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Status Review of California's Low Carbon Fuel Standard

Spring 2013
(REVISED VERSION)

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The Low Carbon Fuel Standard (LCFS) is a performance-based regulation adopted in California in 2009 that requires regulated parties (e.g., oil producers and importers to California) to reduce the carbon intensity (CI) of their fuel mix by at least 10% by 2020. It sets declining annual targets, starting slowly with a 0.25% reduction in 2011 and 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 (AB 32).

This is the second in a series of periodic status reports of California's LCFS. Each report will provide updates on LCFS compliance and markets, and address selected special topics. The reports review data, analyze trends, and identify potential challenges, but avoid making predictions. This second report addresses the following topics:

1. Credits and deficits
2. Carbon intensity of fuels
3. Credit trading and credit prices
4. Federal Renewable Fuel Standard (RFS2) and implications for LCFS feedstocks
5. Issues that affect compliance (special topic)

Highlights:

- In 2012, low carbon fuels displaced roughly 1.06 billion gallons of gasoline and 45 million gasoline gallon equivalents (gge) of diesel (representing 6.2% of total gasoline and diesel fuel) at average carbon intensities of 84.95 gCO_2e/MJ (grams of carbon dioxide equivalent per megajoule) and 58.34 gCO_2e/MJ respectively.
- By the end of 2012, the program recorded net excess credits of 1.285 million metric tons (MMT) of CO_2e. This bank of excess credits represents about half of that needed to meet the 2013 LCFS obligation, though some of these credits may be required to offset deficits created from use of higher carbon petroleum fuels in 2011 and 2012.
- Of these net LCFS credits 78% were generated from ethanol, 12% from natural gas and bio-based gases (as liquid and compressed natural gas), 9% from biodiesel/renewable diesel, and 1% from electricity. Biofuels made from waste materials comprised less than 1% of biofuel volumes but generated 10% of biofuel credits, due to their very low CI.
- LCFS credit prices reported to the California Air Resources Board (ARB) averaged about \$13.50/MT CO_2e (metric tons of carbon dioxide equivalents) in 2012 and \$27.70 for the first two months of 2013. Credit prices increased to over \$35 between mid-January and late February 2013, according to Oil Petroleum Information Service (OPIS) and Argus Media (Argus) reports.
- Since implementation, regulated parties have responded to the LCFS by lowering the CI of the California fuel pool. Continued LCFS compliance will require continued CI reductions.

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[1] This revision corrects an error in Section 5a on compliance issues, and in the associated highlight (final bullet on Page 1), that appeared in the initial release of this Spring 2013 Status Review. We apologize for the mistake.

Introduction

In January 2010, the California Air Resources Board (ARB) 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 at least 10% by 2020. The standard is back-loaded with increasing stringency in later years, starting with required reductions of 0.25%, 0.5%, and 1% in 2011, 2012, and 2013, respectively.

The LCFS policy aims to reduce emissions of greenhouse gases (GHGs) by creating financial incentives for innovation and deployment of low carbon fuels. Regulated parties have several options to meet the standard. They can produce their own low carbon fuels, buy fuels from producers to sell on the market, purchase credits generated by others, or use some combination of these strategies. Potential low carbon fuel technologies include biofuels from waste and cellulosic materials, natural gas, electricity used in plug-in vehicles, and hydrogen used in fuel cell vehicles.

In the last status review, which examined compliance in 2011 through August 2012, we found California's low carbon fuel market was growing and regulated parties were exceeding the requirements for 2011 and Q1 2012 by a substantial margin. Based on available data, we found the average compliance cost in August 2012 (the first period that LCFS credit prices were tracked by the industry) was \$13/MT CO_2e, adding about \$0.1 per gallon to the production cost of gasoline (Yeh and Witcover 2012). In this issue, we review LCFS compliance for 2011 through December 2012. We examine credits and deficits generated and fuel volumes (Section 1), carbon intensity of fuels (Section 2), and credit trading and prices (Section 3). We turn to the Federal Renewable Fuel Standard (RFS2) and implications for LCFS feedstocks with a focus on Brazilian sugarcane, cellulosic biofuels, and corn ethanol (Section 4). Finally, we examine three issues related to compliance (Section 5). Those three issues are: (1) meeting the standard under the status quo; (2) the link between the California LCFS compliance schedule and the potential changes in the corn ethanol indirect land-use change (ILUC) carbon intensity value; and (3) interactions between the LCFS and California's Cap-and-Trade program under AB 32.

