The California Low Carbon Fuel Standard and Its Consequences

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Since 2011, California’s Low Carbon Fuel Standard (LCFS), intended to reduce greenhouse gas (GHG) emissions from transportation, has heavily influenced California’s fuel markets. The LCFS allows refiners to generate credits if they produce a low-carbon fuel, and requires them to buy credits if they produce a high-carbon fuel. The energy mix has changed substantially since the policy's introduction. In addition, refineries have been converted to generate credits, and motor fuel prices have risen.

In 2011 the California Air Resources Board (CARB) started implementing the Low Carbon Fuel Standard (LCFS). According to CARB, the LCFS is “designed to encourage the use of cleaner low-carbon transportation fuels in California, encourage the production of those fuels, and therefore, reduce GHG emissions and decrease petroleum dependence in the transportation sector.”

In the following article, we discuss how CARB has implemented the LCFS and whether or not it is achieving its goal of reducing GHG emissions.

The LCFS works as an add-on to the federal Renewable Fuel Standard (RFS), implemented in 2006. It creates strong incentives through a carbon credit trading scheme and has caused large changes in the fuel mix in the state.

The main goal of the LCFS is a 20% GHG emission reduction by 2030 along the path shown by the blue line in Figure 1 (on page 2). The yellow line in Figure 1 shows GHG reductions estimated by CARB over the years. If the yellow line is below the blue line, it means the state has claimed a higher
reduction than the standard requires. For example, in 2023, the standard was an 11.25% reduction, but the estimated reduction was 15.34% according to CARB.

Oregon, Washington, and British Columbia have instated similar policies following the LCFS introduction in California. New Mexico also announced its own “Clean Fuel Standard” on February 20, 2024. In this article we consider the workings of the LCFS policy in more detail and discuss its indirect impacts on other outcomes, such as agricultural production and land use.

**How Does the Policy Work?**

The LCFS functions through an accounting mechanism that measures each fuel type against a carbon intensity (CI) target. Carbon intensity equals the number of grams of CO₂ emitted by a fuel per megajoule of energy produced. CARB estimates the CI for each energy source using models that account for emissions throughout a fuel’s life cycle.

Life cycle emissions include not only the tailpipe emissions of a fuel, but also the emissions from the fuel’s entire supply chain. For example, this method accounts for emissions from transporting the fuel from another state to California, emissions from processing inputs (feedstocks) into fuel, and any emissions from converting land to produce more feedstock.

Dirty fuels have a higher CI than the target and accrue deficits; cleaner fuels have a lower CI than the target and generate credits (see Figure 1). For the state to hit the target, the credits must balance the deficits. Over time, as the target becomes more stringent, the number of deficits accrued by each gallon of high CI fuels such as gasoline and diesel increase.

The LCFS’s emissions method also allows for variation in credits generated per gallon across suppliers for the same fuel type, unlike the federal RFS biofuel program. These differences arise from the feedstock used, co-products produced, plant-level efficiency, energy used for processing, and transportation of fuel to California. For example, an ethanol plant powered by renewable natural gas would have a lower CI and generate more credits per gallon than one powered by fossil natural gas.

**Who Is Subject to the LCFS?**

The LCFS regulates obligated parties, defined as petroleum importers,
refiners, and wholesalers. Each year, obligated parties must acquire enough credits to offset their deficits. There are two ways of obtaining credits: 1) buying and blending fuels that generate credits and/or 2) buying credits in the open market.

To better understand the mechanism, consider a refiner producing petroleum diesel (CI=100). Suppose the CI target for diesel is 90 in 2024. As an alternative to petroleum diesel, trucks and buses can run on renewable diesel (RD) made from vegetable oils or animal fats. Renewable diesel made from soybean oil has a CI of about 50 and RD made from used cooking oil has a CI of about 20.

Petroleum diesel is 10 CI units above the target, whereas soybean-oil RD is 40 units below the target, and used-cooking-oil RD is 70 units below the target. Our refiner could comply with the standard by selling one gallon of soybean-oil RD for every four gallons of petroleum diesel, or they could sell one gallon of used-cooking-oil RD for every seven gallons of petroleum diesel. Alternatively, the refiner could buy credits from other companies that sell RD.

This mechanism creates an implied subsidy to produce renewable fuels, especially those with a low CI, while also imposing a tax on dirty fuels. Thus, LCFS credit markets function as a tax transfer mechanism from high CI fuel producers to low CI fuel producers. The higher the credit prices, the higher the subsidy for clean fuel production. Compared to no policy, costs of producing dirty fuels are increased because of the need to either produce clean fuels or purchase credits. Because fuel suppliers are compelled to use a different fuel mix than they otherwise would, we end up with a more expensive fuel mix, which implies higher prices for consumers at the pump.

What Are the Main Sources of Credits?

The main sources of deficits are fossil diesel and gasoline, but an array of different fuels can qualify as credit-generating fuels in the LCFS. Figure 2 shows the energy mix (Figure 2A) and the credit generation (Figure 2B) from credit-generating fuels. Corresponding to the overall large reduction in CI illustrated in Figure 1, we see a large increase in the production of low CI fuels. In 2023, RD was the most consumed renewable fuel in California (Figure 2A), followed by ethanol, biodiesel, biomethane, and electricity.

