Status Review of California's Low Carbon Fuel Standard (LCFS) 2011- August 2012

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The Low Carbon Fuel Standard (LCFS) is a performance-based regulation adopted in California in 2010 that requires regulated parties (e.g., oil producers and importers to California) to incrementally reduce the carbon intensity (CI) of the state's transportation fuel mix starting in 2011 with a 0.25% reduction, increasing to 10% reduction by 2020. This regulation contributes to California's overall greenhouse gas (GHG) emission reduction goals under the Global Warming Solutions Act of 2006 (AB32).

This is the first in a series of periodic status reports of California's LCFS. Each report will provide updates on LCFS compliance and markets, and address a selected topic, as follows:

1. Status of LCFS compliance. The observed level of industry compliance and critical questions that affect observed compliance levels.
2. Status of the credit market. Trends in California's LCFS credit trading: number of trades and credit prices.
3. Special topic. In this issue, we examine the effect of the U.S. summer drought on feedstock availability and LCFS compliance.

Highlights

- California's low-carbon fuel market is growing
- Regulated parties in the State's LCFS exceeded the requirements for 2011 and Q1 of 2012 by a substantial margin
- Based on available data, average compliance cost in August 2012 is \$13/MT CO_2e, adding about 0.1 cents per gallon to the production cost of gasoline
- Summer drought increased costs of corn ethanol, but the full impact of the drought on CA-LCFS compliance and compliance costs will not be known for some time

Summary
We find that regulated parties in the California LCFS (CA-LCFS) exceeded the standard in 2011 and the first quarter (Q1) of 2012 by a substantial margin. Companies achieve compliance when credits equal deficits. Regulated parties generated 1.58 million credits (metric tonnes CO_2e reduction) in the first 15 months, nearly double the amount of deficits (0.78 million), for a net surplus of 0.80 million credits to exceed the required reduction level by about 0.8 million metric tonnes CO_2e. Companies relied on ethanol to generate 86% of the credits. The CI of ethanol fuels used to generate CA-LCFS credits in 2011 and first quarter of 2012 averaged around 84 gCO_2e/MJ, compared to baseline values of 95.6 for gasoline.

Because no central trading mechanism exists, we used available information on actual trades, bids, and offers in August 2012 to estimate that CA-LCFS carbon credits were valued at \$10-18/metric tonne (MT) CO_2e, with an average of \$13/MT CO_2e. At this price (\$13/MT CO2e) and given the 2012 requirement of

0.5% CI reduction, companies who choose to meet their obligation purely by purchasing CA-LCFS credits for compliance would incur an added cost of about 0.1 cents per gallon of gasoline produced.

The special topic addressed in this review is the effect of the 2012 U.S. summer drought. We find that poor yields due to extreme drought in the Midwestern U.S. raised corn prices about 60% from mid-June through August, causing ethanol prices to rise about 60 cents per gallon. The actual impacts of the drought on this year's CA-LCFS compliance and on other food/fuel prices are not yet clear. Even with current higher corn prices, corn ethanol is still less expensive than gasoline on a per gallon basis and considerable amounts are being exported. Given that companies have until March 31, 2013 to acquire additional credits to meet 2012 compliance requirements, and corn and sugarcane ethanol markets are still adjusting to the drought's effects, it is too soon to gauge the drought's overall impact on CA-LCFS compliance and compliance cost.

We will continue periodic publication of the LCFS Status Review and provide in-depth analysis on critical issues associated with the performance of the CA-LCFS as more data become available.

1. Introduction

In January 2010, California began implementation of the Low Carbon Fuel Standard (LCFS), a performance-based regulation that requires sellers of transportation fuels (e.g. oil companies, refiners) to reduce the average carbon intensity (CI) of the transportation fuel mix by 10% by 2020. Regulated parties have several options to meet the standard. They can produce their own low carbon fuels; buy them from producers and sell on the market; purchase credits generated by others; or use some combination of these strategies.

