

Converting a Petroleum Diesel Refinery for Renewable Diesel

By Erin Chan

As refiners consider renewable, low-carbon alternatives, renewable diesel — refined from agricultural products using petroleum refinery processes — is gaining traction. Rather than constructing new grassroots renewable diesel production units, refineries with existing hydroprocessing units may be able to increase their speed to market with conversion projects.



The use of fossil hydrocarbons has fostered growth and prosperity more than any other fuel resource in modern times. Today's stronger focus on environmental, social and governance issues has driven interest in more sustainable alternatives. Renewable diesel, in particular, is on the rise among those who seek renewable and sustainable transportation fuels.

Renewable diesel is refined from agricultural products, particularly vegetable oils, waste cooking oils and animal fats that are sustainable and available. Because it uses the same hydrotreating and separation processes used for petroleum diesel, it employs the same basic infrastructure and equipment. Renewable diesel does not contain oxygen, eliminating the freezing, storage and blending challenges associated with other renewable fuels, such as biodiesel. Because renewable diesel has the same chemical structure as petroleum diesel, it can be used in engines designed to run on conventional diesel fuel — a “drop-in” diesel substitute with no blending limit.

Making The Grassroots Vs. Conversion Decision

The question refiners interested in renewable diesel are now asking is whether to build a new renewable diesel plant or convert an existing hydrotreater unit.

For many, the answer may seem simple. Refiners often realize multiple benefits by converting an existing refinery hydrotreater unit rather than constructing a grassroots plant. Perhaps the most significant is time savings. A typical renewable diesel conversion project can be completed in about two years, or roughly half the time needed to design and build a new grassroots unit.

Because the power, water, waste, utility and flare systems needed to support a hydrotreater for renewable diesel are already present in a refinery, a conversion project will cost less than a grassroots project. A renewable diesel plant on a greenfield site will require the addition of this new infrastructure.

Even more than initial construction cost savings, the greater financial benefit of a conversion project is the ability it gives a refiner to get renewable diesel products to market more quickly.

The largest market for renewable diesel fuel in the U.S. today is California, where credits from the federal Renewable Fuel Standards program in combination with California's Low Carbon Fuel Standards help make it cost competitive. Thirteen other states currently have legislation in place for transportation fuel standards comparable to California. The refiners who are first-to-market in these states will be the biggest beneficiaries of fuel credits. Once the market is saturated, credit availability will likely decline.

Time-to-market, however, is not the only factor to consider when choosing whether to convert an existing unit or build a new one. To determine if an existing unit is a good fit for a conversion, it is important to evaluate the condition and usability of its existing equipment and ancillary systems. Process simulations and other analysis will likely be needed to demonstrate the viability of a conversion project. Among the factors to consider:

High reaction exotherm — Whether using agricultural waste or crude oil, a hydrotreater's reaction releases heat when breaking chemical bonds in the feedstock. Renewable diesel reactions, however, are significantly more exothermic than petroleum diesel desulfurization reactions. It is important, therefore, for these units to be equipped with high liquid product recycle capacity that can be used to absorb this heat. It is also necessary to recalibrate production expectations based on the high product recycle through the unit. A hydrotreater that operates at 50,000 barrels a day for petroleum diesel production may only be able to accommodate 5,000 barrels a day of fresh feed when converted to renewable diesel.

Emergency depressurization systems — Because of the high heat release associated with renewable diesel reactions, hydrotreaters require emergency depressurization systems to manage the reaction safely in the event the recycle and quench systems fail. These systems quickly depressurize the reactor to a flare, stopping the reaction.

Hydrogen consumption — Renewable diesel reactions consume a significant amount of hydrogen. Refineries with excess hydrogen capacity, therefore, are particularly good candidates for conversion projects. Refineries with limited hydrogen availability may need to budget for the construction of an additional hydrogen plant.

Feed train considerations — Depending on the quality of the renewable diesel feedstock, it may be necessary to upgrade the metallurgy in the unit's feed train system.

Feedstock that is high in free fatty acids, for example, has the potential to create a corrosive environment. Another special consideration for renewable feedstocks is the potential for polymerization in the feed train. When hydrogen is absent, renewable feedstocks can polymerize, which causes gumming and fouling in the equipment. The addition of hydrogen could make the equipment susceptible to high temperature hydrogen attack.

One option is to update feed-side metallurgy to protect against corrosive conditions. Another is to create two separate pre-heat trains, with separate systems for liquid recycle and fresh feed.

Water and carbon dioxide production — Renewable diesel reactions produce water and carbon dioxide in much larger quantities than petroleum hydrotreaters, creating potential carbonic acid corrosion concerns downstream of the reactor. Metallurgy upgrades may be required in the reactor effluent air cooler system. Consideration must be given to the handling, treatment and disposal of the extra water and carbon dioxide produced in these reactions. If water is routed to the refinery's sour water stripper, for example, it may produce high concentrations of carbonic acid in the sour water streams, impacting how the water is treated and reused.

Heat tracing — The vegetable oils and animal fats used as feedstock become waxy and solidify at ambient temperatures. To load it into trucks and rail cars for shipment and, later, unload and charge it to a hydrotreating unit, these feedstocks must be in liquid form. That requires steam or electric heat tracing systems that raise the temperature of pipes, tanks and vessels to liquefy the fats and oils. The addition of significant heat tracing capacity will likely be required for both existing hydrotreating infrastructure, as well as the rail, truck or barge piping and equipment used to store and transfer feedstock into the unit.

Any of these factors could potentially give a refiner pause on a renewable diesel conversion project. More likely, they will provide insight on the right way to move forward. The transition to renewable diesel will continue, either way. The time for refiners to consider their options is now.

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