RD also generated the most credits, followed by electricity, biomethane, ethanol, and biodiesel (Figure 2B). The amount and sources of credit generation are fundamental in determining the value of LCFS credits and, therefore, implied subsidies.

Biomethane has experienced a surge in credit generation since 2020 while contributing only a small increase in energy supply in the state. Biomethane from dairy farms is driving this result. Dairy farmers wash manure into large lagoons, where microbes eat it and emit methane, a potent GHG. Farmers can install an anaerobic digester, which is like a giant cover on the lagoon, to capture the methane and process it for use in natural gas vehicles. Biomethane typically has a large negative CI because farmers get credit based not only on the emissions from the fuel produced but also because covering the lagoon prevents methane emissions that would otherwise have occurred.

The Rise and Fall of Credit Prices

When credit prices are high and expected to remain high, there is an incentive to invest in clean fuel production capacity and to scale back dirty fuel distribution. When credit prices drop, the incentive to produce low CI fuels is reduced.

Credit prices are determined by the supply and demand for credits, given the CI target. Demand for credits is a function of the consumption of dirty fuels; the more dirty fuels consumed, the higher the demand for credits. The supply of credits is determined by the production of clean fuels, i.e., those with a CI lower than the threshold.

From 2018 until late 2021, credit prices traded at relatively high prices, around $200 per metric ton (MT) of carbon dioxide equivalent (CO₂e), as shown in Figure 3. The high prices were due to the lack of credit supply, while deficits from dirty fuels increased. High credit prices mean high subsidies, leading to a significant growth in the investment in credit-generating fuels. After the surge in investment around 2019–2020, especially in RD and biomethane.
production, credit prices—currently at their lowest levels since late 2015—started to trend downward, trading around $60/MT of CO₂.

**LCFS Shortcomings**

The LCFS has reduced measured GHG emissions by encouraging credit generation through, for example, RD production using waste oils. However, the policy also has drawbacks.

First, the LCFS subsidizes fuels with positive emissions, e.g., fuels with a CI above 0 grams of carbon dioxide equivalents per megajoule of energy. Both biofuels and petroleum fuels have net positive emissions, and the LCFS standard is a positive value that lies between the emissions of these two fuels. Petroleum fuels are taxed under the LCFS, but their tax rate may be less than it would be under a full carbon tax. Biofuels are subsidized instead of taxed because they have a CI below the standard. The standard encourages switching from fuels with higher emissions to fuels with lower emissions, but the program still subsidizes fuels with emissions greater than zero. As a result, the program can encourage overconsumption of fuels with net positive emissions.

Second, it is unclear how much of the estimated reduction in emissions would have happened in the absence of the policy. Because of the RFS, biofuels will be consumed in the United States no matter what CARB does in California. Therefore, it is possible that the LCFS is partly shifting consumption of biofuels from other states like Iowa and Texas to California rather than generating emissions reductions at the national level.

Third, generating credits through RD production has caused a large increase in the use of RD feedstock, mainly soybeans, canola, and tallow. This feedstock is converted in large refineries in Louisiana, Texas, and California and then used as fuel in trucks, buses, and trains in California. This consumption of RD in California generates credits, but it has also increased feedstock demand in the United States.

One way in which the United States has been able to meet this higher demand has been through a reduction in soybean and soybean oil exports. There has been a corresponding increase in soybean oil production, for example in Brazil. (See the third article in this issue of ARE Update.) This may have resulted in more deforestation.

In short, despite its effort to reduce emissions intensity, the LCFS mandate falls short when accounting for secondary effects. For example, if the increased demand for agricultural inputs, such as corn or soybeans, causes deforestation, CARB’s calculations may not adequately account for this impact. That means that the substitution from fossil fuels to biofuels might not be as clean as the estimated carbon intensities imply.

**Where Is the Policy Heading?**

Balancing credit prices is the central challenge CARB faces when determining yearly targets. On one hand, high credit prices are good for investment in clean fuels but are generally viewed as burdensome for consumers. Low credit prices, however, are less burdensome but can be insufficient to properly support investment in clean energy. So, what comes next?

CARB has released a new proposition to amend the current LCFS mandate that runs through 2030. The proposal aims to “strengthen the CI reduction benchmarks,” which means the proposal would make dirty fuels generate more deficits. Under these new rules, CARB would increase reduction targets to 30% by 2030, compared to 20%, and a 90% reduction by 2045, compared to 85%.

While this proposal is still under discussion, its clear goal is to elevate credit prices to high enough levels to support continuous investment in the sector. Is this where California should be heading? The stated goal of a drastic increase in the level of GHG reduction from the policy, and the corresponding likely rapid increase in credit prices, means that the current adverse consequences of the policy—higher fuel prices, potential for deforestation, and reduction in agricultural land being used for food production—could be made more severe. A local reduction in GHG is not necessarily beneficial for the planet if GHGs are increased elsewhere as a result of California’s policy.

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