FLEXJET PROJECT, SUSTAINABLE JET FUEL FROM FLEXIBLE WASTE BIOMASS

Hornung, A.[1], Ouadi, M.[1], Galileu Speranza, L.[1]; Apfelbacher, A.[2]; Hornung, T.[3], Hofmann, M.[3]; Hygate, J.[4], Hilditch, P.[4], Lima, S.[4]; Lieftink, D.[5]; Capaccioli, S.[6], Grassi, A.[6]; Contin, A.[7], Righi, S.[7], Marazza, D.[7], Quaranta, M.[7], Vogli, L.[7], Macrelli, S. [7]; Blakey, S.G.[8], Lewis, C.[8]; Valk, M.[9]; Tuck, C.[10], Langley, M.[10]; Ott, T.[11], Winkel, M.[11]; Bastos, J.[12], Claret I Carles, A.[12].

[1]University of Birmingham, Birmingham, United Kingdom
[2]Fraunhofer-Institut UMSICHT, Sulzbach-Rosenberg, Germany
[3]Susteen Technologies, Sulzbach-Rosenberg, Germany
[4]Green Fuels Research, Berkeley, United Kingdom
[5]HyGear Technology and Services BV, Arnhem, Netherlands
[6]ETA – Florence Renewable Energies, Florence, Italy
[7]Università di Bologna, Bologna, Italy
[8]Sheffield University, Sheffield, United Kingdom
[9]SkyNRG, Amsterdam, Netherlands
[10]WRG, Exeter, United Kingdom
[11]Biga Energie, Engstingen, Germany
[12]Leitat – Technological Center, Terrassa, Spain

ABSTRACT: flexJET project will build a pre-commercial demonstration plant for the production of advanced sustainable aviation biofuel (SAF) from waste vegetable oil and organic solid waste biomass, successfully demonstrating the “Sustainable Aviation through Biofuel Refining” (SABR) process for the refining biodiesel from organic waste oils combined with Thermo-Catalytic Reforming (TCR®) combined with hydrogen separation through pressure swing adsorption (PSA)) to produce SAF, a fully equivalent jet fuel blend (in compliant with ASTM D7566 Standards). This project will deliver respective environmental and social sustainability mapping of SAF production and it will validate its a comprehensive exploitation. The consortium brings together some of the most renowned scientific departments, applied research institutions, key industrial companies in the renewable energy sector, particularly in terms of bioenergy studies and the development of relevant projects in Europe. Partners are from 5 different European countries. From 2018 until 2022, this conjoined effort will make use of the precious assistance of respected industry experts to advise and guide the project.
Keywords: organic waste, vegetable oil, synthetic fuel, biofuel, green hydrogen, Thermo-Catalytic Reforming, transesterification, hydrodeoxygenation, pressure swing adsorption.

1 FLEXJET PROJECT WITHIN EU CONTEXT

flexJET is a four-year project part funded by the European Commission through the Horizon 2020 research initiative.

The innovative flexJET project is diversifying the feedstock for sustainable aviation fuel (SAF) beyond vegetable oils and fats to biocrude oil produced from a wide range of organic waste. This is also one of the first technologies to use green hydrogen from the processed waste feedstock for the downstream refining process thereby maximising greenhouse gas savings and further contributing towards the Paris Agreement GHG reduction goals.

The flexJET process is highly scalable and less capital-intensive than current technologies and can be integrated into existing infrastructure. It provides for a sustainable, cost-competitive aviation fuel by combining regional and local supply and demand strategies in a circular economy. As a key factor to the decarbonisation of the aviation transport sector, it contributes to the Renewable Energy Directive Targets in Europe and to the fulfilment of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) goals.

