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# Status Review of California's Low Carbon Fuel Standard

## July 2014 Issue

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# Status Review of California's Low Carbon Fuel Standard

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Adopted and implemented in 2010, the Low Carbon Fuel Standard (LCFS) was the world's first policy to address the carbon pollution caused by transportation fuels. A model for similar policies in British Columbia and other U.S. states, the LCFS is designed to reduce greenhouse gas (GHG) emissions, stimulate technology improvements, and help California achieve its climate change goals.

The LCFS contributes to California's overall GHG emission reduction goals under the Global Warming Solutions Act of 2006 (AB 32). It is a performance-based regulation that requires regulated parties (fuel producers and importers to California) to reduce the rated carbon intensity (CI) of the state's transport fuel mix by at least 10 percent by 2020. It sets declining annual targets, starting with a 0.25 percent reduction in 2011 and reaching a 10 percent reduction by 2020.

This report is part of a series providing status reviews on California's LCFS. The periodic status review series by ITS-Davis provides updates on LCFS compliance and markets,[1] and addresses selected special topics. This fourth report addresses the following:

1. Credits and deficits
2. Carbon intensity of fuels
3. Credit trading and credit prices
4. The Federal Renewable Fuel Standard (RFS2), LCFS, and U.S. biofuel imports
5. Special topics: Carbon prices and interactions with a cap-and-trade, key proposed amendments in re-adoption, Pacific Coast Climate and Energy Action Plan

## Highlights:

- **Excess or "net" credits continued to rise**. Fuel suppliers in the program generated excess LCFS credits beyond what was required in every quarter since the program was initiated. Excess credits accumulated from 2011 through 2013 totaled 2.62 MMTCO$_2$e, more than the deficits generated in any single year.
- **Reported emission reductions achieved is equivalent to annual emissions from about 900,000 cars**. From 2011 to the end of 2013, the LCFS generated 6.6 million emission reduction credits (measured in metric tons (MT) of $CO_2$e), equivalent to emissions from about 900,000 cars for a year. Cumulative net credits for the program totaled 3.2 million MT by March 2014.
- **Alternative fuels' energy share increased.** Alternative fuels' share of California LCFS transportation fuels (by energy content) was 6.2 percent in 2011 and 2012 and 7.3 percent in 2013.
- **Ethanol's contribution to credits dropped below 50 percent.** Biofuel accounted for 88 percent of credits for 2011-2013. Ethanol contribution to overall credits dropped below 50 percent for the first time in Q4 2013 (47 percent), due to a thirteen-fold increase in biodiesel and renewable diesel use between 2011 and 2013 [from 14 million gasoline gallon equivalents (GGE) to 185 million GGE].
- **U.S. foreign imports of biodiesel and renewable diesel grew.** U.S. imports of biodiesel and renewable diesel grew

substantially in 2013, to 525 million gallons from 61 million gallons in 2012. California renewable diesel use accounted for 3 percent of total U.S. domestic production plus foreign imports of renewable diesel in 2011, 7 percent in 2012, and 19 percent in 2013.

- **LCFS credit prices have fluctuated.** Daily market reports indicate a peak LCFS credit price in November 2013 near $80, a low in early April 2014 (near $20), and a recent average price just over $25 for the first half of June 2014. The California Air Resources Board's (ARB) reported prices per credit suggest some lags compared to these daily market reports, higher averages and much wider ranges.

The LCFS remains in effect despite several legal challenges in federal and California state courts. Court rulings have pushed back its implementation schedule, however, and will require a program re-adoption, expected in 2015. Proposed program amendments accompanying the re-adoption include streamlined processing of new fuel pathways and LCFS credit price cost containment provisions, aiming to stimulate innovation and commercial production of low-carbon fuels and create market stability for investor expectations.

Looking ahead, California's conventional fossil-based transport fuels will be included in the state's Cap-and-Trade Program beginning in 2015. The Cap-and-Trade Program can have several effects on the LCFS, including impacts on: (1) fuel mix, (2) overall fuel demand, and (3) LCFS credit prices. Meanwhile, other Western states, mainly Washington and Oregon, are considering implementing similar low carbon fuel policies.

## Introduction

The LCFS aims to reduce California's transportation GHG emissions by financially incentivizing innovation and commercial use of low-carbon fuels. Regulated parties can meet the standard by producing low-carbon fuels, buying them to sell on the market, purchasing credits generated by others' production of low-carbon fuels, or combining these strategies. The regulation allows for all fuel types (technology neutral); potential low-carbon fuels include biofuels from waste or cellulosic material, natural gas from petroleum or biomass sources, electricity for plug-in vehicles, and hydrogen for fuel cell vehicles. Due to a state Fifth District Court of Appeal ruling, the standard's 2013 level of 1 percent must remain in effect until the regulation is readopted with corrections to environmental impact analysis procedures, a process likely to go into 2015.[2]

In this issue, we review LCFS compliance metrics from 2011 through 2013: credits and deficits generated and transport fuel energy (Section 1), fuel carbon intensity (Section 2), and credit trading and prices (Section 3). We report on fuel use under the federal Renewable Fuel Standard (RFS2) and the LCFS, focusing on U.S. biofuel imports and California use (Section 4). As special topics, we examine implications of carbon cost under the LCFS, a cap-and-trade program, and the two combined; proposed LCFS amendments that are part of the re-adoption process and the Pacific Coast Action Plan on Climate and Energy (Section 5).

## 1. Credits and Deficits

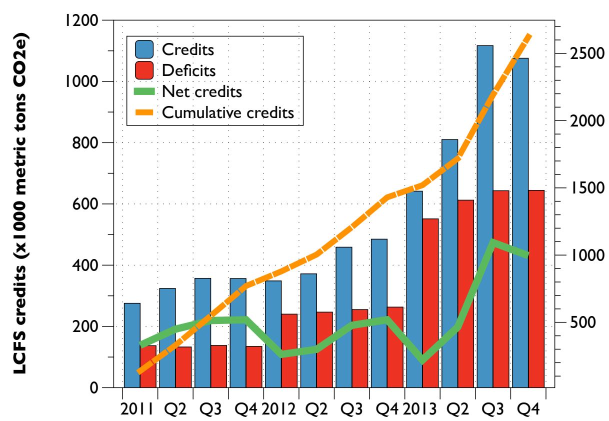


**Figure 1. California LCFS carbon credits and deficits generated per quarter.** Secondary y-axis shows cumulative credits.