The LCFS policy is designed to reduce emissions of GHG by creating financial incentives for innovation in, and deployment of low-carbon fuel technologies. For a variety of reasons as described below, many promising low-carbon fuels have higher initial costs than conventional fuels, even when the expected cost of carbon from cap and trade is included (CARB 2009b; Sperling and Yeh 2009). Potential low carbon vehicle-fuel technologies include biofuels from wastes and cellulosic materials, electricity used in plug-in vehicles, and hydrogen used in fuel cell vehicles. These technologies, however, are not widely available, and face significant early market hurdles in terms of initial costs, economies of scale, technological know-how, and market barriers (Yang and Yeh 2012; Sperling and Gordon 2009; NRC 2011, 2004, 2010). The LCFS is a technology-neutral policy that encourages companies to invest in low-carbon fuels technology to meet increasingly stringent performance targets over time in order to overcome these barriers.

After California instituted the policy, other countries and regions have adopted similar programs, including the European Union and British Columbia, Canada, or are considering adopting programs, including Washington, Oregon, and the Northeast and Mid-Atlantic states.

We review compliance progress and estimate credit prices for the California LCFS (CA-LCFS) in Sections 2 and 3, and provide a special topical report on recent weather-related price shocks in Section 4.

2. Compliance

Transportation fuel importers and suppliers in California are required to reduce their average fuel carbon intensity (CI) by 10% by 2020. The standard is back-loaded with increasing stringency in the latter years (Figure 1).

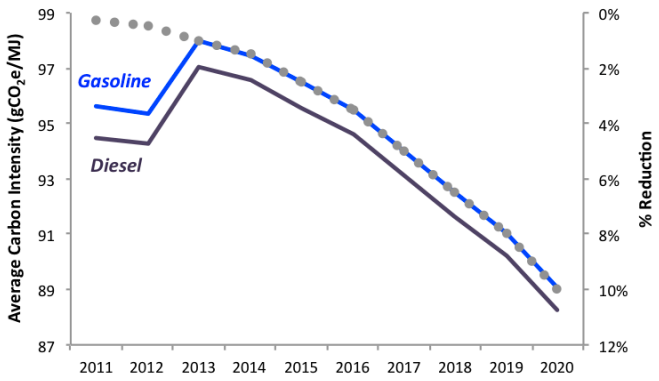


Figure 1. LCFS Compliance Schedule. Regulated parties are required to reduce the carbon intensity of their gasoline and diesel fuels and fuels substitutes (solid lines, left axis) sold in California by increasing percentages, reaching 10% by 2020 (dashes, right axis).[1]

Credits and Carbon Intensity of Fuels. We report on credits and deficits generated through the first five quarters of implementation. Companies achieve compliance when credits equal deficits. Excess credits can be sold or banked for future compliance. In each of these quarters, CA-LCFS regulated parties generated more credits than deficits (Figure 2a), providing them with extra credits that they can use for future compliance obligations. The net credit (credits minus deficits) decreased in the first quarter of 2012 when the CI reduction requirement increased from 0.25% (2011) to 0.5% (2012). Regulated parties generated 1.58 million credits (MT CO_2e reduction) in the first 15 months, nearly double the amount of deficits (0.78 million). Ethanol, primarily from corn, constituted 86% of the credits generated (Figure 2b). The other 14% of credits came mostly from natural gas and biodiesel. Based on Figure 2b, we calculate that the average CI of ethanol used to generate CA-LCFS credits during the period to have been around 84 gCO2e/MJ (compared to baseline values of 95.6 gCO2e/MJ for gasoline).

