How the California Low Carbon Fuel Standard Resulted in a Renewable Diesel Boom

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The United States is in the midst of a renewable diesel (RD) production boom, which has led to an increased demand for vegetable oil. Most of the RD produced in the United States is used as motor fuel in California—in response to the state’s Low Carbon Fuel Standard (LCFS), coupled with the national Renewable Fuel Standard (RFS). These policies increase demand for vegetable oils, which serve as inputs (feedstock) for RD production and have resulted in increased U.S. imports of vegetable oils and more global agricultural land allocated to soybeans and palm trees. The increased demand has resulted in higher vegetable oil prices and has contributed to food inflation in the United States.

The combination of the Renewable Fuel Standard (RFS), which is a federal mandate in place since 2006, and California’s Low Carbon Fuel Standard (LCFS), introduced by the California Air Resources Board (CARB) in 2011, has resulted in a large increase in renewable diesel (RD) production, which started to really take off in 2020. RD is a perfect substitute for “conventional diesel,” which means that it does not need to be blended with conventional diesel, unlike biodiesel (BD) which is chemically different from RD. BD and RD (both renewable fuels) differ in their production processes but use similar inputs (feedstocks).

The RFS is mainly a fuel blending policy, requiring minimum percent blends of renewable fuels in the conventional fuel pool. On the other hand, as discussed in the first article, the LCFS has an annually increasing targeted reduction in transportation-related carbon emissions. The policy aims to limit the carbon intensity (CI) of fuels. The program is set up so that low CI fuel (e.g., RD) producers earn “credits,” while high CI (e.g., gasoline) producers must purchase these credits. A few years ago, the price of credits jumped up as the LCFS ratcheted up carbon-reduction targets.

From 2018 to 2020, LCFS credit prices were at all-time highs, trading at around $200 per metric ton (MT) of carbon, compared to $100/MT previously. This translated into high subsidies for renewable fuel producers and, therefore, increased the supply of renewable fuels. One industry that benefited greatly from the high credit prices was the RD industry.

RD production capacity in the United States was 600 million gallons a year in 2018. With the spike in the price of credits, which act as a subsidy to RD production, new investments were made. Old diesel refineries were converted into RD facilities, as was the case for refineries in California and Louisiana. The current RD production capacity in the United States is around 3.85 billion gallons a year, over a 500% increase in five years.

The full impacts of this huge supply increase are still uncertain. For example, the blend rate for retail diesel in California currently is 65% RD and 35% conventional diesel. Before the boom, RD made up less than 5% of the state’s diesel blend. Producing RD requires inputs, such as soybean oil. The shift in RD feedstock demand has also resulted in sharply higher vegetable oil imports.

The Increase in the Use of Soybean Oil as Fuel

Soybean oil is used as a feedstock for either fatty acid methyl esters (FAME) BD or RD. Soybean oil accounts for approximately 60% of BD feedstocks. The FAME production process is limited to a narrow range of feedstocks and the resulting fuel is not a perfect substitute for conventional diesel, unless it is blended.

In contrast, RD can be produced out of almost any type of oil or fat. This allows producers to use different inputs and gives a “second life” to products like used cooking oil (UCO), tallow, and non-edible distillers corn oil. These oils are referred to as waste oils and fats; RD produced using them yields some of the lowest CI fuels that fall under the LCFS.

However, refiners also use large amounts of other inputs to produce RD, for example edible vegetable oils, such as soybean, canola, and palm. When RD production was low (before the “boom”), tallow, UCO, and distillers corn oil represented more than 90% of the RD feedstock, and no edible vegetable oils were used. This is because of the lower CI of UCO as compared to soybean oil, and therefore the ability to generate more credits.

After the RD boom, the waste oils and fats share decreased to 65%, with the rest of the RD feedstock mainly being edible vegetable oils (soybean and canola now account for 25% of total U.S. RD inputs). This feedstock change is mainly because there is an insufficient supply of waste oils and fats. In total, around 50% of the U.S. production of soybean oil is used as the main feedstock for BD and RD.
U.S. Demand for Vegetable Oils

The surge in demand for oils and fats, combined with the inelastic supply of waste oil, led to the introduction of vegetable oils as a major feedstock for RD. This has reshaped the domestic market for vegetable oils in the United States and has had a global impact.

Vegetable oils have two main uses: food and industrial (energy). Food use includes the food processing sector, restaurants, and homes, which mainly use these oils for cooking purposes. Demand for food use has not changed much. From 2018–2023 food use demand increased by less than 8%.

