California Environmental Protection Agency

Air Resources Board

SUPPORTING DOCUMENTATION FOR THE DRAFT REGULATION FOR THE CALIFORNIA LOW CARBON FUEL STANDARD

DRAFT – FOR DISCUSSION ONLY

October 2008

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Note: The draft regulation for the California Low Carbon Fuel Standard is posted on the ARB website at http://www.arb.ca.gov/fuels/lcfs/101008lcfsreg_draft.pdf.

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I. Introduction

This document presents the Air Resources Board (ARB/Board) supporting documentation for the draft regulation for the California Low Carbon Fuel Standard (LCFS). This latest release builds upon the draft concept outline issued in March 2008 and reflects staff's evaluation of the many comments and discussions with stakeholders. Staff appreciates these comments.

The Board is tentatively scheduled to consider the LCFS at the March 2009 public hearing. Staff expects to conduct additional workshops and stakeholder meetings prior to the release of the proposed regulation in February 2009. This current draft is provided to solicit additional comments on approaches and technical analyses. There are several areas that have not yet been addressed in detail. These areas are noted in the text of the document and the draft regulation. These include limits on banking of credits in the early years and consideration of the federal definition of renewable biomass. In addition, staff is continuing to evaluate all aspects of the draft regulation.

In general, the LCFS is based on a system whereby "credits" that are generated from fuels with lower carbon intensity than the standard balance "deficits" that result from the use of fuels with higher carbon intensity than the standard. A regulated party, defined in the draft regulation, is in compliance if the amount of credits is equal to, or greater, than the deficits. Credits and deficits are determined based on the amount of fuel sold, the carbon intensity of the fuel, and the efficiency by which a vehicle converts the fuel into useable energy. The calculated metric is tons of greenhouse gas (GHG) emissions. This determination is made for each year between 2010 and 2020. Credits may be banked and traded within the LCFS market to meet obligations.

The LCFS is based on the use of alternative fuels to conventional gasoline and diesel fuel. Alternative fuels include, but are not limited to, biofuels such as ethanol, biodiesel, and renewable diesel fuel, and compressed or liquefied natural gas, liquefied petroleum gas, hydrogen, and electricity. Each of these fuels will have carbon intensity values associated with the lifecycle analysis that will ultimately include any indirect effects. To date, ARB staff has published draft lifecycle analyses for eight fuel pathways. The published draft analyses do not include indirect effects. These analyses are being conducted separately.

This document presents the current draft analysis of the GHG emissions due to land use changes associated with crop-based ethanol. The analysis reflects staff's commitment to address land use changes and other indirect effects as part of the LCFS. Staff is continuing to conduct analysis on this important part of the LCFS and is working closely with researchers from the University of California, Berkeley and Purdue University. The information in this document reflects the latest analysis and assumptions, along with an estimate of the emission impacts of using crop-based ethanol. However, the values provided are a preliminary estimate and may change significantly as more work is conducted. Other crop-based fuels are also being analyzed (e.g. soybeans and sugarcane), as well as the analysis of any other indirect effects for conventional and alternative fuels. In addition, staff is working closely with staff from the U.S. Environmental Protection Agency (U.S. EPA). This will ensure that work done as part of the LCFS benefits from the analysis of land use changes being performed as part of the 2007 Energy Independence and Security Act (EISA).

This document generally follows the outline of the draft regulation. The draft regulation is provided under separate cover at
http://www.arb.ca.gov/fuels/lcfs/101008lcfsreg_draft.pdf.

II. Applicability of the Low Carbon Fuel Standard

Applicability identifies the transportation fuels subject to, or excluded from**,** the Low Carbon Fuel Standard (LCFS). The LCFS will require transportation fuel providers in California to ensure that the mix of fuel they sell into the California market meets, on average, a minimum of 10 percent reduction in the carbon intensity by 2020 measured in carbon dioxide equivalent gram per unit of fuel energy sold (gCO2e/MJ)**.** The carbon intensity measures the amount of GHG emissions in the lifecycle of a fuel, including extraction/feedstock production, processing, transportation, and final consumption, per unit energy delivered.

In order to meet the 10 percent reduction target and achieve additional climate stabilization beyond 2020, California will need to diversify its portfolio of transportation fuels. This portfolio includes lower carbon ethanol, advanced low-carbon fuels, low-carbon blendstocks, and corresponding vehicle technologies.

For the LCFS, transportation fuel means any fuel used or intended for use as a motor vehicle fuel, other than racing fuel. In addition, transportation fuel includes diesel fuel used or intended for use in nonvehicular sources other than interstate locomotives, aircraft, and marine vessels (except harborcraft). There may be future opportunities to create procedures for reductions in these fuels to gain LCFS credits.

The definition of transportation fuels essentially covers the types of use that are subject to ARB's current standards for gasoline and alternative fuels. In California, "motor vehicle" is defined broadly to include off-road construction and farm vehicles. In addition, "transportation fuel" would include diesel fuel used in nonvehicular sources that are currently covered by ARB's standards for ultra-low sulfur diesel fuel (ULSD). This includes all applications other than locomotives that are not subject to ARB's diesel fuel standards for intrastate locomotives, and marine vessels that are not subject to ARB's diesel fuel standards for harborcraft. Since this broader pool of diesel fuel is all currently subject to the same ARB ULSD standards, there has been no need to segregate different batches being used for vehicular versus covered nonvehicular applications.

The section below presents the staff analysis and rationale behind the selection of the preferred alternative.

A. Discussion

In designing the LCFS, staff determined that excluding particular fuels from the LCFS would reduce incentives to develop and use the full range of low-carbon technologies necessary to achieve the minimum 10 percent reduction by 2020. Therefore, the staff recommends that the LCFS apply to gasoline, diesel, natural gas, propane, electricity, hydrogen, biofuels and biofuel blends such as ethanol and biodiesel/biomass-based diesel used as a transportation fuel.

One of the benefits of this approach is that the inclusion of natural gas and propane pose no particular technical or administrative difficulties and may generate credits under the LCFS program. Additionally, electricity and hydrogen could generate significant credits and play an instrumental role in on-road fuels of the future through innovative fuel production and vehicle technologies. However, electricity and hydrogen pose some complexities.

Including electricity under the LCFS could result in overlaps with other policy instruments such as AB 32, under which emissions for the electricity sector are capped. Furthermore, it would also be necessary to distinguish the electrical energy used to charge battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) from electrical energy consumed for uses unrelated to transportation.

Currently, PHEVs and BEVs can be charged at over 1000 charging stations in California. PHEVs can also be charged from standard 120-volt outlets used for other appliances. Appropriate fuel quantification methods and policies need to be in place to ensure that electricity emissions from transportation or non-transportation uses are clearly distinguished to avoid crediting non-transportation uses. Adequate measurement technologies must be available. The current proposal for electricity is based on the premise that high quality measurement of electricity for vehicular electricity is needed to generate credits in the LCFS. At this time, staff is not proposing to allow estimation techniques for generating credits. Discussions with electricity stakeholders suggest that various measurement technologies are under development.

Hydrogen currently powers a smaller number of on-road vehicles than electricity, but has the potential to expand greatly and provide transportation energy with very low carbon intensity. However, the availability of fuel cell vehicles and the challenges of hydrogen refueling infrastructure development mean that large scale commercialization will not occur in the early years of the LCFS. In addition, the diverse range of GHG emissions from various fuel production technologies (i.e. natural gas reformation, electrolysis, solar, wind, nuclear, and others) provides an additional challenge for immediate regulation. Consequently, staff initially considered the allowance for hydrogen to voluntarily opt-in, in part, due to the low quantity of hydrogen currently used for transportation applications and the challenges associated with hydrogen. However, further discussions with stakeholders suggested that excluding a particular fuel may create an inequitable regulatory framework since other low-carbon fuels, such as electricity, are included in the LCFS.

Staff's current proposal is to include hydrogen but modify the standard to include an Exemption Provision. This provision will allow a fuel provider in some instances to be exempted from the LCFS if the aggregate amount of fuel provided for transportation use in California is below a threshold quantity. The provider of the exempted fuel may still voluntarily provide data to obtain credits but does not have to submit reports for compliance purposes. The exemption from the LCFS is intended to allow alternative fuel providers, particularly small-volume producers whose fuels have inherently low carbon intensities, adequate lead-time to develop the technologies necessary to make their fuels viable for future transportation applications. In the implementation of the LCFS, the exemption could apply to hydrogen, electricity, liquefied propane gas, and other fuels under research and development.

Biofuels such as pure denatured ethanol and pure biodiesel/biomass-diesel, and fuel blends such as E85 and B20 will also be included in the standard. However, they will not qualify for a limited volume exemption.

B. Summary of Staff Recommendations

The staff recommends that the LCFS include mandatory participation for all gasoline, diesel, natural gas, propane, electricity, hydrogen, biofuels such as ethanol and biodiesel/biomass-based diesel, and fuel blends such as E85 and B20 sold, imported or used in California for transportation purposes. The standard does not include fuels used for interstate locomotives, aviation, or certain marine vessels. In addition, the standard exempts alternative fuel producers whose fuels are already low in carbon intensity and fall below a predetermined statewide quantity threshold.

Bibliography

Farrell, A. E., and Sperling, D., 2007. A Low-Carbon Fuel Standard for California. Part 2: Policy Analysis. August 1, 2007, available at http://www.arb.ca.gov/fuels/lcfs/lcfs_uc_p2.pdf

Western States Petroleum Association, July 2007, comments on “A Low Carbon Fuel Standard for CA, UC Report Part II”

U.C. memo on the issue of diesel drive train efficiency and the AFCI values and targets, January 7, 2008

III. Standards

This chapter presents the staff's draft recommendations for the basic structure of the LCFS, the baseline from which the carbon intensity reductions will be measured, and the compliance schedule from 2010 to 2020. The last section presents possible compliance scenarios that could be used to meet the draft compliance schedule included in this section to illustrate how the LCFS might be implemented.

A. Basic Structure of the LCFS

The LCFS establishes steadily decreasing carbon intensity values against which future reductions are measured. These standards are set for each year from 2010 through 2020, in the form of a compliance schedule. Staff expects that more stringent standards will be set in the future for the years past 2020 in order to achieve additional GHG emission reductions to help meet 2050 GHG emission reduction goals.

Staff is proposing that there be two separate compliance schedules listing the standards for each year. The first compliance schedule includes standards that apply to gasoline and alternative fuels that substitute for gasoline. The second compliance schedule includes standards that apply to diesel fuel and alternative fuels that substitute for diesel fuel. In general, alternative fuels that substitute for gasoline and are used for light-duty or medium-duty applications will be compared to the gasoline standard. Similarly, alternative fuels that substitute for diesel fuel and are used in light-duty diesel vehicles, heavy-duty diesel vehicles, locomotives, and off-road diesel vehicles are compared to the diesel standard.

B. Establishing the Baseline

Establishing the baseline includes the baseline year and the baseline carbon intensity of gasoline and diesel, as discussed below.

1. Baseline Year

ARB staff is proposing that 2010 be designated as the LCFS baseline year. Unlike earlier baseline years (such as 2006), gasoline in 2010 is expected to be at or very close to the maximum volume content of 10 percent allowed by federal regulations. The vast majority of ethanol used is expected to be produced from corn. The current draft preliminary analysis of the average carbon intensity of ethanol produced from corn, including the indirect land use change impacts, produces a slight increase in the average carbon intensity of California's gasoline pool from today's level. The land use impacts are discussed in detail in Appendix A.

Therefore, establishing 2010 as the baseline year best represents the gasoline pool in 2010 and provides a solid starting point for reducing the carbon intensity of gasoline and alternative fuels that substitute for gasoline.

The baseline for diesel fuel and alternative fuels that substitute for diesel fuel is also set at 2010. Staff does not expect any significant penetration of alternative fuels that would affect the carbon intensity of the baseline diesel fuel between 2006 and 2010. Therefore, for consistency, the baseline is also set at 2010.

2. Baseline Carbon Intensities of Gasoline and Diesel

The 2010 baseline carbon intensities for gasoline and diesel were calculated using the CA-modified GREET version 1.8b, available at www.arb.ca.gov/fuels/lcfs/lcfs.htm. In order to determine the carbon intensity of gasoline, we assumed an ethanol content of 10 percent by volume. Table 1 shows the assumptions made for average corn ethanol. Twenty percent of the ethanol was assumed to come from the wet milling process, while 80 percent was from the dry milling process. Of the dry milling process, 80 percent of the plants were assumed to dry their distiller's grains and 20 percent sold their distillers grains wet. The total carbon intensity value for gasoline, including 10 percent by volume ethanol, has a carbon intensity of 96.7 gCO_2/MJ. The carbon intensity of diesel in 2010 was calculated to be 95.8 gCO_2/MJ. Details for both gasoline and diesel carbon intensity calculations can be found in the draft lifecycle analyses that are posted on the ARB website.

Table 1
Assumptions for Average Corn Ethanol

Process	Type of DGS	CI	% of Dry Mill	% of Ethanol Mix
Dry Mill	Dry DGS	68.7	80%	80%
Dry Mill	Wet DGS	60.2	20%	
Wet Mill		72.9		20%

3. Standards for 2020

To achieve a full 10 percent reduction from 2006 levels, the standard affecting gasoline and alternative fuels that substitute for gasoline, will need to reach a CI of 86.5 gCO_2/MJ by the year 2020. This reduction will preserve the benefits that the regulation would have achieved in the absence of ethanol-driven land use change impacts. If the CI of gasoline is reduced to 86.5 gCO_2/MJ from 96.7 gCO_2/MJ, a 10.5 percent overall reduction will result.

The greater than 10 percent reduction in the CI of gasoline is driven by the expected changes in gasoline formulations between 2006 and 2010. Today, gasoline contains about 6 percent ethanol made from corn. As discussed previously, by 2010, California's gasoline is expected to contain about 10 percent ethanol made from corn. Emissions from indirect land use changes associated with the production of ethanol from corn are expected to result in a higher carbon intensity in 2010 compared to today's fuel mix. By establishing the LCFS baseline in 2010 and establishing a slightly higher than 10 percent reduction in intensity by 2020, the LCFS will produce a net 10 percent benefit from the 2006 baseline.

No similar issue exists for diesel fuel and alternative fuels that substitute for diesel fuel. Therefore, staff is proposing a 10 percent reduction in the carbon intensity for 2020 for this standard.

C. Compliance Schedules

Table 2 summarizes the draft LCFS regulatory compliance schedule. As discussed previously, there are two separate compliance schedules. The first compliance schedule includes standards that apply to gasoline and alternative fuels that substitute for gasoline. The second compliance schedule includes standards that apply to diesel fuel and alternative fuels that substitute for diesel fuel. These schedules apply to these fuels as they will exist in the baseline year, as well as to the various substitutes and blends that will become available over the compliance period. As Table 2 shows, implementation of the regulation begins in 2010.