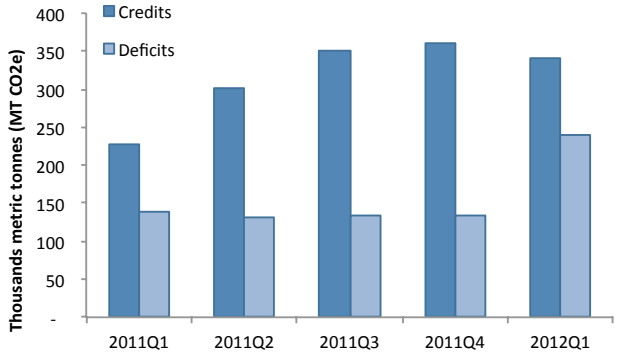
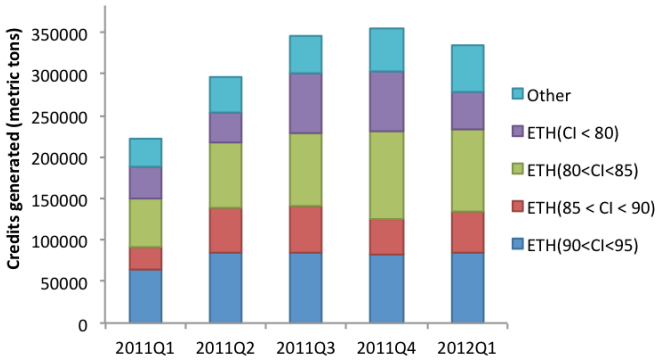


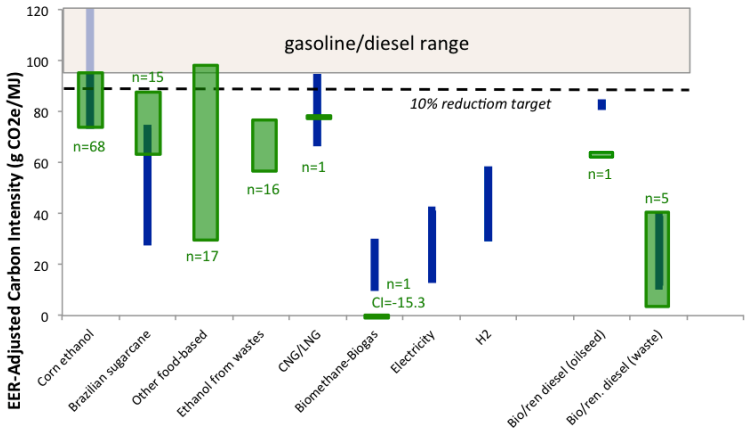
Figure 2. Compliance, Sources of Credits, and CI Values

(a) Total credits and deficits reported by regulated parties through the four quarters of 2011 and the first quarter of 2012. Source: (CARB 2012a)

[1] The average CI requirements for years 2011 and 2012 reflect reductions from base year (2010) CI values for California's reformulated gasoline (CaRFG) calculated using the CI for crude oil supplied to California refineries in 2006. The average CI requirements for years 2013 to 2020 reflect reductions from revised base year (2010) CI values for CaRFG calculated using the CI for crude oil supplied to California refineries in 2010.



(b) Total credits (MT CO_2e) generated by fuel type and CI value ranges. Source: (CARB 2012a)



(c) Lifecycle carbon intensity of fuels by fuel or feedstock type, including default values (blue lines) published by CARB and opt-in values (green bars) submitted as of July 2012. Also included are the numbers of opt-in values for each fuel/feedstock type. Waste diesel category includes waste, corn oil & animal fats. Sources: (CARB 2012b). There is a wide range of pathways within each fuel/feedstock type, resulting in no clear relationship between default vs. opt-in values in this graph.

Opt-in Values. Regulated parties have submitted 124 opt-in CI values for existing or new fuel pathways (Figure 2c). All can be used to generate credits, though nearly 4 out of 5 of the pathways are still awaiting final approval. Some opt-in values exceed default values (Figure 2c), because opt-in pathways using the same feedstock can have very different production processes from what is specified in default pathways (see Method 2b, explained in the LCFS Initial Statement of Reasons (CARB 2009b)).

Principal Feedstocks Used. Based on the ethanol CI value breakdown from Figure 2(b) and CI values from Figure 2(c), a mix of corn and Brazilian sugarcane-based ethanol was the principal means of complying with the CA-LCFS. Without additional data (such as a breakdown of fuel volumes or credits generated by corn vs. sugarcane ethanol in California), we cannot determine the precise role of each fuel.

