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Are U.S. low carbon fuel standards driving a structural change in oilseed demand that could support farmland returns?

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INTRODUCTION

Low carbon fuel standards are U.S. state-level programs that seek to reduce emissions of carbon dioxide and other pollutants from transportation fuels. Several fuel sources offer compliance within this scheme, including charging stations for electric vehicles and ethanol. However, one fuel type, renewable diesel, possesses chemical attributes that simplify the switch to low carbon fuel for refiners and motorists alike. In this paper, potential implications for oilseed demand and farm margins stemming from low carbon fuel standards and the expansion of renewable diesel refining capacity are analyzed.

"*Over the next four years, the U.S. will see renewable diesel refining capacity more than quadruple so that refiners and distributors can achieve compliance and supply low carbon transportation fuel in LCFS states.*"

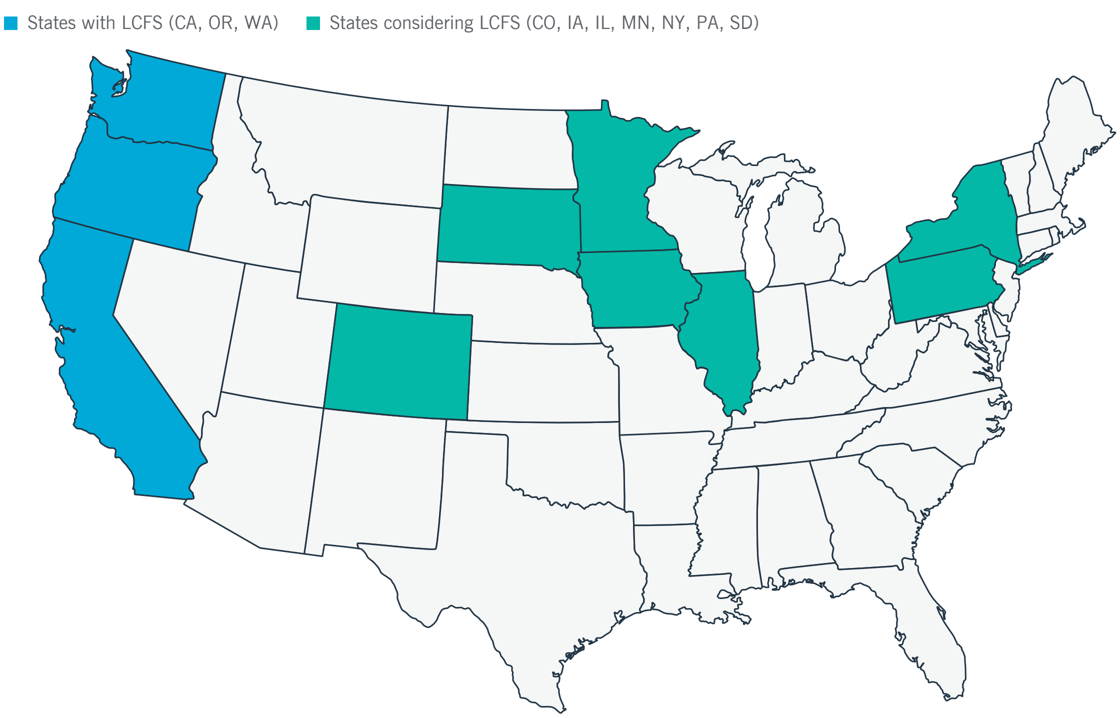
WHAT ARE LOW CARBON FUEL STANDARDS?

As the effects of climate change have become more apparent, several U.S. states have enacted legislation to lower carbon emissions within their jurisdictions. One legislative framework targeting the transportation sector is the Low Carbon Fuel Standard (LCFS). Originally developed in California and subsequently ratified in Oregon and Washington, LCFS establish annual carbon intensity benchmarks for transportation fuels that decrease over time. Essentially, the policy gradually decreases the amount of petroleum-based fuel within the transportation sector over a 20-year horizon.