By the end of 2013, regulated parties had generated a total of 6.62 million LCFS credits and 4.00 million deficits (Figure 1) under the program. LCFS credits and deficits are generated based on emissions below or above the annual standard, and can be traded or banked for later use. Each credit or deficit represents 1 MT $CO_2$e. More "net" credits (credits minus deficits) per quarter were accumulated in the second half of 2013 than in previous quarters (green line, Figure 1). Net cumulative credits (the area under the green line, and shown by the orange line, right axis) totaled 2.62 million at the end of 2013, and 3.2 million MT LCFS credits through March 2014 (ARB 2014). Total credits from alternative fuels generated in the program (6.6 million MT $CO_2$e) are equivalent to emissions from about 900,000 cars over a year.[3]

In the three-year review period (2011-2013), biofuels accounted for 88 percent of credits generated. Ethanol generated 64 percent of credits, biodiesel and renewable diesel about12 percent each, natural gas from both fossil gas and renewable gases (biogas) about 11 percent [about 8 percent compressed natural gas (CNG), and 3 percent liquefied natural gas (LNG)], and electricity less than 2 percent (Figure 2). Biodiesel and renewable diesel generated 35 percent of total credits in 2013, up from 13 percent in 2012; ethanol's share was 54 percent, and dropped below half (47 percent) in 2013 Q4 (Figure 2, bottom).

Nationally biodiesel and renewable diesel volumes in 2013 increased 73 percent from the 2012 level (Section 4), while the volumes in California increased by five times during the same period, almost entirely from feedstocks generated as a byproduct of other processes: tallow, waste beverages and used cooking oil (Figure 3). Soy biodiesel's share of biofuel credits was less than ½ percent. Sugar-based fuels (sugarcane and molasses ethanol) contributed 11 percent of total biofuel credits and 6 percent of biofuel volume for the period, and generated credits in every quarter for the first time in 2013 (outside the primary Brazilian sugarcane harvest season, Q3 and Q4).

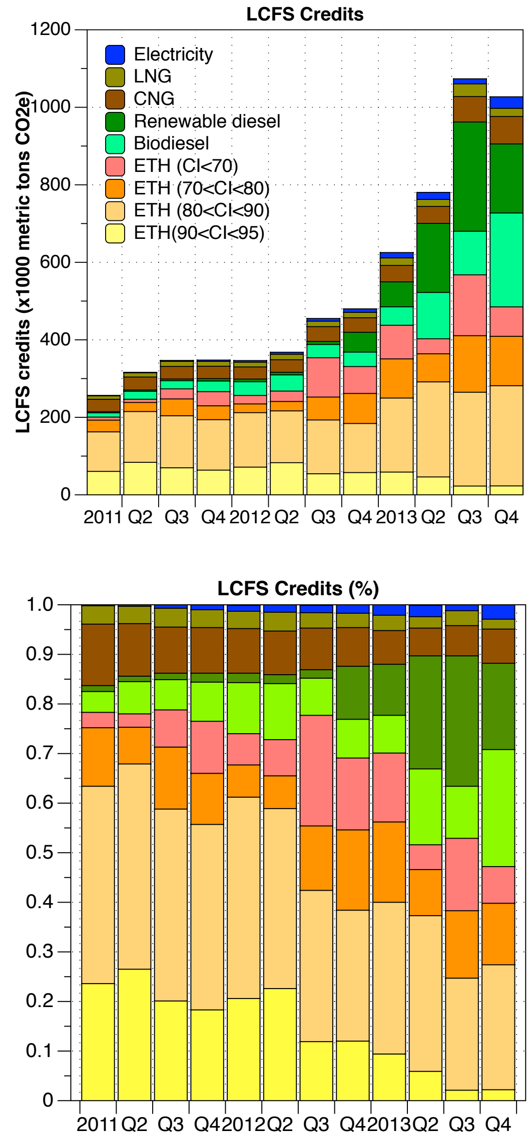


**Figure 2. Total net LCFS credits by fuel type per quarter: number of credits (top) and percentage shares (bottom).** CI is carbon intensity, in grams $CO_2$e per megajoule ($gCO_2e/MJ$).

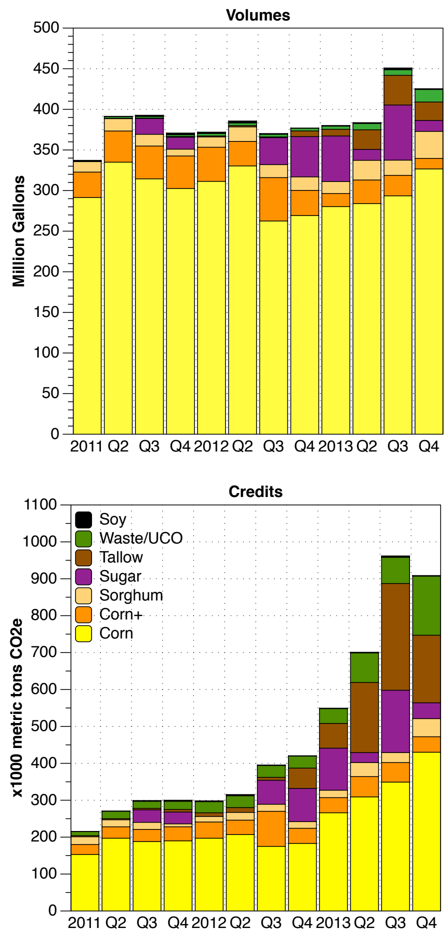


**Figure 3. LCFS biofuels by feedstock per quarter: volumes (top) and number of net credits generated (bottom).** "Corn" pathways include corn ethanol and corn oil biodiesel. "Corn+" pathways include fuels using mixed feedstocks: corn, wheat slurry, and sorghum, plus relatively small volumes of 100 percent canola biodiesel.[4] The "Waste/UCO" category includes diesel substitutes from used cooking oil, and waste beverages to ethanol.