1. Credits and Deficits

From 2011 through Q4 2012, cumulative credits generated under the LCFS total 2,835,662 metric tons of CO_2e, while cumulative deficits total 1,550,698 metric tons CO_2e, for a net excess of 1.285 million credits (metric tons of CO_2e) (Figure 1). If all available for use,[1] the bank of excess credits represents about half of what is needed to cover the 2013 obligation.[2]

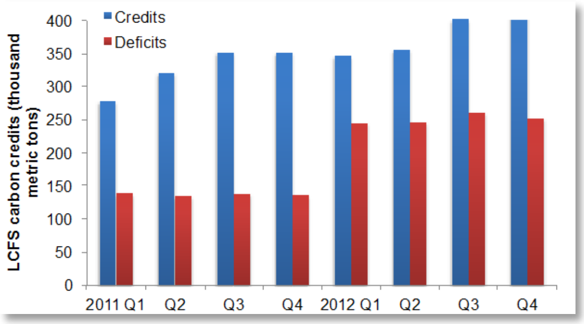

Figure 1. California LCFS carbon credits and deficits generated in each quarter.

Net LCFS credits (excess of credits over deficits) generated per quarter showed an upward trend (Figure 2, top). Credit shares for most fuel types remained relatively constant (Figure 2, bottom). Roughly 78% of net LCFS credits were generated from ethanol, 12% from fossil and bio-based LNG or CNG, and 9% from biodiesel/renewable diesel. Electricity generated 1% of the net credits. The share of electricity grew from negligible levels in 2011 to reach about 2% by the final quarter of 2012.

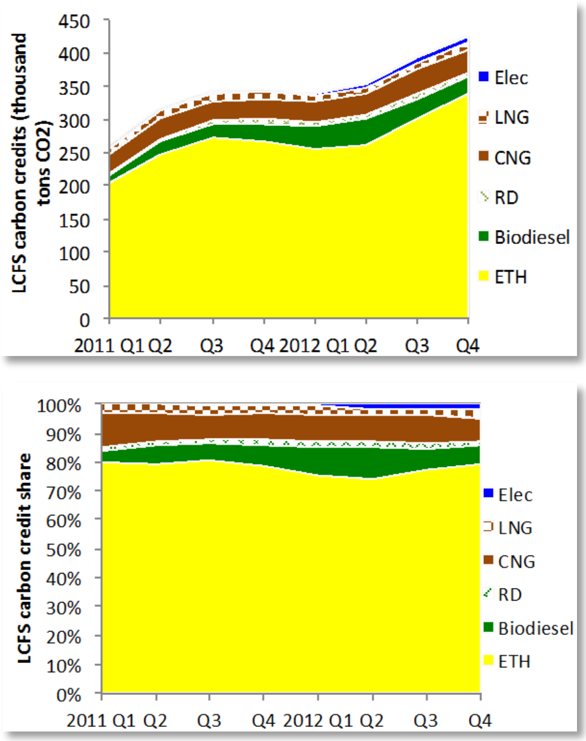

Figure 2. Total net LCFS credits by fuel type per quarter: number of credits (top) and percentage shares (bottom).

Among biofuels, corn and corn/sorghum/wheat mixed ethanol pathways (corn+) constituted the majority of the fuel volume (95%, Figure 3, top) and net credits (80%, Figure 3, bottom). Biofuels using waste as a feedstock (for biodiesel and ethanol) comprised less than 1% of biofuel volumes but 10% of biofuel credits due to their low CI (see next section). Corn/sorghum/wheat mixed ethanol pathways (corn+ in the figure) contributed about 19% of biofuel credits.

Rolling four-quarter averages of net biofuel credits show an increased but still modest contribution from sugarcane ethanol, plus subtle shifts in the feedstock mix towards lower-CI ethanol grain mixes (corn+) and waste (Figure 4 and next section).

Overall, in 2012, non-petroleum based fuels contributed 6.19% (energy content) of the total transportation fuel mix (Table 1). This amounts to an annual average displacement of about 1.06 billion gallons of gasoline and 45 million gasoline gallon equivalents (gge) of diesel. The average fuel mix was about 11.5% (by volume) ethanol in the gasoline mix (some fuels are sold as E85, 85% ethanol blended in gasoline) and 0.5% biodiesel/renewable diesel in the diesel mix.

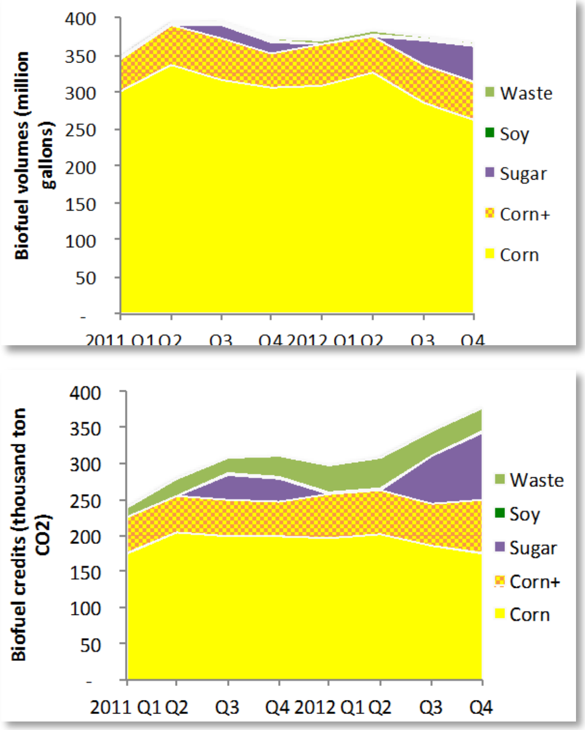

Figure 3. LCFS biofuels by feedstock per quarter: volumes (top) and number of net credits generated (bottom).