Table 2
LCFS Compliance Schedules

Year	CI for Gasoline and Fuels Substituting for Gasoline[1] (g/MJ)	Gasoline and Fuels Substituting for Gasoline % Reduction	CI for Diesel and Fuels Substituting for Diesel (g/MJ)	Diesel and Fuels Substituting for Diesel % Reduction
2010	96.7	0	95.8	0
2011	96.5	-0.3	95.6	-0.3
2012	96.2	-0.5	95.3	-0.5
2013	96.0	-0.8	95.1	-0.8
2014	95.5	-1.3	94.6	-1.3
2015	94.5	-2.3	93.6	-2.3
2016	93.1	-3.8	92.0	-4.0
2017	91.4	-5.5	90.5	-5.5
2018	89.4	-7.5	88.6	-7.5
2019	87.5	-9.5	86.7	-9.5
2020	86.5	-10.5	86.2	-10.0

[1]Justification for the 10.5 percent reduction can be found in the baseline year discussion in the previous section.

The carbon intensity reductions shown in Table 2 are displayed graphically in Figure 1 and Figure 2.

Figure 1

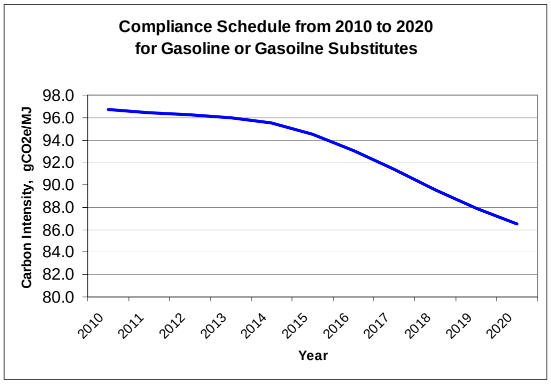
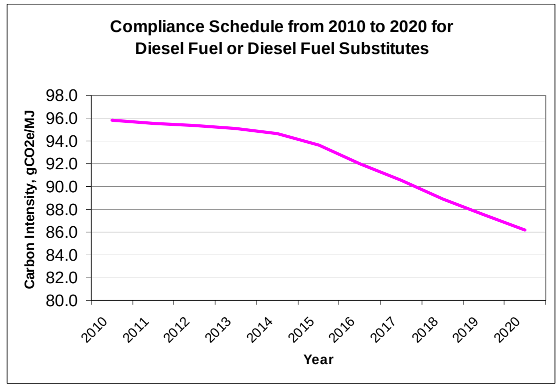


Figure 2



D. Compliance Scenarios

1. Introduction

The draft regulation does not specify which combination of fuels the regulated parties must provide to comply with the standards. Instead, the draft regulation requires producers and importers of transportation fuels to meet an overall carbon intensity for the fuel mix they supply to California. Regulated entities may meet the LCFS by using a combination of fuel blends, alternative fuels, and LCFS credits. Based on current and developing fuel and vehicle technologies, feedstock availabilities, and other factors, ARB staff has identified a number of plausible compliance scenarios. In addition, staff expects to evaluate additional scenarios that are reasonable as well.

In this analysis, staff presents seven possible compliance scenarios; four for gasoline and its substitute fuels and three for diesel fuel and its substitute fuels. Each of these scenarios includes a mix of fuels that satisfy the LCFS. The purpose of describing compliance scenarios at this time is to demonstrate how the draft carbon intensity reductions are achievable, given prevailing and foreseeable future conditions. The compliance scenarios are not intended to predict or forecast the likely combination of fuels and vehicles that will actually be used.

There are uncertainties about the development of future fuel and vehicle technologies. The technologies which currently appear to be most likely to produce marketable quantities of low-carbon fuels and vehicles using low-carbon fuels over the near- to mid-term could encounter technical problems or other delays. The development of other, currently less well known technologies, could benefit from unexpected breakthroughs. One or more of these outcomes could result in a set of compliance scenarios that is different from the set described below.

2. Basis for Developing the Scenarios

There are some basic considerations that apply to the scenarios. These are listed below:

- For fuels derived from corn ethanol, there are improvements in the overall process that results in lower carbon intensity. For the purpose of this analysis, there are two levels of improved corn ethanol: (1) a low-carbon ethanol having a carbon intensity that is about 10 percent better than CARBOB and is representative of the new ethanol plants being built in California, and (2) a low-carbon ethanol having a carbon intensity that is about 20 percent better than CARBOB and that meets the performance standard specified in the 2007 EISA. These fuels are referred to as low-CI ethanol and RFS-compliant ethanol.
- For each gasoline-related scenario, the staff assumed that there was a baseline of approximately 300 million gallons of low-CI ethanol available beginning in 2010 and that this volume would remain available in the California market through 2020.
- There are feedstocks available to produce sufficient quantities of cellulosic ethanol, advanced renewable ethanol, sugarcane ethanol, biodiesel, renewable diesel, and other renewable fuels, as necessary. These feedstocks include, but are not limited to cellulosic waste materials from agricultural, sugarcane, forestry wastes, and municipal wastes.
- There are sufficient numbers of flexible fuel vehicles (FFVs) or advanced technology vehicles to meet the demand for E85, electricity, or hydrogen, as needed. For ethanol, staff assumed that the gasoline blends consist of the maximum allowable 10 percent (E10) in the gasoline fleet or E85 in the FFV fleet.
- Each gasoline-related scenario includes a number of advanced technology vehicles that qualify for credits under the ARB's zero-emission vehicle program. These vehicles could be battery electric vehicles (BEVs), plug-in hybrid vehicles (PHEVs), or fuel cell vehicles (FCVs). For the purposes of this analysis, we have assumed that the percentage of vehicles in each class of these vehicles is the same as that projected for compliance with the 2008 ARB Zero Emission Vehicle (ZEV) regulation.
- The estimate of the carbon intensity of electricity is based on the California marginal electricity mix, where 79% of the electricity comes from highly efficient natural gas plants and 21% comes from renewable sources. Both electricity and hydrogen when used in advanced vehicles result in significant reductions in the carbon intensity of the fuel/vehicle system.
- The LCFS baseline for the gasoline-related standard is projected off the expected California fuel mix in 2010 and assumes E10 is the baseline fuel. Relative to growth, staff assumed that there was a 1.4 percent annual increase in demand for E10 under a business as usual case. For this analysis, staff

- The LCFS baseline for the diesel fuel-related standard is projected off the expected California fuel mix in 2010 and assumes that there are no changes in the carbon intensity of the diesel fuel. Relative to growth, staff assumed that there was a 2.4 percent annual increase in demand for diesel fuel under a business as usual case.
- For each scenario, staff assumes that there is no banking of credits. That is, all credits that are generated are used in the year that they are generated.

Table 3 lists the carbon intensities of the fuels used in the compliance scenarios developed below. These carbon intensities are generally derived from the draft lifecycle analyses posted on the ARB website. (See Chapter VII for a discussion of the basis for the carbon intensity values.) The draft value for corn-based ethanol includes staff's preliminary analysis of the indirect land use change effects. The preliminary analysis of the land use change effects is summarized in Appendix A. In general, other draft values for the indirect land use change effects are estimates assuming that the effects are similar to corn-based ethanol. The indirect land use change term for cellulosic ethanol was assumed to be about one-half that of corn-based ethanol. Staff is continuing to evaluate these impacts and expects to refine these numbers.

A very small portion of the diesel that will be available in 2010 will be blended with biodiesel. Advanced biodiesel's primary feedstocks have no identified lifecycle emissions associated with indirect land use change impacts. These feedstocks include waste fats and oils. Crop-based biodiesel, however, may have land use change impacts and these are estimated in Table 3, based on the preliminary estimates for the land use change impacts of ethanol derived from corn.

In general, the renewable fuel requirements of the Energy Independence and Security Act of 2007 (EISA) provides federal goals for the development of low carbon fuels. EISA increased the amount of renewable fuels that gasoline and diesel fuels must contain under the U.S. EPA's Renewable Fuels Standard. In 2008, 9 billion gallons of renewable fuel must be used, increasing to 36 billion gallons per year by 2022. Beginning in 2013, a certain percentage of the renewable fuels must be advanced- and/or cellulosic-based biofuels and biomass-based diesel, pending final rulemaking by U.S. EPA. In effect, EISA establishes minimum renewable fuel production levels and carbon reduction performance metrics at the national level.

Table 3
Descriptions and Carbon Intensities of Fuels Included in Compliance Scenarios

Foot-note	Gasoline, Gasoline Blendstock, or Replacement	Definition	CI	Land Use Change Term[2]	Current CI Estimate
1	CARBOB	CARBOB in 2010	96.2	0	96.2
1	CaRFG – 2010 baseline fuel	E10	96.7	0	96.7
1,3	Average corn Ethanol	Derived from corn	68.2	35	103.2
4	Low CI Ethanol	Derived from corn, maximize co-product value, improved efficiency, etc.	55.0	35	90.0
4,2	RFS-compliant Low CI Ethanol	This ethanol achieves a 20% CI reduction over CARBOB	42.3	35	77.3
4	Cellulosic Ethanol	Derived from crops	20.0	18	38.0
4	Advanced Renewable Ethanol	Derived from waste	20.0	0	20.0
1	Sugarcane Ethanol	Derived from Brazilian sugarcane	18.7	35	53.7
1,5	Electricity	CA marginal mix, 2010	106.7	0	106.7 (28 adjusted)
1,5	Hydrogen	Derived from methane reforming	153	0	153 (69.6 adjusted)

Foot-note	Diesel Fuel, Blendstock, or Replacement	Definition	CI	Land Use Change Term[2]	Current CI Estimate
1	Diesel	ULSD in 2010	95.8	0	95.8
1	Conventional Renewable Biodiesel	derived from crop	35.3	35	70.3
1	CNG	in 2010	67.9	0	67.9
1,5	Electricity	CA marginal mix, 2010	106.7	0	106.7 (39 adjusted)
4	Advanced Renewable Biodiesel	derived from waste	20.0	0	20

1 CI was calculated using CA-GREET 1.8b with the ARB Interface Tool v1.2_19.
2 Note that the method of treating GHG emissions from indirect land use changes over time is still under review. ARB staff is using 30 years simply as one approach. ARB staff will consider a number of different approaches to evaluate how emissions that occur at land conversions should be considered over time. This could include different time periods (20, 100 years) or alternate approach such as using the net present value approach. Under this approach, future emissions would be assigned a discounted value by sing a discount rate for a specified time interval. Staff is seeking comments on this important issue.
3 CI was calculated using the average available technology and considered the ethanol anhydrous.
4 Best estimate based on the current analysis.
5 The CI of CA marginal electricity and hydrogen is adjusted using electric vehicle energy efficiency ratios.

3. Compliance Scenarios for Gasoline and Gasoline Substitutes

Staff developed four compliance scenarios for gasoline and gasoline substitutes. These scenarios differ in the volumes of corn-based ethanol, cellulosic ethanol, sugarcane ethanol, and advanced renewable ethanol. The number of FFVs assumed to be using E85 and the number of advanced vehicles (BEV, PHEV, FCV) using electricity or hydrogen also change significantly in several scenarios.

In general, the four scenarios can be characterized as follows:

> Scenario 1: Increasing volumes of RFS-compliant ethanol through 2015, then gradual decline to 2020 as advanced renewable fuels replace the RFS-compliant ethanol. Conventional corn ethanol gradually decreases to zero in 2017, but lower intensity corn ethanol remains. Gradual increases in the number of FFVs using E85. The number of advanced technology vehicles (BEV, PHEV, FCVs) using electricity or hydrogen as a fuel increases to about 560,000 vehicles in 2020. This volume is consistent with the penetration schedule in the 2008 ARB ZEV regulation.
>
> Scenario 2: Similar to Scenario 1 except that a wider mix for cellulosic ethanol, advanced renewable ethanol, and sugarcane ethanol is used to comply with the RFS.
>
> Scenario 3: Similar to Scenario 2 except that the number of advanced technology vehicles is increased from 560,000 vehicles to 1 million vehicles in 2020. In turn, the number of FFVs using E85 in 2020 and the amount of cellulosic ethanol, advanced renewable ethanol, and sugarcane ethanol are reduced.
>
> Scenario 4: Similar to Scenario 3 except the number of advanced technology vehicles is increased to 2 million vehicles in 2020 and biofuel amounts are reduced.

The year-by year assumptions used in each scenario are presented in Appendix C. In general, the LCFS can be met through about 2015 with a combination of low-carbon ethanol or RFS-compliance ethanol or through the use of ethanol from sugarcane. For these years, almost all biofuels are used in E10 and very little E85 is needed. However, as the LCFS becomes increasingly more stringent, then the scenarios all transition to either higher volumes of very low carbon ethanol, higher numbers of FFVs using E85, higher numbers of advanced vehicles, or a combination of all three. In all cases, once a specified volume of biofuel is produced, staff assumed that that volume would be maintained throughout 2020. In addition, all scenarios retain about 300 million gallons of low-carbon ethanol that are expected to be produced at existing or under construction California ethanol production facilities.

The results for 2020 are summarized in Tables 4, 5, and 6. Table 4 presents a summary of the amount of fuel used in 2020 for biofuels, electricity, and hydrogen. Table 5 presents a breakdown of the types of ethanol used for each scenario in 2020. Table 5 also shows the amount of ethanol used as a percent of the total amount of E85 and E10 and the amount of ethanol used as a percent of gasoline. For each gasoline-related scenario, Table 6 shows the percent contribution that each fuel type plays in reducing GHG emissions as part of the LCFS for gasoline in 2020.

Table 4
Summary of Fuels and Vehicles Used in Each Scenario to Meet the 2020 Standard for Gasoline and Fuels that Substitute for Gasoline

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Total Volume of Ethanol (Million Gallons)	2,540	2,950	2,430	1,830
Total Amount of Electricity (Gigawatt Hours)	1,153	1,153	2,211	4,422
Total Amount of Hydrogen (Megagrams)	15,800	15,800	24,800	49,600
Number of Advanced Vehicles (Battery Electric, Plug-in Electric, and Fuel Cell Vehicles) (Million of Vehicles)	0.56	0.56	1.0	2.0
Number of Flexible Fuel Vehicles Operating on E85 (Millions)	2.15	2.8	2.0	0.9

[1] Baseline gasoline consists of 90% CARBOB and 10% Ethanol by volume.

Table 5
Summary of Ethanol Use in the Various Scenarios for Fuels that Substitute for Gasoline in 2020

Ethanol	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Low CI Ethanol (Million Gallons)	300	300	300	300
Cellulosic Ethanol (Million Gallons)	0	640	300	370
Advanced Renewable Ethanol (Million Gallons)	2,240	1,400	1,530	820
Sugarcane Ethanol (Million Gallons)	0	610	300	340
Total Volume of Ethanol (Million Gallons)	2,540	2,950	2,430	1,830
Overall Percent of Ethanol in Gasoline	17.7	20.4	17.3	13.6
Volume of E85 (Million Gallons)	1,480	1,930	1,380	620

[1] Baseline gasoline consists of 90% CARBOB and 10% Ethanol by volume.