Alternative fuels contributed 6.2 percent of California's transportation fuels by energy content reported under the LCFS for 2011 and 2012 and 7.3 percent in 2013 (Table 1). Non-biofuel based alternative fuels contributed 7.6 percent, 8.7 percent and 9.0 percent of total non-petroleum energy in transportation in 2011, 2012, and 2013, respectively. Electricity contributed 0.4 percent, 1.3 percent and 2.5 percent of the total non-biofuel alternative energy in 2011, 2012 and 2013, respectively [or 1.2 percent, 3.7 percent, and 7.9 percent, after adjusting using ARB's energy economy ratio (EER) for electric drivetrains].[5] The rest was CNG and LNG.

**Table 1. Total transportation energy use [in billion gasoline gallon equivalent (GGE), unless specified as million GGE (mgge)] reported in California's LCFS program.**

| | 2011 | 2012 | 2013 |
|---|---|---|---|
| CARBOB (gasoline) | 12.86 | 12.96 | 12.84 |
| ULSD (ultra-low sulfur diesel) | 3.92 | 4.12 | 3.86 |
| Ethanol | 1.01 | 1.00 | 1.02 |
| Biodiesel (mgge) | 12.0 | 21.1 | 89.8 |
| Renewable diesel (mgge) | 2.0 | 9.6 | 95.3 |
| CNG/LNG (mgge) | 83.2 | 95.5 | 110.2 |
| Electricity (mgge) | 0.35 | 1.22 | 2.76 |
| **Total*** | 17.9 | 18.2 | 18.0 |
| **Alt Fuel (percent of total energy)** | **6.2** | **6.2** | **7.3** |

*The rounded figures are identical if this figure is adjusted by the EER (energy efficiency ratio). See endnote 5 for an explanation of the EER.

## 2. Carbon Intensity

The average fuel carbon intensity (AFCI) of LCFS fuels substituting for gasoline and diesel (and adjusted for EER) declined from 86.7 to 81.3 $gCO_2e/MJ$, and 64.6 to 47.6 $gCO_2e/MJ$, respectively from 2011 to 2013. From Q4 2012 through 2013, lower program average CI rating of the diesel pool and all alternative fuels reflected increased volumes and declining average CI rating of diesel substitutes (Figure 4).

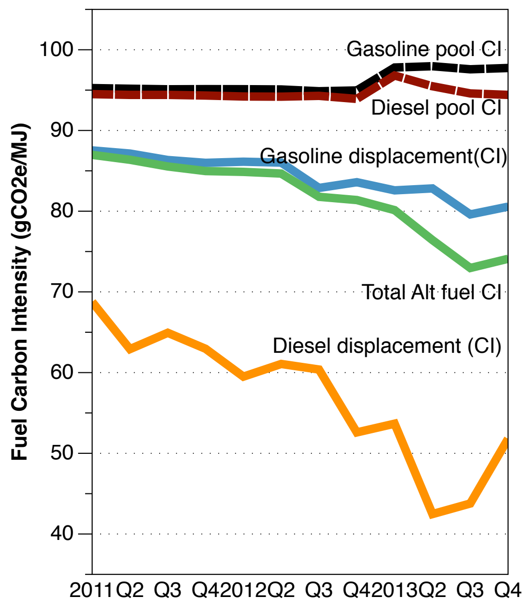


**Figure 4. Average fuel carbon intensities (AFCI) of gasoline and diesel fuels and substitutes** (includes adjustment for EER; see endnote 5).

As of early April 2014, the LCFS had 256 different transportation fuel pathways available for use (plus the two reference fuels), 50 from ARB and 206 provided by regulated parties.[6] Figure 5 shows CI ratings for available pathways, including 154 biofuel pathways submitted for use by individual facilities. There were 168 regulated parties in the LCFS, and a total of 554 individual registered biofuel pathways from 296 registered biofuel facilities, over half of which had demonstrated and had approved a physical route to California from the point of production.[7]

