Eni Refinery, Venice

This is the first time that a conventional oil refinery has ever been converted into a **biorefinery**. During a difficult period for the European refining industry, Eni has found a way to repurpose the catalytic hydrodesulphurisation section of its **Venice refinery**. The reconfiguration makes use of Eni's proprietary **Ecofining™ technology**, developed by the firm in its San Donato Milanese laboratories in collaboration with Honeywell UOP.

Since May 2014 the biorefinery has been producing **extremely highquality biofuels** – predominantly green diesel, but also green naphtha, LPG and potentially even jet fuel – from biological feedstock. It is thus helping to meet the requirements of the EU directive on renewable energy and ensure that its conventional fuels have at least a 10 per cent component derived from renewable sources by 2020.

Eni's Venice refinery processes approximately 360,000 tonnes of vegetable oil a year, a figure that will rise to around 600,000 tonnes once construction work on the conversion project is complete. Currently European-certified palm oil is used due to its wide availability compared to supplies of second and third- generation feedstock. However, these alternative fuels are already being tested and preparations are being made to process them in the future.

Repeated industrial testing has confirmed that raw materials that do not compete with the food supply chain, such as used vegetable oils from across the country and animal fats, are suitable for processing. With this in mind, partnerships are under discussion with public waste authorities to increase the collection of used oils from homes for use in the biorefinery. In addition, possible additions to oily biomass refinery plants are being considered, so that the waste products from this process – 'advanced' fuels such as distilled fatty acids and glycerine – can be reused. Testing on oils derived from algae is also currently being carried out in Gela.

The issue

The **European Union's Renewable Energy Directive1** (also known as RED 20-20-20) set challenging targets for European countries to achieve by the end of 2020:

- A 20 per cent reduction in emissions of greenhouse gases (CO2, CH4, N2O etc.) compared to 1990 levels;
- A 20 per cent reduction in energy consumption compared to the projections made for 2020;
- 20 per cent of energy production from renewable sources, with 10 per cent (calculated on an energy basis) of fuels used for transportation made from renewable and sustainable biofuels.

Although adding bioethanol and biodiesel to traditional fuels is the quickest and simplest way to comply with the regulations, the quality of such products is poor compared to conventional fuels, making their use problematic. Biodiesel in particular has disadvantages related to its poor chemical stability, poor performance at cold temperatures, fouling and its low energy content per unit of volume, and many car manufacturers now advise against using biodiesel in their engines. The maximum proportion of biodiesel that can be added to conventional fuels without causing severe engine problems currently stands at around 7 per cent.

Furthermore, current regulations (the Fuel Quality Directive, or FQD) require a minimum 6 per cent reduction in greenhouse gas emissions from fossil fuels – an impossible target using biodiesel alone. **New biocomponents for fuels** that could, at least in part, replace biodiesel and improve engine efficiency while reducing emissions, must therefore be developed. The solution proposed by Eni is **green diesel**, 2 produced using the firm's proprietary Ecofining technology. This fuel meets all of the above requirements.

Strategy

The **biorefinery project** involved reimagining the Venice and Gela refineries, identifying innovative solutions to **convert** the previously installed operating capacity, based on traditional production cycles, into 'green' processes, which are both environmentally and financially sustainable. A business model was developed that, by enhancing existing

plants and making use of proprietary Eni technologies, allows the **conversion of low-cost, non-conventional biological feedstock** (such as vegetable oil and biomass) **into high-value products** (green diesel, green LPG, green naphtha etc.). This model is of particular interest given that biofuel demand in Italy is forecast to rise.

The process is based on innovative Ecofining technology, developed by Eni and tested in its laboratories. It produces very high-grade, **sustainable biofuels** without any of the disadvantages which affect other fuels currently on the market (fatty acid methyl esters or FAMEs). Consequently, it offers reduced particulate emissions and improved engine efficiency in line with current legislation and EU directives.

The raw materials of biological origin used in the process can be divided into first generation feedstock (vegetable oils in competition with the food supply chain), second generation feedstock (animal fats, used cooking oils and agricultural waste) and third generation feedstock (oils from algae or waste). Ecofining can also be applied to second and third-generation feedstock, so anticipating any future changes in the regulations.

Technology

To convert a conventional refinery into a biorefinery that complies with all regulations while also producing biocomponents for high-grade fuels, Eni chose to use its **proprietary Ecofining technology**. This process was developed by Eni and Honeywell UOP and produces green diesel.