Table 6
Contribution to Reducing GHG Emissions in the LCFS
For Fuels Substituting for Gasoline Fuel in 2020

Fuel Type	**Percent of Reductions Provided by Each Fuel Type Substituting for Gasoline in 2020**[1]			
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
Cellulosic Ethanol	0	19	10	12
Advanced Renewable Ethanol	89	54	61	35
Sugarcane Ethanol	0	12	6	6
Electricity	10	12	22	45
Hydrogen	1	1	1	2

[1] Baseline gasoline consists of 90% CARBOB and 10% Ethanol by volume.

4. Compliance Scenarios for Diesel Fuel and Substitutes for Diesel Fuel

Staff developed three possible compliance scenarios for the diesel fuel group as summarized below:

Scenario 1: The first scenario is based on a diversification of the liquid fuel pool using available low-carbon-intensity fuels.

Scenario 2: The second scenario includes not only a variety of liquid fuels, but also CNG vehicles penetrating the fleet.

Scenario 3: Diesel Compliance Scenario 3 increases the compliance options by expanding Diesel Scenario 2 to include additional advanced technology vehicles, including PHEVs used to replace conventional diesel vehicles.

All three scenarios require the availability of two categories of non-petroleum diesel:

- Conventional Biodiesel which includes the following:
    - o Conventional biodiesel, made from oil derived from crops uses the fatty acid to methyl ester (FAME) process. Oil from algae can also be used to produce biodiesel via the FAME process. Conventional biodiesel has a carbon intensity of 70 gCO_2/MJ.
    - o Renewable diesel is a hydrocarbon fuel made from the same feedstocks used to produce conventional biodiesel. Renewable diesel is produced using the fatty acids to hydrocarbon–hydrotreatment (FAHC) process. Oil

from algae can also be used to produce biodiesel via the FAHC process. Renewable diesel also has a carbon intensity of about 70 gCO_2/MJ.

- Advanced renewable diesel is a fuel made from non-crop-based cellulosic feedstocks. These fuels do not have a land use change impact. Advanced biodiesel has a carbon intensity of 20 gCO_2/MJ.

The year-by year summaries are presented in Appendix C. In general, as the penetration of CNG vehicles and advanced technology vehicles increases, the need for biodiesel and advanced renewable biodiesel decreases. The increased vehicle penetration also reduces the amount of biodiesel and advanced renewable biodiesel needed for blending into conventional diesel. Even in Scenario 1, where liquid fuels are providing all of the necessary reductions, the amount of alternative fuels needed for blending is less than 20%.

The results for 2020 are summarized in Tables 7, 8, and 9. Table 7 presents a summary of the amount of fuel used in 2020 for biofuels, electricity, and natural gas. Table 8 presents a breakdown of the types of biodiesel and advanced renewable biodiesel used in for each scenario in 2020. Table 5 also shows the amount of biodiesel and advanced renewable biodiesel used as a percent of the total amount of diesel. For each diesel-related scenario, Table 9 shows the percent contribution that each fuel makes to reduce the deficits that result from a business as usual case of using conventional diesel in 2020.

Table 7
Contribution to Reducing GHG Emissions in the LCFS for Diesel Fuel and Fuels that Substitute for Diesel Fuel

	Scenario 1	Scenario 2	Scenario 3
CNG (mmscf)	0	14,300	17,200
Total Amount of Electricity (Gigawatt Hours)	0	0	431
Number of CNG Vehicles	0	18,300	21,900
Number of Advanced Technology Vehicles	0	0	7,300
Volume of Biodiesel and Advanced Renewable Diesel (Million Gallons)	770	730	700
Overall Percent of Biodiesel and Advanced Renewable Diesel in Conventional Diesel	16.4	15.9	15.4

Table 8
Summary of Biofuel Use in the Various Scenarios for Fuels that Substitute for Diesel Fuel

Potential Fuels	Summary of Biofuel Volumes Used in 2020 For Each Scenario		
	Scenario 1	Scenario 2	Scenario 3
Conventional Biodiesel (Million Gallons)	260	250	250
Advanced Renewable Biodiesel (Million Gallons)	510	480	450
Volume of Biodiesel and Advanced Renewable Diesel (Million Gallons)	770	730	700

Table 9
Contribution to Reducing the Deficits for Fuels Substituting for Diesel Fuel in 2020

Potential Fuels	Percent of Reductions Provided by Each Fuel Type Substituting for Diesel in 2020		
	Scenario 1	Scenario 2	Scenario 3
CNG	0	4	4
Electricity	0	0	4
Conventional Biodiesel	12	10	10
Advanced Renewable Biodiesel	88	86	82

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IV. Applicable Standards for Alternative Fuels

Regulated parties that provide an alternative fuel or a biofuel for use as a transportation fuel shall calculate credits and determine compliance using the following guidelines.

- *Carbon Intensity Requirements for Natural Gas:*
    - A regulated party must use the gasoline-standard carbon intensity value for its CNG or LNG that is intended for use in light- or medium-duty vehicles.
    - A regulated party must use the diesel-standard carbon intensity value for its CNG or LNG that is intended for use in vehicles other than light- and medium-duty vehicles.
- *Carbon Intensity Requirements for Liquefied Petroleum Gas ("LPG" or "Propane"):*
    - A regulated party must use the gasoline-standard carbon intensity value for its LPG that is intended to be used in light- or medium-duty vehicles.
    - A regulated party must use the diesel-standard carbon intensity value for its LPG that is intended to be used in vehicles other than light- or medium-duty vehicles.
- *Carbon Intensity Requirements for Electricity:*
    - A regulated party must use the gasoline-standard carbon intensity value for its electricity that is intended to be used in light- or medium-duty vehicles.
    - A regulated party must use the diesel-standard carbon intensity value for its electricity that is intended to be used in vehicles other than light- or medium-duty vehicles.
- *Carbon Intensity Requirements for Hydrogen*
    - A regulated party must use the gasoline-standard carbon intensity value for its hydrogen that is intended to be used in light- or medium-duty vehicles.
    - A regulated party must use the diesel-standard carbon intensity value for its hydrogen that is intended to be used in vehicles other than light- or medium-duty vehicles.

- *Carbon Intensity Requirements for E100 or an Ethanol Blend*

  - A regulated party must use the gasoline-standard carbon intensity value for its pure denatured ethanol or ethanol blend that is used or is intended to be used in

    - Light-duty vehicles
    - Medium-vehicles
    - Heavy-duty vehicles
    - Off-road transportation applications, or
    - Off-road equipment.

- *Carbon Intensity Requirements for B100 or a Biomass-based Diesel Blend*

  - A regulated party must use the diesel-standard carbon intensity value for its biomass-based diesel or a biomass-based diesel blend that is intended to be used in:

    - Light-duty vehicles
    - Medium-duty vehicles
    - Heavy-duty vehicles
    - Off-road transportation applications
    - Off-road equipment
    - Locomotives

Table 10
Summary of Applicable Standards for LCFS-Participating Transportation Fuels

For Fuel Used In	Representative Examples	Applicable Standard
Dedicated or multi-fuel vehicles used in LMD applications (except LMD diesel) OR Dedicated or multi-fuel vehicles operating on gasoline or ethanol blends	Grid-independent hybrids (i.e. Prius); BEV; PHEV; CNG (i.e. Honda CNG); Hydrogen FCV or ICEV; Hydrogen plug-In FCV or ICEV; E85 FFV (LMD or HD); Conventional gasoline vehicle	Gasoline
Dedicated or multi-fuel vehicles used in HD applications OR Dedicated or multi-fuel vehicles operating on diesel fuel or biodiesel/biomass-based-diesel blends OR Off-road transportation, off-road equipment, locomotive	CNG Buses, LNG trucks, Hydrogen FC or ICE Buses Diesel plug-in hybrid (LMD, HD), Conventional diesel vehicle (LMD, HD), Vehicles using B5, B20 Truck-stop electrification, forklifts, tractors	Diesel

V. Compliance

A. Regulated Parties

1. Introduction

The LCFS regulation designates which entities in the fuel supply chains are obligated to demonstrate compliance with the LCFS.

In addition to identifying regulated parties, some earlier papers discussed the concept of identifying the “point of regulation”. As staff developed the regulatory language, it became clear that identifying the “point of regulation” was less important than identifying the “regulated party.” The regulated party is the party responsible for the fuel and for reporting fuel information to the Board. In general, for gasoline and diesel, regulated parties are the producers and importers. However if ownership of the fuel is transferred, the recipient becomes the regulated party unless the original owner and the recipient agree that the original owner retains the responsibility. For alternative fuels, the regulated parties are those who provide the finished transportation fuel.

2. Discussion of “Regulated Party” versus “Point of Regulation”

In developing the regulatory language, staff believes it is important to recognize the potential enforcement differences between the LCFS and current standards for liquid fuels such as California Reformulated Gasoline (CaRFG) and ultra low sulfur diesel. The CaRFG regulation considers the point of regulation to be the point at which the refiners release finished fuel CaRFG throughout the distribution system. Compliance can be determined systematically through fuel sampling and testing.

Unlike the CaRFG and diesel rules, the draft LCFS regulation uses calculated lifecycle fuel carbon intensity. Carbon intensity is based on measured properties; however, it cannot be abstracted directly from the fuel or measured by analytical instruments. Therefore, in addition to the ideal attributes above, the LCFS point of compliance needs to take into consideration which entity is in the best position to document that a fuel’s appropriate carbon intensity values have been used. Based on this and other considerations, staff determined that identifying the “regulated party” would better serve the LCFS program than identifying the “point of regulation.”

The following sections describe staff’s analysis and recommendations for identifying the regulated party for all fuels considered under the LCFS.

a. Gasoline and Diesel

For gasoline and diesel - ‘traditional’ transportation fuels, crude oil is taken from the ground and then transported to a refinery where it is processed into various refinery products, including material that eventually goes into gasoline and diesel fuels. California refineries produce California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB), which is transported through pipelines, blended with ethanol at distribution terminals, and distributed to retail outlets as finished gasoline.

The CaRFG regulations (Title 13, California Code of Regulations) describe the standards applicable to all gasoline produced or imported into California. Imported gasoline must be CaRFG compliant. Enforcement is done initially at the distribution terminals and, if necessary, continued further downstream up to the final distribution facilities. However, as described earlier, CaRFG provides standards that can be enforced through quantitative analysis. Fuel quality can be tested and compliance can be easily determined. For the LCFS regulation, however, the definition of regulated parties must also take into consideration the availability of carbon intensity data and the extent to which the data are verifiable.

Currently, the seven largest oil companies supply about 90 percent of the gasoline sold in California, while the 20 largest oil companies supply over 99 percent of gasoline sold (U.C. Report, Part II). Producers and importers are already subject to CaRFG regulations and are also considered to be the regulated parties for the federal Renewable Fuel Standard (RFS). Therefore, it seems logical to make them the regulated parties for LCFS as well.

For the majority of the transportation fuel in California, producers and importers retain control of the ownership throughout blending and distribution. In the instance where a producer or importer transfers ownership of CARBOB or diesel, the LCFS obligation can also transfer with the fuel unless agreed upon by the parties.

In the instance where additional ethanol or biodiesel is blended into finished fuel (i.e. gasoline or diesel), the blender becomes the regulated party. This blender is only responsible for the additional ethanol or biodiesel that they blend into the finished fuel.

Recommendation for Gasoline and Diesel

Through staff analysis and discussions with stakeholders and ARB Enforcement personnel, staff proposes that a modified approach to regulation at the producer and importer is likely to be the most administratively feasible approach and has the advantage of consistency with existing federal regulations. For gasoline (and biofuel blends), diesel (and diesel substitutes):

- The regulated party is the producer of the fuel, the importer that imports the fuel, or certain recipients, as specified in the regulation;
- Upon transfer of custody or title to the fuel, the obligation to maintain compliance with the LCFS regulation may flow from the transferor to the recipient (i.e., the transferee). However, the parties may enter into a contract for the transferor to

retain the compliance obligation (along with the credits and deficits for the transferred fuel). The transfer document would be required to clearly state:

- o The volume and average carbon intensity of the transferred fuel; and
  a. The recipient accepts that it is now the regulated party that is responsible for the acquired fuel and for meeting the requirements of the LCFS regulation for the transferred fuel, along with the CaRFG, CARB diesel, and any other applicable State or federal regulations, or
  b. Responsibility has been maintained by the transferor.

As an extension to the fuel transfer provision above, staff also recommends a provision prohibiting any party from adding or making any other modifications to a transferred fuel unless the party making the modifications:

- has become the regulated party, as discussed above [note: in this case, the recipient or transferee is the regulated party that is responsible for LCFS compliance]; or
- is under a contractual obligation with the regulated party to make the modification as specified in the contract [note: in this case, the transferor remains the regulated party that is responsible for LCFS compliance].

b. Compressed Natural Gas (CNG)

The general production and distribution path for most CNG is as follows. Natural gas, after extraction from the production well, may be treated to bring it up to gas pipeline specifications at a processing plant. The gas is then sent through the transmission system to the “city gate,” where it is decompressed and odorized. The gas is then sent to the fueling station via the low-pressure distribution system.

There may be several approaches for choosing the appropriate regulated party in selecting the regulated party for CNG focused on identifying the entity in the production and distribution process that:

- is as far downstream in the process without involving numerous end users to the extent feasible;
- involves an actual physical facility or other presence within California for jurisdictional purposes;
- has a relative low number of potential facilities that enforcement staff need to visit; and
- has access to records that would provide insight on the upstream steps so that ARB staff can verify the fuel-cycle carbon intensity that is claimed by the regulated party.

Recommendation for CNG and Biomethane-to-CNG

Given the above goals and the process by which NG is produced and imported into California, staff proposes the regulated party as follows. For CNG and biomethane sold in the State, the regulated party is the person or entity that provided the fuel for transportation use.

In most cases, the regulated party would be the local utility company. However, if the gas is purchased from an energy service provider, the energy service provider will be the regulated party since title to the gas would belong to the energy service provider, and the energy service provider is the entity that would be providing the gas for transportation use. In this case, the local utility company is serving only as a conduit for the gas to be transported at the behest of the ESP. The ESP is providing the gas for transportation use, is responsible for the gas quality, and therefore it should be the regulated party in such cases.

c. Liquefied Natural Gas

For LNG as a transportation fuel, production methods and, by association, fuel providers, can vary. At present, LNG for motor vehicle fuel use is derived via two main routes. These are liquefaction of pipeline natural gas, which may be used directly at the source of liquefaction or involve truck transport of the LNG to a separate end-user, and the liquefaction and direct-use of bio-methane derived from landfill gas. Other production routes for LNG are possible, and are briefly stated below:

- Liquefaction and direct use of bio-methane derived from anaerobic digestion. Here, anaerobic digestion includes stand-alone digesters receiving one or more types of biodegradable, organic residue; digesters located on dairy, cattle and pig farms; and water treatment/wastewater treatment plant facilities;
- Truck transport of liquefied bio-methane;
- Pipeline transmission of bio-methane, which later is used as LNG;
- Truck transport of LNG received from LNG shipping of NG derived from remote sources; and
- Re-gassed LNG that is transmitted by pipeline before being re-liquefied for motor vehicle fuel use.