On the other hand, industrial demand, driven by feedstock use, significantly increased. The surge in RD production has led soybean and canola oil demand for industrial use to increase by 63% from 2018–2023, according to the Foreign Agricultural Service of the U.S. Department of Agriculture (FAS-USDA). Figure 1 plots U.S. vegetable oil fuel and food use, along with net imports (trade balance).

Effects on Global Demand for Vegetable Oils

In 2023, the United States accounted for approximately 10% of the global vegetable oil demand. Other significant users were China (20%), India (13%), and Brazil (5%). However, most of this demand in these other countries is not for fuel use. Global demand for food use, which is around 70% of total demand, increased by 9% from 2018 to 2023. Over the same period, demand for industrial use rose by 18%. Demand for RD feedstock in the United States was the key driver of this growth.

Supply of Vegetable Oils and Land-Use Changes

Global demand for vegetable oils increased by 11% over the RD boom period, while U.S. demand increased by around 27%. Global vegetable oil supply has responded by increasing the area planted by around 15% from 2018–2023. Most of this growth came in the years after the boom, when supply was trying to catch up with demand.

While the demand expansion happened in the United States, supply expansion did not. From 2018–2023, U.S. soybean acreage remained mostly flat at around 86 million acres. Acreage increases were significant in Brazil and Indonesia, two of the top ten vegetable oil producers. Brazil’s soybean acreage increased by 28%, from 89 million acres to 114 million acres. Indonesia, the world’s largest palm oil producer, increased palm acreage by 15%, from 30 million acres to 35 million acres.

Land expansion into vegetable oils in Brazil and Indonesia was already underway. However, there was a significant increase in the land expansion growth rate after the RD boom, especially in Brazil where the yearly growth rate jumped from 3% to 6%. Figure 2 highlights land-use changes during this period. The left axis is the acreage for Brazil and the United States, while the right axis is acreage for Indonesia.

Trade Flow Changes

The RD boom has affected U.S. vegetable oil trade flows. By 2023, U.S. exports of vegetable oils decreased from 1.2 million MT before the boom to almost zero. Meanwhile, imports increased from 3.5 million MT before the boom to 5.5 million MT in 2023. In short, the United States has almost stopped exporting vegetable oils and significantly increased imports, resulting in the vegetable oil trade deficit doubling (Figure 1).
Because consumption of vegetable oils outside of the United States did not decline, other countries increased exports. Canada, for example, increased canola oil exports to the United States. From 2018–2023, Brazilian soybean oil exports increased by 60%, with a record export number of 1.2 million MT in 2022. When interpreting quantities, one could therefore think of Brazilian exports filling the additional gap in global demand created by the U.S. renewable fuel policies.

**What Does This Mean for U.S. Consumers?**

From cooking oil at home to an input in several processed food products, vegetable oil consumption represents a significant share of the expenditure of U.S. households. The increased demand for vegetable oils for motor fuel has intensified inflationary pressure. Data from the USDA indicates that fats and oils were the food sector with the highest inflation in recent years. Specifically, food at home inflation was equal to 27% from 2018–2024, while fats and oils inflation was equal to 83% over the same period.

While recent inflation was not exclusively caused by biofuels policy, it has certainly played a role in inflation because it drives up the price of both vegetable oils and motor fuel. Figure 3 shows that the correlation between energy and vegetable oil inflation has never been as high as it is now, especially after the RD boom. Note: CPI=Consumer Price Index; PPI=Producer Price Index. Energy CPI data accounts for all items a typical household consumes. That includes fuel, electricity, and gas as collected by the Bureau of Labor Statistics. We use PPI for vegetable oils for two reasons: 1) CPI for vegetable oils is skewed toward olive oil, which is not an oil studied here, and is not used as fuel; and 2) the majority of vegetable oils are used in the food industry, thus the inflation is at the food processor level and is passed to consumers through several products.

The additional vegetable oil imported by the United States is not necessarily used in the production of RD, but instead goes into food use, backfilling the gap in supply. The state of California (through its agency CARB) measures CI scores for RD. But that measure falls short in capturing all of the environmental effects since CARB only measures the land-use effects of vegetable oil directly used in RD production. Failing to fully capture the environmental effects of increased land conversion leads to overestimating any reduction in greenhouse gas emissions associated with the LCFS policy. CARB seems to be aware of this issue, as discussed in their latest Staff Report, and is making progress in terms of more accurately measuring the CI of biofuels.

**Suggested Citation:**

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