Ecofining is essentially a two-stage process:

- During the first stage, the hydrodeoxygenation of vegetable oil, the biological feedstock is transformed into a mixture of linear C16-C18 paraffins; 3
- During isomerisation, the second stage, paraffin isomers are transformed to give the product the cold properties it needs and meet the specifications of diesel fuel.

Stage 1 Hydrodeoxygenation	**Stage 2** Isomerisation
Reactions • Cracking of the triglyceride structure • Deoxygenation of the oil • Saturation of double bonds	**Reactions** • Cracking of the paraffin • Isomerisation of the paraffin
Product Fully deoxygenated paraffin hydrocarbon with a high cetane number and poor cold properties (CP>20°C)	**Main Product** Green Diesel, a paraffin-based component with an isomerisation level that meets cold property requirements
By-product: propane	**By-products**: biogasoline and bioLPG

The **end product**, known as hydrotreated vegetable oil (HVO) or **green diesel**, is a very high-quality diesel with excellent cetane levels (cetane number5 >70, similar to top quality diesel obtained from gasto-liquids processes). It has a high calorific value and is free from aromatic compounds and heteroatoms (sulphur, nitrogen or oxygen).

The product is also immiscible with water and entirely compatible with diesel produced from petroleum (to which it can be added in a proportion of up to 30 per cent without any issues). Thus the fuel obtained respects the strictest regulations and offers the best performance for both engines and the environment.

The high calorific value of green diesel allows reduced consumption of plant feedstock (initially palm oil, certified to European standards) compared with traditional processes. In addition, in the near future, **second and third-**

generation feedstock will also be able to be used, such as animal fats, used cooking oil, agricultural waste, oil from algae and other waste.

Advantages

Eni's proprietary Ecofining technology has allowed it to convert its conventional refineries in Venice and Gela into **innovative biorefineries** for the production of high-grade fuel that complies with current legislation and EU directives.

In the current climate of European refining, in which dozens of refineries have closed in recent years, the Venice plant, which would otherwise have been shut down, has been kept in operation. The conversion project has given the plant a new lease of life through an innovative hi-tech processing cycle. Eni's decision to convert existing plants has the additional benefit of lower investment costs compared to building a new unit. Integrating the technology into existing facilities significantly reduced the project's investments costs.

Another advantage is the significant reduction in emissions from the Venice operation, which benefits the environment.

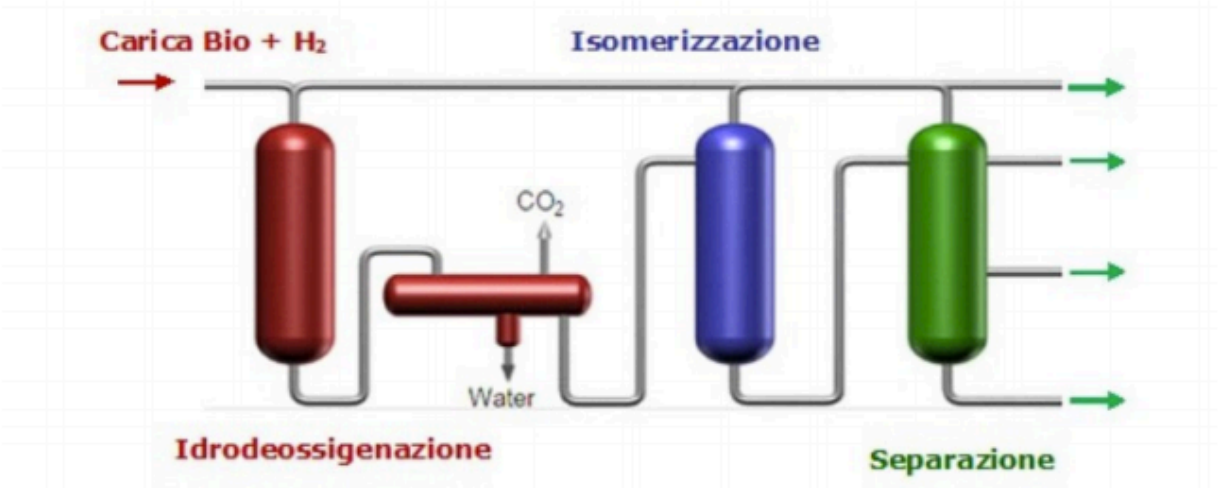

Figura 4: Schema di processo Ecofining