Corn+ refers to corn/sorghum/wheat mixed ethanol pathways.

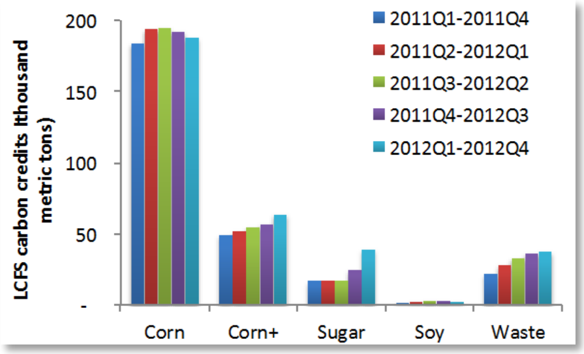

Figure 4. Rolling four-quarter averages of LCFS net credits generated by biofuel feedstock.

Table 1. Total transportation fuel volumes (in billion gge, unless specified as million gge (mgge)) reported in California LCFS program.

	2011	2012
CARBOB (gasoline)	12.90	12.78
ULSD (ultra-low sulfur diesel)	3.91	4.02
Ethanol	1.02	1.00
Biodiesel/renewable diesel (mgge)	13.2	21.9
CNG/LNG (mgge)	74.4	84.0
Electricity (mgge)	0.12	1.06
Total	**17.92**	**17.91**

2. Carbon Intensity of Fuels

The average fuel carbon intensity (AFCI) of gasoline and diesel substitutes declined over the period, from 87.7 and 63.4 gCO_2e/MJ, respectively, in Q1 2011 to just below 83.2 gCO_2e/MJ and 59.6 gCO_2e/MJ, respectively, in Q4 2012 (Figure 5).

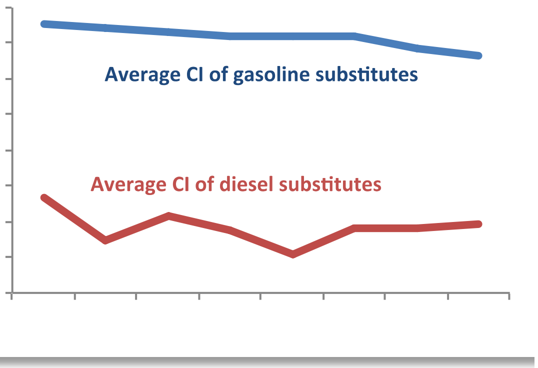

Figure 5. Average fuel carbon intensities (AFCI) of gasoline and diesel substitutes.

CI within fuel types and feedstock pathways in California's LCFS fuel pool remained relatively stable over the review period (Figure 6). From this and previous figures and tables (Figures 2-4, Table 1), we conclude that, over the period, California achieved a gradual decline in AFCI with a fairly stable contribution from alternative fuels. The reduced AFCI came mostly from moderate CI reductions within corn and corn+ pathways and slightly greater reliance on pathways with lower carbon intensities.

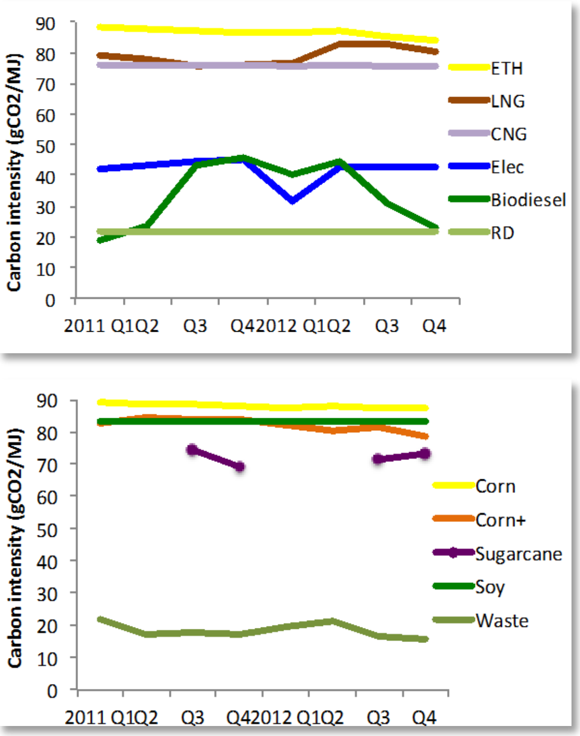

Figure 6. Change in AFCIs over time by fuel type (top) and AFCIs of biofuels by feedstock pathway (bottom).

