BIOFIT

Bioenergy Retrofits for Europe's Industry

FIRST-GENERATION BIOFUEL SECTOR

SECTORAL RECOMMENDATION PAPER

Retrofitting in terms of the BIOFIT project means the adaption or replacement of a plant characteristic (e.g. equipment, feedstock or auxiliary) to foster the use of bioenergy instead of fossil energy or to improve the overall sustainability of the process. The retrofit measures can result in using (additional) biomass as an input to the production plant or producing additional output from biomass at the production plant.

SECTOR STATUS-QUO

The **European first-generation (1G) biofuel sector is a diverse sector**, combining pathways with different feedstock, technologies and products. Three main representatives are the production of biodiesel (fatty acid methyl esters - FAME), hydroprocessed esters and fatty acids (HEFA, also known as HVO) and bioethanol. While the (trans-) esterification to FAME and the catalytic hydrotreatment to HEFA are processing oil-containing feedstock, the fermentation to 1G ethanol is dependent on sugar or starch-based material. Taking this diversity into account, the specific needs and challenges can be various.

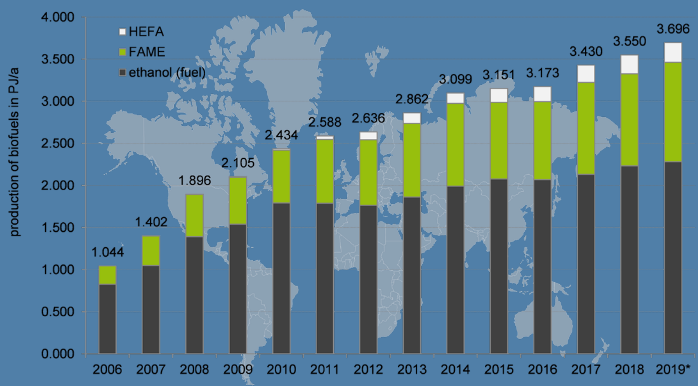

Figure 1: global production of biofuels 2006-2019 in PJ/a [2] (Source: F.O.Lichts World Ethanol and Biofuels Report)

In comparison to oil refineries, **European biofuel production plants are usually rather small scale.** While FAME and ethanol plants commonly h ave an installed capacity of 10.000 t/a to 200.000 t/a of product (rarely above), European HEFA plant capacities range from 180.000 t/a to 500.000 t/a. Even higher capacities are projected, e.g. in Singapour (1,3 Million t/a, Neste Oyj). Worldwide, more than 3.600 PJ of HEFA, FAME and ethanol were produced in 2019 (see figure 1), over 610 PJ are produced by plants in the European Union. The predominant share of the installed biofuel plants in Europe are seen as 1G biofuel plants (using cultivated biomass as feedstock).

The **European biofuels sector is a relatively new industry.** Most of the installations have been built in the early 2000s. Hence, major investments in retrofitting measures may seem early from a plant operator's view. This results in a small number of technical retrofits in this sector.

Recently, technical measures in this sector were aimed at an increased flexibility of the plants and improved quality of the products. Hence, developments have been made for FAME and HEFA production in terms of the range of feedstock, with a special focus on waste oil processing. The by-product of FAME production (glycerol) was purified and used to create a broader product portfolio. Side-streams from the hydrotreatment of oils and fats (short-chain hydrocarbons) were used internally for energy supply and hydrogen recovery. For ethanol production, the recovery of pure CO_2 from the fermentation process and add-ons for the usage of side-streams for animal feed production were demonstrated. These measures aim to optimize the overall process in terms of energy and material utilization as well as greenhouse gas savings. Overall, the biofuel production plants have increasingly developed into biorefineries in recent years. In future, feedstock flexibility in terms of type and quality will still be focused, necessitate also new types of manufacturing technologies. Furthermore, a shift from a predominantly road fuel producing industry to an open transport fuel sector is expected – e.g. concentrating also on the ship and aviation fuel sectors.

