working with Moorella, while protocols are being developed to transform the Clostridia and Moorella strains by electroporation. All the described activities are highly active and the experiments are in progress.

Regarding acetate fermentation, seven strains of the oleaginous yeast Y. lipolytica have been tested.

All the experiments have been performed in shake-flask culture, which caused a slow growth of the yeast due to critical drop of the pH in the medium.

As a result, the experiments must be reproduced in bioreactors. The main fatty acids are palmitic, linoleic and oleic acids. Protocols are under development to improve the production of TAGs by metabolic engineering in the wild type yeast strains W29 or YB-392.

In the coming months, the final bacteria and yeast strains with the best performance in terms of syngas and acetate fermentation will be selected and the next phase of the project which is the process optimisation at lab scale will begin. ●

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