Until 2010, the U.S. was a net importer of ethanol, primarily from Brazil and the Caribbean (Figure 3a). Starting in 2010, U.S. corn-ethanol exports started trending upward, suggesting adequate supply for domestic needs. In 2011, the U.S. exported more than 28 million barrels of corn ethanol, the highest level in history, to Brazil, Canada, and European countries (Figure 3b, left). In the same year, the U.S. imported about 4.1 million barrels of fuel ethanol, principally Brazilian sugarcane ethanol (EIA 2012a). In 2012, U.S. ethanol exports have remained relatively high, and Canada has been the primary destination (Figure 3b, right). Ethanol imports, mostly from Brazil, climbed up briefly during the second part of 2011 and in summer 2012 (Figure 3a).

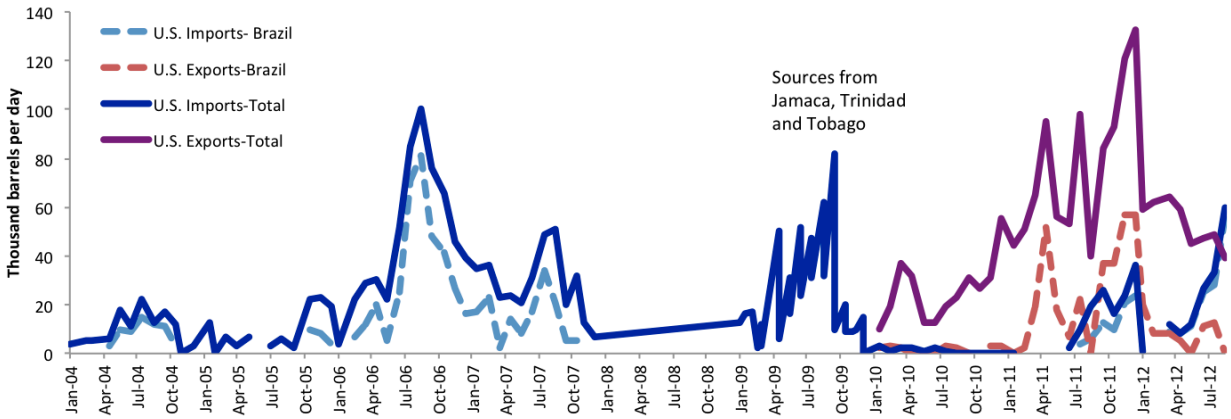


Figure 3a. Fuel Ethanol Imports and Exports, 2004 - August 2012. Source: (EIA 2012a).

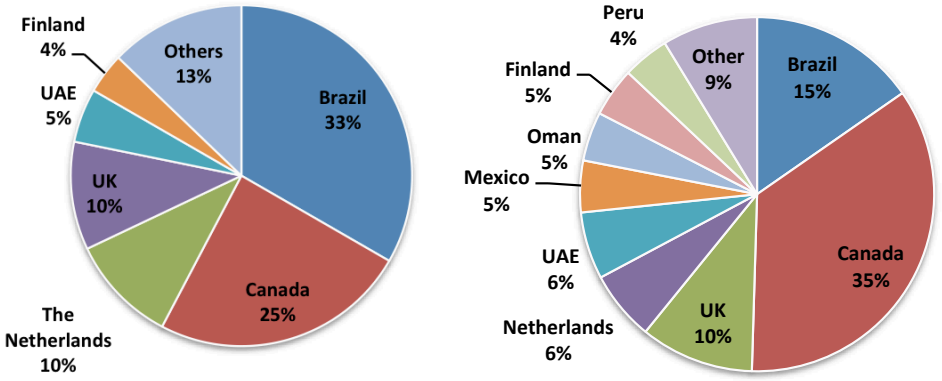


Figure 3b. U.S. Ethanol Exports by Country of Destination in 2011 (left) and January-August 2012 (right). Source: (EIA 2012a).

3. Carbon Credit Trading

By the first quarter of 2012, CA-LCFS had 81 regulated parties, up from about 73 the previous year. They include petroleum fuel producers and importers (explicitly covered by the regulation), as well as low-carbon fuel providers (CARB 2012a) that voluntarily opted into the program to generate and trade low-carbon credits.[2] Roughly half of these opt-in providers are registered in California.