The reduction in carbon intensive fuels is achieved through a credit trading system wherein refiners or distributors generate credits by supplying fuel that has a carbon intensity below an annual benchmark set by the state. Conversely, debits are generated for fuels supplied that are above the benchmark, and a business maintains compliance with a LCFS when their credits equal or exceed their debits. The carbon intensity of a fuel is determined by the measure of greenhouse gas emissions associated with producing, distributing, and consuming that fuel, which is measured in grams of carbon dioxide equivalent per megajoule of energy. Each LCFS credit represents one metric ton of carbon dioxide reduced through the consumption of a fuel with a carbon intensity lower than the annual benchmark. Businesses may use credits to offset more carbon intensive enterprises like the production of gasoline or diesel or sold on an exchange to another producer whose debits exceed any credits they may have. As time has passed and the carbon intensity benchmark of fuels has decreased, the amount of credits traded and the value per credit has increased. For example, in California, 13.3 million credits were traded at an average price of $160 per credit in 2018. By 2020, the average credit price increased 24% to $199 with a total of 21.7 million credits traded. Clearly, LCFS incentivizes the production of renewable and less carbon intensive fuels while making petroleum-based fuels more expensive.

Currently, California, Oregon and Washington have enacted LCFS legislation. While this seems minimal in number compared to the other 47 states comprising the country, it is important to

Exhibit 1: U.S. states with LCFS and those that are considering LCFS



Source: Nuveen analysis

remember the size of California's economy relative to that of the U.S. According to the U.S. Bureau of Economic Analysis, California represented 14.6% of total U.S. GDP in 2019. From a fuel demand perspective, California is the largest user of on-road diesel in the U.S., consuming more than 3.2 billion gallons in 2019. Although they represent far less demand, Washington and Oregon consumed 798 and 596 million gallons of diesel in 2019, respectively. This demand of 4.6 billion gallons of on-road diesel represents the current addressable market for renewable diesel, but there are other states considering comparable legislation. States such as New York, Pennsylvania and Illinois have considered similar policies. When the demand in these states is included, the addressable market size increases to 7 billion gallons, or about 17% of total U.S. consumption. The full list of states that have enacted or are considering LCFS can be seen in Exhibit 1. Outside the U.S., British Columbia has enacted an LCFS with the entire nation of Canada poised to follow suit. As will be seen, the refining industry is positioning itself accordingly, not only to maintain compliance within LCFS states and supply those markets with renewable diesel, but to lower their own carbon footprint.

RENEWABLE DIESEL VS. BIODIESEL

There is a common misconception that renewable diesel and biodiesel are one and the same product. While the two fuels are derived from the same feedstocks of fats and oils, the two are chemically different. Renewable diesel is a hydrocarbon and is chemically identical to conventional diesel but refined from a renewable feedstock like used cooking oil, soybean oil or tallow. Given this chemical property, renewable diesel can be produced, transported and stored in the same facilities originally designed for petroleum-based diesel with modest capital expenditure. For diesel engines, no modification or additives are needed and no blending with petroleum-based diesel is required, making it a drop-in, low carbon substitute for conventional diesel. Since there are no blending requirements to run in an unmodified engine, there is potential for a 50 - 85% reduction in carbon intensity relative to conventional diesel and up to a 10% reduction in NOx emissions. Considering California's legislation only requires a 20% reduction in the carbon intensity of fuels by 2030, unblended renewable diesel is capable of more than covering that reduction requirement.

While biodiesel is also produced from renewable feedstock, it is an ester that requires blending with petroleum-based diesel to be compatible in most engines. With this blending requirement comes a higher carbon intensity, making it a less attractive product to supply in LFCS markets, in addition to requiring separate facilities from existing diesel refining and distribution infrastructure. There are issues with gelling and buildup of solidified fuel in the pumps, filters and injectors of engines and additional management is sometimes required in cold temperatures. These limitations are part of the reason why the production of biodiesel has not increased significantly over the last 20 years. With the development of LCFS policies, major oil refiners have had to increase production of low carbon fuels, and it is clear why renewable diesel is preferred to biodiesel by both refiners and vehicle owners.