Figure 7 shows California transportation fuel CIs by individual pathways by the end of 2012, including default values set by the ARB and values provided by regulated parties through Method 2A (improvement through existing pathways) and Method 2B (improvement through new pathways) approaches[3] for a total of 129 default pathways and 105 pathways from regulated parties.

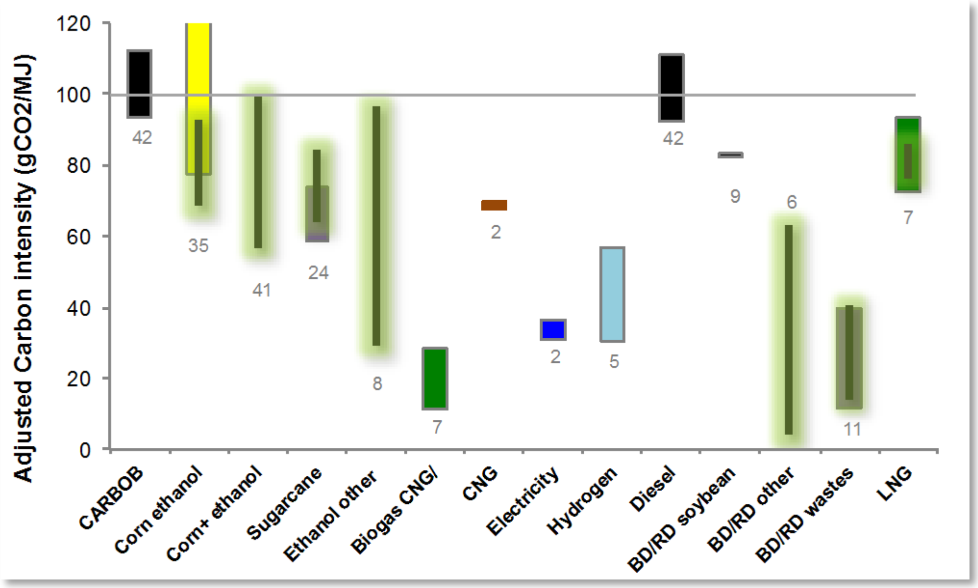

Figure 7. Carbon intensity (CI) values of fuel pathways in use in California's LCFS as of February 2013.

Bars represent the default values determined by the ARB. Glowing lines represent values provided by regulated parties through Methods 2A and 2B. The horizontal line represents the default gasoline (CARBOB) and diesel (ULSD) values (not distinguished at this scale). Numbers under each bar represent the number of default and opt-in CI values for each pathway. Some opt-in values can be lower than the default values in a particular pathway due to differences in the designed vs. actual technologies used. CI values are adjusted with an energy efficiency ratio (EER) of 3.4 for electricity and 2.5 for hydrogen (gasoline displacement). Corn+ pathway is ethanol produced from a mix of grain-based feedstock including corn, sorghum, and wheat slurry. "Ethanol other" includes feedstock from other grains (e.g. sorghum) or waste (e.g. waste beverage). "BD/RD other" includes biodiesel or renewable diesel from other oil seeds or corn oil.

3. Credit Trading and Credit Prices

There is no official record of credit trades and corresponding prices among regulated parties, but the ARB as well as industry trade groups (Oil Price Information Service and Argus Media Limited — OPIS and Argus, respectively) provide some information on the California LCFS credit market.

The ARB's quarterly LCFS summaries track a rise in total number of transactions reported, from five in Q1 2012 to 17 through Q3 2012, to 32 through Q4 2012, with trade volumes ranging from 60–47,500 MT. The most recent ARB summary data indicate a total of about 45 transactions, with 13 occurring thus far in 2013, and more than 250,000 credits traded overall.

Reported credit trade prices ranged from $10–$31 for 2012 and from $25–$35 for 2013 thus far. As of mid-March 2013, the average 2012 LCFS credit trade price reported was $13.50, and the 2013 the average was $27.70.

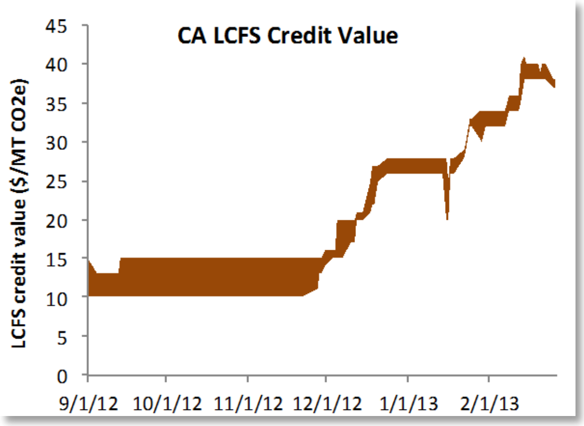

Figure 8. Range of daily price assessment (traded price range or range of bids and offers) on LCFS credit prices.
Based on data extracted from the OPIS Daily Market Overview.