California Air Resources Board (CARB), the regulatory agency of CA-LCFS, only requires trading activity to be reported aggregated over the year. There is no official record of individual CA-LCFS carbon credit trades and prices. However, there are at least three different ways of tracking the trading and value of CA-LCFS carbon credits:

1) **CARB Quarterly Reports**. Through June 2012, CARB reported five LCFS credit trades, ranging in size from 100 to 33,000 MT per trade (CARB 2012a). While total quantity and prices of traded credits were not reported, CARB did include information from news sources of two trades that were executed at $24/MT (CARB 2012a).

[2] It is hard to tell how many out of 81 companies are regulated parties vs. low-carbon fuel providers. A company can be both, or can be a registered oil company in other states but enter California market aiming to provide low-carbon fuels.

2) **Industry Reports.** Data are reported in news media and industry trade groups. In March 2012, Argus Media reported the first delivery of traded CA-LCFS credits earlier that month, when Clean Energy Renewable Fuels (a company that sells compressed natural gas) transferred 33,000 MT CO_2e CA-LCFS credits; the company expect to generate at least 60,000 CA-LCFS credits from its compressed natural gas fuel, and made plans to sell 1.2 million dollars' worth ($20/MT, if for all 60,000 credits) (Argus 2012).

   In August 2012, both Argus and the Oil Price Information Service (OPIS) started publishing CA-LCFS credit market price assessments. OPIS reports a daily range for carbon credits generated for compliance under CA-LCFS, either the traded price range or the range of bids and offers.[3] In that month, the OPIS reported values stayed within a $10-$18/MT range (average of $13/MT)(see orange area in Figure 4).

3) **Implied LCFS Carbon Price.** This price can be calculated based on the same-day price difference between fuels of different CI values, as a proxy for the price of carbon credits. We used the prices of biofuels with different CI values sold in California (in $/gallon of ethanol), dividing by the heating value of denatured ethanol (81.5 MJ/gal, LHV (CARB 2009a)) and the carbon intensity difference (gCO_2e/MJ), multiplied by 10^6. Only two types of corn ethanol prices are currently tracked by OPIS (CI = 90.1 and CI = 98.4 gCO_2e/MJ). Therefore the implied carbon price for meeting CA-LCFS can currently be based only on these fuels, and calculated based on the following equation

$$\text{Implied Carbon Price} = \frac{P_{CI=90.1} - P_{CI=98.4}}{81.5 \times (98.4 - 90.1)} \times 10^6$$

The implied CA-LCFS carbon price has ranged from $0-$33/MT CO_2e (average $16) since late December 2011 (solid lines in Figure 4, right axis). The CA-LCFS carbon credit values reported by OPIS since August 2012 fall in a narrower range than the calculated "implied carbon price" for the same period (comparing the orange area with the solid lines in Figure 4, right axis). At this price ($13/MT CO2e) and given the 2012 requirement of 0.5% CI reduction, companies who choose to meet their obligation purely by purchasing CA-LCFS credits for compliance would incur an added cost of about 0.1 cents per gallon of gasoline produced.

[3] http://opisnet.com/methodology.asp #westcoast. Argus launched a published market price assessment for CA-LCFS credits around the same time. In the future, we hope to compare CA-LCFS credit price assessments in OPIS and Argus data.