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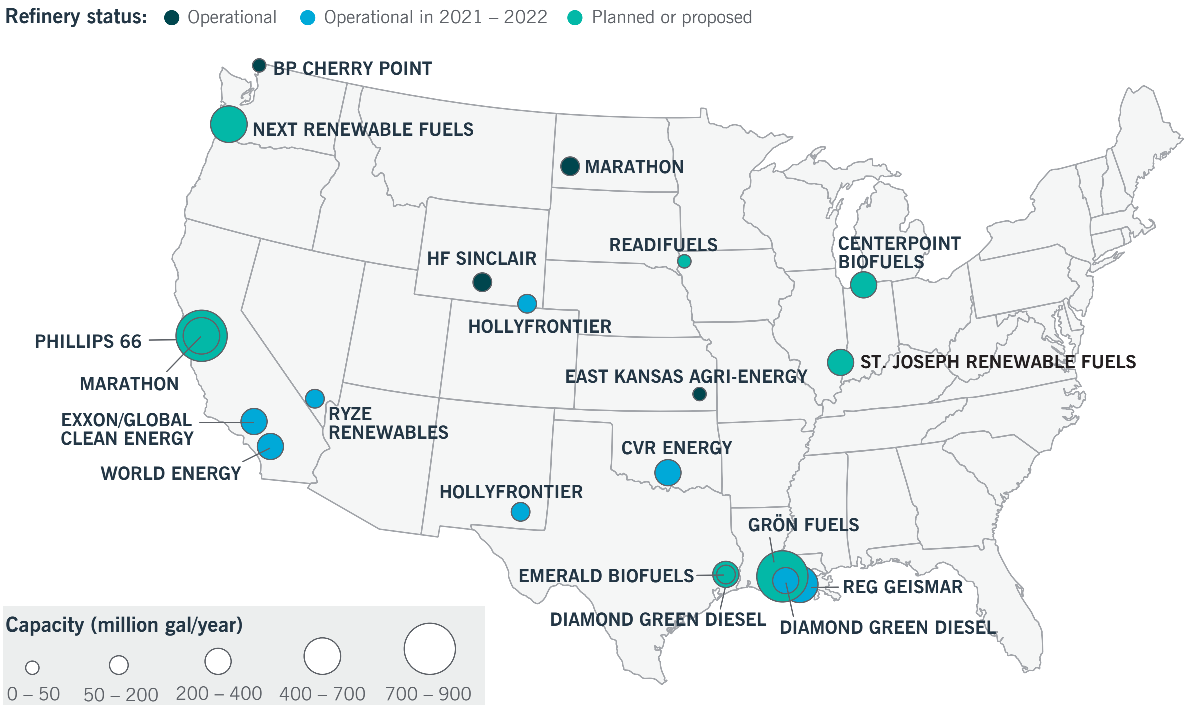
THE EVOLVING LANDSCAPE OF U.S. REFINING CAPACITY

The incentives offered by LCFS policies in addition to oil companies' carbon reduction efforts have led to a spate of capacity expansion announcements for the refining of fats and vegetable oils into renewable diesel. Conversion of existing oil refineries to produce renewable diesel is a major point of distinction between the modest increase in biodiesel production that occurred following the passage of the Renewable Fuel Standard (RFS) in 2005. While some major oil refiners began and continue to operate biodiesel facilities, several small and medium-sized firms also entered the market with smaller-scale facilities near areas

Exhibit 2: Current and planned U.S. renewable diesel refining capacity



Source: Nuveen analysis

of soybean production. In the case of renewable diesel, oil majors can repurpose or expand their existing refineries, a number of which are capable of producing hundreds of millions of gallons per year, as seen in Exhibit 2.