Fuel providers can also vary. Although LNG service stations are privately held and operated by fleets, some also provide public access. A few LNG stations also provide CNG. At present LNG used in the State at LNG service stations is either transported by truck or provided directly from landfill gas (for example, the Waste Management, Inc. landfill gas-to-LNG demonstration project). However, initiatives are underway to provide LNG from pipeline natural gas, particularly in the northern part of the State, where gas quality issues are currently not a concern. For example, an LNG liquefaction plant is under constructed in Boron, California.

The sources of natural gas used for the production of CNG and LNG tend to be same; only the end application and life cycle steps tend to vary. Both can be produced from any source of fossilized natural gas. These can include associated gas wells, non-associated gas wells, and coal-bed methane deposits. The source of natural gas can either be domestic and pipeline-based, or it can be imported and either pipeline or LNG-derived from remote natural gas. LNG can also be produced from biogas, landfill gas, or even manufactured gas.

The life cycle pathways for LNG and CNG share some similarities, but they also have important differences. CNG production typically involves four life cycle segments- production, processing, transmission and distribution, and only requires compression at the point of end-use. In contrast, depending upon the way the LNG is sourced, its production may involve as few as four life cycle segments (production, processing, liquefaction and shipping/truck transport) and as many as nine life cycle segments before the point of end-use. Finally, it is possible at the point of end-use to produce CNG from LNG, which further complicates the analysis of life cycle pathways.

Recommendation for LNG and Bio-methane to LNG

In-State and Out-of-State

For simplicity, staff proposes that the regulated party be the entity that provides the LNG and biomethane-to-LNG for transportation use in California.

d. Liquefied Petroleum Gas (LPG or Propane)

For propane, an important consideration in identifying the preferred regulated party is the method by which the fuel is transported and dispensed to light-duty and heavy-duty vehicles. Because propane is typically not sold only as a transportation fuel, regulation and enforcement at the service station level is probably necessary. The volume of propane dispensed to light-duty vehicles and heavy-duty vehicles can be determined at the station level. At the fueling station, it is the fuel supplier's responsibility to ensure that the propane meets ARB's LPG motor vehicle specifications. Therefore, the producer (which is sometimes the distributor) is the entity responsible for ensuring gas quality to the fueling station.

Recommendation for LPG

Similar to CNG and LNG, staff proposes that the regulated party for LPG be the entity that provides the LPG for transportation use.

e. Electricity

Electricity in California is delivered to customers by Load Servicing Entities. Load Servicing Entities are composed of public utilities and investor owned utilities. In the electricity delivery system, Load Servicing Entities have the most comprehensive knowledge of emissions associated with the fuel lifecycle that will influence the carbon intensity. Load Servicing Entities also have the most influence on the availability, cost, convenience and public knowledge of electricity as a transportation fuel. Staff therefore believes Load Servicing Entities will most often be the regulated parties for electricity provided under the regulation. The California Electric Transportation Coalition agrees that Load Servicing Entities have the tools and capability to influence the market development and deployment of low-GHG fuels in the transportation sector.

However, Load Servicing Entities are not the only potential regulated parties. There may be cases where a separate entity has contracted with the Load Servicing Entity to install charging stations for electric transport. In these cases, the entity supplying the electricity to the vehicle would become the regulated party.

Unlike most liquid fuels, electricity is consumed in sectors that are both regulated and unregulated by the LCFS. The regulated party would be responsible only for electricity that is delivered to vehicles. The quantification of electricity used as a transportation fuel is a critical consideration in the design of the LCFS.

Existing electricity generation infrastructure should be able to support a high level of plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV) penetration, particularly if off-peak refueling is encouraged. In the case of private residences, this could be achieved by offering rate incentives and by supplying advanced direct metering systems. Direct meters are capable of detecting electric vehicle electricity consumption only.

Direct meters can be installed as separate electricity meters associated with garaged electric vehicles. However, this type of refueling is not practical for many Californians living in urban areas or apartment buildings. In addition, many electric vehicle owners will require the option to refuel away from home as necessary. Therefore, public charging stations and charging stations installed in apartment complexes will be required. These charging stations are also required to include direct meters for accurate measurement of the electricity dispensed. Meters installed on individual electric vehicles may also be used for the measure of electricity dispensed. Public station meters will not always be able to delineate the type of vehicle fueled (light duty or heavy duty), but fuel dispensed at a particular station will be used for transportation purposes. A network of charging stations can be established by municipalities and parking lot owners as well as in apartment complexes and other central public areas.

Recommendation for Electricity

Staff proposes Load Servicing Entities and other entities supplying electricity to the vehicle serve as regulated parties for the LCFS regulation for electricity used for transportation purposes. The regulated party is the party who transfers the electricity to the vehicle.

f. Hydrogen

Regulating hydrogen use by vehicles presents some challenges, due primarily to the variety of hydrogen production sources and distribution channels. Currently, 95 percent of the hydrogen produced in the United States (approximately nine million tons per year) is generated by steam methane reformation of natural gas feedstock. Hydrogen can also be generated by other thermal processes such as gasification of coal or biomass, reformation of renewable liquid fuels or high temperature water splitting. Electrolytic process (using electricity from grid, solar, or wind to split water), and photolytic processes (using light energy to split water) are also potential sources for hydrogen as a transportation fuel.

Hydrogen can be generated on-site at the fueling station or off-site at a production facility and trucked to the station as compressed gas or as a liquid. Hydrogen pipelines are also under development with approximately 700 miles of pipeline currently operating. Research is focused on overcoming technical concerns related to pipeline transmission, including the potential for hydrogen pipelines to become embrittled (including welds); the need to control hydrogen permeation and leaks; and the need for lower cost, more reliable, and more durable hydrogen compression technology.

Since hydrogen is currently not a commercially available fuel (and, hence, not for “sale”), the point of fuel delivery to vehicles can be considered to be the point of sale. Since there are diverse production and delivery methods with a range of differences in GHG emissions, identifying the regulated party would center around which entity produces the hydrogen for transportation use in California.

Recommendation for Hydrogen

Staff proposes that for hydrogen produced onsite, the regulated party is the station owner. For fuel hydrogen delivered to stations, the regulated party is the hydrogen producer. In all cases, hydrogen will be treated on a case-to-case basis. With less than fifty stations statewide, it is possible to monitor at the individual station level.

B. Reporting and Recordkeeping

1. Introduction

Under the LCFS, each regulated party would report to ARB carbon intensity and other information for each fuel supplied in California on a quarterly basis. Any regulated party, including those under the small volume exemption, who wishes to claim LCFS credits must submit a quarterly report.

In addition, regulated parties must submit an annual compliance report to ARB regarding the yearly aggregated carbon intensity and other information for each fuel supplied in California for each compliance period of the LCFS. The ARB

Executive Officer will determine whether the regulated party complies with the LCFS based on this annual report.

2. Reporting Frequency

A regulated party must submit to ARB reports for compliance purposes. The reports consist of quarterly progress reports and annual compliance reports. The reporting frequencies of these reports are set forth as follows:

a. Quarterly Progress Reports For All Regulated Parties and Credit Generators

For each year in the life of the LCFS program (starting in 2010), a regulated party (including one that only generates credits) must submit quarterly progress reports to ARB by:

- May 31st – for the first calendar quarter covering January through March;
- August 31st – for the second calendar quarter covering April through June;
- November 30th – for the third calendar quarter covering July through September; and
- February 28th (29th in a leap year) – for the fourth calendar quarter covering October through December.

Quarterly progress reporting will enable both ARB staff and the regulated parties to carefully monitor the program implementation and detect any problems in the early stages. Progress reports at this frequency will also help ensure that credits are available for purchase throughout the year.

b. Annual Compliance Reports.

By April 30th of 2011 and March 20th of each year thereafter, a regulated party would be required to provide annual compliance reports for the prior calendar year.

3. LCFS Quarterly Progress Reporting

Under the LCFS, any regulated party would submit a carbon intensity report to ARB on a quarterly basis.

This section sets out the requirements for the LCFS Quarterly Report to be submitted by fuel suppliers to ARB. It demonstrates the format for quarterly reporting and describes how quarterly reporting relates to the issuing of LCFS credits. This guidance will be of particular interest to regulated parties and any other fuel suppliers who wish to claim LCFS credits.

The ARB is developing an online reporting tool that includes a secure web-based data submission form for compliance or credit reporting. With the reporting tool, all reporting can be completed and submitted online. The online reporting tool will provide an interactive graphical user-interface with detailed annotations and online help to facilitate the reporting process.

The following paragraphs provide detailed information relative to the quarterly reporting.

- CARBOB and diesel fuel producers and importers are LCFS regulated parties. They have obligations to ensure that the CARBOB and diesel fuel produced or imported meet the LCFS compliance requirements.

- The producers or importers of CARBOB and diesel fuel may keep ownership of the fuels they produced or imported until the fuels are delivered to the facility at which the fuel will be dispensed into motor vehicles.

- The producers or importers of CARBOB and diesel fuel may sell the fuels they produced or imported to another party. If CARBOB or diesel is traded between regulated parties, or between a regulated party and a non-regulated party (i.e. a distributor), the parties must prepare a written agreement specifying who maintains the obligation for meeting the LCFS complance. Parties must also report to the ARB who maintains the obligation for meeting the LCFS compliance.

- The Quarterly Report should contain the following information (summarized in Table 11):

  General Information:
  - Company or organization name
  - Reporting period
  - Type of fuel
  - Blended fuel (yes/no)
  - Number of blendstocks or alternative fuels used to comply
  - Type(s) of blendstocks or alternative fuels used to comply

  Blendstock Specific Information:
  - Batch number
  - U.S. EPA RIN number
  - Type(s) of blendstocks or alternative fuels used to comply
  - Blendstock or alternative fuel feedstock
  - Feedstock origin
  - Production process

- The blendstock or alternative fuel Average Fuel Carbon Intensity ($UAFCI_i$)
- Amount of each blendstock or alternative fuel (MJ)

Finished Fuel Information:

- Fuel carbon intensity of the finished fuel
- Amount of each fuel used as gasoline replacement (MJ)
- Amount of each fuel used as diesel replacement (MJ)
- Credits/deficits (tons)
- Credibility level

4. Sustainability Reporting

ARB staff is evaluating whether to include voluntary reporting of sustainability provisions, but have not yet drafted a proposal. Staff is seeking comments on such provisions.

Table 11
Checklist of Reporting Requirements for LCFS Quarterly Report

(R = Required, O = Optional)

Parameters to Report	**Gasoline & Diesel**	**CNG, LNG, LPG**	**Electricity**	**Hydrogen**	**Biofuel Blends (i.e. E85, B20, B5)**	**Pure Biofuels Used As a Finished Fuel**
Company or organization name	R	R	R	R	R	R
Reporting period	R	R	R	R	R	R
Type of fuel	R	R	R	R	R	R
Blended fuel (yes/no)	R	R	R	R	R	R
Number of blendstocks	R	R	R	R	R	R
Type(s) of blendstock	R	R	R	R	R	R
For each blendstock						
Batch number	R	n/a	n/a	n/a	R	R
RIN number	R	n/a	n/a	n/a	R	R
Blendstock type	R	R	R	R	R	R
Blendstock feedstock	O	O	O	O	O	O
Feedstock origin	O	O	O	O	O	O
Production process	O	O	O	O	O	O
The blendstock Average Fuel Carbon Intensity ($UAFCI_i$)	R	R	R	R	R	R
Credibility level	R	R	R	R	R	R
Amount of each blendstock (MJ)	R	R	R	R	R	R
For the finished fuel						
The actual average fuel carbon intensity of the finished fuel ($UAFCI_{actual}$)	R	R	R	R	R	R
Amount of each fuel used as gasoline replacement (MJ)	R	R	R	R	R	R
Amount of each fuel used as diesel replacement (MJ)	R	R	R	R	R	R
Credits/deficits (tons)	R	R	R	R	R	R

5. Annual Compliance Reporting

Each regulated party must submit an annual compliance report to ARB regarding the yearly aggregated carbon intensity information of its fuel supplied in California, for each LCFS compliance period. The ARB Executive Officer will determine whether the regulated party complies with the LCFS based on this annual report.

The compliance report must meet, at a minimum, the requirements outlined in quarterly reporting, including the additional requirements. The report must also contain all calculations; show all credits generated, acquired, and used; show all deficits generated; and contain all of the following:

- The total credits generated by the regulated party in the current year and used for compliance;
- Any credits or deficits carried over from the previous year;
- The total credits acquired from another party (identify which party) used for compliance;
- The total credits sold or otherwise transferred to other parties and to whom those credits were transferred;
- The summation of LCFS credits and deficits in the reporting year;
- Any deficits to be carried into the next year; and
- Any additional information specified by ARB to be included in the report.

One of the major pieces of information in the annual report from each regulated party consists of the aggregated data from quarterly reports over a single compliance period (one year). Such data include:

- Yearly Aggregated Carbon Intensity Report, in the same format as the Quarterly Report; and
- Yearly aggregated report of the volumes of CARBOB or diesel fuel that were sold to other parties, and a list of the recipients. If the CARBOB or diesel fuel were produced from non-conventional crude, the carbon intensity data of the CARBOB or diesel fuel as listed in the Blendstock Specific Information of Quarterly Report must be reported to ARB.

C. Determination of Compliance

The Online Compliance Tool will automatically compare the overall yearly averaged carbon intensity of the fuels supplied by the regulated party to the target of the given compliance period to determine whether the regulated party complies with the LCFS. The Online Compliance Tool will also report that compliance determination to instruct the regulated party. If the regulated party is in violation of the LCFS, the Online Compliance Tool will notify the regulated party to contact ARB staff.

1. Over-Compliance

If a regulated party has acquired more LCFS credits than it needs to demonstrate compliance, then, in general, it can retain the excess LCFS credits for use in complying with the LCFS in the following year or transfer the excess LCFS credits to another party.

2. Under-Compliance

If a regulated party has not generated, purchased, and carried over sufficient LCFS credits to meet its obligation for the given compliance period, the regulated party is in violation of the LCFS.

Provided the violation is not substantial, the regulated party would have one year to come into compliance, i.e. to reconcile the LCFS credit deficit, with no penalty. ARB staff is proposing this as a compliance flexibility provision, which is similar to what is allowed under the federal RFS.

A violation is not a substantial violation when the regulated party has met the previous year's standard, and has provided at least 90 percent of the credits necessary to meet the current compliance year standard. ARB staff is seeking comments on the concept of a substantial violation.

If the regulated party is in substantial violation, they have one year to make up the deficit and are subject to penalties and possibly other enforcement provisions.