2 FLEXJET PROJECT FEATURES

The primary ambition of this project will be to demonstrate and validate the technical and economic viability of the integrated SABR-TCR® technology approaches, together with their environmental and social sustainability, as well as the cost-competitiveness, at commercial scale through the construction of a demonstration plant that will also serve as an exemplar to facilitate rapid uptake and significantly de-risk subsequent commercial exploitation. This project will mark the first pre-commercial scale deployment of the technology at a scale capable of processing up to 3,482 tonnes per year of dried food waste and 1,358 tonnes per year of waste vegetable oil into 1,200 tonnes per year of sustainable aviation fuel.

The process offers better economics and improved overall sustainability by processing waste feedstocks near the source and at a scale that matches the waste availability. This is one of the first technologies to use green hydrogen from processed waste feedstock for downstream refining thereby maximising greenhouse gas savings.

This project provides clear technical and economic validation, by building a demonstration plant at pre-commercial scale to deliver high quality SAF. The flexJET project is delivering a blueprint for the production and distribution of this novel SAF technology. This will be a showcase of the medium to long-term impact on the aviation industry in Europe and beyond.

A consortium of 13 partners from five different European countries is coordinated by the University of Birmingham in the UK. As part of Horizon 2020’s new research and innovation programme, this project is assisting in the long-term goal of bringing innovative advanced biofuels from different kinds of sustainable raw materials to the market.

The project consortium comprises key industrial stakeholders with the knowledge and expertise to develop and implement a full commercial scale technology. The industrial partners include feedstock provider such as BIGA, engineering providers such as Green Fuels Research, Susteen Technologies, HyGear Technology and Services, and Fraunhofer Umsicht, and SkyNRG for the downstream SAF supply chain and access to the aviation market. Academia is also heavily involved, with collaborators including the University of Bologna, the University of Birmingham and the University of Sheffield. Specific tasks supporting the technology/knowledge transfer and public outreach are being led by LEITAT, ETA-Florence and WRG Europe, project partners with valuable expertise in these fields.

3 FLEXJET INTEGRATED PROCESS

The plant will combine a "Sustainable Aviation through Biofuel Refining" (SABR) process from Green Fuels Research for the refining of biodiesel from organic waste oils with Thermo-Catalytic Reforming (TCR®) technology (an advanced form of pyrolysis) from Susteen Technologies that will produce biocrude oil from organic waste. The hydrogen required for the refining steps will be separated from the syngas (an output of the TCR® process) using a decentralized technology from the project partner HyGear.

As a first step, non-food competing waste vegetable oils (cooking oils) will be transformed into sustainable aviation fuel (SAF) in line with existing standards (HEFA route – ASTM D7566, Annex A2). Using hydrogen from residual biomass conversion and renewable process energy enables a significant reduction in the remaining CO_2 footprint of regular HEFA SAF. In the second step, SAF output will be increased by producing SAF through co-refining of organic waste fats with biocrude oil from the TCR®: the resulting novel SAF will be targeted for the ASTM approvals process.

The size of the commercial plant will be determined by economic data from the project, which will optimise the plant size versus waste collection radius. This means that the commercial-scale facility could be a regional network of local small-scale SABR-TCR® reactors instead of a single large-scale unit. Each plant can be integrated into existing refinery infrastructures.

3.1 SABR process

In the HEFA process, vegetable oil feedstock (from oil crops or waste oils) is first converted in fatty acid methyl esters (FAMEs) through transesterification with subsequentially hydrotreatment, i.e. hydrodeoxygenetaion (HDO) and hydrocracking (HC). HEFA biorefineries operate in highly capital-intensive facilities, specifically designed and implemented to process vegetable oil to renewable jet fuel (to be blended 50% with kerosene) and renewable diesel.

Currently most of the fuel produced in HEFA plants is sold as renewable diesel, since most of the fuel produced after hydro treatment and fractionation can be fed into diesel engines but not the other way around, since normally 77% diesel and 10% jet fuel are usually produced [8]. These figures could be changed by additional process steps which entails extra costs and lower the production yield, which is a disincentive for producers to make renewable jet fuel. For this reason, although HEFA has the most competitive production cost for renewable jet fuel compared to other existing routes (potential price < 1 €/litre) [1], there are not many HEFA biorefineries globally.