OPIS and Argus both began regular reporting on the LCFS credit market in August 2012.[4] OPIS data show that average daily credit value remained close to $12.50 until late November 2012, rose over the next month to plateau at about $26, and underwent another increase after mid-January 2013 to over $35 in late February (Figure 8).[5] Argus's reported credit values follow a similar trend.

4. Federal Renewable Fuel Standard (RFS2) and Implications for LCFS Feedstocks

Because the RFS2 mandates specific volumes of fuels at particular CI thresholds, it affects the feedstock used to produce U.S. fuels. Such RFS2 feedstock decisions, in turn, have implications for fuel and feedstock use under the LCFS. We examine several feedstock-specific issues in this section.

4a. Brazilian sugarcane ethanol

"Fuel shuffling" generally refers to a case when fuels are moved or "shuffled" from one market to another without any significant change in overall production or fuel characteristics. Low carbon fuel policies provide incentives to use lower CI fuels (such as Brazilian sugarcane ethanol) in place of higher CI ones (such as corn ethanol). Shuffled fuels could indicate that markets are responding to policies that differentiate fuels on the basis of CI. At the same time, if policy incentives do not ultimately encourage the production of more low carbon fuel and less high carbon fuel, shuffling may not reduce emissions and may even increase emissions from transport of the fuels (Meyer, Schmidhuber, and Barreiro-Hurlé 2012).

Many pointed to the fact that U.S. exports of corn ethanol to Brazil increased from zero prior to 2011 to near 1.7 million barrels in December 2011, while U.S. imports of Brazilian ethanol followed a similar pattern (but with lower volume) over the same period. The following year, U.S. corn ethanol exports dropped off due to the summer drought and sugarcane ethanol imports increased, but a two-way trading pattern still existed. Were these examples of policy-induced fuel shuffling?

Factors other than policy play an important role. The global production and trade of ethanol are significantly affected by weather (including the U.S. drought in summer 2012 and poor Brazilian sugar harvest of 2011), prices, and domestic and global demand for biofuels. Global demand is influenced by economic growth, global oil prices, and biofuel and other policies at subnational and national levels in the U.S., Brazil, and elsewhere. The lack of a formal definition of fuel shuffling and the many factors that affect fuel production levels and trade patterns make it difficult to make a conclusive statement about fuel shuffling between corn ethanol and Brazilian sugarcane ethanol during the review period. Several observations emerge from our analysis of monthly trade data[6] (Figure 9):

1. U.S. corn ethanol exports were driven in large part by favorable production economics and soft demand due to economic recession and the E10 "blend wall" that limits the mix of ethanol to no more than 10% of the volume of blended gasoline. A poor sugarcane harvest in Brazil created opportunities for U.S. exports to Brazil and other markets that Brazil usually supplied.[7] Of total corn ethanol exports in 2011–2012, 25% went to Brazil; the rest were delivered to Canada, the United Kingdom, the Netherlands, United Arab Emirates, and others.

2. Federal mandates for advanced biofuels may have been a key factor driving U.S. sugarcane ethanol imports. At the same time, California used 19% of total U.S. imports of sugarcane ethanol during this review period while accounting for only 10% of U.S. consumption of corn ethanol and total fuel. This usage pattern could well be due to the more favorable treatment of Brazilian sugarcane ethanol under the LCFS.

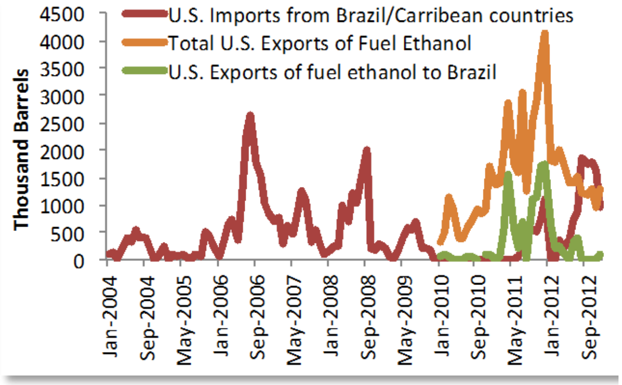

Figure 9. U.S. fuel ethanol exports and imports.