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VI. LCFS Credits and Deficits

The LCFS is structured much like an emissions reduction credit program in which credits are awarded based on fuel performance that exceeds a regulatory standard. The LCFS includes a flexible combination of fuel-vehicle systems and awards credits to the fuel provider if the total emissions generated by the supply and consumption of the fuel are below those of the corresponding reference gasoline or diesel standard. Beginning 2010, regulated parties could start generating credits on a quarterly basis. These credits can be banked indefinitely[1], used for compliance purposes, sold to other regulated parties, and purchased and retired by regulated parties. In addition, the credits can be exported to other GHG emissions reductions programs such as AB 32, subject to the requirements of these GHG programs.

In this section, staff presents the overall method for determining compliance with the standard and the calculation methodology. In addition, staff discusses innovation credits, credit borrowing, offset/opt-in credits, and a credit-banking-and-trading scheme that balances stakeholder inputs with program goals.

A. Determination of Compliance Using Credits and Deficits

In the LCFS, the amount of credits generated (or the deficits incurred) by a regulated party is directly related to the ability of the regulated party to comply with the LCFS. For each compliance period, a fuel provider calculates the amount of credits and deficits generated for the amount of fuel supplied as either a gasoline or diesel fuel replacement. The total credit, as calculated in equation 2 below, is summed over all the fuels supplied by the regulated party. If a fuel provider's total credit amount is greater than or equal to 0.0 metric tons (MT), the fuel provider is compliant with the LCFS. If the fuel provider's total amount is negative, then a deficit is incurred and the fuel provider is under compliant.

B. Credit Calculation Methodology

For each applicable fuel under the LCFS, credit/deficit is determined by the overall performance of the fuel, indicated by the carbon intensity value, and the extent to which the fuel displaces a conventional fuel such as gasoline or diesel.

The two primary components of a credit/deficit calculation are:

1. The reported unadjusted average fuel carbon intensity value ($UAFCI_{standard}$) of the standard (gasoline or diesel fuel); and

[1] Additional staff review is underway to determine if credits generated in the early years (2010 – 2012) of the LCFS implementation should be capped.

2. The portion of the fuel used in light/medium-duty (gasoline replacement) or heavy-duty/off-road applications (diesel replacement), indicated by the superscript "XD" in equation 1.

The $UAFCI_{standard}$ in equation 1 below indicates the carbon intensity of the gasoline or diesel standard for a given year, which is established as part of the LCFS. Notice the amount of credits generated depends on the extent to which the carbon intensity value of a fuel is below that of the standard fuel.

For each alternative fuel, such as electricity or hydrogen, the amount of credits/deficits generated is also determined by the amount of conventional gasoline or diesel fuel that is displaced, indicated by the parameter $E_{displaced}^{XD}$ in equation 1. The amount of conventional energy displaced can be determined using a fuel displacement factor called the Energy Economy Ratio (EER), which compares the fuel economy of an alternative fuel vehicle to that of a conventional gasoline or diesel vehicle.
The total credits awarded to or deficits incurred by a regulated party are the sum of the credits/deficits calculated from the displacement of gasoline or diesel.

All credits/deficits are in units of metric tons. The corresponding equations for the calculation are:

$$Credits^{XD}(MT) = \left(UAFCI_{standard} - AFCI_{compliance}^{XD}\right) \times E_{displaced}^{XD} \times C \tag{1}$$

$$Credits^{TOT}(MT) = Credits^{gasoline} + Credits^{diesel} \tag{2}$$

A positive value of $Credits^{TOT}$ represents credits generated; a negative value of $Credits^{TOT}$ represents a deficit. $Credits^{TOT}$ is used for the determination of LCFS compliance. A zero or positive total credit value means the regulated party is at compliance or over compliant, respectively. A negative value means under compliance.

The superscript *XD* denotes whether the credits are generated under the gasoline standard *XD*= "gasoline", or the diesel standard *XD*= "diesel";

For a provider of a blended fuel such as E10, E85 or a provider of two or more fuels,

$$AFCI_{acompliance}^{XD} = \frac{\sum_{i}^{n} E_i^{XD} \times UAFCI_i}{E_i^{XD} \times EER_i^{XD}} \quad \text{and} \quad E_{displaced}^{XD} = \sum_{i}^{n} E_i^{XD} \times EER_i^{XD}$$

For a provider of an unblended fuel such as electricity, hydrogen, CNG/LNG, or LPG

$$AFCI^{XD}_{compliance} = \frac{UAFCI_1}{EER^{XD}_1} \quad \text{and} \quad E^{XD}_{displaced} = E^{XD}_1 \times EER^{XD}_1$$

$Credits^{XD}(MT)$ is the amount of LCFS credits awarded (or in deficit) to a regulated party in metric tons;

$UAFCI_{s\tan dard}$ is the <u>unadjusted</u> average fuel carbon intensity of either the gasoline or diesel standard for a given year;

$AFCI^{XD}_{compliance}$ is the <u>adjusted</u> average fuel carbon intensity value reported for compliance or credit determination, in gCO2e/MJ;

$UAFCI_i$ is the <u>unadjusted</u> average fuel carbon intensity of each blendstock, i, determined by a default ARB CA GREET fuel pathway or an approved custom pathway, in gCO2e/MJ;

E_i is the energy of each blendstock, in MJ, determined from the energy density conversion factor for each blendstock;

i is the blendstock index ;

n is the total number of blendstocks that produce a fuel;

$E^{XD}_{displaced}$ is the total amount of gasoline or diesel energy displaced, in MJ per compliance period, by the use of an alternative fuel.

EER^{XD}_i is the dimensionless Energy Economy Ratio (EER) defined in the TIAX AB1007 report. This term is also known as a Fuel Displacement Factor in the LCFS to account for the amount of gasoline or diesel that is displaced by the use of an alternative fuel. The subscript identifies the specific EER for a given fuel. For instance, $EER^{gasoline}_{electricity}$ means an EER of fuel electricity measured relative to gasoline. EER values are published in the LCFS Regulatory Outline, version 2.0;

C is a factor used to convert credits to units of metric tons and has the value of

$$C = 1.0x10^{-6} \frac{(MT)}{(gCO_2e)};$$

$Credits^{TOT}$ is the total credit awarded or in deficit, in metric tons.

For a derivation of the credit equations and examples of calculations, see the LCFS Regulatory Outline, version 2.0, Appendices A and B.

C. Banking

Beginning 2010, regulated parties could start generating credits on a quarterly basis. Both the gasoline and diesel standards are backloaded so that, if necessary, credits that were banked in the early years will help with compliance in the later years.

Currently, staff is evaluating if it will be necessary for the success of the LCFS to set a limit for banking credits, particularly in the early years (2010-2015) when the program is being implemented slowly to allow technology to mature to produce advanced alternative fuels.

D. Trading

1. 3rd Party Credit Acquisition and Trading

One of the key cost-reduction LCFS design elements is the creation of a market for carbon intensity credits. Under a market-based system, regulated parties would be able to buy and sell credits. To keep LCFS credit transactions simple in the early years and to ensure there are an adequate number of credits in the program, staff proposes that 3rd party entities not be allowed to purchase, sell, and retire LCFS credits at the onset of the LCFS. As part of the periodic reviews, staff will re-evaluate the ability of 3rd party entities to participate in LCFS credit transactions.

2. Exporting Credits to Other Markets

Credit export is the process of bringing credits generated in one GHG emission reduction program into a complementary, external program for compliance under that program. The draft regulation allows for the exporting of credits to other GHG trading programs, subject to the requirements of these other programs. ,

The range of responses from stakeholders on this issue is diverse. Several stakeholders caution that credits exported to AB32 could undermine the integrity of the AB 32 cap and force the LCFS to be considered a substitute policy rather than a complementary policy. They further argue that since transportation should be already included in an economy-wide market, trading between the two programs would amount to double counting. Other stakeholders believe that reductions in areas overlapping both the LCFS and AB32 should receive credits under both programs, thus eliminating the need for exports. Still others support the export of LCFS credits and see it as a mechanism to ensure there is a market for the generated credits.

ARB staff believes that the LCFS should not restrict the use of these credits in other markets. However, the use of these credits will be dictated by the requirements of these other programs, including the AB 32 trading programs. Such flexibility may incentivize the development of innovative low-carbon fuel technologies within the LCFS.

E. Other Credit Considerations

1. Borrowing

Under a credit borrowing system, credits would be 'borrowed' from anticipated future emissions reductions in order to meet compliance in the present. Funds raised from the sale of borrowed credits could be used to increase a regulated entity's near-term ability to invest in the development of lower-carbon fuels. These increased investments could bring lower carbon fuels to market sooner than might otherwise be possible. Credit borrowing systems are relatively untested, and any attempt to implement one in California could be problematic. Staff is not proposing to allow the borrowing of LCFS credits.

2. Innovation Credits

Innovation credits are credits awarded to fuel-vehicle systems that often require higher-risk investments to bring to market but could potentially have very low global warming potential. Staff recommends that innovation credits not be included in the LCFS credit system.

3. Offset Credits

The offset process extends the LCFS credit trading market to entities other than providers of on-road transportation fuels which are subject to regulation under the LCFS. Offset credits, if allowed, would permit regulated entities to obtain credits for GHG-reduction activities in areas other than regulated transportation fuels. Staff recommends that, at its inception, the credit market not include the issuance and trading of offset credits—whether for opted-in transportation fuels or for reductions from outside the transportation sector. Staff will continue to evaluate the feasibility and effectiveness of allowing offset credits from the marine and aviation transportation areas, and will provide an update at the scheduled milestone review point.

<u>Recommendations</u>

In summary, based on internal analysis and careful consideration of the recommendations and stakeholder comments, ARB staff proposes the following:

- Credits can be banked starting in 2010 and will not expire; however, the credits may be discounted in early years due to reduced rate of program implementation;

- Credits can be generated on a quarterly basis;
- Credits are awarded for fuel performance determined by the fuel's carbon intensity value and the amount of conventional gasoline and diesel that is displaced by use of the fuel;
- For alternative fuels, credits are generated separately for the portion of the fuel used in light-duty (gasoline replacement) and heavy-duty/off-road applications (diesel replacement), the total credit is the sum of the two;
- A regulated party under the LCFS may purchase or sell LCFS credits. An exempted party may option to generate and sell LCFS credits. An external 3rd party entity that is not a regulated party or an exempted party, or acting on behalf of a regulated or an exempted party, may not purchase, sell, or trade LCFS credits.
- Credits can be exported to other GHG emissions reduction programs such as AB32 subject to the requirements of these programs, but not be imp0orted from those programs;
- Innovation credits are not allowed;
- Credits cannot be borrowed from future reductions; and
- Offset and opt-in credits are not allowed.

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Farrell, A. E., and Sperling, D., 2007. A Low-Carbon Fuel Standard for California. Part 2: Policy Analysis. August 1, 2007. available at http://www.arb.ca.gov/fuels/lcfs/lcfs_uc_p2.pdf

Low Carbon Fuel Standard Regulatory Outline, Version 2.0, available at http://www.arb.ca.gov/fuels/lcfs/lcfs.htm#wg

VII. Determination of Carbon Intensity Values

A. Background

The LCFS is built on the concept of assigning a carbon intensity (CI) value to a each fuel. The assigned CI value plays a key role in determining whether a regulated party has complied with the LCFS rule. Therefore, it is important that the methods used for assigning CI values accurately reflect the multiple steps involved in producing and using the fuel. To reflect the full impact of producing the fuel, the CI values also need to be adjusted to account for impacts on the fuel's overall carbon intensity due to indirect land use changes or other identified indirect effects.

To achieve these goals, ARB staff has designed CI lookup tables (Method 1), as well a method for customizing the lookup table CI values (Method 2). These methods, as well as the indirect land use change and other identified indirect effects, are discussed in more detail below.

1. Identify the Fuel Pathways

The carbon intensity of a particular fuel is dependent on the complete identification of the fuel pathways (i.e., the well-to-tank process). For example, as shown below, the production of ethanol involves many steps that influence the resulting CI value:

- Farming practices (e.g., frequency and type of fertilizer used);
- Crop yield;
- Harvesting;
- Collection (transportation);
- Fuel production process;
- Fuel used (Coal/CNG/Biomass);
- Co-products (value);
- Technology (dry vs. wet mill, energy efficiency);
- Distribution; and
- Combustion in vehicles.

Once the pathways are fully defined and characterized, a computer model can be used to project and sum up the carbon intensity impacts from each of the pathway factors. For this purpose, ARB staff is proposing to use the California-modified GREET2 model (v. 1.8b). GREET is used in Methods 1 and 2 for calculating CI values and is described in more detail below. Table 12 shows a list of pathways that ARB staff has developed, or plans to develop, and the release date of these pathways. Other pathways may be developed either in response to public comments or based on staff identified need. To

[2] GREET (**G**reenhouse gases, **R**egulated **E**missions, and **E**nergy use in **T**ransportation).

date, the ARB has posted eight pathways on the ARB website at http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

Before the two methods for calculating CI values are discussed, it is important to first address the impact on calculated CI values due to changes in land use associated with the production of certain alternative fuels. This change is referred to as an indirect land use change. The next section summarizes the staff's analysis of indirect land use changes. Appendix A provides a more detailed discussed.

Table 12
Fuel Pathways

Fuels	Feedstock Types	Origin	Process	Release Date or Estimated Release Date
CARBOB	Crude	CA Average	CA Average Refining	04/22/08
CaRFG	94% CARBOB, 6% Ethanol by Volume	CA Average	Average	04/22/08
Diesel	Crude	CA Average	CA Average Refining	04/22/08
Ethanol	Corn	U.S. Midwest	Dry Mill	04/22/08
			Wet Mill	04/22/08
	Sugar Cane	Brazil	Average production	10/30/08
	Cellulosic Waste	CA	CA Bio-refinery	10/30/08
	Cellulosic Switchgrass	CA	CA Bio-refinery	10/30/08
Biodiesel	Soy Oil Biodiesel	U.S. Midwest	Esterification in CA	10/02/08
	Palm Oil Biodiesel	International	Esterification international	11/15/08
	Waste	CA	Esterifacation in CA	11/15/08
Renewable	SoyOil	CA	CA Bio-refinery	10/30/08
	Palm Oil	S. E. Asia	Bio-refinery international	11/15/08
	Meat Processing Waste	CA	CA Hydrotreating	11/15/08
Electricity		CA Average	n/a	04/22/08
		CA Marginal	n/a	11/15/08
Bio Methane	Waste Landfill	CA	n/a	10/15/08
	Digester	CA	n/a	12/01/08
CNG	Natural Gas	North America	Compression	04/22/08
LPG	Crude	North America	Average production	11/21/08
LNG	Natural Gas	North America	Average production	11/21/08
		International	Average production	11/21/08
		Middle East	Average production	11/21/08
Hydrogen (liquid)	Natural Gas	North America	n/a	07/29/08

2. Indirect Land Use Changes

Indirect land use change emissions in this context refers to GHG emissions that are released when land conversions occur in response to the increased use of crops (such as corn or soybeans) as biofuel feedstock. These conversions can occur around the world as agricultural markets adjust to replace the food or feed production that was lost due to using crops for biofuels. For example, native grasslands in Brazil might be converted to soybean farming and replace U.S. soybean cultivation that was displaced by increased corn cultivation to meet increased demand for ethanol. This change can result in the rapid release of GHG emissions from previously uncultivated land that stored significant amounts of carbon both in plants and soils. ARB, in cooperation with the University of California, Berkeley, and Purdue University, are conducting studies to quantify these impacts.