Exhibit 3 below shows refinery plans for converting or constructing renewable diesel capacity, which highlights the magnitude of the shift to renewable diesel. As of early 2020, there were approximately 400 million gallons of renewable diesel produced in the U.S. A survey of the industry shows 1.9 billion gallons per year of incremental capacity due to come online by 2024 that is either under construction or expansion. When projects that are proposed or still being permitted are factored in, another 3.5 billion gallons of production capacity could be added.

Over the next four years, the U.S. will see renewable diesel refining capacity more than quadruple so that refiners and distributors can achieve compliance and supply low carbon transportation fuel in LCFS states. Many of the facilities that will produce the fuel will have an output in the hundreds of millions of gallons per year. With such a large increase in

Exhibit 3: Renewable diesel refining capacity growth

Refinery	Location	2021	2022	2023	2024
Diamond Green (Valero & Darling)	Louisiana	675	675	675	675
REG Geismar	Louisiana	90	90	340	340
World Energy	California	45	330	330	330
Ryze Renewables	Nevada	100	100	100	100
HollyFrontier	New Mexico		55	55	110
HollyFrontier	Wyoming		45	45	90
Exxon & Global Clean Energy	California		230	230	230
Total (million gallons per year)		**910**	**1,525**	**1,775**	**1,875**

Source: Nuveen analysis

production, an important question comes to mind: where will the feedstock of fats and oils come from to enable this expansion?

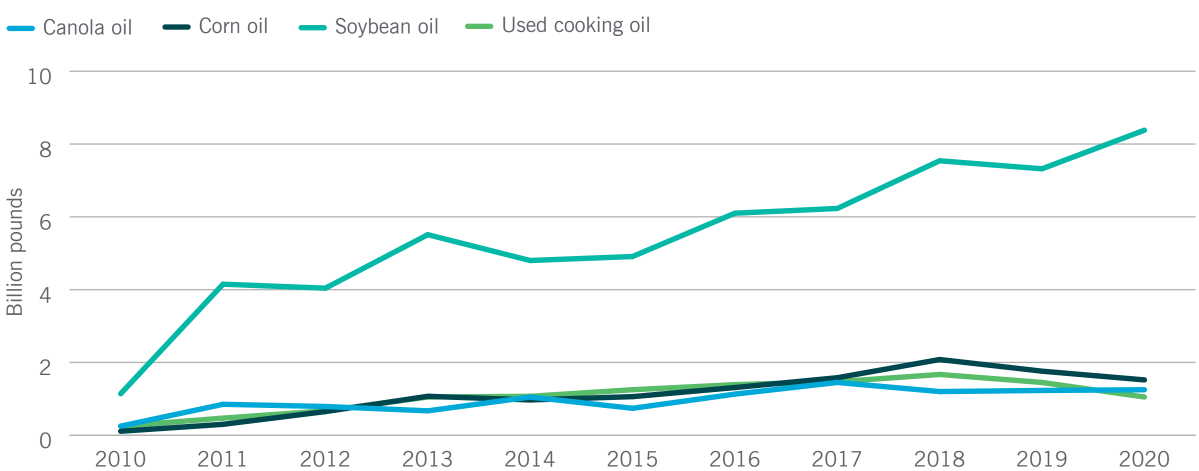
WHAT FEEDSTOCKS ARE USED IN RENEWABLE DIESEL PRODUCTION?

The raw feedstocks that are refined to produce renewable diesel include vegetable oils such as soybean and canola oil, fats like tallow from the animal protein industry, and used cooking oil collected from foodservice. The LCFS policies currently in place consider the entire lifecycle of a fuel to determine its carbon intensity and the value of the credits attributed to it. Thus, a recycled feedstock like used cooking oil or a by-product like tallow is more advantageous from a LCFS crediting perspective since they do not require the land, machinery, and chemicals that soybeans or canola produced for oil do. In California's case, the incentive to utilize less carbon intensive feedstocks for higher credit prices has worked. In 2020, materials such as used cooking oil, tallow and distiller's corn oil comprised 93% of the credit value generated from biodiesel and renewable diesel.