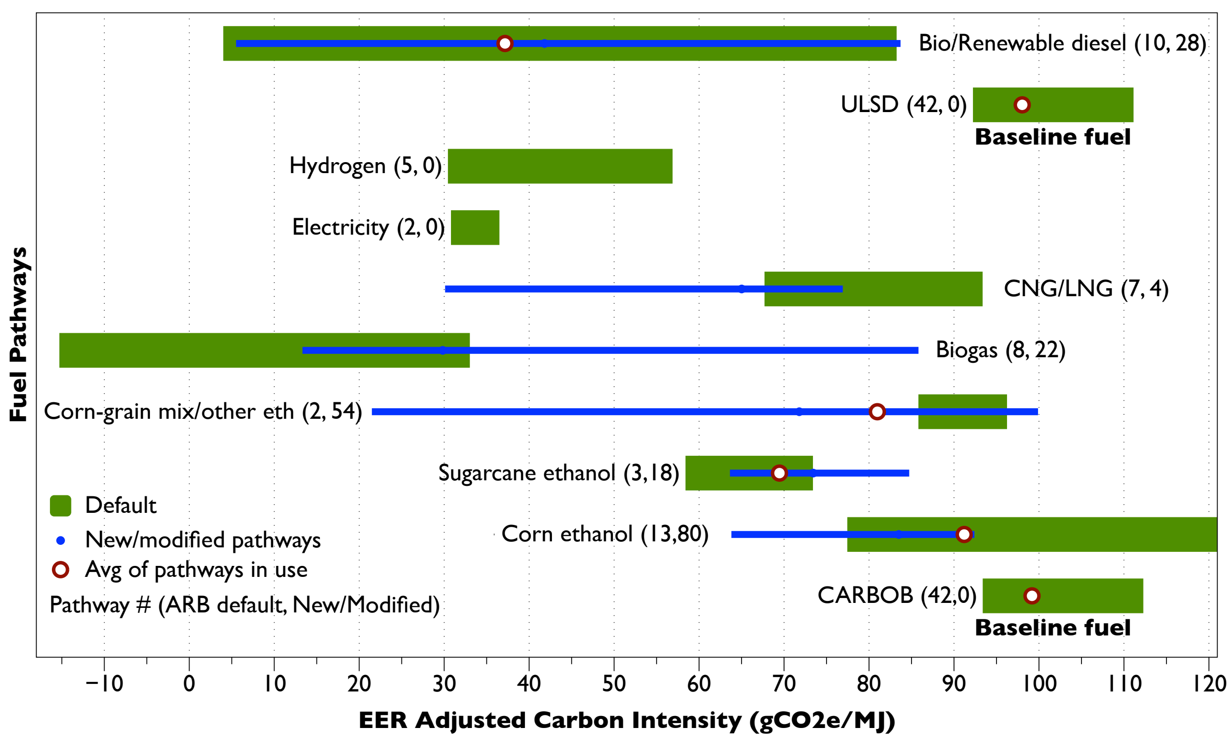


**Figure 5. Carbon intensity (CI) ratings of feedstock/fuel combinations in California's LCFS as of April 2014.** Green bars represent ARB-derived ratings (pathway defaults). Blue bars represent pathways submitted by regulated parties (through Methods 2A and 2B). Red circles represent the average CI ratings of individual biofuel pathways in use (both defaults and new/modified (not weighted by volume). California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB) and Ultra-Low Sulfur Diesel (ULSD) pathway values are calculated using country of crude oil origin; the mean is the reference fuel value used in the regulation. Modified values can be higher than the defaults for a particular feedstock/fuel combination due to differences in technologies used. CI values are adjusted with an energy efficiency ratio (EER) of 3.4 for electricity. "Corn-grain mix/other" ethanol pathways include corn/sorghum, corn/sorghum/wheat mixes, and ethanol from sorghum, molasses, and waste beverages.

## 3. Credit Trading and Credit Prices

LCFS credits are used to meet program compliance, and can be generated, bought, or sold by regulated parties. ARB is not involved with LCFS credit sales, but transfers of credits must be reported to ARB (price reporting is optional). Credit trade and price information is available from several sources: Oil Price Information Service (OPIS) reports on daily bid/ask spreads; Progressive Fuels Limited (PFL), an independent broker in physical biofuel wholesale markets, compiles similar information in a daily biofuels market report; Argus (Argus Media Limited) reports information on transactions; and ARB issues data on traded volumes and average credit price reported to them in a monthly report (http://www.arb.ca.gov/fuels/lcfs/lrtmonthlycreditreports.htm).

Daily market reports indicate a peak LCFS credit price in November 2013 near $80, a recent low in early April 2014 (near $20), and a recent average price just over $25 for the first-half of June 2014 (Figure 6). ARB's reporting of the average price per credit appears to lag when compared to OPIS and PFL (Figure 6), likely to be partly explained by the time difference between buyers accepting a trade and the transfer of credits, which can range from days to months.[8] In addition, the daily market price data is based on volunteered information and prices inferred from bids and asks, whereas ARB reports the weighted average of all executed transactions for which a price was reported. These differences can be important for a thin market like the LCFS credit market.

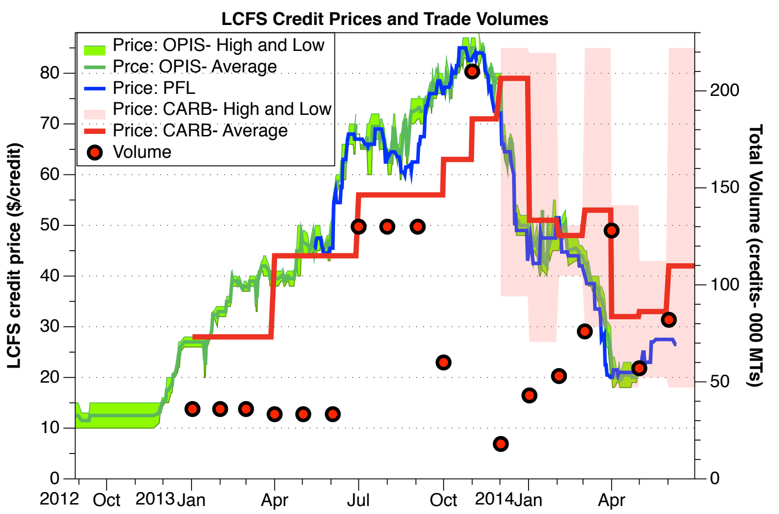


**Figure 6. Range of daily price assessments (range of bids and offers) of LCFS credit prices** from Oil Price Information Service (OPIS) and Progressive Fuels Limited (PFL) daily market reports. From ARB, volumes of LCFS credits transferred (dots, right axis), and average and range of reported credit prices (aggregated quarterly by ARB until 2013 Q4 and shown here as monthly averages; monthly thereafter).

As of June 2014, ARB records show 345 trades involving 1.5 million LCFS credits. Trading volumes peaked in Q3 2013, when court rulings allowed the LCFS to stay in place but froze the standard at 1 percent until the program's re-adoption, expected in 2015 (see Yeh and Witcover, January 2014 and Introduction). Nearly half (48 percent) of the 168 regulated parties reported having transferred credits – 23 percent have sold only, 14 percent have bought only, and 11 percent have both bought and sold credits.