FIRST-GENERATION BIOFUEL SECTOR FRAMEWORK CONDITIONS FOR RETROFITTING

Political Conditions

Political targets, legislative framework and their implementation have a decisive impact on the development of the biofuel industry.

The **political frame on EU level** is mainly set by the Renewable Energy Directive (2018/2001, REDII) and the Fuel Quality Directive ((EU) 2015/1513, FQD), which were implemented into national legislation by the member states. The aim is to reduce the life cycle greenhouse gas emissions per energy unit of fuel in the transport sector, to increase the share of renewable energy and to limit the use of critical feedstock, e.g. from food or feed crops or with high risk of indirect land use change. This is achieved by minimum greenhouse gas emission thresholds, specifying minimum and maximum blending limits as well as establishing energy-based multiple-counting of selected fuels on the saving targets. Besides the positive developments, this can cause a reduced physical production quantity of fuel due to the crediting method (e.g. double counting of specific feedstock), resulting partial use of installed plant capacities and a lack of sustainable feedstock for the biodiesel industry. These aspects result in uncertainties for the future market development, nevertheless the regulation set up a market exclusively based on sustainable feedstock until 2030.

Entrepreneurial Conditions

For companies, next to political regulations also economic and technical aspects are significant drivers or barriers for the implementation of bioenergy retrofitting measures.

Technical solutions are not restricted by external factors and mainly driven by an intended flexibility of the plant, the advantage of a fast implementation and the existence of expertise in the company. It has to be considered that FAME and ethanol plant operators are mainly specialized in their respective fields, while HEFA plants are commonly built-up and operated by oil refineries. This is decisive when evaluating the conditions and outreach of the respective measures.

In terms of the economic perspective, the feedstock price is a decisive parameter. Depending on the oil used, the provision of the unpurified feedstock can account for 85 % of the total production costs. Also considering the increasing amount of heterogeneous raw material, which might be contaminated with impurities, multi-feedstock plants are more and more interesting and feasible for plant operators. For FAME and HEFA producers this could result in larger efforts in implementing relevant pre-treatment technologies and for ethanol plants investigations in the field of yeast selection and adaption have to be considered.

FIRST-GENERATION BIOFUEL SECTOR TECHNICAL OPTIONS FOR RETROFITTING

Due to the already mentioned diversity of the 1G biofuels sector, only a small selection of options can be given here and will not fit for a wide range of production sites.

OPTION I: CO_2 SEPARATION

In the aerobic fermentation of sugar, starch or cellulosic feedstock approximately 0.95 kg carbon dioxide (CO_2) is produced for 1 kg ethanol. This co-product has a purity of 97-98 % in the gaseous phase. After collecting and for further utilization, the CO_2 has to be washed, compressed, dried, liquefied and stored. The separation from such a concentrated source might be a valuable option, when considering increasing CO_2 prices. Further usage of CO_2 can be as carbon source in Power-to-X (PtX) technologies, in biological processes as the production of biogas (together with hydrogen in the hydrogenotrophic methanogenesis) or the cultivation of microalgae and cyanobacteria.

First-generation biofuel options in Europe (Source: DBFZ)

picture caption (Source: xxx)

OPTION II: ALCOHOL-TO-JET

To add a further possibility of using bioethanol, synthetic paraffinic kerosene can be produced from alcohol in an alcohol-to-jet (ATJ) process. At high temperatures and under high pressure the OH groups of the alcohol molecules are dehydrated and then converted into longer hydrocarbons. The resulting mixture of hydrocarbons of different lengths is distilled into desired fractions and remaining double bonds are saturated by using hydrogen. As by-products during distillation, diesel and naphtha fractions usually accrue. Both, ATJ from ethanol and from butanol, are certified in ASTM D7566 for the use as drop-in fuel in conventional fossil-based JET A/A-1 by a volume of up to 50 %. Especially with regard to a currently discussed European blending mandate for sustainable aviation fuel, a much higher biofuel demand is expected in this transport sector.