However, there are constraints to the supply and sourcing of these feedstocks. According to the North American Renderer's Association, approximately 4.4 billion pounds of used cooking oil are collected and recycled annually. Using a conversion of 7.6 pounds per gallon, that is just 579 million gallons of potential feedstock for the entire biodiesel and renewable diesel industries to use annually. Comparing this to the 1.9 billion gallons of renewable diesel refining capacity set to come online by 2024, a void will have to be filled by other fats and oils as carbon intensity benchmarks decrease and conventional diesel becomes costlier to produce and sell in LCFS states.

Although there is no publicly available data on the feedstock composition for renewable diesel produced in the U.S., the Energy Information Administration (EIA) has recorded complete monthly data on biodiesel feedstock use since 2010. This information provides an understanding of what feedstocks have historically been used for biomass-based diesel and what proportion of the overall mix they occupy. Exhibit 4 organizes this data into a time series, and it becomes apparent that soybean oil has occupied most of the feedstock mix since data were recorded. Further, from 2010 – 2020, soybean oil use as biodiesel feedstock grew from 1.1 billion pounds to 8.4 billion pounds, with the share of other sources such as corn oil and used cooking oil remaining relatively flat since 2017. Examining the 2020 data shows that soybean oil comprised 62% of the biodiesel feedstock mix. Given the muted growth of other feedstocks in recent years, it is expected this proportion will maintain and expand for the feedstock mix processed into renewable diesel.

Exhibit 4: Feedstock breakdown in U.S. biodiesel industry over time



Source: EIA, Nuveen analysis

POTENTIAL IMPACT ON SOYBEAN DEMAND

The expansion of renewable diesel production in the U.S. will certainly increase demand for soybean oil and, ultimately, soybeans. To gain perspective on how much demand could be augmented, the estimated incremental demand from new refining capacity was added to the June 2021 USDA World Agriculture Supply and Demand Estimates (WASDE) for U.S. soybean oil (see exhibit 5).

A few assumptions are required to estimate the additional demand, the first of which is that soybean oil will occupy 65% of the feedstock mix. The additional refining capacity considered for this exercise is the previously mentioned 1.9 billion gallons of capacity that is either under construction, expansion or retrofitting and requires no additional regulatory clearance. Lastly, a conversion of 7.6 pounds of soybean oil per gallon is used to translate the WASDE estimates from pounds to gallons.

Total estimated supply of U.S. soybean oil for the 2021 – 2022 marketing year is 3.7 billion gallons while total use is 3.5 billion gallons. When the estimated incremental demand from the expansion of renewable diesel production is factored in, an additional 1.2 billion gallons of soybean oil- 65% of the 1.9-billion-gallon expansion- is added to use. In theory, this would result in a domestic supply shortfall of approximately 1 billion gallons of soybean oil.

Exhibit 5: U.S. soybean oil balance sheet

U.S. soybean oil	Million gallons	Million pounds
Beginning stocks	237.9	1,808
Production	3,413	25,944
Imports	78.9	599.6
Total supply	**3,730**	**28,353**
Biofuel use	1,578	11,999
Feed, food, other industrial	1,763	13,400
Exports	190.7	1,450
Total use	**3,532**	**26,850**
Ending stocks	197.8	1,503
Incremental demand from capacity expansion	1,218	9,262
Total potential use	**4,751**	**36,112**
Difference between current supply and total potential use	**-1021**	**-7759**

Source: USDA WASDE, Nuveen analysis

To understand what this shortfall means in terms of bushels of soybeans, a conversion of 10.7 pounds of soybean oil per bushel is used, resulting in 725 million bushels needed to supply the incremental demand for soybean oil. When those bushels are added to current use on the soybean balance sheet, a hypothetical deficit of 570 million bushels of soybeans occurs as shown in Exhibit 6. Assuming an average yield of 50 bushels per acre, this would require 11.4 million additional acres of soybeans to be grown in the U.S. per year. Given this additional demand is grounded on the assumption that soybean oil will comprise most of the feedstock, the numbers presented here are a starting point to understand the sheer volume of soybeans that would be needed to achieve such an increase in renewable diesel output.