For fuels that have indirect land use changes, adjustments to the calculated CI values (under Methods 1 and 2 below) must be made. As GREET does not account for indirect land use changes, a separate model must be employed for this purpose. Accordingly, ARB staff is proposing to use the Global Trade Analysis Project (GTAP) model to assess these indirect land use changes. The development and use of GTAP is described in Appendix A to this report, along with details of the preliminary modeling results for corn-based ethanol. Staff is continuing the analysis of indirect land use changes and other indirect effects and expects to refine the numbers based on public comments and staff's own analysis.

B. Method 1 – Lookup Table

As noted, the CI lookup tables are a set of categorized and predefined CI values that ARB staff has established for various fuels. ARB staff calculates the lookup table values by running the California-modified GREET model, using available generic fuel-pathway information for each fuel or fuel blendstock. The lookup table values vary with the source of the fuel, the processing of feedstock and fuel, and other important parameters that affect the total CI for the fuel based on its "source-to-wheel" life cycle.

As the name implies, the lookup tables allow regulated parties to determine the CI values for their particular fuels simply by finding the CI values assigned to those fuels in the appropriate tables. This allows regulated parties to avoid the cost and effort of having to develop their own process-specific information necessary to run the GREET model. Staff developed the lookup tables to assign CI values in four different tiers (Level 1, 2, 3, and 4). This provides an incentive for the regulated parties to provide as much information as possible about their fuel production, distribution, and marketing process.

For a given production process, the lowest level (Level 1) establishes the highest CI values for a given fuel because it is based on the least amount of information for that fuel. Conversely, Level 4 assigns the lowest CI value for the same fuel because it is based on the most complete generic information for that fuel. Thus, for compliance and credit generation purposes, the LCFS regulation requires affected parties to use the highest CI value in the lookup table for a particular fuel, unless they can provide information to qualify for a lower CI number.

Table 13 summarizes the hierarchy of the four levels of lookup table values for each fuel produced under a given process.

Table 13
Hierarchy of LCFS Carbon Intensity Lookup Table Values

Level 1	Fuel Type Level Values	These values are used when the only information known is the fuel type. These values are the most conservative since they are set equal to the highest carbon intensity among the feedstock level values (see below) for the fuel in question.
Level 2	Feedstock Level Values	These values are used when both the fuel type and feedstock are known. They are set equal to the highest carbon intensity among the feedstock & its origin level values (see below) for the feedstock in question.
Level 3	Feedstock & Its Origin Level Values	These values are used when the fuel type, feedstock, and place of the feedstock's origin are known. They are set equal to the highest carbon intensity among the fuel processing characteristic level values (see below) for the feedstock in question.
Level 4	Fuel Processing Characteristic Level Values	These values are used when the fuel type, feedstock, and method of processing are known, including place of feedstock's origin. These values are based on the predefined individual data points (for California Modified GREET model) that are needed to calculate the carbon intensity of a fuel. Most of these predefined data points are set at industry average level (discussed in the following sections).

Table 2 provides a sample lookup table for corn ethanol; the LCFS regulation will be based on many such lookup tables, one each for a given fuel (e.g., ethanol) and production process (e.g., ethanol from cellulosic feedstock). As noted, there are four levels of CI values, each corresponding to a different level of information provided by the regulated party. For example, suppose Company Y is a regulated party that wants to sell corn ethanol fuel in compliance with the LCFS regulation. In this hypothetical, Company Y has documentation that shows the corn ethanol is produced in the U.S. Midwest region using a wet mill, natural gas and biomass-fueled process. From Table 2, Company Y will see that the CI value denoted by “XXO4C” would be applicable to its process and level of information. On the other hand, if the only documentation that Company Y can provide shows that its regulated fuel is ethanol, Company Y would be required to use the Level 1 CI value (“XXO1”).

Table 14
Sample Lookup Table
Carbon Intensity Lookup Table (Method 1) for Corn Ethanol

<table>
<tr><th>Fuel</th><th>Feedstock</th><th>Feedstock Origin</th><th>Processing Characteristics</th></tr>
<tr><td rowspan="16">Ethanol (XXO1)</td><td rowspan="16">Corn (XXO2)</td><td rowspan="8">US Midwest (XXO3A)</td><td>Wet Mill, Custom Selected Fueling (XXO4A)</td></tr>
<tr><td>Wet Mill, Natural Gas and Coal Fueling (XXO4B)</td></tr>
<tr><td>Wet Mill, Natural Gas and Biomass Fueling (XXO4C)</td></tr>
<tr><td>Wet Mill, Natural Gas Fueling (XXO4D)</td></tr>
<tr><td>Dry Mill, Custom Selected Fueling (XXO4E)</td></tr>
<tr><td>Dry Mill, Natural Gas and Coal Fueling (XXO4F)</td></tr>
<tr><td>Dry Mill, Natural Gas and Biomass Fueling (XXO4G)</td></tr>
<tr><td>Dry Mill, Natural Gas Fueling (XXO4H)</td></tr>
<tr><td rowspan="8">US Other Regions (XXO3B)</td><td>Wet Mill, Custom Selected Fueling (XXO4I)</td></tr>
<tr><td>Wet Mill, Natural Gas and Coal Fueling (XXO4J)</td></tr>
<tr><td>Wet Mill, Natural Gas and Biomass Fueling (XXO4K)</td></tr>
<tr><td>Wet Mill, Natural Gas Fueling (XXO4L)</td></tr>
<tr><td>Dry Mill, Custom Selected Fueling (XXO4M)</td></tr>
<tr><td>Dry Mill, Natural Gas and Coal Fueling (XXO4N)</td></tr>
<tr><td>Dry Mill, Natural Gas and Biomass Fueling (XXO4O)</td></tr>
<tr><td>Dry Mill, Natural Gas Fueling (XXO4P)</td></tr>
</table>

1. ARB Process for Developing GREET Input Data

For a given fuel sub-pathway, GREET requires various input data points to calculate the fuel's CI based on its fuel life cycle. Input data points for the fuel pathways are determined based on industry average values, adjusted as described below.

ARB staff established three criteria for determining the magnitude of GREET input data points:

a. Difficulty of Obtaining and Reporting Input Data Points

Some data inputs of GREET are relatively easy for stakeholders to obtain; for example, a biofuel producer should be able to report on the fuel yield, the energy efficiency, and the fuel mix used at its plants. As a result, the stakeholders are likely to report their process-specific data to replace the predefined values on such data points. This will aid in the staff development of GREET carbon intensity values.

However, some other data are impractical to collect. For example, in biofuel production, specifically accounting for the agricultural phase of GHG emissions may be infeasible due to significant measurement, monitoring, and tracking challenges. As an alternative approach, regional average carbon intensity values for crop-based feedstocks can be established, without distinguishing between crops at the field or farm level. ARB staff expects to examine USDA reports every three years to determine whether an update in these data points is necessary to capture any systemic changes in practices that impact the GHG emissions from the agriculture activities. This approach captures the most significant agricultural feedstock and regional differences while avoiding significant costs and administrative challenges.

Therefore, ARB staff believes it is appropriate to set GREET input data that are difficult to obtain and report at values that reflect industry average practices.

b. Verifiability of Input Data Points

Ensuring that the records and reports are verifiable is an essential requirement of any regulation. The verification procedures could be conducted by either ARB or independent third party verifier. While some GREET input data points are relatively easy to verify, others may be practically unverifiable (e.g., the agricultural phase of GHG emissions). For those unverifiable data points, the draft regulation sets the data point values to reflect average industry practices, rather than conservative ones. This is because such input data points are unverifiable, regardless of whether they are set to reflect conservative or industry average practices. Thus, setting such data points to reflect average practices serves two purposes: (1) it simplifies the analysis, and (2) it is administratively less burdensome than having ARB spend resources trying to verify an unverifiable input data point (in the case where a regulated party submits for ARB approval a process-specific but unverifiable input data point).

Therefore, ARB staff believes that unverifiable GREET input data points should be set to reflect industry average practices and that these data points be established as "Invariant Data."

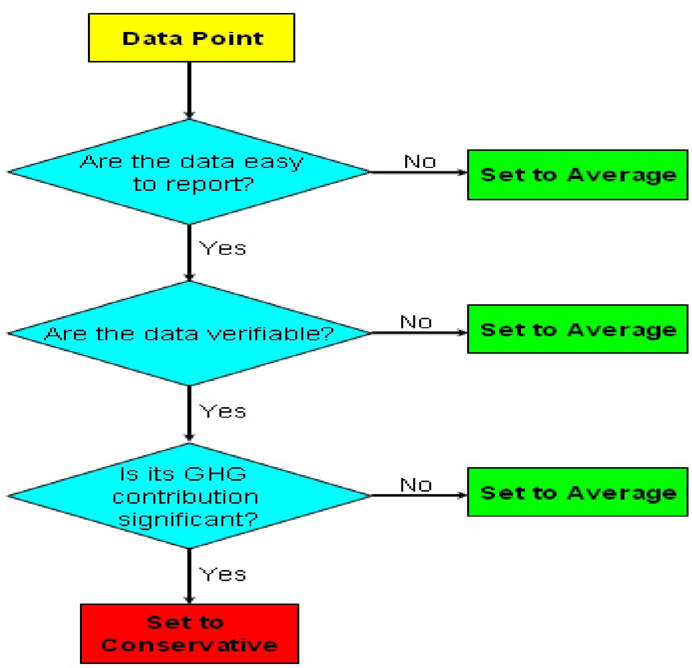
c. Significance of the Contribution from the Data Point to the Overall Fuel Sub-Pathway Carbon Intensity

The input data points are not equally important in terms of their contributions to a fuel's carbon intensity. If a regulated party prefers to report process-specific data (described in Method 2) on their fuel pathway, they can evaluate the options available in Method 2.

Developing, reporting, and enforcing process-specific data on the sources of emissions that represent 10 percent or less of a fuel's total CI may not be the most optimal use of resources. Setting these data points conservatively causes the fuel's CI to be overestimated without creating sufficient incentive for companies to report custom data. Therefore, ARB staff believes GREET input data points that contribute less than 10 percent of a fuel's overall CI should be set at a magnitude representing average practices. Additionally, if the volume of fuel is below 10 million gallons, the changes to the value will not be significant enough to warrant a recalculation.

To summarize, the value of each GREET input data point is determined by the ease of reporting process-specific data, the verification possibility, and its contribution to the overall fuel pathway CI (as shown in Figure 3).

Figure 3
Process for Selecting Appropriate Magnitude for Input Data Points



2. Process for Generating Carbon Intensity Lookup Tables

Once the GREET input data points have been established, ARB staff uses those data points to generate the lookup table CI values in a process that can be summarized as follows:

1. For each GREET input data point, obtain the following information:
    - What are the values of best practice, typical practice, and worst common practice?
    - What is the distribution of the practices within the above ranges?

   Based on the above information, determine the average value and conservative value for the data point.
2. Select either the average value or conservative value for each GREET input data point, based on following criteria:
    - The ease with which data could be collected; if the data are difficult to report, set the data point to the average value.
    - The verifiability of the collected data; if the data are unverifiable, set the data point to the average value.
    - The contribution of the data to the overall fuel pathway carbon intensity. If the data contribute less than 10 percent of the full life cycle carbon intensity of a fuel pathway, set the data point with average value.

   The conservative value could be set to the data point only if the data meet all of the three criteria.
3. Run the GREET model to calculate the Carbon Intensity Lookup Table Value for that specific fuel sub-pathway. All of these lookup table values consist of the level 4 of the lookup table, Fuel Processing Characteristic Level Values.
4. The level 3 lookup tables, Feedstock & Its Origin Level Values, are set equal to the highest carbon intensity among the Fuel Processing Characteristic Level values.
5. The level 2 lookup tables, Feedstock Level Values, are set equal to the highest carbon intensity among the Feedstock & Its Origin level values.
6. The level 1 lookup tables, Fuel Type Level Values, are set equal to the highest carbon intensity among the Feedstock level values.

C. Method 2 – Customized Lookup Table

As noted earlier, a regulated party has the option of replacing some of the predefined GREET input data points for a given fuel or blendstock with its own process-specific data to calculate a GREET-based custom CI value.

1. Thresholds for Custom Values

Because of the resources involved in verifying custom values, ARB staff proposes that a regulated party be required to meet the following thresholds before ARB accepts for review such custom data points and values:

- the custom value must be at least 10 percent below the lookup table's CI value that otherwise would be assigned to that fuel; and
- the regulated party must be providing or capable of providing a minimum of 10 million gallons per year of that fuel.

Regulated parties that cannot meet these two thresholds would not be permitted to use customized carbon intensity values. Instead, those regulated parties would be limited to using the lookup values under Method 1.

2. Software Compliance Tool

For those regulated parties that meet the two threshold requirements noted above, the staff is proposing to develop a standardized way for calculating custom carbon intensity values. To this end, ARB staff is exploring the feasibility of developing a Software Compliance Tool. Such a tool will act as the interface between the user and the GREET model. Using the Software Compliance Tool, a regulated party will be able to input a limited set of GREET input values that are specific to its circumstances.

As noted in the next section, not all GREET inputs will be available for a regulated party to customize. Only those GREET inputs that are not "invariable" will be available for customizing. Customizing a GREET input does not mean replacing a GREET input with something that is not explicitly included in GREET. For example, a regulated party cannot create an input value (e.g., refinery efficiency) that is not already predefined and built into the model as a GREET input. Instead, the regulated party, through the Software Compliance Tool, will be able to customize only a specific, limited set of "variable" GREET inputs, which in turn would yield custom carbon intensity values applicable to the regulated party and other regulated parties with similar processes.

3. Variable and Invariable Input Data

The predefined GREET input data are set to average values if they do not meet the three criteria specified in section VII.B.1 above. ARB staff believes that once the data points are set to values reflecting average practices, these data points should not be replaced by any process-specific data under Method 2. This is because such replacements may cause underestimations of the total carbon intensity of the fuel pool. Therefore, staff proposes that these data be defined as Invariable Data in the Software Compliance Tool. The draft regulation would allow only the remaining inputs (i.e., the "Variable Data") to be replaced by process-specific data. Where two or more data points are strongly correlated, the regulation would not permit submittal of process-specific data for just one of these inputs.

Staff will review the comments on the accuracy of all of the invariable values for the GREET model and determine how frequently the values should be updated.

4. Process for Generating Customized CI Values

Similar to the process for generating the lookup table values under Method 1, the process for generating customized CI values begins once ARB has approved the custom GREET input data points.

Upon ARB approval of the custom values, ARB staff will incorporate these values into the appropriate lookup tables. Approved custom values then become part of the lookup table values and can be used by any regulated party under similar process conditions (see section C.5 below).