4b. Availability of cellulosic biofuels

In 2012, 21,093 gallons of cellulosic biofuels were produced from waste materials (including 20,069 gallons of cellulosic ethanol and 1,024 gallons of cellulosic diesel). None reached California's market. The actual production was far short of the 8.65 million gallons revised requirement set by the U.S. Environmental Protection Agency (U.S. EPA) under the RFS2. The 2012 requirements were recently vacated by a federal appeals court.[8] For 2013, the U.S. EPA proposed an RFS2 cellulosic biofuel requirement of 14 million gallons, citing likely production from two companies: KiOR (producing gasoline and diesel from wood waste at its plant in Columbus, Miss.) and INEOS Bio (producing cellulosic ethanol from vegetative waste at its plant in Vero Beach, Fla.).[9]

4c. Corn ethanol and RIN values

Renewable Identification Numbers (RINs) are codes assigned to renewable fuel volumes to track RFS2 compliance. RIN prices associated with corn ethanol rose sharply from less than $0.10 per gallon in late 2012 to over $0.40 per gallon in late February 2013 (Figure 10, top), to over a dollar in March 2013 (beyond the period for which we currently have daily data).

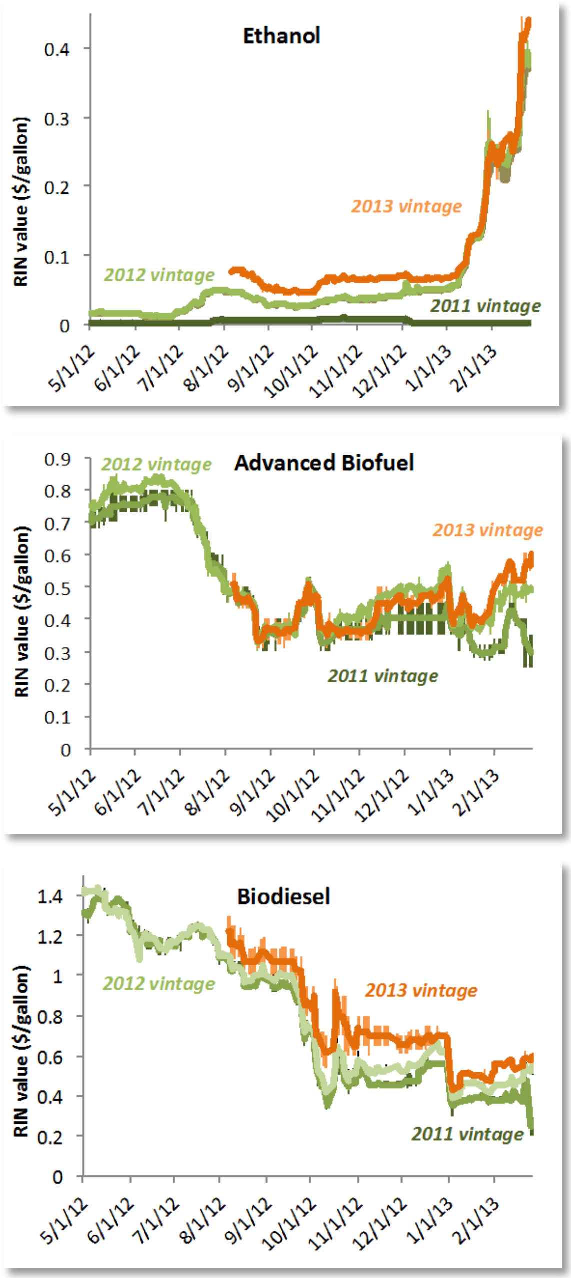

Figure 10. Ethanol, advanced biofuel and biodiesel RIN values (May 2012 - Feb 2013). Note different scales on each of the three y-axes. Based on data extracted from the OPIS Daily Market Overview.

Many believe that this price increase was caused in part by a restriction in the availability of corn ethanol RINs due to the 10% ethanol blend limitation in gasoline. Because refiners are only assigned ethanol RINs after ethanol is blended into gasoline, the 10% ethanol blend wall limits the amount of ethanol that can be blended, and therefore the supply of ethanol RINs. Projections of relatively low post-recession gasoline use may mean fewer RINs generated than needed to meet RFS2 mandate levels in the near future.

Higher ethanol RIN values provide a strong economic incentive for fuels that are not constrained by the blend wall to generate high-value RINs. Such fuels include butanol, E15 (15% ethanol) and E85[10], and so-called "drop-in" fuels like renewable gasoline. But these fuels require technological advances, changes to fueling infrastructure, and/or new vehicle sales.

Values for advanced biofuel RINs (e.g., sugarcane ethanol) and biodiesel RINs (Figure 10, middle and bottom, respectively) were generally higher than those of corn ethanol RINs. Both fuels' RINs saw significant price drops in the second half of 2012, indicating improved expectations of adequate supply for meeting RFS2 requirements in those categories. Ethanol RIN values close to biodiesel RIN values may prompt more biodiesel blending;[11] this could affect use of biodiesel in California.