Exhibit 6: U.S. soybean balance sheet

U.S. soybeans	Million bushels
Beginning stocks	135
Production	4,405
Imports	35
Total supply	**4,575**
Crushings (oil)	2,225
Exports	2,075
Seed	104
Residual	15
Total use	**4,420**
Ending stocks	155
Incremental demand from capacity expansion	725
Total potential use	**5,191**
Difference between current supply and total potential use	**-570**
Acres needed to supply incremental soybean demand (millions)	**11.4**

Source: USDA WASDE, Nuveen analysis

WHERE COULD ADDITIONAL SOYBEAN SUPPLY COME FROM?

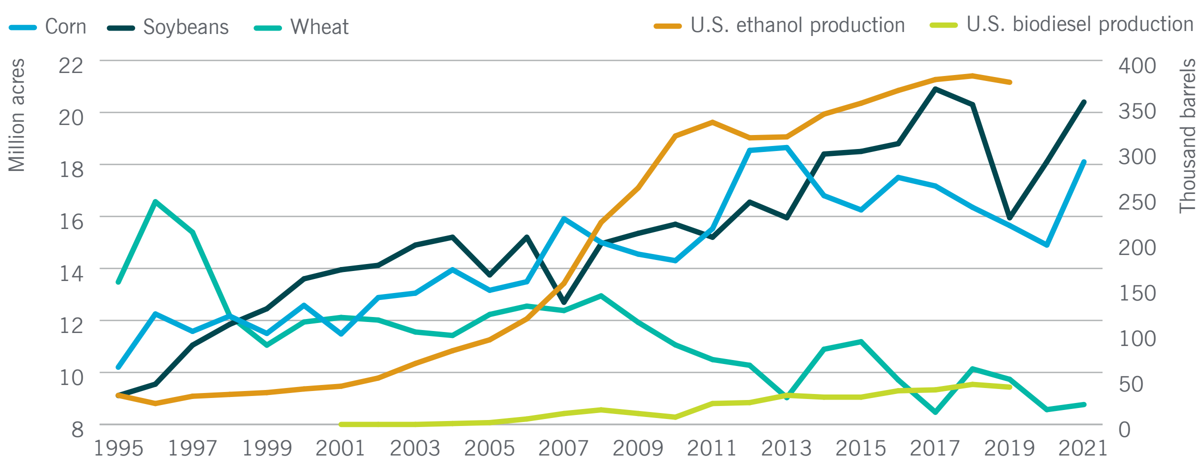
From an acreage perspective, the U.S. would theoretically be able to produce enough soybeans to meet the additional demand outlined in the previous section. Yet, this would come at the cost of other crops being planted such as corn, cotton, and rice, and would result in an inflationary environment for several agricultural commodity prices. Nevertheless, acreage shifts can occur, as was the case following the passing of the RFS in 2005 that greatly increased corn-based ethanol production. Historically, Minnesota and North and South Dakota have produced a large amount of spring wheat, but over the last 15 years the region has seen total crop acres expand, and corn and soybean production increase at the expense of wheat acres. Exhibit 7 demonstrates this shift in production following the implementation of the RFS and increase in corn demand resulting from the increase in ethanol production.

