Integration of HVO production in the Thessaloniki refinery of Hellenic Petroleum in Greece

Rising concerns about global warming and the ever-increasing demand for electricity/heat and transport fuels, have led to the implementation of new energy policies at a European level. The revised RED - Renewable Energy Directive 2018/2001/EU that was adopted in December 2018 as part of the Clean Energy for all Europeans package, was a decisive turning point on how the EU countries could meet their emission reduction commitments under the Paris Agreement. The RED Directive (Annex V, part C) includes a methodology for evaluating (i) the total greenhouse gas (GHG) emissions and the (ii) emissions saving to be incurred by substituting fossil fuels with biofuels. Furthermore, it establishes a new binding objective of a minimum 32% share of RES in final energy consumption by 2030, with a clause for a possible upwards revision by 2023.

The EU has set itself the ambitious target for GHG emissions reduction by at least 55% below 1990 levels by the year 2030. This is a substantial increase compared to the existing target of at least 40% GHG emissions reduction. The aforementioned target sets Europe on a responsible path to achieving climate neutrality by 2050. The upcoming review of RED II (scheduled for June 2021) will provide an updated policy framework to further deploy renewable energies across all sectors. The framework of RED II had been adopted before the EU agreed to pursue the climate-neutrality by 2050 and does not drive action sufficiently in terms of scope and timing, to reach this objective. The Impact Assessment report aims to inform and support this political decision by investigating: (i) different policy scenarios based on different policy instruments available and (ii) how each sector of the economy could contribute to these targets. In the case of expanding carbon pricing alongside moderately increasing the ambition of Energy Efficiency and RES policies, achieving around 55% GHG ambition arrive at a RES share of 38.4%, final energy savings of 35.9%, and primary energy savings of 39.7%.

Hydrotreating vegetable oil (HVO) is considered as a premium “drop-in fuel” that can replace diesel fuel without modifications to existing refueling systems and/or vehicles. Hydrotreating of vegetable oils is an attractive way to produce very high-quality biobased diesel fuels, without compromising fuel engine components, exhaust after-treatment devices or exhaust emissions. In addition, the high cetane number of HVO ensures efficient and clean combustion, and provides extra power compared to conventional biodiesel (Fatty Acid Methyl Ester - FAME). HVO can also deliver up to 90% lower GHG emissions compared to petroleum-based diesel, and reduce PM, NO_x and CO_2 emissions by 33%, 9% and 24%, respectively. Moreover, its cold flow properties can be adjusted in accordance with regional specifications by modifying process severity or through additional catalytic processing involving isomerization of paraffins.

HVO can be distributed in a blend with petroleum-based diesel as high as 15% v/v; more than double the maximum FAME content allowed by EN590 diesel fuel standard (7% v/v). It can also be used in most heavy-duty engine manufacturers and an increasing number of passenger car manufacturers as they have certified their vehicles for pure renewable diesel (RD100). Many well-proven processes for the HVO production have been developed by various technology providers, such as Axens, Neste, Haldor Topsoe, Honeywell-UOP, Eni, etc.

The purpose of the present case study was to investigate the possibility of co-feeding Used Cooking Oil (UCO) alongside conventional straight run Light Gas Oil (LGO) in an existing diesel hydrotreater unit in the Thessaloniki Refinery of Hellenic Petroleum, in Greece. Significant aspects, such as (i) the identification of potential modifications to the existing equipment and/or installations of new items to ensure reliable operation, (ii) supply chain assessment and market analysis, and (iii) financial and environmental benefits, were investigated in order to provide better understanding of the technical, economic and environmental viability of the proposed retrofit.

The supply chain assessment carried out showed that, even with a high fresh oil consumption, the amount of UCO collected in Greece is estimated not to be sufficient for co-processing. Therefore, import of UCO from other countries (e.g., from Ukraine) will be necessary. Generally, the EU countries are highly dependent on UCO imports from Asian countries, such as China, Indonesia, and Malaysia. It is worth mentioning that the RED II Directive as well as other regulations, do not distinguish between the domestically collected UCO and the one imported from third countries. However, when importing UCO, sustainability and traceability should be ensured. Average costs for UCO in Greece were found to be ranged from 650 € to 720 €.

Regarding the legal framework in Greece, UCO is listed in the RED II Annex IX, Part B as waste-based advanced biofuel source and it is eligible for double counting. HVO from UCO is capped with 1.7% of national road and rail transport consumption. It can be concluded that co-processing of UCO to produce HVO in the Thessaloniki refinery of HELPE is remaining within the limits of the cap and the current HELPE market share.

The rigorous economic analysis carried out indicated that co-feeding UCO in the existing Thessaloniki Refinery is in general financially attractive. However, potential fluctuations in either the buying price of UCO or the selling price of the green LAGO product significantly affect the profitability of the suggested retrofit. Initial cost reduction efforts should be focused primarily on the installation of the pre-treatment unit and the modifications required in the Light Gasoil HSD unit to make co-feeding possible.

From an environmental perspective, it was shown that the current operation of the Light Gasoil HSD unit has the worst environmental performance, mainly due to the CO_2 intensive processes of LAGO production and diesel combustion. On the other hand, co-feeding UCO and LAGO - in a 5/95 ratio - shows positive results towards lowering overall GHG emissions. This could be attributed to the modifications required to make co-feeding possible and the zero emissions from the combustion process of the HVO fuel due to its biogenic origin. The selection of the location of the waste UCO collection centers – within a transport radius of 1500 km – was found not to be an important factor from the environmental point of view. It was further shown that the construction of a newly refining unit using 100% UCO as feedstock presents significant emissions savings. The aforementioned findings of this study indicate that further investigation needs to be done with respect to the environmental impacts of clean fuel production processes. However, due to the max cap on UCO usage imposed by RED II legislation, alternative sources of bio feedstock will have to be considered.

Finally, the risk assessment analysis showed that the most significant factors associated with the supply chain of UCO (high importance) are the availability and price of UCO, as well as the legal environment regarding the UCO import. The risk related to the feedstock availability refers either to problems in imports from other countries, or to the lack of feedstock on a national level. Regarding the refining process, the most important factor (high importance) is the lack of provision of financial incentives by the Greek government. The legal framework should recognize that biofuels contribute to the energy transition attempted by the EU. Governmental decisions on regional, national and international level are crucial for the future of such an investment. Last, but not least, the most important factor associated with the HVO distribution (medium importance) is the competitive price of HVO compared to alternative fuels. In every case the project should be designed in a way to provide resilience and secure constant processing.