5. Incorporation into Lookup Tables and Unrestricted Public Use of Data in Submitted Support of Method 2

As noted previously, a regulated party may, under Method 2, submit customized input values only for the "variable" GREET inputs. Regulated parties would not be permitted to customize GREET by modifying those inputs identified by ARB as "invariable." Further, regulated parties would not be permitted to customize GREET by introducing new inputs (e.g., refinery efficiencies) that are not already included in GREET. The customized GREET inputs that are permitted would have to meet the thresholds for substantiality noted in section VII.C.1 above and reflect the conditions specific to the regulated party that is proposing the customized values.

ARB staff is proposing to incorporate these customized GREET input values into the publicly available lookup tables, discussed under Method 1 in section VII.B above, rather than allowing regulated parties to use such custom carbon intensity values without disclosure. This ensures full transparency in all carbon intensity values used for compliance and credit generation under the LCFS regulation. This also allows other regulated parties who have effectively identical processes to use the incorporated custom values in their calculations; the use of the customized values by other regulated parties would be subject to ARB approval. ARB staff believes this is a fair and reasonable requirement given the substantial State resources and effort that will be required to verify modifications or alternatives to the California-modified GREET input values that are proposed by regulated parties.

6. Example of Method 2 Procedure: Conventional Fuels Derived from Conventional and Non-Conventional Crude

ARB staff do not assign source-specific CI values in the lookup tables to CARBOB and diesel produced from conventional crude. Instead, the carbon intensities for these conventional fuels made from conventional crude will be based on the average fuel-pathway values derived from the California-modified GREET. The carbon intensities of these fuels will serve as the baselines for the LCFS.

For conventional fuels made from non-conventional crude, the draft regulation creates a rebuttable presumption that the carbon intensity of such fuels will be greater than 10% of the analogous conventional fuel made from conventional crude. In general, using non-conventional crude to make conventional fuels involves processes that increase the fuel's carbon intensity. But the regulation permits this presumption to be rebutted in one of three specified ways.

The first scenario is one in which either ARB or the regulated party calculates a carbon intensity value for the fuel that is very close to that of conventional fuel derived from conventional crude. In this case, if the carbon intensity values calculated by both ARB and the regulated party for the fuel are within 10% of the carbon intensity value for the fuel derived from conventional crude, the regulation allows the regulated party to use the conventional crude value.

The second scenario is one in which either ARB or the regulated party calculates a carbon intensity for the fuel that is more than 10% lower than the value calculated for the fuel derived from conventional crude. In that case, the draft regulation would require the regulated party to use, as the presumed value, the calculated carbon intensity value that is closer to the conventional crude value. However, the regulated party may rebut this presumption (i.e., use its own calculated value) only if the party has demonstrated, to ARB's satisfaction, the validity of the party's claimed carbon intensity value. This demonstration must be based on adequate documentation, and the claimed carbon intensity value is subject to ARB approval. This provides a conservative method for providing "credit" to a conventional fuel derived from nonconventional fuel.

The third scenario is one in which either ARB or the regulated party calculates a carbon intensity for the fuel that is more than 10% greater than the value calculated for the fuel derived from conventional crude. In that case, the regulation would require the regulated party to use as the presumed value the calculated carbon intensity value that is further from the conventional crude value. However, the regulated party may rebut this presumption (i.e., use its own calculated value) only if the party has demonstrated, to ARB's satisfaction, the validity of the party's claimed carbon intensity value. This demonstration must be based on adequate documentation and the claimed carbon intensity value is subject to ARB approval. This provides a conservative method for assigning a carbon intensity value to conventional fuel derived from nonconventional fuel.

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VIII. Multimedia Evaluations

A. Statutory Requirements

Senate Bill 529, enacted in 1999 and set forth in Health and Safety Code (H&S) section 43830.8 ("the statute"),[3] generally prohibits ARB from adopting a regulation establishing a specification for motor vehicle fuel unless the regulation is subject to a multimedia evaluation by the California Environmental Policy Council (CEPC). (Stats. 1999, ch. 813; SB 529, Bowen.) Pursuant to Public Resources Code section 71017(b), the CEPC was established as a seven-member body comprised of the Secretary for Environmental Protection; the Chairpersons of the ARB, State Water Resources Control Board, and Integrated Waste Management Board; and the Directors of the Office of Environmental Health Hazard Assessment, the Department of Toxic Substances Control, and the Department of Pesticide Regulation. Key components of the evaluation process are the identification and evaluation of significant adverse impacts on public health or the environment and the use of best available scientific data.

"Multimedia evaluation" means the identification and evaluation of any significant adverse impact on public health or the environment, including air, water, or soil, that may result from the production, use, or disposal of the motor vehicle fuel that may be used to meet the state board's motor vehicle fuel specifications. H&S §43830.8(b).

The statute generally provides that ARB may adopt a regulation establishing a motor-vehicle fuel specification without undergoing the prescribed multimedia evaluation process if the CEPC, following an initial evaluation of the proposed regulation, finds that the regulation will not have significant adverse impacts on public health or the environment.

B. Applicability of H&S §43830.8 to the LCFS Regulation

The provisions in H&S §43830.8 are relatively straightforward for a fuel regulation that unquestionably constitutes a fuel specification. However, before the substantive requirements of the statute can be discussed, we first need to address an important threshold question in this case: Does the statute apply to the LCFS regulation itself, or does it apply only to subsequent ARB rulemakings establishing new or amended motor-vehicle fuel specifications to implement the LCFS program?

1. H&S §43830.8 Applies To ARB Adoption Of Regulations That Establish Specifications For A Motor Vehicle Fuel.

[3] All statutory references in this chapter are to H&S §43830.8 unless otherwise noted.

By its terms, the statute clearly focuses on prohibiting ARB from adopting regulations that establish specifications for motor vehicle fuels unless the regulation has been subjected to a multimedia evaluation as specified. Presumably, this is to avoid, among other things, requiring ARB to conduct a multimedia evaluation for rule amendments that are merely technical in nature and have no substantive effect on motor vehicle fuel specifications. Another possibility is that the Legislature did not want to require a multimedia evaluation whenever ARB adopted fuel *use* requirements, which affect the use of a fuel and operation of equipment using that fuel, rather than affecting the fuel itself.[4] A third possibility is that the Legislature did not want to require multimedia evaluations for emissions averaging or similar regulatory schemes for which an enforceable goal is set but the exact methods for achieving that goal are not specified by the regulation (i.e., through motor vehicle fuel specifications).

Further, the Legislature presumably used the term “specification,” rather than more broad terms such as “standard” or “requirement,” to express an intent to focus on those regulations in which ARB is proposing to dictate what is added (or prohibited from being added) into a motor vehicle fuel. This would be consistent with the legislative history of SB 529, which was promulgated after refiners began to use methyl *tert*-butyl ether (MTBE) in gasoline in the 1990s to meet ARB oxygenate requirements. The Legislature enacted SB 529 after MTBE was subsequently shown to leak out of underground storage tanks unexpectedly into aquifers.

With these considerations in mind, the next questions that follow are, “What is a motor vehicle fuel specification?” and “Is the LCFS a regulation that establishes a fuel specification for motor vehicle fuels?”

2. The LCFS Regulation Does Not Establish a Specification for Motor Vehicle Fuels.

For purposes of this discussion, the primary LCFS requirement of interest is the requirement for regulated parties to reduce their carbon intensity by 10%.[5] This 10% reduction in overall carbon intensity would cover the party’s overall motor vehicle fuel pool, including all fuels subject to the LCFS, as well as any credits/deficits from overcompliance and undercompliance with the requirement in a given compliance period.

Unfortunately, the statute provides no explicit definition for “specification.” However, there is evidence indicating that the Legislature intended the term “specification” as a reference to the permissible ingredients that comprise a fuel (i.e., the fuel’s

[4] An example is the California requirement for locomotives and commercial harbor craft to use California ultralow sulfur diesel. 13 CCR §2299 and 17 CCR §93116.

[5] That is, the regulated party’s carbon intensity must be no greater than the carbon intensity (CI) for gasoline or diesel as the CI for those fuels are reduced by 10% between 2010 and 2020 in accordance with the proposed regulation’s compliance schedule (the gasoline CI applies generally for light duty vehicles and the diesel CI for heavy duty vehicles).

“composition”). In H&S §43018, a statute last amended nine years before SB 529 was enacted, the Legislature mandated that ARB:

> “adopt standards and regulations which will result in the most cost-effective combination of control measures on all classes of motor vehicles and *motor vehicle fuel*, including, but not limited to, all of the following:…(4) *[s]pecification* of vehicular fuel *composition*…” [emphasis added].

H&S §43018(c)(4) [Added Stats. 1988, ch. 1568; amended Stats. 1989, ch. 559; amended Stats. 1990, ch. 932].

In this context, the Legislature seems to use the term “specification” as a subset of motor vehicle “standards,” “regulations,” and “measures.” Thus, one can reasonably presume that, in the context of motor vehicle fuels, the Legislature intended the term “specification” to be an ARB mandate on a vehicular fuel’s permissible composition, rather than on the production process for the fuel.

This view of the legislative intent is further supported when one looks at the common usage for the term “specification” in the area of motor vehicle fuels. To this end, we first discuss the general characteristics of a specification and then look at several examples of existing ARB specifications. From these examples, it is possible to glean whether the Legislature intended for a regulation like the LCFS to trigger the multimedia evaluation requirement.

<u>Characteristics of a Motor Vehicle Specification</u>

The Oxford American dictionary defines “specification” as follows:

> “*A detailed description of the design and materials used to make something.*”

(Oxford 2006). This suggests that a specification is prescriptive in nature, i.e., telling the reader that material X is required in Y amount. A useful analogy is a typical cooking recipe, in which not only are the ingredients specified, but also their relative quantities. Motor vehicle fuel specifications, like cooking recipes, also specify what materials are permitted to be in a legal motor vehicle fuel and the relative quantities of those materials.

There are numerous examples of motor vehicle fuel specifications that were in existence at the time SB 529 was enacted. For instance, California’s diesel regulation in 1999 applied specifications that limited aromatic hydrocarbons to 10% by volume and 500 parts per million (ppm) sulfur in diesel.[6] Another example is the California regulation establishing specifications for E-85 (gasoline with 85% ethanol), which contains the following specific requirements:

[6] 13 CCR §2282(a)(1)(A) and §2281(a)(1), respectively. The 500 ppm sulfur limit was reduced for most applications to 15 ppm beginning in June 2006. *Id*. at §2282(a)(2).

Table 15
Select Specifications for E-85 Fuel Ethanol

Specification	Value	Test Method
Ethanol	79 vol. % (min.)	ASTM D 3545-90
Other Alcohols	2 vol. % (max.)	ASTM D 4815-89
Hydrocarbons + aliphatic ethers	15-21 vol. %	ASTM D 4815-89, and then subtract concentration of alcohols, ethers and water from 100 to obtain percent hydrocarbons
Acidity as acetic acid	0.007 mass % (max.)	ASTM D 1613-85
Total chlorine as chloride	0.0004 mass % (max.)	ASTM D 3120-87 modified for the det. of organic chlorides, and ASTM D 2988-86
Copper	0.07 mg/l (max.)	ASTM D 1688-90 as modified in ASTM D 4806-88

Source: 13 CCR § 2292.4 (adopted by ARB in 1992); footnotes omitted.

A third, more current example is the CaRFG regulation, which specifies the following:

Table 16
Select Specifications for CaRFG3

Property	Flat Limits	Averaging Limits	Cap Limits
Reid Vapor Pressure, psi, max	7.00 or 6.90	--	6.40 – 7.20
Benzene vol%, max	0.8	0.70	1.10
Sulfur, ppmw, max	20	15	30
Aromatic HC, vol%, max	25	22	35
Olefins, vol% max	6.0	4.0	10
Oxygen, wt%	1.8 to 2.2	--	1.8 - 3.5 0 – 3.5
T50 (temp. at 50% distilled) ^oF, max	213	203	220
T90 (temp. at 90% distilled) ^oF, max	305	295	330

Source: 13 CCR §2260 et seq.; footnotes omitted.

Of course, motor vehicle fuel specifications are not cooking recipes, as they entail highly technical properties and measurements for the affected fuels. But like a cooking recipe, all the above examples of existing fuel specifications share a common characteristic – the specifications contained in the requirements are quantifiable and measurable chemical or physical properties that are intrinsic to the final fuel itself, not how it is produced. In other words, one can take a sample of diesel and measure its sulfur and aromatic content to see if it meets the specified limits on those properties. Similarly, a sample of gasoline can be analyzed in a laboratory for its Reid vapor pressure or sulfur content. To determine compliance with the specifications for these fuels, it is irrelevant to ask how these fuels were made – the only question is whether the finished product has the desired physical and chemical properties.

In contrast, it is as important, or even more important, to know *how* a fuel or blendstock was made under the LCFS regulation than knowing the fuel's actual constituents. The LCFS requires a regulated party to achieve a specified performance reduction in its motor vehicle fuel pool's overall carbon intensity. This is the sum of all carbon intensities associated with all steps required to produce, distribute, market and use the party's fuel, plus any credits purchased, generated, or used by the party. As such, a regulated party's carbon intensity cannot be directly measured in a sample of gasoline, diesel, or any other fuel. Simply put, one cannot take a gallon of gasoline and measure its carbon intensity in a laboratory like one would for determining the fuel's boiling point.

Rather, a fuel's carbon intensity is inferred from the various steps taken to produce that fuel and the relative impacts to climate change associated with each step (vis-à-vis the steps' carbon intensity), as well as accounting for any credits used, generated, or traded by the regulated party. Thus, the relevant question for the LCFS is exactly the opposite of the above examples of actual fuel specifications: Exactly how was the product made, since the process for producing and distributing the product is what affects the product's carbon intensity?

To further illustrate, a gallon of ethanol made from corn grown and processed in the Midwest will, under a microscope or other analytical device, look identical in every material way to a gallon of ethanol processed from sugar cane grown in Brazil. Both samples of ethanol will have the same boiling point, the same molecular composition, the same lower and upper limits of flammability – in other words, both will have identical physical and chemical properties because both products consist of 100% ethanol. On the other hand, the corn ethanol made from the Midwest will have a different carbon intensity than the sugar cane ethanol from Brazil. Thus, the relevant inquiry with carbon intensity is not so much what is contained in a fuel, but how was that fuel made, distributed and used?

An additional complication is that a regulated party's carbon intensity is not only reflective of its fuels' carbon intensities, but also whether any credits that are used or traded are also reflected in the party's overall carbon intensity. Thus, from the above example, even if the corn ethanol and sugar ethanol were to have identical carbon intensity, one regulated party using corn ethanol would almost certainly have a different overall carbon intensity than another party with sugar ethanol, simply because each party would have different rates of credit generation and usage.

The above considerations strongly suggest that the LCFS regulation, unlike other existing California regulations, does not establish prescriptive[7] fuel specifications. Instead, the nature of the LCFS regulation points to a rule that is much more akin to a performance[8] requirement, one that establishes an enforceable goal but does not dictate the process for how to achieve compliance with that goal. As such, ARB staff believes the LCFS regulation, by itself, does not establish motor vehicle fuel specifications; therefore, the LCFS rule should not be subject to the multimedia evaluation requirement.

