Neste Porvoo Renewable Diesel
PATHWAY DESCRIPTION

1 INTRODUCTION

Neste is the leading global producer of renewable diesel with on-line capacity of 2.6 million metric tons per year (2.6 Mt/a) equivalent to 880 million gallons per annum distributed among its three production plants in Porvoo, Finland; Rotterdam, Netherlands and Singapore. Branded under the name Neste MY Renewable Diesel™, this 100% hydrocarbon fuel is fully fungible and a proven low-emission renewable fuel. Compared to fossil diesel, Neste MY has a higher cetane number and contains no aromatic compounds or sulfur.

This report outlines the renewable diesel production process, using used cooking oil (UCO) feedstock, as realized in the Neste Porvoo facility located at Neste's refinery area on the southern coast of Finland some 40 kilometers to the east of Helsinki. The production plant is integrated into the Neste Porvoo refinery's existing industrial infrastructure such as hydrogen production, steam & power as well as waste water treatment, port and storage services.

2 FEEDSTOCK SUMMARY

Neste sources used cooking oil (UCO) globally from collectors directly and through 3rd party traders that aggregate UCO volumes from multiple collectors. Shipping distances vary by source and a conservative approach to calculate the CI based on maximum distance is used. CA-GREET Tier II tool has been used to compute the pathway CI value.

3 NEXBTL® PROCESS OVERVIEW

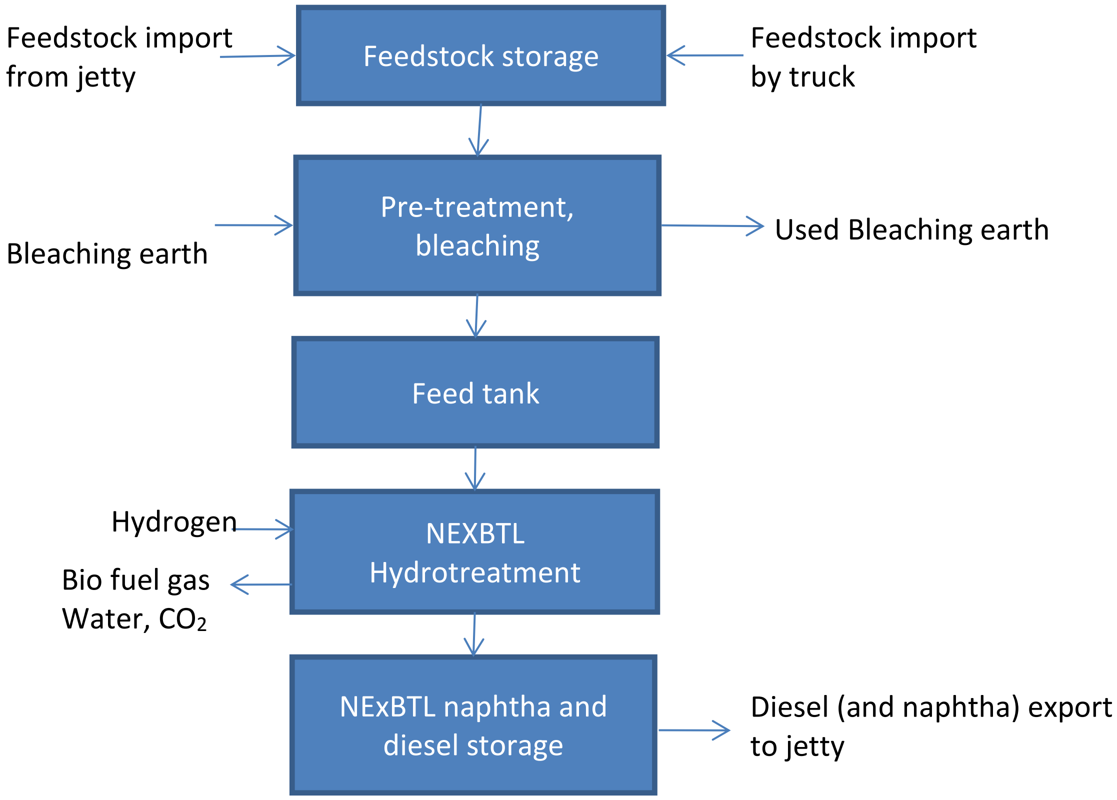
The overall features of the Porvoo renewable diesel production plant are shown in Figure 1. As with all of the NEXBTL plants the hydro treatment is conducted in separate, dedicated units. The Porvoo plant is composed of two production units each having a nominal capacity of 200 000 t/a. Units have been commissioned in 2007 and 2009 and are integrated using the same pretreatment unit.

The NEXBTL process is comprised of a number of sub process units which are listed and described in more detail below:

- Pre-treatment (impurities removal);
- Hydro treatment (oxygen removal, paraffins production and branching;)
- Stabilization (removal of residual light gases);
- Recycle (hydrogen recovered & recycled; water, carbon dioxide removal, light gases recovered)

The propane rich off gas from the recycle section is inserted into the refinery's fuel gas network. The refinery gases are utilized for different purposes in the refinery e.g. as a feed for hydrogen production units.