## 4. The Federal Renewable Fuel Standard (RFS2), the LCFS, and U.S. Biofuel Imports

This section examines the relationship between biofuel volumes used under the LCFS and RFS2 programs, focusing on recent import patterns.[9] California represents roughly 10 percent of U.S. transport fuel energy. California sugar-based fuels constituted roughly 20 percent of U.S. sugarcane ethanol imports in 2011, 17 percent in 2012 (when the U.S. imported 486 million gallons during a severe drought that drastically reduced the U.S. corn harvest), and 52 percent in 2013 (Figure 7, left).[10]

U.S. imports of biodiesel and renewable diesel grew substantially in 2013, to 525 million gallons from 61 million gallons in 2012. Principal drivers included federal renewable fuel targets under the RFS2, which increased biomass-based diesel demand to satisfy advanced fuel mandates, and a shift to the U.S. as export destination from other countries, likely due to European Union (EU) antidumping measures imposed on Argentinian biodiesel (U.S. Energy Information Administration (EIA), 2014a). According to the EIA, over 77 percent of total U.S. renewable diesel imports in 2013 came from Singapore and entered the country via the West Coast [Petroleum Administration for Defense District (PADD) 5], probably for use in California for LCFS compliance (EIA, 2014a). Singapore is the source of a Neste Oil registered tallow-based renewable diesel pathway under the LCFS (CI rating 33.5 $gCO_2e/MJ$). Singapore and Finland (another key location for Neste Oil) together accounted for 91 percent and 96 percent of total U.S. renewable diesel imports in 2012 and 2013. California renewable diesel use accounted for 3 percent of total U.S. domestic production plus imports of renewable diesel in 2011, 7 percent in 2012, and 19 percent in 2013 (Figure 7, middle).[11] California's share of U.S. biodiesel is relatively low (7%, Figure 7, right) because of the relatively high CI rating of biodiesel from soybean (83.3 $gCO_2e/MJ$), the predominant U.S. feedstock, compared to alternatives.

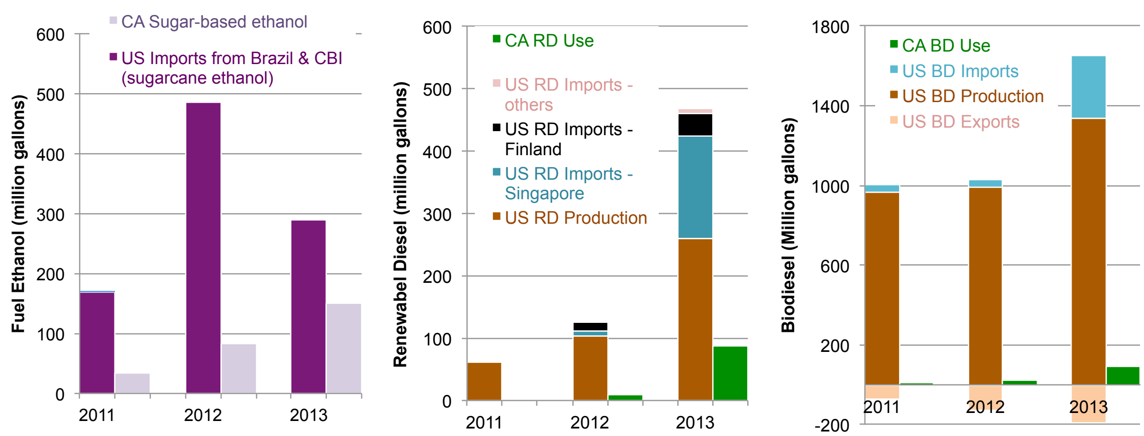


**Figure 7. US biofuel production, imports and use in California – sugar-based ethanol (left), renewable diesel (middle) and biodiesel (right).**[12]

## 5a. Special Topic: Carbon Prices in California's LCFS and Cap-and-Trade Programs and the Supply Cost of Transportation Energy

***Behind \$/ton $CO_2e$: the conceptual difference between an LCFS credit price vs. a cap-and-trade allowance price***

California's LCFS relies on a market mechanism to reduce GHG emissions, captured in the LCFS credit price (measured in \$/MT $CO_2e$). California's Cap-and-Trade Program also relies on a carbon price, measured in the same units, to incentivize GHG emission reductions. Starting in 2015, sectors covered under California's Cap-and-Trade Program will include carbon embedded in fossil energy in the transport sector.

The two market mechanisms and two carbon prices are very different. In a cap-and-trade program, all carbon-emitting sectors covered by the program are subject to a carbon price, known as an allowance price. In contrast, the LCFS imposes a credit price only on transportation fuel emissions *exceeding* the annual standard and applies the same credit price to subsidize transportation fuel emissions *below* the standard. Both a cap-and-trade program and LCFS increase the cost of emissions from petroleum fuels. But an LCFS also adds value to fuels with carbon intensities below the standard. Because of their different price mechanisms, the two policies have different impacts on the costs associated with supplying transport fuels in California.

The fundamental driver of LCFS credit prices is the difference between the cost of the last (i.e., most expensive) unit of fuel used to meet the standard and the cost of the conventional fuel (Lade and Lin 2013). The marginal fuel could be cellulosic ethanol, "E85" (a blend of 85 percent denatured ethanol and 15 percent gasoline), biodiesel, or any other fuel, depending upon relative price differences across fuels. These differences reflect factors such as production cost, capacity constraints to deploy certain fuel technologies, and differences in consumer preferences for alternative fuels and alternative fuel vehicles. An LCFS credit price puts a value on carbon that "bridges" the fuel cost difference between petroleum fuel and low-CI fuels by adding to the cost of providing petroleum fuel while lowering that of the low-CI fuels. On the other hand, the fundamental driver of a cap-and-trade allowance price is the cost of reducing the last (i.e., most expensive) ton of carbon emissions in *all* covered sectors needed to meet the cap; the allowance price is a cost that accrues to *every* ton of covered carbon emitted throughout the system.

***Revenue neutrality of the LCFS***

To illustrate how the two programs' carbon prices numerically translate into dollars per gallon of the various fuels, we consider, as a hypothetical example, the sale of 10,000 MJ of transport energy, using different fuel mixes: all petroleum fuel with CI above the LCFS standard (which incurs a carbon cost under both programs), and two mixes of petroleum and low-carbon fuels (the petroleum incurs a cost under both programs, and the low-carbon fuel receives an incentive under the LCFS). This example of calculated carbon cost does not consider other market effects, including extent of pass-through of cost to the consumer.

In the all-petroleum fuel mix, 10,000 MJ (~84 gallons) of petroleum fuel with a CI of 100 $gCO_2e/MJ$ emits 1MT of $CO_2e$ (10,000 MJ × 100 $gCO_2e/MJ$ = 1,000,000 g or 1 MT). Under a cap-and-trade, a $15/ton allowance price would add $15, or ($15/84 gallons) 18 cents/gallon.