5. Special Topic: Issues that Affect Compliance

5a. Maintaining the status quo — implications for compliance (REVISED)[2]

In 2012, low carbon fuels displaced roughly 1.06 billion gallons of gasoline and 45 million gge of diesel (or 6.2% of the total volume) at average CIs of 84.95 and 58.34 gCO_2e/MJ, respectively (Section 2). Continuing with the same average fuel mix and CI as reported during the last four quarters of implementation, use of banked credits would allow regulated parties to achieve compliance in 2013 (Figure 11).[12]

This exercise illustrates how the status quo relates to requirements for increased stringency in upcoming years, and is not meant to predict or project how the next few years will play out. Since implementation, regulated parties have responded to the LCFS by lowering the CI of the California fuel pool (Section 2). Continued LCFS compliance will require continued CI reductions. Possible technologies and strategies to comply with the LCFS include continued reductions in CI values of existing biofuels, greater use of low CI fuels such as liquid and gaseous biofuels made from wastes, new investments in cellulosic biofuels, and increased use of CNG, LNG, electricity, and hydrogen.

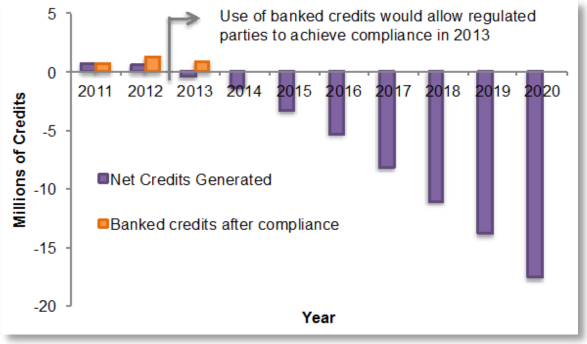

Figure 11. Continued LCFS compliance will require continued CI reductions.

Net credits generated is the number of credits or deficits generated in each period; banked credits after compliance is the number of excess credits banked from the current or previous compliance years.

5b. Corn iLUC factor revision — potential implications for compliance schedule for gasoline and fuels used as a substitute for gasoline

As part of an upcoming regulatory review,[13] the ARB is reviewing its indirect land use change (iLUC) factor values for a range of feedstock pathways, including corn and sugarcane ethanol, soybean biodiesel, and potentially other new feedstocks such as palm, canola, and sorghum. *Only changes to the iLUC factor value associated with corn ethanol would impact the compliance schedule since corn ethanol contributed 7% (on an energy basis) to the 2010 baseline fuel mix* (and the compliance schedule is based on percentage reductions to the carbon intensity of the 2010 baseline fuel mix). While changes to iLUC factors of other feedstock pathways will affect compliance opportunities (i.e., number of carbon reduction credits generated), they will not affect the compliance schedule.

Figure 12 shows how changes in the corn ethanol iLUC factor could change the compliance schedule for gasoline and gasoline substitutes. The larger a change in the corn iLUC factor, the larger the associated shift in compliance schedule AFCI values in the same direction. For example, an increase in the corn ethanol iLUC value from the current value of 30 gCO_2e/MJ would mean: (a) AFCI compliance schedule would be adjusted higher; (b) greater reductions in AFCI values would be required by 2020, and (c) low carbon fuels *other* than corn ethanol would earn more LCFS credits compared to the current standard. A decrease in the corn ethanol iLUC value would cause similar effects in the opposite direction.

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[2] Due to a data entry error (not updating the CARBOB and ULSD default CIs to reflect the most recent changes), the first release of this Spring 2013 Status Review was incorrect. This version corrects that error. We thank stakeholders for feedback that helped us find the mistake.

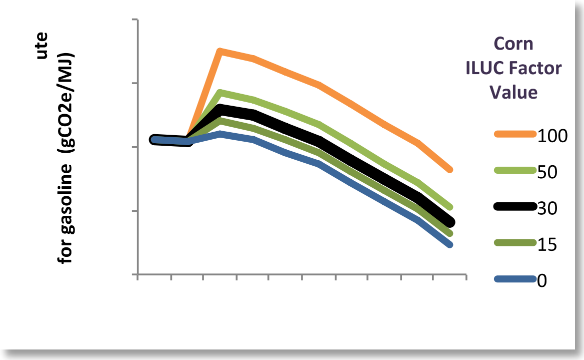

Figure 12. Possible change in requirement for gasoline and gasoline substitutes (from 2013) for a range of corn iLUC factors.
The current compliance schedule corresponds to a corn iLUC factor of 30 gCO_2e/MJ.