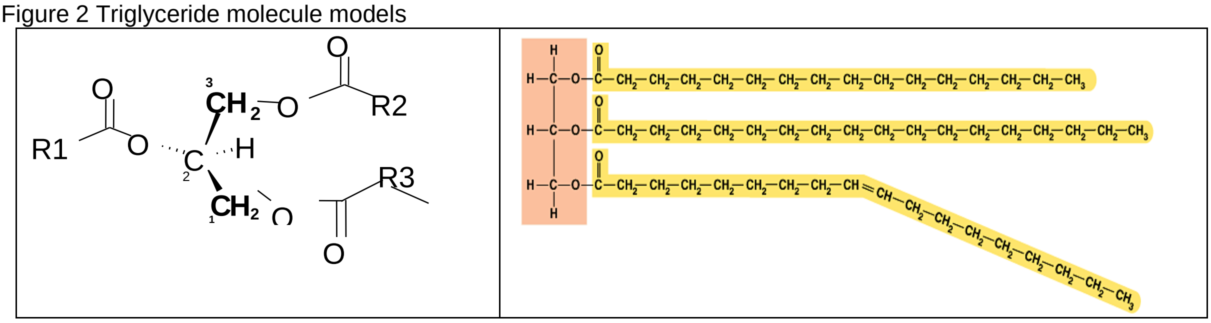
Figure 1 NEXBTL® Porvoo Process Diagram



4 MASS BALANCE (THEORETICAL)

Feedstocks for the process are vegetable oils and animal fats. Common triglyceride representations are shown below. The side chains R1, R2, R3 vary by length and are typically in the range of C14 to C18.

Figure 2 Triglyceride molecule models



A simplified mass balance for a model triglyceride $C_{57}H_{102}O_6$ (molecular weight 882 g/mole) is presented. Oxygen is removed as both water (H_2O) and as carbon dioxide (CO_2). The ratio depends on the catalyst and particular conditions employed. A typical ratio is shown in the example below. The equation is written without the production of bio-naphtha as only very small volumes of light hydrocarbons are formed.

A simplified mass balance of the renewable diesel process can be written as:
1.18 kg $C_{57}H_{102}O_6$ + 0.035 kg H_2 →1 kg RD +0.05 kg CO_2 +0.1 kg H_2O +0.06 kg C_3H_8

Since there are impurities removed in the pre-treatment of purification stage which must be removed prior to processing a slightly higher amount of feed is needed than in the above equation.

5 REALIZED PORVOO MASS BALANCE

The RD units in Porvoo have now been operating for 8-10 years.

Actual mass & energy balance for a two year operating period, 2015-2016, has been used to calculate the CI with the CA-GREET model. Compared to the theoretical mass balance presented in chapter 4 the actual mass balance indicates a little higher amounts of both the feed and propane rich off gas.

Hydrogen used at the site is a combination of two streams. One is pure hydrogen from a steam methane reforming plant and the second is a hydrogen rich refinery gas. Refinery gas hydrogen content has been analyzed and the total hydrogen input to the process has been used to calculate the CI value.

6 FEEDSTOCK PRE-TREATMENT SECTION

*****

The pre-treatment unit is designed for the continuous processing of vegetable oils and fats. The pre-treatment process is based on a bleaching unit (BLU). The bleaching unit can be operated independently from the rest of the plant and the operational configuration depends on the type and quality of the feedstock to be treated.

The bleaching process begins with the addition of an acid, forming a salt and removal of the salt by precipitation. The resultant feedstock is then fed through silica and/or bleaching earth which act as adsorbents for further reduction of impurities. Spent bleaching earth is disposed off-site.

7 HYDRO TREATING SECTION

7.1 Hydro deoxygenation (HDO)

The catalytic hydro treatment of triglycerides occurs through consecutive reactions forming three, straight chain paraffins; plus propane, water and carbon dioxide with the amounts described earlier. There is 100% conversion of triglycerides in the reactor. This reaction step is normally referred to as hydro deoxygenation or HDO. The reaction takes place by contacting the triglycerides with hydrogen over catalysts at elevated temperatures and pressures. The HDO hydro treating reactions are exothermic. The excess heat that is produced must be removed from the process. This excess heat is used to heat up the incoming feed. This reduces the requirement for external energy. The gases produced during this step are fed to the recycle section after water has been condensed out for recycle and reuse.

7.2 Isomerization

After the HDO step, the paraffins are branched or isomerized. Isomerization is used to improve the cold flow properties of the final fuel. The reaction is carried out in an atmosphere of hydrogen but there is negligible hydrogen consumption in this step

The liquid hydrocarbons are next fed to the diesel stabilization column.

8 STABILIZATION SECTION

The product from the isomerization reactor is routed to the stabilization column where light hydrocarbons are separated by stripping with low pressure steam. The stripping steam is supplied from the refinery's steam network and it is generated in boilers at Kilpilahti Power Plant located at the refinery area. Natural gas, refinery gas and residual & heating oils are used as fuels. Residual oil has been used in the CA-GREET model.

9 GAS SEPARATION AND RECYCLE SECTION

The function of this section is to separate the gas mixture into individual gas streams for use or removal and disposal. Hydrogen is returned to the process for use while the off gases are sent back to the refinery.

The carbon dioxide, hydrogen and light hydrocarbon gases are selectively and sequentially removed by first absorption or washing with an aqueous amine solution followed by amine regeneration where the individual gases are separated.

The recycle section is comprised of a number of wash columns and regeneration columns. The carbon dioxide and water streams are cleaned before releasing to the atmosphere or to the wastewater system.

Hydrogen is recovered by its selective permeation through a membrane. Hydrogen is then compressed and ready for use in the process.

10 RENEWABLE DIESEL PHYSICAL DELIVERY

RD is transported from the production plant to a storage tank via pipeline over a distance of less than 1 mile. From the storage tank to a vessel the RD is transported via another pipeline over a similar distance.

RD is then shipped from Porvoo to California discharge ports via ocean-going vessels over a distance of 8 672 nautical miles. Upon arrival, it is discharged from the vessel to the onshore storage tanks.

11 PATHWAY CI SUMMARY

The final carbon Intensity of the proposed pathway is summarized in the table below.

Neste UCO Pathway, Porvoo	Tier II
Feedstock CI	*****
Renewable Diesel CI	*****
Total WTT	*****
Total TTW	*****
Total WTW	*****