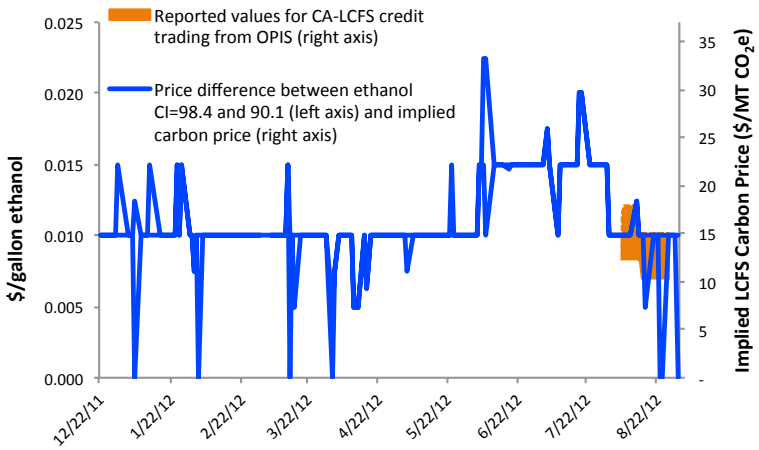
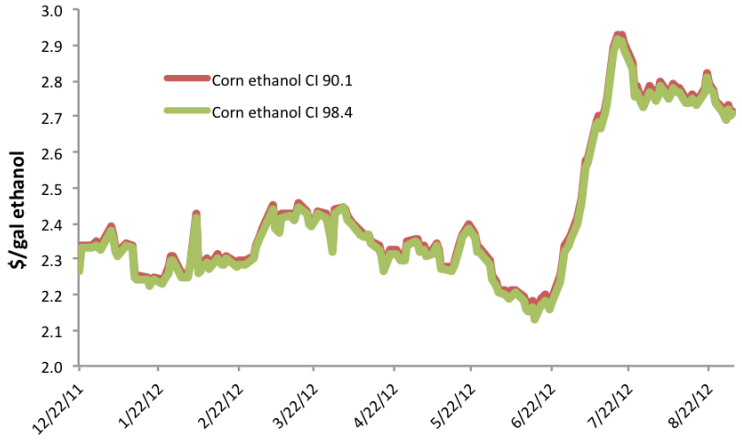


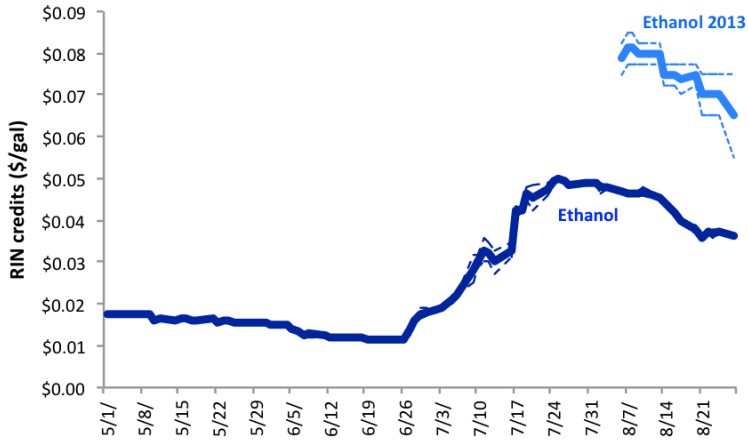
Figure 4. CA-LCFS Carbon Credit Prices. The price differences (left axis) between the two different types of corn ethanol sold in California (CI = 90.1 vs 98.4 gCO_2e/MJ). The right axis shows estimated implied carbon prices ($/MT CO_2e). The orange area shows the reported daily traded price range or range of bids and offers on CA-LCFS carbon credits. Source: based on data extracted from Oil Price Information Service (OPIS) Daily Market Overview.

4. Special Topic: 2012 U.S. Summer Drought

In each status review, we pick a topical issue to discuss. The topic addressed here is the impact of the U.S. summer drought on LCFS compliance. Poor yields from dry weather conditions can raise crop prices, and, consequently LCFS compliance costs. From mid-June to August this year, corn prices rose about 60% and ethanol prices by 60 cents per gallon due to the worst U.S. drought in half a century. California spot prices for corn ethanol reflect these trends (Figure 5a). Higher corn prices could potentially raise the compliance costs of California's LCFS (which uses roughly one tenth of U.S. corn ethanol), as well as the federal Renewable Fuel Standard (RFS2). There are also concerns about compliance with mandates and standards impacting corn prices (with effects on food/feed).

