BIOFIT

Bioenergy Retrofits for Europe's Industry

FOSSIL REFINERIES

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

Fossil fuel refineries convert crude oils into products such as fuels for transport. Each refinery is unique, because of the differences in geographical location, crude oil specifications, markets, product specifications, etc. Core processes in each refinery are 1) the separation of the crude oil in various fractions, and 2) processing these fractions into various products.

Figure 1: Fossil refineries are large industrial complexes. (Source: Thessaloniki Refinery of Hellenic Petroleum)

With a crude refining capacity of about 13.2 million barrels per day[1], representing 13% of total global capacity[2], the EU is the second largest producer of petroleum products[3]. In the EU's 90 refineries, direct employment is provided to 120,000 persons, and indirectly to 1.2 million people. The transport sector in the EU is currently for 95% fueled by liquid (fossil) fuels[4], and is responsible for more than 25% of GHG emissions in the EU[5].

In the last decade – roughly from 2007 onwards – the EU refining sector has seen a market contraction, due to changing market demand and competition from more modern refineries outside Europe. In total about 20 refineries have been either closed, or converted to biorefineries, and several have also reduced their capacities. This has resulted in a decrease in the number of refineries from 110 to 90.

Starting in 2015, margins have increased, slowing down the closures of European refineries. The modernisation of European refineries has allowed them to process heavier and more contaminated crudes. The recent COVID-19 pandemic has however dealt a severe blow to this recovery, and further closures are expected.

FOSSIL REFINERIES FRAMEWORK CONDITIONS FOR FOSSIL REFINERIES

Political conditions

The main political framework is set by the Renewable Energy Directive. The fossil refinery sector itself has set climate neutrality in 2050 as their target.

In the Renewable Energy Directive (RED) (2009/28/EC), it was stipulated that by 2020, the EU would have 10% of the transport fuel of every EU country come from renewable sources such as biofuels. Fuel suppliers are also required to reduce the greenhouse gas intensity of the EU fuel mix by 6% by 2020 in comparison to 2010. It is – also within the sector itself - accepted that a main challenge of the refining sector is how to manage the transition to a low-carbon economy[6]. The European platform organisation of refineries, FuelsEurope, has issued its own vision document Clean Fuels for all in 2020, in which they propose a potential pathway to achieve climate neutrality in 2050. It is unlikely that a single, standardised solution is possible for the large and complex fossil refinery sector. For this reason, it is crucial for the sector to have a stable and clear policy framework to rely on in order to justify large investments. Policies are known to change over time due to new insights or changes in the political climate. Therefore, rather than aiming at maintaining policies for a long period of time, a clear and concise end-goal should be formulated. This allows the detailed policies to change while keeping the same end goal and maintaining an overall stable policy framework.

Entrepreneurial Conditions

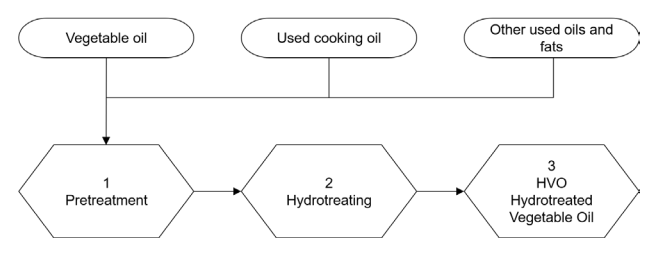
Many short term solutions are available for retrofitting fossil refineries and enabling the transition to a low-carbon economy. Long term solutions can be achieved by successful cooperation of governments and fossil refineries.