Analyzing the 2021 planted acreage data from the USDA National Agricultural Statistics Service (NASS) survey shows there are around 19 million acres of cropland planted to cotton, rice and wheat that could potentially grow soybeans. Most of these acres shifting to soybean production is unlikely for several reasons, but to satisfy the estimated demand for soybean oil from renewable diesel, around 60% would need to be devoted to soybean production. Recognizing the U.S. is the major producer of several crops and its exchanges set global pricing benchmarks, the disappearance of acreage devoted to other crops would create upward pressure on commodity prices, all else equal. Of course, commercial farms are businesses, and profitability is the main factor determining planted acreage. The price of soybeans has increased significantly over the past year, but net returns would have to be consistently higher than other crops year after year to induce such a shift. Although there is precedent for acreage shifts, and specifically in response to renewable fuel mandates, the outsize demand of the renewable diesel expansion could continue to place upward pressure not only on soybean prices, but other crops as well.

IMPACT ON SOYBEAN AND SOYBEAN OIL PRICING

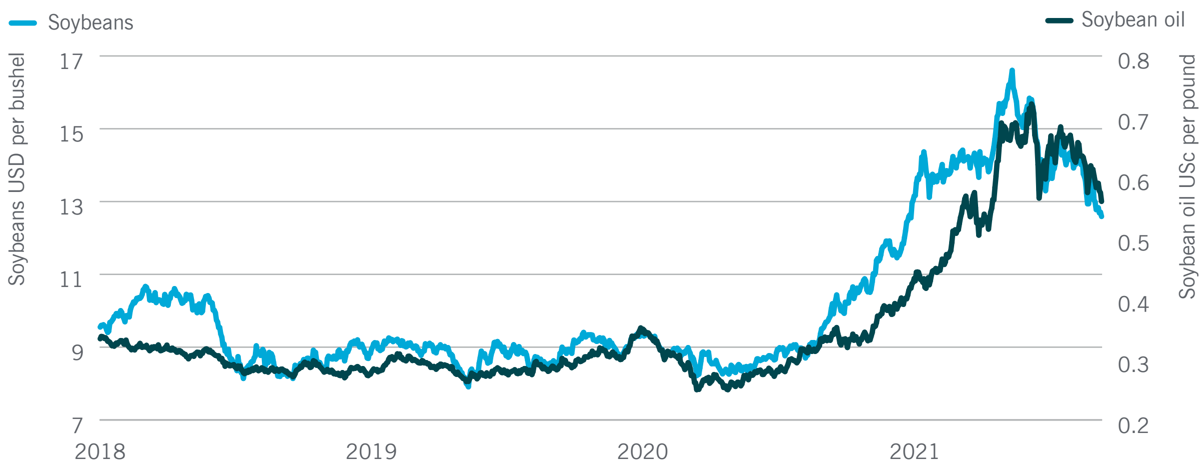
As seen in Exhibit 8, soybean and soybean oil prices have hit near multi-year highs in 2021, and it is no surprise that current and expected demand from the renewable diesel industry has contributed to the rise. For soybean farmers, these price levels are considered an incentive pricing environment in which demand growth outweighs supply growth and commodity prices are typically determined by the highest cost producers. Thus, prices sit at a level that incentivize the highest cost producers to produce and weather events that limit production can cause price spikes, as has been the experience during the 2021 growing season in the U.S.

Exhibit 7: Crop acres in Minnesota, North Dakota and South Dakota relative to U.S. ethanol and biodiesel production



Source: USDA NASS, EIA, Nuveen analysis

Exhibit 8: Soybean and soybean oil prices



Source: Macrobond

Farm profitability has seen an uptick with higher soybean and other agricultural commodity prices. Considering the correlated nature of those prices, a new demand scenario for soybeans, and the production possibilities discussed in the previous section, commodity prices have the potential to remain elevated. This favors farmer margins if input costs can be managed, as those usually rise with farmer income. With healthy farmer margins come increased returns to land which could translate into both income and appreciation upside for farmland.

The increase in soybean and soybean oil prices has been favorable for both farmer and soybean crushing margins. Recognizing the demand pull from renewable diesel for soybean oil, crushers have announced over $1 billion in investments to expand crushing capacity in the U.S. On the other hand, the high cost of feedstock, partially resulting from refineries coming online or being planned, could slow the expansion of the renewable diesel industry. Originally included in this paper's analysis of imminent refinery capacity, CVR Energy announced in August 2021 it was pausing plans to produce 100 million gallons per year of renewable diesel at a refinery in Oklahoma due to high feedstock prices. While this is just one refinery of several expected to come online in the next five years, it is a sign that high input costs could hinder expansion in the near term.