SABR technology was developed and patented by Green Fuels (US8715374 B2), a global leading and longest established manufacturer of biodiesel production equipment, with over 30 major bio-refineries already commissioned around the world, along with thousands of decentralised biodiesel processors producing over 100,000 litres of biodiesel every day. This process is presented in Figure 1.

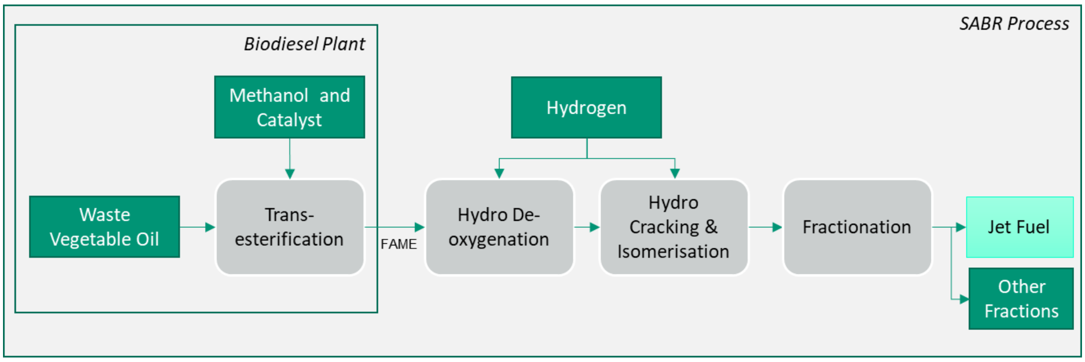

Figure 1: SABR process layout.

SABR is a new process to obtain renewable aviation fuel from waste cooking oil, animal fat residues or other waste bio-oils, which is ideal to meet the market request of the aviation industry (end users) and biodiesel manufacturers (clients) for the following key purchasing factors:

- Scalable and low capital intensity plant;
- Integration to existing biodiesel plants;
- Flexible production;
- Flexible feedstock.

3.2 TCR® process

TCR® produces renewable liquid fuels from waste organic feedstocks such as sewage sludge, paper industry residues, the organic fraction of municipal solid waste, anaerobic digestate, etc. [2][3][4]

The TCR® technology converts a broad range of residual biomass into three main products, as shown in Figure 2: H_2-rich synthesis gas, biochar, and liquid bio-oil. By integrating hydrodeoxygenation (HDO) and conventional refining processes, the bio-oil can be upgraded to green fuels.

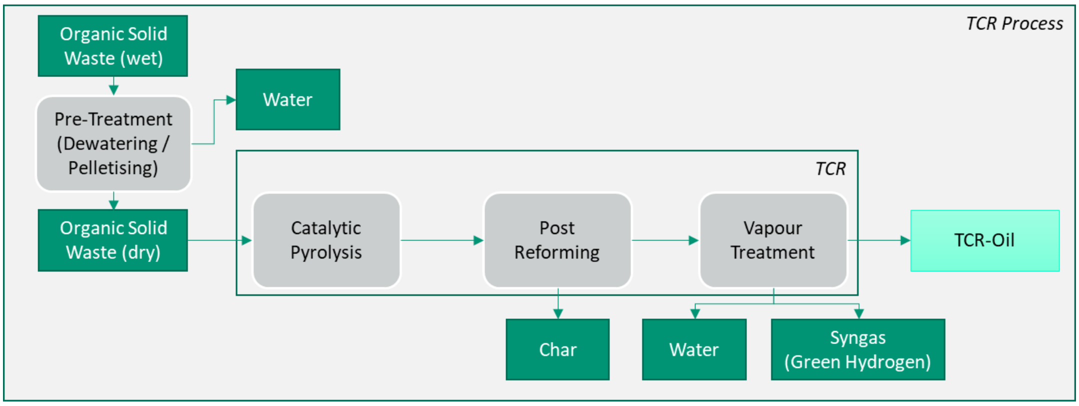

Figure 2: Thermo-Catalytic Reforming TCR®: A Platform Technology to use residues and to produce sustainable and storable energy carriers. [3]