On the short term, many technical advances within the fossil refineries will increase their efficiency and decrease the need for fossil feedstocks. Another important opportunity is retrofitting fossil refineries to include a biomass feedstock, such as HVO or pyrolysis oil. Co-feeding these biomass feedstocks can be achieved on short term and will directly lower the need for fossil feedstock. Several refineries, such as the two ENI refineries in Porto Marghera (I) and in Gela (I), and the Total refinery in La Mede (Fr) have been converted to biobased feedstocks, and others are likely to follow. Because of existing infrastructure, refineries are in a unique position to quickly convert or scale up their renewable fuels production. For the long-term, solutions are required that fully replace the need of fossil-based feedstocks. This transition will at first not be the economical most attractive option due to the high price of sustainable solutions compared to the low price of fossil-based systems. For this reason, also governmental input is required in order to achieve the transition to sustainable fuels and chemicals. This transition can be achieved via several means to tackle the hurdles.

FOSSIL REFINERIES TECHNICAL OPTIONS FOR FOSSIL REFINERIES

OPTION I: HYDROGENATED VEGETABLE OIL INTEGRATION

Hydrogenated Vegetable Oils (HVO), or hydroprocessed esters and fatty acids (HEFA), are produced from vegetable oils, such as used cooking oils. After a pre-treatment to remove impurities, the HVO is produced by hydroprocessing, followed by an isomerization step. This results in a compound similar to diesel, with no oxygen or double bonds remaining.



Simplified block flow diagram of the HVO process. (Source: BTG Biomass Technology Group)

One example of HVO integration is the Total refinery La Mède in France. Since 2015 Total has transformed the fossil fuel refinery into a biorefinery. Today it has a capacity of 500,000 tonnes of HVO-type biodiesel. The start of the production was in July 2019. In the future aviation fuel can be produced as well. Another example is the HVO integration performed by Eni in Gela (Italy). Outside Europe, HVO production volumes are smaller.

OPTION II: PYROLYSIS CO-REFINING

Pyrolysis is a process in which biomass is heated in the absence of air and oxygen. Under these conditions the organic material decomposes, forming vapours, permanent gases and charcoal. The vapours are condensed to form pyrolysis oil. The production of pyrolysis oil is currently being carried out at several locations in Europe. The EMPYRO pyrolysis plant in Hengelo, the Netherlands converts 5 tonne per hour of dry woody biomass to pyrolysis oil. The plant was completed in 2015 and has reached full production – 24,000 tonne of pyrolysis oil per year – in 2018. Currently, the consortium behind the Empyro plant – a cooperation between the companies BTG-BTL and TechnipFMC - is constructing a second full-scale plant in Finland. Fortum and Valmet have implemented a 50,000 tons of pyrolysis oil production plant, integrated with the Joensuu CHP plant in Finland. The pyrolysis plant was commissioned in 2013. The companies Preem and Setra have established a joint venture – Pyrocell AB - to invest in a pyrolysis oil plant at Setra's Kastet sawmill outside Gävle, Sweden. The plant is expected to be operational by the end of 2021. The pyrolysis oil will be used as a renewable biocrude feedstock in the production of biofuels at Preem's refinery in Lysekil.

Empyro pyrolysis plant in Hengelo, the Netherlands. (Source: BTG Bioliquids)

RETROFITTING PROVIDES THE FOSSIL REFINERY SECTOR WITH SEVERAL SOLUTIONS TOWARDS CLIMATE NEUTRALITY THAT CAN ALREADY BE IMPLEMENTED TODAY.

CONCLUSIONS

In the Renewable Energy Directive (RED) (2009/28/EC), it was stipulated that by 2020, the EU would have 10% of the transport fuel of every EU country come from renewable sources such as biofuels. Moreover, the European platform organisation of refineries, FuelsEurope, has issued its own vision document Clean Fuels for all in 2020, in which they propose a potential pathway to achieve climate neutrality in 2050.

On the short term, this can be achieved with several retrofitting solutions, which will decrease the need for fossil feedstocks. An important example is the integration of HVO or pyrolysis oil. For the long-term, solutions are required that fully replace the need of fossil-based feedstocks. For this phase, governmental input is required in order to achieve a full transition to sustainable fuels and chemicals.

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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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