5c. Interactions between LCFS and the Cap-and-Trade program

Increased activity in the LCFS credit market occurred in the same timeframe that California held its first two auctions for carbon allowances under its Cap-and-Trade (C&T) program (November 2012 and February 2013, respectively). C&T is meant to incentivize emissions reductions as part of California legislation to reduce GHG emissions to 1990 levels by 2020. The two C&T auctions resulted in carbon allowance prices of \$10.09/MT CO_2e and \$13/MT CO_2e, respectively. While both the LCFS and C&T involve carbon prices, the two carbon markets are not currently linked. Therefore, there is no expectation that the LCFS credit price and C&T allowance price will affect one another.

That said, there are areas of potential overlap between the two programs that could influence carbon prices in both markets in the future for three reasons. First, refinery emissions are counted under the C&T program as well as included in fuel pathway lifecycle emissions accounting under the LCFS. (Under the C&T program, refineries currently receive free allowances covering 75%–100% of emissions in the first compliance period, depending on the complexity of the refinery. On average, 75% of emissions would be freely allocated through 2017, and 50% thereafter.) Improvements in refinery efficiencies can earn allowances under the C&T program but no credits in the current LCFS (though future changes might be possible as discussed in footnote 13).

Second, distributors of transport fuels (including gasoline, diesel and natural gas providers), a group currently covered under the LCFS, will be covered under the C&T program after 2015.

Finally, forest and livestock sectors can generate offset credits under the C&T program. Activity in these sectors could also potentially affect lifecycle emissions of biofuel production.

We are not aware of any quantitative analysis examining the interaction between these two programs. An exploration of possible interactive effects between the programs is a potential special topic in a future issue in this series.

Acknowledgments

The authors would like to thank Air Resources Board staff for generously providing data for this status review. We appreciate research input and comments by Daniel Sperling (Institute of Transportation Studies) and Anthony Eggert (Policy Institute for Energy, Environment and the Economy), University of California, Davis. We also want to thank Bill Peters of Argus Media for his useful insights and generous discussion of various topics covered in this report. The Air Resources Board provided funding for this report as part of a research contract with UC Davis supporting environmental and economic impacts assessments of California's Low Carbon Fuel Standard (contract #11-409).

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Endnotes

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[1] Regulated parties must use banked credits to offset any deficits incurred from importing high carbon crudes in 2011 and 2012. At a recent public workshop, the ARB indicated it would interact with regulated parties to resolve this issue soon. All credits and debits are based on reported quarterly data that may undergo some adjustment after initial reporting but prior to annual reporting deadlines.

[2] Based on ARB projections, and a study of the implementation of a California LCFS (Yeh, Lutsey, and Parker 2009), gasoline and diesel demand will be declining in coming years. Using a more conservative estimate and assuming gasoline and diesel demand remain static at 18.1 billion gge in 2013, meeting the 1% reduction target in 2013 would require approximately 2.55 million credits (metric tons of CO_2e savings).

[3] http://www.arb.ca.gov/fuels/lcfs/lu_tables_11282012.pdf

[4] OPIS makes a daily price assessment, reporting on bids and offers or actual trading range. Argus reports trading prices and volumes for transactions. In the fall 2012 issue of this Status Review, we used the differential in corn ethanol spot prices of varying carbon intensities (reported by OPIS) to compute an implicit price of carbon, to compare against LCFS credit trades. As of October 2012, OPIS reports on corn ethanol only with CI 90.1, so this analysis is no longer possible.

[5] The initial price increase came just after official approval of LCFS regulatory amendments (11/26/2012), and before the onset of 2013 CI reduction requirements (of 1% from 2010 baseline, compared to the 0.5% CI reduction required in 2012). Regulated parties have until they submit 2012 annual reports at the end of April 2013 to trade credits to meet 2012 compliance.

[6] EIA online data, Petroleum & Other Liquids, http://www.eia.gov/petroleum/data.cfm#imports

[7] http://www.reuters.com/article/2011/08/25/us-usa-ethanol-exports-idUSTRE77O3EO20110825

[8] The court found that the requirement had been set with the intention of furthering the technology innovation goals of the RFS2, rather than in line with expectations (as the court interpreted the legislation).

[9] http://www.epa.gov/otaq/fuels/renewablefuels/documents/rfs-2013-standards-nrpm.pdf

[10] U.S. Energy Information Administration. Short-term energy and summer fuels outlook. April 2013. http://www.eia.gov/forecasts/steo/

[11] ibid

[12] Assuming fuel demand remains the same as noted in Section 1. Since a full accounting for high carbon crudes during the review period is pending, this could mean fewer net credits generated and banked credits for 2011 and 2012. As a result, the "status quo" described here could change, along with compliance implications of maintaining the status quo. Given the lack of information, we do not know the magnitude of this effect at this time.

[13] Issues that may be addressed in a scheduled Fall 2013 regulatory review include indirect land use change values, a refinery-specific approach to calculating carbon intensity, electricity credits for fixed guideway transportation and forklifts, and cost containment provisions (the so-called safety valve or price cap).