FURTHER SUPPLY AND DEMAND CONSIDERATIONS

This paper contemplates a possible demand shift for soybeans resulting from the expansion of the renewable diesel industry and its need for soybean oil feedstock. This expansion is mainly driven by three states' LCFS that lower the carbon intensity of on-road transportation fuel over time. Yet, other factors exist that could increase the demand for soybean oil further. Three factors not considered in this paper are:

1. The increased use of sustainable aviation fuel (SAF) and biomass-based diesel in the maritime shipping industry. Both would rely on similar feedstocks and end up competing for their use along with renewable diesel.
2. Other states are considering LCFS legislation, and the ratification of those policies would only increase demand for renewable diesel and, in turn, soybean oil
3. The feedstock ratio of soybean oil exceeds 65% as supply of other alternatives remains constrained

There is also the possibility that the supply of soybean oil increases over time, or other uses of the oil decline, freeing up supply for renewable diesel. This could be achieved in several ways, but the most obvious is the gradual decline of the biodiesel industry freeing up feedstock for renewable diesel refiners. In 2020, the biodiesel industry used approximately 1.1 billion gallons of soybean oil. Given the advantages of renewable diesel, it is not unrealistic to believe biodiesel will be outcompeted, but the dissolution of that industry will take time. From a soybean production standpoint, the ratio of soybean to corn acres in areas like the midwestern U.S. could become larger, but that would require consistently higher margins as well as some continuous production, which would be detrimental to agronomics.

The electrification of transportation vehicles poses a downside risk to the estimated demand for soybean oil from the expansion of the renewable diesel industry. Considering the types of vehicles that currently run on diesel in the U.S.- semis, heavy-duty trucks, and fleets like garbage trucks- electrification is not as imminent as with passenger vehicles. The electrification of heavy duty and fleet vehicles will take more time to develop to fully meet the needs of their users in terms of power and distance traveled between charging. This will leave a gap to be filled in the medium term by renewable diesel while electrification catches up to performance standards. Additionally, fleet owners like local governments and construction companies will not purchase all new vehicles once electric trucks with sufficient performance arrive, but will likely phase that capital expenditure over time. While estimating this reduction in diesel demand is beyond the scope of this paper, the California Advanced Biofuels Association estimates a 1% decline in diesel demand per year to 2030 as a result of electrification and renewable natural gas.

A final factor to consider is the political risk around LCFS themselves. The policies already in place in California, Oregon, and Washington are unlikely to change, but LCFS and other initiatives to reduce carbon emissions will add to the cost of living in those states in the near term which could cause pushback from residents and revisions to policy. Further, the food versus fuel and land use debate could sway current or future policies to be more stringent on the carbon intensity of feedstocks, where soybean oil lags compared to recycled fats and oils.

CONCLUSION

State-level LCFS policies are transforming renewable fuel production in the U.S. through credit systems that incentivize low carbon fuel production and adds costs to petroleum-based products. Positioning from new and existing refiners suggests renewable diesel will be a major component of the low carbon transition of transportation fuels. Additionally, the fuel requires no modification to diesel engines and only a small amount of capital expenditure to convert existing petroleum refining and distribution systems.

Through an analysis of company announcements, a conservative 1.9-billion-gallon refining capacity expansion was determined to be imminent over the next four years. This will have a large effect on soybean oil demand and ultimately the demand for soybeans. Prices for both commodities have factored in this additional demand and remain elevated compared to levels experienced over the past five years. This is expected to persist until supply increases or current use adjusts to free up more soybean oil for renewable diesel production. As prices remain elevated, higher farm margins are expected, providing support for returns to land that soybeans and other row crops are produced on.

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A word on risk

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