Under an LCFS with a standard at 90 $gCO_2e/MJ$ (a 10% CI reduction by 2020 from 100 $gCO_2e/MJ$), a $15/MT LCFS credit would add only $1.50 to the same fuel at the same volume (or 1.8 cents/gallon), because just 0.1 MT of the same 1MT of $CO_2e$ emissions would be above the LCFS standard (10,000 MJ × (100 – 90) $gCO_2e/MJ$ = 100,000 g or 0.1 MT). This is illustrated in Figure 8 (left chart).

At the same time, the LCFS provides a financial incentive to low-carbon fuels, proportional to their reduction in carbon intensity. For a fuel mix to meet the LCFS, a certain amount of low-carbon fuel needs to be brought to the marketplace to offset petroleum fuel use. The required amount of low-carbon fuels will vary depending on the carbon intensity of the low-carbon fuel(s), as well as the quantity of the conventional fuel.

For a fuel mix that just meets the standard, the LCFS will always be revenue neutral—that is the calculated carbon cost of emissions exceeding the standard will always just equal the benefits of emissions below the standard. Figure 8, middle and right, illustrates two fuel mixes with identical total energies (10,000 MJ) but different volumes of petroleum and low-carbon fuels that both meet the hypothetical LCFS standard (90 $gCO_2e/MJ$): the CI of the low-carbon fuel is 60 $gCO_2e/MJ$ in one mix (middle chart) and 30 $gCO_2e/MJ$ in the other (right chart). The mix with a lower CI fuel can meet the standard using less alternative transport energy. The costs to high-carbon fuel and the benefits to low-carbon fuels would be exactly the same in the two fuel mixes: $1.13 (1.3 cents/gge) and $1.29 (1.5 cents/gge) for fuel mixes with low-carbon fuels of CI = 60 $gCO_2e/MJ$ and CI =30 $gCO_2e/MJ$, respectively, in this particular example.

Under California's Cap-and-Trade Program, the calculated carbon cost for the fuel rises or falls proportionally solely with the amount of petroleum fuel used because the program exempts biofuel emissions. Because blending more biofuels into the fuel mix to meet the standard means less petroleum fuel is needed to meet a constant energy demand, the middle scenario has the lowest cap-and-trade calculated carbon cost in this hypothetical example.

The calculated carbon costs in this illustrative example do not account for relative price effects and market factors that will also affect fuel costs under both programs will most certainly go beyond this illustrative example given the relative prices of fuels and market factors. These are discussed in the next subsection.

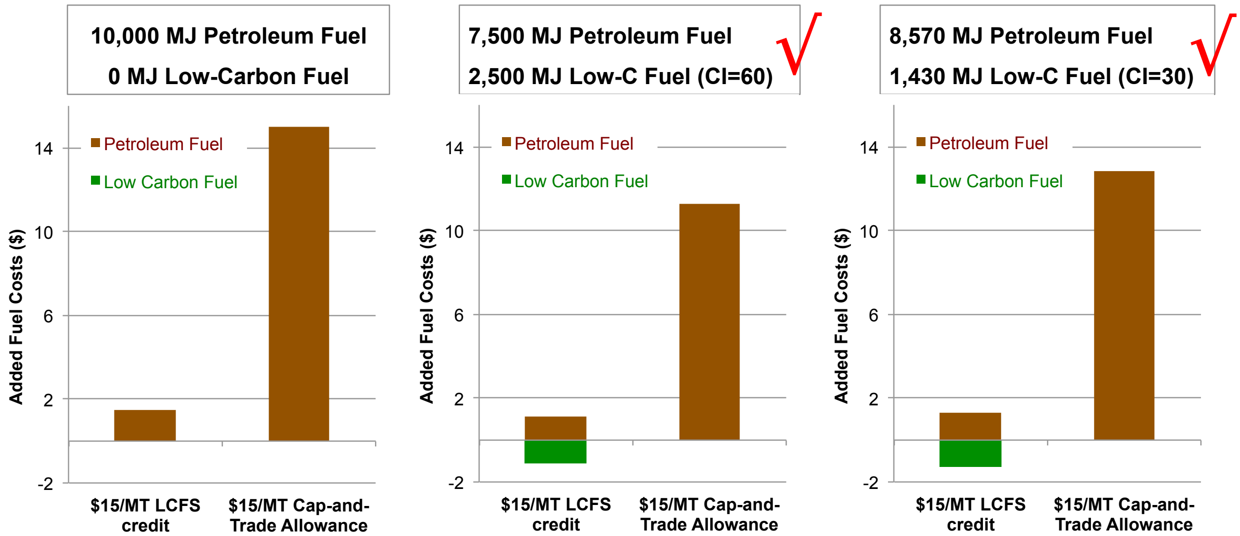


**Figure 8. Simple illustration of added carbon cost under the LCFS (assuming a standard of 90 $gCO_2e/MJ$) and a cap-and-trade program (both at $15/MT carbon price)** for three hypothetical examples of fuel mix totaling 10,000MJ of transport energy. The example on the left does not meet the LCFS standard, and the added cost under the LCFS is to buy compliance credits to cover the LCFS deficit generated by the petroleum fuel. The other two examples exactly meet an LCFS target of 90 $gCO_2e/MJ$ (red check in upper right).