OPTION III: GLYCEROL UPGRADING

Further upgrading of crude glycerol to value added products has high potential for the biodiesel production. Purified glycerol is a platform chemical and can be used in different ways, e.g. as fuel, solvent, emulsifiers or building block for further reactions. The necessary process steps are distillation to remove the water, deodorization to remove smells and flavors and bleaching to remove colorants. Comparing purified and crude glycerol, the upgrading can result in nearly doubled revenues for this by-product.

CLEAR, STABLE AND AMBITIOUS FRAMEWORK CONDITIONS AND ECONOMIC SUPPORT FOR TECHNOLOGY DEVELOPMENT CAN PROVIDE THE INVESTMENT SECURITY NEEDED TO FOSTER BIOENERGY RETROFITS.

CONCLUSIONS

Biofuels make and will continue to make an important contribution to achieve national and European climate protection goals. Biofuels from cultivated biomass (so-called first generation biofuels) are the backbone of the currently accessible GHG emission reduction in the transport sector. The 1G biofuels sector is a diverse and comparably young industry. Starting with producers focusing mainly on the fuel itself, biofuel plants developed to be biorefineries and oil refiners entered the market.

Experiences from 1G biofuel plant operators and technology providers can support the shift towards higher GHG savings by using sustainable feedstock and efficient technologies. Retrofitting of existing plants is an appropriate measure for this purpose. In comparison to a greenfield installation retrofitting **can result in lower capital expenditure (CAPEX), shorter lead times, faster implementation, less production time losses and lower risks**. For this, retrofitting investors need a clear, stable and ambitious long-term strategy at national and European level, covering all types of fuels. In addition to a cap on 1G biofuel mandates, CO_2 prices and binding blending mandates for sustainable aviation fuels business opportunities have to be provided to support the relevant measures of this industry.

Due to the diversity of the 1G biofuel sector there is no universal solution. Hence, various approaches should be investigated and approved, overcoming the current slack on the market for technical retrofits in this sector.

REFERENCES

[1] Braune, M.; Grasemann, E.; Gröngröft, A.; Klemm, M.; Oehmichen, K.; Zech, K. (2016): Die Biokraftstoffproduktion in Deutschland – Stand der Technik und Optimierungsansätze. 1st edition. Leipzig: DBFZ (DBFZ-Report No. 22). ISBN: 978-3-9817707-8-0.

[2] Naumann, K.; Schröder, J.; Oehmichen, K.; Etzold, H.; Müller-Langer, F.; Remmele, E.; Thuneke, K.; Raksha, T.; Schmidt, P. (2019): Monitoring Biokraftstoffsektor. 4th revised and expanded edition. Leipzig: DBFZ (DBFZ-Report Nr. 11). ISBN 978-3-946629-36-8.

Related literature: Rutz, D.; Janssen, R.; Reumerman, P.; Spekreijse, J.; Matschegg, D.; Bacovsky, D.; Gröngröft, A.; Hauschild, S.; Dögnitz, N.; Karampinis, E.; Kourkoumpas, D.; Grammelis, P.; Melin, K.; Saastamoinen, H.; Susmozas Torres, A.; Iglesias, R.; Ballesteros, M.; Gustavsson, G.; Johansson, D.; Kazagić, A.; Merzić, A.; Trešnjo, D.; Dagevos, H.; Sijtsema, S.; Reinders, M.; Meeusen, M. (2020): Technical options for retrofitting industries with bioenergy - a handbook, 1st edition, Munich, WIP Renewable Energies, ISBN: 978-3-936338-51-5

THE BIOFIT PROJECT

This sectoral recommendation factsheet was prepared within the BIOFIT project. The project aims to facilitate the introduction of bioenergy retrofitting in Europe's industry. Target industries are first-generation biofuels, pulp and paper, fossil refineries, fossil firing power and combined Heat and power (CHP).

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