Renewable Identification Numbers (RINs) track fuels used to comply with the RFS2; prices for RIN credits give an indication of market expectation about national fuel availability for meeting the RFS2 mandate, and by extension California's LCFS. Prices for RIN credits associated with corn ethanol increased from 1-2 cents per gallon prior to the drought to a peak of 5 cents per gallon in late July (Figure 5b), a reflection of higher corn prices and lower profitability of corn ethanol production (EIA 2012b). RIN credits associated with other fuels were less affected by the drought (Figure 5c). The price difference between the two types of corn ethanol traded in California (CI = 90.1 vs 98.4 gCO2/MJ) increased in June and July 2012 (Figure 4, solid lines, left axis), increasing the implied carbon price by 30% for these two months (Figure 4, solid lines, right axis). Implied carbon price dropped in August 2012, to below the year's average of around \$15/MT CO_2e, and then to almost zero. The evidence suggests that the drought temporarily increased the value of CA-LCFS credits.





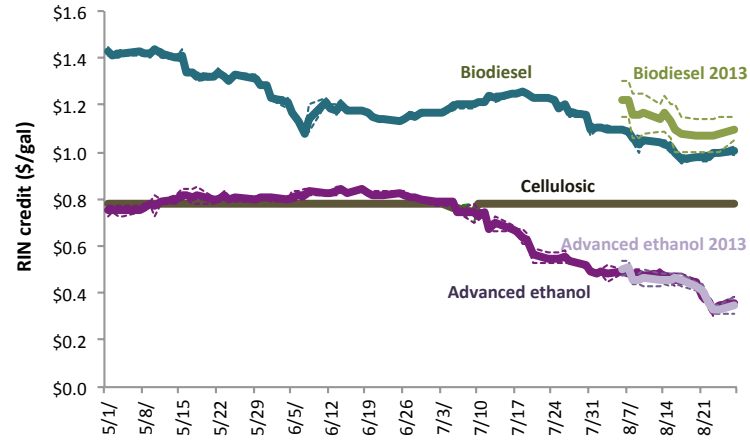


Figure 5. Daily Biofuels Spot Price. Source: based on data extracted from Oil Price Information Service (OPIS) Daily Market Overview.

(a) Ethanol spot price ($/gal) traded in California December 2011-August 2012. 90.1 and 98.4 indicate the carbon intensity of corn ethanol (Midwest; Dry Mill; Wet DGS; NG produced versus Midwest; Dry Mill; Dry DGS, NG produced, respectively).

(b) Corn ethanol RIN prices May-Aug 2012 and 2013 prices (what's being paid to start fulfilling 2013 obligation) for July-Aug 2012. The dashed lines represent the daily max and min values.

(c) Biodiesel, cellulosic and advanced ethanol RIN prices May-Aug 2012 and 2013 prices (what's being paid to start fulfilling 2013 obligation) for July-Aug 2012. Advanced ethanol is currently essentially sugarcane ethanol. The cellulosic is the 0.78 cents cellulosic biofuel waiver credit. The dashed lines represent the daily max and min values.

The ultimate impacts of the drought on the costs of compliance for the CA-LCFS, the RFS2 mandate, and food/fuel prices are less clear. Despite higher RIN and ethanol prices, corn ethanol is still less expensive than gasoline on a per gallon basis (a critical comparison for the blending market) (Tyner, Taheripour, and Hurt 2012). Net U.S. ethanol exports declined through August 2012 relative to 2011, and the U.S. was a net ethanol importer for the month of August. At the same time, ethanol is still being exported at high levels compared to years before 2011 (Figure 3a).

For the RFS2, about 2.5 billion banked RIN credits (~20% of the mandate) are available that could go toward meeting the 2012 mandates (Paulson and Meyer 2012). The use of more banked RIN credits to comply with the RFS2 mandate may imply less corn ethanol available, however, and a potentially higher cost for LCFS compliance. Given that companies have until March 31, 2013 to acquire additional credits to meet 2012 compliance requirements, and corn and sugarcane ethanol markets are still adjusting to the drought's effects, it is too soon to gauge the drought's overall impact on CA-LCFS compliance and compliance cost.

Acknowledgement

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