***Fuel Costs Under the Policies***

Revenue neutrality does not imply zero cost. If a low-carbon fuel is more expensive than petroleum fuel, bringing it into the fuel mix will increase overall fuel costs all else being equal, as illustrated in Figure 9 below—using the same hypothetical examples that we illustrated above, with the petroleum fuel and low-carbon fuel of CI = 60 at price parity, and a low-carbon fuel of CI = 30 $gCO_2e/MJ$ that is $0.50/GGE more expensive than the petroleum fuel.[13]

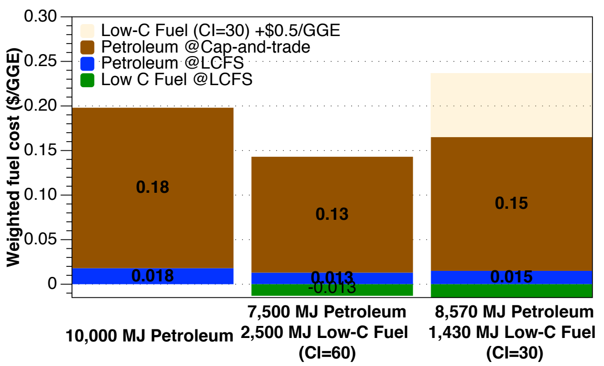


**Figure 9. Overall fuel mix cost increase in a hypothetical example of $15/t LCFS credit price and cap-and-trade allowance price** using the same three fuel mixes as in the hypothetical example illustrated in Figure 8. "Low C Fuel +$0.50/GGE" bar calculates the added cost to the fuel pool if the low-carbon fuel of CI = 30 $gCO_2e/MJ$ is $0.50/GGE more expensive than the petroleum fuel.

Our example above assumed a given level of fuel demand and costs, and several supply possibilities (fuel mix to meet that demand). In real markets, supply and demand for the various fuels will respond to price changes due to both programs, and there will be interaction between the two policies, including their credit prices. Using a simulation model that specifically looks at the relationship between California Cap-and-Trade allowance prices and LCFS credit prices under stylized but calibrated conditions, a study by Lade and Lin (2013) pointed out that interactions between California's LCFS and Cap-and-Trade Program can be important. The Cap-and-Trade Program can have several effects on the LCFS, including impact on: (1) fuel mix, since it slightly distorts relative fuel incentives because the cap does not differentiate between moderate and low-carbon biofuels, only the amount of petroleum in the fuel mix; (2) overall fuel demand, since it further increases the cost of fossil fuels; and (3) LCFS credit prices, lowering them since the program narrows the cost gap separating conventional fuels and the lowest carbon fuel used to comply, the main driver of the credit price (see above). By taking into account a range of possible basic market relationships in supply and demand elasticities (which capture how markets respond to price changes), and assuming all fuel costs are passed along to the consumer (because short-term demand for fuel is only mildly responsive to a price change), the study found that at a $100/ton $CO_2e$ allowance price, fuel prices increased around $0.50/gallon and the LCFS credit price was 30-39 percent lower than without the Cap-and-Trade Program modeled. The study results are not a prediction but a simplified exercise to examine market dynamics. California's Cap-and-Trade Program has a $40-50/ton price reserve (so the $100/ton allowance price is only illustrative); allowances are currently trading around $12/ton.[14]

### 5b. Special Topic: Proposed Re-adoption Amendments[15]

Due to a court ruling, ARB is developing proposed amendments to the LCFS as part of the re-adoption (see Introduction). The revised regulation is expected to be finalized in 2015, and take effect in 2016. The more significant amendments include provisions on:

- **Cost containment.** In the event of high credit prices, ARB is considering several alternative mechanisms for instituting a "cap" on credit prices to provide (1) confidence in the durability of the regulation; and (2) an alternative for compliance, in order to strengthen incentives to invest in low-carbon fuels over the long term. ARB is also considering instituting a floor on credit prices, to further increase the stability of the market signal. An earlier LCFS status review discussed cost containment provisions (Yeh and Witcover, January 2014).
- **Land use change emissions.** The estimates for land use change emissions due to market-mediated effects (so-called "indirect land use change," or iLUC) are being updated. The update reflects a review of, and changes to, the Global Trade Analysis Project (GTAP) economic model that is used to estimate the location, size, and land covers involved in land use change, and a separate agroecological zone emissions factor (AEZ-EF) model. Updated iLUC values could change the relative attractiveness of particular feedstocks. An earlier LCFS status report discussed potential changes to the 2010 baseline for gasoline fuels due to a new corn ethanol iLUC value (Yeh, Witcover, Kessler 2013).
- **Pathway CI evaluation.** ARB is proposing to change the way new pathway applications are evaluated through use of a two-tier method that distinguishes between conventional and innovative pathways. The aim is to streamline the eligibility process for fuel pathways that are well understood (Tier 1) and devote more resources to evaluating CI for newer, less familiar pathways (Tier 2).
- **Innovative crude oil production.** The proposal aims to further incentivize innovative methods to reduce CI on site at crude oil production facilities, such as use of steam, solar, or biomass-based heat or electricity, or carbon capture and storage, by allowing facility owners to directly generate credits. Because all California petroleum fuels have the same CI rating (the California average, based on average crude slate and refinery CIs), the change expands opportunities under the LCFS for actions within the crude oil supply chain to offset petroleum fuel deficits.[16]
- **Electricity credit generation.** The amendment would allow two off-road electricity transport sources to opt in to the program and earn credits: fixed guideway electricity used for transport (such as light rail) and electric forklifts.

Program changes will involve an updated 2010 baseline CI (due to an updated calculation of 2010 California crude average CI and if the updated corn iLUC value is different from the current number). The 10 percent CI reduction target for 2020 remains the same, but the calculated target CI will be updated based on the updated baseline. The compliance trajectory to the 10% CI reduction target for 2020 may also be adjusted because of the 'frozen' standard—1 percent for 2013 to 2015—due to the court ruling (see Introduction).

### 5c. Special Topic: Pacific Coast Action Plan on Climate and Energy

In October 2013, the governments of California, Oregon, Washington, and British Columbia committed to a cooperative leadership plan to combat climate change, including actions to "transition the West Coast to clean modes of transportation and reduce the large share of greenhouse gas emissions from this sector" (Offices of the Governors of California, Oregon, Washington and the Premier of British Columbia, 2014). In each jurisdiction, the mechanism is adoption (Oregon and Washington) or continuation (California and British Columbia) of existing low carbon fuel standards, working towards an integrated West Coast low-carbon fuel market.

A broader market for low-carbon fuels should create a stronger market signal for use of these fuels, and potentially stimulate their production, either in the region or elsewhere.[17] With scale-up of these policies comes a need for proper policy design to identify, monitor, and mitigate any potential undesired consequences such as leakage and shuffling, land use change and other adverse environmental or social impacts.