The TCR® process generates significant quantities of green hydrogen as a product (approximately 160 m^3 per tonne of biomass), which can be separated, purified and used as a stand-alone fuel: it can also be used to hydro-deoxygenate (HDO) the TCR-oil, to give a Thermo-Catalytic Reformed Hydro-deoxygenated (TCR-HDO) liquid fuel which can be subsequently fractionated and refined to produce aviation fuel. [5]

To demonstrate and validate the technical and commercial viability of this integrated approach, the project will combine in the TCR® plant with pressure swing adsorption (PSA) technology to separate from the synthesis gas the produced H_2, that can be used in the HDO and HC, creating a new value chain.

The main objective is to create value products from the upgraded TCR® bio-oil. The bio-oil feedstock from the TCR® will be fed with hydrogen from the PSA unit into the SABR reactors. There, catalytic reactions will occur, resulting in the removal of heteroatoms of the bio-oil such as sulphur, nitrogen and oxygen, increasing the quality of the oil.. To maximise economic efficiencies unused hydrogen recovered from hydro treatment will be recycled through the PSA unit, designed by the project partner HyGear.

3.3 flexJET whole process

Figure 3 depicts the entire flexJET process. As it was mentioned above, the objective is to integrate different key technologies into one single process.

The SABR component of the process from Green Fuels will directly produce HEFA fuels that are already certified under ASTMD7566.

The TCR® is able to provide the green hydrogen required for the HDO/HC processes for aviation fuel production. The SABR combined with the TCR® process is a very attractive means of increasing liquid yields to obtain sufficient quantities of liquid fuels which is required for aviation (given that one trans-atlantic flight consumes 150,000 litres of aviation fuel).

The SABR-TCR® project is more attractive because it integrates the SABR process producing HEFA fuels with the TCR® process that is able to provide the hydrogen (from PSA) for the hydrotreating component as well as additional aviation fuel. It uses waste vegetable oil and organic waste biomass as feedstock and it is not competitive with food crops. Maximum carbon capture and sequestration is achieved by locking in valuable carbon into byproducts from the process such as biochar which itself can be useful in generating additional fuels. By using organic solid wastes as a feedstock the process also benefits from reduced production costs for the jet fuel as the feedstock received by the plant is chargeable receiving a gate fee of up to 85 Euro/tonne. Also, SABR is a flexible, scalable and low capital-intensive alternative to the traditional HEFA process that could be integrated with the downstream of existing biodiesel facilities and municipal waste treatment plants.

flexJET process advantages can be summarised as follows:

- High feedstock flexibility;
- Green hydrogen: hydrogen separated from TCR® syngas by PSA to be used in HDO/HC;
- Side and end products flexibility;
- Highly scalable (small scale decentralised facilities can be built);
- It can be integrated into existing infrastructure.

3.4 Evaluations related to the whole life cycle

flexJET has dedicated work packages (WP) that will address the environmental and social sustainability of the process.

To evaluate environmental sustainability of integrated SABR-TCR technology, the project will use sustainability metrics including LCA, GHG calculations, mass and energy balance and will compare the results vs conventional fossil-based jet fuel technologies and feedstock alternative valorisation routes in support of subsequent commercialisation. The project will map the full carbon footprint of the demonstration facility and determine the process sustainability with respect to greenhouse gas emissions and net carbon savings. In addition, all aspects related to the overall environmental impact of the process will be considered by means of the comprehensive Environmental Life Cycle Assessment methodology [6][7].