What the low-carbon fuel market signal would look like depends on the specific designs of the various programs, especially methods for calculating fuel carbon intensity, stringency of program targets, details of program design and implementation, and other factors affecting low-carbon fuel costs in the jurisdictions and beyond (Yeh et al., 2012). Balancing local jurisdictional requirements with the need for harmonization on key program characteristics to meet a longer-term goal of an integrated North American Pacific Coast low-carbon fuel market will require continuous coordination. The plan could also generate key lessons about the adoption of climate policies in multiple jurisdictions as well as expansion into new jurisdictions, including broader international agreements.

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## Endnotes

[1] Summaries and data spreadsheets (including updates of data from previous quarters) from the California Air Resources Board (ARB), which administers the LCFS, are our principal data source (http://www.arb.ca.gov/fuels/lcfs/lrtqsummaries.htm).

[2] http://appellatecases.courtinfo.ca.gov/search/case/mainCaseScreen.cfm?dist=5&doc_id=2002322&doc_no=F064045

[3] Assumes an average fuel economy of light-duty vehicles in California of 21.5 mpg and average miles travelled of 13,254 miles/year, taken from 2010 data (EMFAC2011 Emissions Inventory, ARB).

[4] The "Corn+" category represents different feedstocks than in our January issue: 100 percent sorghum ethanol was previously included in this category but is now separated into its own category (as of ARB data release covering 2013 Q4).

[5] The energy economy ratio (EER) adjusts for the difference of engine efficiency between gasoline engines and electric drivetrains. The ARB EER value for light-duty electricity use was 3 in 2011 and 2012, and 3.4 in 2013. http://www.arb.ca.gov/fuels/lcfs/CleanFinalRegOrder112612.pdf. The change in EER value in 2013 was responsible for a small part of the percentage increase in electricity energy reported in that year.

[6] Of these, 70 have received final approval (http://www.arb.ca.gov/fuels/lcfs/lu_tables_11282012.pdf), and the rest can be used as they await ARB hearings (www.arb.ca.gov/fuels/lcfs/2a2b/040414lcfs_apps_sum.pdf).

[7] http://www.arb.ca.gov/fuels/lcfs/regulatedpartiesreporting20140407.pdf, http://www.arb.ca.gov/fuels/lcfs/reportingtool/registeredfacilityinfo.htm. Average CI rating for added pathways in 2014 Q1: 39.5 $gCO_2e/MJ$ (N=9).

[8] For this reason, ARB is proposing to limit the time the buyer has to accept a trade (15 days) to reduce the amount of pending transfers that would carry from month to month (section 95487(c)(1)(C)).

[9] We report trends but do not account for the many factors that affect the market competition of fuels, such as relative cost of fuel production (e.g., relative feedstock prices), blending credits for use of particular feedstocks, import tariffs or other trade policies in the U.S. and major trading partners for biofuels, such as the EU and Brazil.

[10] Sugar ethanol imports are U.S. fuel ethanol imports from Brazil, the Caribbean Basin Initiative countries, and the U.S. Virgin Islands (EIA 2014b). The figures (imports and California use) include an unknown, but likely relatively small, quantity of sugarcane molasses ethanol.

[11] The U.S. exported some biomass-based diesel in these years (73 million gallons, 128 million gallons, and 188 million gallons in 2011, 2012, and 2013, respectively) (EIA 2014b), but the share from renewable diesel is not available. The figures above are the minimum California share of U.S. renewable diesel use (actual share is higher if renewable diesel is part of reported biomass-based diesel exports).

[12] U.S. renewable diesel production an approximation, derived by subtracting renewable diesel imports (EIA 2014) from domestic renewable diesel Renewable Identification Numbers (RINs) generated under the Renewable Fuel Standard (RFS2) (EPA 2014). Sources: Energy Information Agency (EIA) (import data), Environmental Protection Agency (EPA) (RIN data) and ARB (California fuel use under the LCFS).

[13] Figure 9 (brown, blue, and green columns) shows added fuel carbon costs from Figure 8 in \$/GGE. \$/GGE = total added fuel cost / total MJ x CARBOB energy density (MJ/gallon). e.g., for 10,000 MJ of petroleum under a \$15 LCFS credit (Figure 8, left, left column): (\$1.50/10,000 MJ) x 119 MJ/gallon = \$0.018/GGE (Figure 9, blue section in left column). In the two columns on the right, low-carbon fuels receive LCFS benefits in accordance with their

energy contributions (2500 MJ and 1430 MJ) to the fuel mixes and their CI benefits (green bars). Similarly, petroleum fuel is subject to carbon tax also in accordance with its energy contribution (7500 MJ and 8570 MI)(brown bars, brown bars). If low-carbon fuel of CI = 30 $gCO_2e/MJ$ is on average $0.50/GGE more expensive than petroleum, the resulting additional cost to the fuel mix is simply $0.50/GGE x the proportion of low-carbon fuel in the fuel mix (e.g. $0.50/GGE x 1430 MJ / 10,000 MJ as shown in the right column, light orange).

[14] California carbon allowance future prices for July 2014, reported at http://calcarbondash.org/, based on Intercontinental Exchange (ICE) End of Day reports.

[15] This section draws on ARB's re-adoption concept paper (http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/030714lcfsconceptpaper.pdf), and public workshop materials (http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/lcfs_meetings.htm).

[16] The innovative methods would generate program credits for carbon savings relative to current site operations (not relative to the standard). Under a second proposal, individual fossil fuel refiners would be able to generate credits for site-specific carbon-reducing improvements relative to current operations. In both proposals, participating sites would continue to be included in the calculation of the average CI for California petroleum. Thus, crude oil credit-generating activity would also lower the average California petroleum CI.

[17] California's LCFS is source-neutral. But since lifecycle CI calculations include fuel transport emissions, the locally sourced feedstock could have a lower lifecycle CI, all else being equal. The agreement calls out an intention to open up regional economic opportunities associated with local production of energy, which could be incentivized under an LCFS or by complementary policies.