The social sustainability will be addressed by developing a set of socio-economic indicators in order to evaluate the socio-economic impacts of the project and based on the methodology of the Guidelines for Social Life Cycle Assessment developed by the Society of Environmental Toxicology and Chemistry (SETAC). Social acceptance of the project has a high priority within the consortium with its own dedicated WP and dedicated partner with significant expertise and record of accomplishment in social sustainability projects. The environmental, health and safety components of the project are also equally important and will be thoroughly addressed.

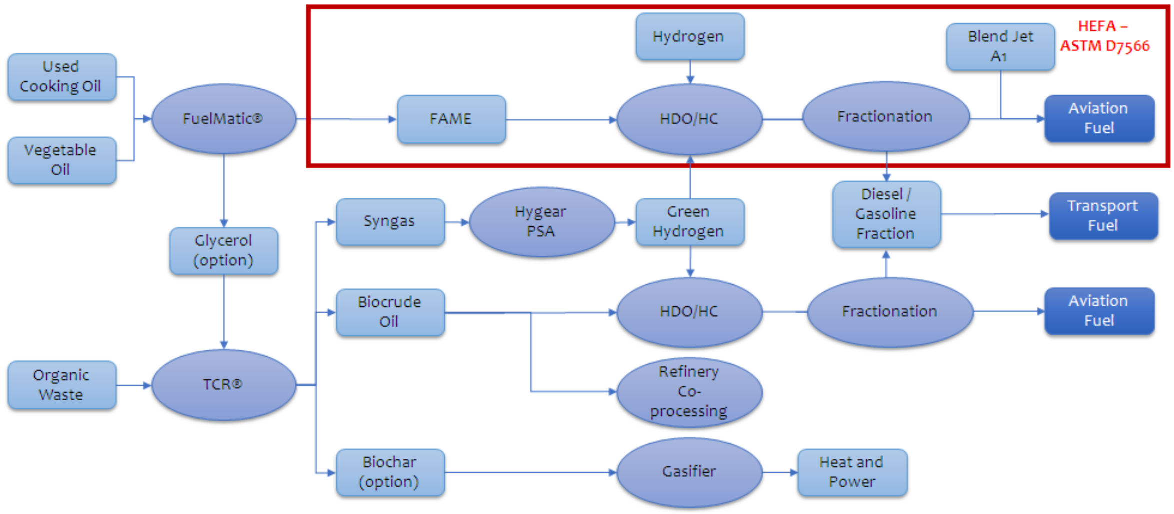

Figure 3: Process flow diagram.

Economic analysis will be the primary focus, achieved through a combination of scenario analysis, business-case model development, business potential analysis, and business planning and lead by industry experts.

Health and Safety issues have the highest priority and their identification and management are coordinated through a risk-dedicated work package; mitigation measures are applied in the engineering phase and evaluation of exposure to chemical substances performed.

4 FLEXJET NEXT STEPS

The Horizon 2020 flexJET project, coordinated by the University of Birmingham, will validate a new integrated process to produce sustainable aviation fuel from waste biomass.

First steps will be those of demonstrating and validating the technical and commercial viability of this integrated process, together with respective environmental and social sustainability mapping, and alongside with business case modelling.

The construction phase will be implemented in the 2019, while the commissioning step will be fulfilled in 2020. The demonstration phase will be running from 2021 up until 2022.

flexJET will set the basis for long-term opportunities to convert organic waste into renewable fuels and to directly implement these fuels into existing petroleum infrastructure.

Stakeholders' engagement is a key aspect of this approach, thus, a database of target stakeholders related to the topics of the project has been defined, currently managed and regularly updated.

Single or grouped stakeholders from any sector being linked to industry, research and innovation in the field of the clean energy, and who are interested in sharing and receiving information about flexJET, best practices regarding market implementation, commercialization and deployment of new technologies and processes, are therefore invited to register themselves to the dedicated platform. [9]

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7 LOGO SPACE