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[7] "Prescriptive standard" means a regulation that specifies the sole means of compliance with a performance standard by specific actions, measurements, or other quantifiable means. (Gov. Code §11342.590.)

[8] "Performance standard" means a regulation that describes an objective with the criteria stated for achieving the objective. (Gov. Code §11342.570.)

3. The LCFS Regulation Does Not Affect Existing Fuel Specifications.

It is important to note that, by its terms, the LCFS regulation does not modify any other existing State or federal specifications for motor vehicle fuels. Section 95420(a)(2) of the proposed regulation includes a saving clause providing, in pertinent part, that:

> *Nothing in this LCFS regulation may be construed to amend, repeal, modify, or change in any way the California Reformulated Gasoline regulations (CaRFG, 13 California Code of Regulations (CCR) §2260 et seq.), the California Diesel Fuel regulations (13 CCR §2281-2285 and 17 CCR §93114), or any other applicable State or federal requirements. Any person, including but not limited to the regulated party as that term is defined in the LCFS regulation, subject to the LCFS regulation or other State and federal regulations shall be responsible for ensuring compliance with all of the LCFS requirements and other State and federal requirements, including but not limited to the CaRFG requirements and obtaining any necessary approvals, exemptions, or orders from either the State or federal government.*

This provision was included to reflect staff's intent that the LCFS regulation, by itself, neither establishes a fuel specification nor amends any other State or federal requirements that apply to the affected fuels, including other requirements that constitute fuel specifications.

This provision also reflects staff's understanding of what will likely occur to gasoline and diesel under the LCFS regulation. To comply with the LCFS regulation, it is unlikely that refiners will change the composition and makeup of gasoline and diesel, since these are relatively mature technologies that still would need to meet applicable State and federal specifications. Instead, refiners are likely to choose less carbon-intensive blendstocks, such as cellulosic ethanol, to help meet their LCFS obligations.

4. There Are Practical Difficulties in Conducting a Multimedia Evaluation for the LCFS Rulemaking.

Even if, for the sake of argument, one were to conclude that the LCFS rule itself somehow triggers the multimedia evaluation requirement, conducting such an evaluation for the overall rule would make it practically very difficult, if not impossible, to conduct such an evaluation. Because the LCFS establishes a performance-based requirement (see above) rather than a prescriptive standard, it is very difficult for ARB to predict with certainty how regulated parties will comply with the LCFS requirement. For instance, there has been substantial mention of the use of genetically engineered algae to provide feedstock for making renewable diesel or other lower carbon intensity fuels. However, such technology is, at best, in its infancy, and no meaningful discussion of the pathways (and, by extension, the associated carbon intensity) can be made until the technology is better developed and ARB has adopted fuel specifications for such fuels.

Given these difficulties, the best that ARB staff can provide at this time is the “functional equivalent” of a multimedia evaluation. Such an equivalent can, to the extent feasible, identify and evaluate the potential adverse impacts on public health or the environment that may result from the production, use, or disposal of motor vehicle fuels that are likely to be used to meet the LCFS requirements. As fuels are developed and produced to comply with the LCFS, ARB can adopt new specifications or amend existing specifications for such fuels as needed. At that time, ARB staff plan to conduct new multimedia evaluations pursuant to H&S §43830.8.

C. Applicability of H&S §43830.8 to Post-LCFS Regulations Establishing Vehicular Fuel Specifications

Based on the above discussion, ARB staff believes that the LCFS regulation itself does not establish motor vehicle fuel specifications that trigger the multimedia evaluation requirement. However, it is clear that post-LCFS rules adopted by ARB would certainly require multimedia evaluations to the extent such rules establish new fuel specifications or modify existing ones. The LCFS regulation incorporates this principle as a pre-sale prohibition applied to fuels that are subject to an ARB specification that is modified or adopted after adoption of the LCFS regulation.[9] In such cases, regulated parties would be prohibited from selling the affected fuels in California to comply with the LCFS requirements until a multimedia evaluation is approved for those fuels pursuant to H&S §43830.8.

Fuels that would not be subject to this pre-sale prohibition include the following (until such time as ARB adopts a new specification or modifies the existing specification for these fuels):

- Those fuels that were "grandfathered” in before July 1, 2000, pursuant to H&S §43830.8(h), or have not had their specifications amended since SB 529 was enacted – these include CaRFG, diesel, E85, E10, CNG, LNG, LPG;
- Those fuels for which there are no existing ARB specifications but are permitted for sale in California pursuant to regulations promulgated by the Division of Measurement Standards -- this includes biodiesel and renewable diesel; and
- Those fuels for which the California Environmental Policy Council has determined no significant adverse impacts would result from ARB’s adoption of a fuel specification (under H&S §43830.8(i)).

For the 2009 rulemaking calendar, ARB staff is currently planning to propose a new motor vehicle specification for biodiesel and renewable diesel and amendments to

[9] See proposed LCFS section 95426(a).

existing specifications for E85 and CNG. Multimedia evaluations will be needed for those upcoming 2009 rulemakings, as provided for in H&S §43830.8.

To comply with the requirements for multimedia evaluations that are applicable to the Low Carbon Fuel Standard:

- Staff recognizes that a full and comprehensive multimedia evaluation, in accordance with H&S §43830.8, is neither required nor practical to conduct for the LCFS rulemaking itself;

- Nevertheless, to implement the "spirit" of H&S §43830.8, staff intends to conduct the functional equivalent of a multimedia evaluation for the LCFS rulemaking to the extent feasible. This functionally equivalent assessment will be conducted in accordance with the Cal/EPA guidance document entitled, "Guidance Document and Recommendations on the Types of Scientific Information Submitted by Applicants for California Fuels Environmental Multimedia Evaluations" ("Guidance Document," June 2008); and

- Staff will conduct full multimedia evaluations, consistent with H&S §43830.8 and in accordance with the Guidance Document noted above, prior to ARB adoption of a new fuel specification or amendment of an existing one for motor vehicle fuels subject to the LCFS rule. The first of these will be rulemakings in 2009 to adopt or amend motor vehicle fuel specifications for biodiesel, renewable diesel, CNG, and E85.

References

Concise Oxford American Dictionary, Oxford University Press, Inc., 2006 Ed., p. 869.

Appendix A

Preliminary Evaluation of the Land Use Change Effects for Corn Ethanol Production

Acknowledgements

This appendix presents the preliminary results for greenhouse gas (GHG) emissions associated with indirect land use changes for the production of ethanol from corn. Much of the analyses that form the basis for this appendix have been done by researchers at the University of California, Berkeley, and Purdue University. In particular, ARB staff would like to thank the following individuals for their work on this project:

University of California, Berkeley
Michael O'Hare
Andrew Jones
Richard Plevin

Purdue University
Thomas Hertel
Alla Golub

Comprehensive modeling of how land use changes due to biofuel use affect GHG emissions is a new field. Refinements and improvements occur on a regular basis as the data driving the models and the coefficients that convert that data into estimates of the impact are expanded and refined. As these improvements are made, revised land use impact factors for ethanol from corn, and for the other crop-based fuels covered by the LCFS, will be released. In addition, staff will continue to work with UCB and Purdue researchers to evaluate the indirect land use change impacts from other biofuels and other indirect effects as they are identified.

1. Introduction

The increasing demand for biofuels may stimulate a corresponding increase in the demand for the crops used to produce those fuels. To meet that demand, farmers can:

- Reduce or eliminate crop rotations, fallow periods, and other practices which improve soil conditions and reduce the number of harvests over time;
- Convert acreage devoted to non-fuel crops and livestock to fuel crop production;
- Convert lands in non-agricultural uses to fuel crop production; or
- Take steps to increase yields beyond that which would otherwise occur.

The land-use impacts these practices create fall into two broad categories:

> Direct land use impacts: An increase in greenhouse gas (GHG) emissions caused by the intensification of agricultural effort on existing biofuel croplands.

These result from the increased use of farm machinery, fertilizers, and pesticides. The increased production and transport of the necessary fuels and agricultural chemicals also contribute to this impact. This category of impact is usually included in traditional fuel life cycle analyses, which estimate the total GHG emissions resulting from a fuel's production, transport, storage and use.

Indirect land use change impacts: These impacts occur when the acreage devoted to biofuel crop production is expanded as a result of increased use of crops for biofuels. Lands in both agricultural and non-agricultural uses may be converted to the cultivation of biofuel crops. Some indirect land use impacts are secondary: when acreage formerly devoted to livestock and non-biofuel crops is converted to biofuel production, shortages in food, feed, and livestock products can occur. The price pressures these shortages create can stimulate the conversion additional non-agricultural land to agricultural uses. When these land use changes result in increased GHG emissions—the release of carbon sequestered in soils and land cover vegetation, for example—an indirect land use impact has occurred. Direct and indirect land use effects that reduce food, feed, and livestock product exports can trigger additional indirect impacts across national borders as trading partners attempt to make up for reduced exports from the US, and increased import demand associated with increased biofuel production.

Although some fuels will create both direct and indirect land use change impacts, others will have only direct or indirect impacts, and others will have no land use change impacts at all. A fuel will have no land use change impacts when it:

- Is not derived from crops;
- Is derived from cover crops, or crops planted between or beneath other crops; or
- Is derived from crops grown on lands that would not support the cultivation any other crop.

Direct land use change impacts are relatively straightforward to characterize and estimate. However, indirect land use impacts can be more difficult to quantify. Attributing specific land use changes to an increase in biofuel demand requires a more complex approach where economic factors need to be taken into consideration.

The conversion of non-agricultural lands into agricultural uses is primarily driven by well documented economic forces. Therefore, economic models can be used to estimate the magnitude of biofuel-driven land use change impacts. A number of models capable of estimating the land use change impacts of crop-based fuels have been developed in recent years. ARB staff is committed to assuring that full lifecycle emissions, including those from both direct and indirect land use change impacts, are included in the carbon intensity ratings fuels will receive under the LCFS. Therefore, in cooperation with researchers from the University of California, Berkeley (UCB) and Purdue University, ARB staff evaluated three possible models for conducting the analysis.

2. Model Descriptions

These models fall into two broad categories: computable partial and general equilibrium (CPE and CGE) and optimization models. These economic models are built around databases that describe all significant transactions that occur within an economy, a portion of an economy, or two or more linked economies. These inputs include, for example, how much corn the ethanol industry consumes, as well as the amount it pays farmers (agribusiness) for that corn. Models that include two or more national economies will contain tables that describe all significant trade exchanges that occur between each pair of nations (in addition to each nation's internal transactions tables).

CGE models are programmed to seek equilibrium between supply and demand in all markets. As such, they are well-suited to modeling policy impacts in a decentralized economy such at the United States. If a change is introduced—increased demand for crop-based fuels, for example—fuel crops, fuels themselves, and a number of related prices will all change until a new equilibrium is reached. Prices that rise (such as the demand-driven price for ethanol) will stimulate higher production. Prices that drop will have the opposite effect. A CGE model will seek that point at which total demand (including demands by consumers, industry and exports) is satisfied by supply (the quantity produced) throughout the modeled economy. Once a new economy-wide equilibrium is reached, the model presents all changes that occurred, as well as the net, economy-wide change.

CGE models can be extended to evaluate different categories of changes, so long as those categories respond to economic stimuli in a manner similar to the traditional economic sectors already included in the model. Data tables and transactions that describe parameters such as pollution levels (including GHG generation), water supply, and land use patterns can be added to the CGE models. The impacts of changes affecting these parameters (usually stimulated by policy changes) can then be reported out along with the corresponding changes in the more traditional economic sectors.

Optimization models were developed to seek optimal allocations of goods, resources, funds, etc. among competing uses, subject to user-specified constraints. In some circumstances these can be viewed as a tool for modeling how a decentralized economy evolves over time. Unlike CGE models, which are specifically designed and used to evaluate economic impacts, Optimization models are aimed at evaluating all sorts of complex allocation problems. The model that ARB staff evaluated allocates available lands to competing uses based on the same basic economic principals used in CGE models. As such, it will generally produce impact estimates similar to those generated by CGE models.

ARB staff, in cooperation with the UCB/Purdue team, evaluated the two CGE models; the Global Trade Analysis Project (GTAP) model, and the Food and Agricultural Policy Research Institute (FAPRI) model. The optimization model evaluated was the Forest and Agricultural Sector Optimization Model (FASOM).

Of the two CGE models staff evaluated, the most comprehensive is GTAP. GTAP was developed by researchers at Purdue University, who also host the model. Within GTAP's scope are 111 world regions, some of which consist of single countries, others of which are comprised of multiple neighboring countries. Each region contains data tables that describe every sector in every national economy in that region, as well as all significant intra- and inter-regional trade relationships. The data for this sizable model is contributed and maintained by more than 6,000 local experts from each of these regions.

GTAP has been extended for use in land-use change GHG emissions modeling by the addition of a land use module that includes data on 18 agro-ecological zones for each region in the model, a carbon emissions factor table, and a co-products module (which adjusts GHG emission impacts based on the market displacement effects of co-products such as the dried distillers' grains with solubles which the ethanol production process yields). Predicted land use change impacts are aggregated by affected land use types (crop land, accessible forest, and pasture).

The FAPRI model is a partial equilibrium dynamic model; it estimates agricultural sector impacts in countries with which the U.S. maintains agricultural trade relationships. Although FAPRI can estimate the amount of land demanded in each crop and livestock activity, it does not explicitly model the land markets themselves, so FAPRI is silent on the issue of crop land conversion.

FASOM is a dynamic, partial equilibrium, optimization model of the U.S. economy. It models the responses of the American forest and agricultural sectors to policy changes. It accomplishes this by predicting optimal allocations of available land to competing agricultural and forestry uses, subject to standard economic constraints. It then estimates the impacts on the commodity markets supplied by these lands and the net greenhouse gas (GHG) emissions associated with these changes. The outputs of the model include estimates of the technical, economic, and environmental impacts of the modeled policy changes, and GHG mitigation opportunities.

Based primarily on its global scope, its maturity, and its long history of use in modeling complex international economic effects, ARB staff is proposing to use the GTAP model to estimate GHG emissions factors from the land use change impacts of the fuels that will be subject to the LCFS. Staff is working with the UCB and Purdue researchers to update various components of the model and include data required for the analysis of sugarcane ethanol, biodiesel, and cellulosic ethanol. The additional work will include, if needed, changes in the input factors and other model inputs.

3. Preliminary GTAP Land Use Change Results for Corn Ethanol

The preliminary corn ethanol land use change results presented below were produced using the GTAP global economic database which represents the 2001 world economy. The 2001 GTAP database builds on the most recent global harvested crop land and land cover data base representing the combined efforts of the UN-FAO, IFPRI and the

University of Wisconsin (SAGE). By incrementally increasing the 1.75 billion gallons of ethanol produced domestically in 2001 to the 15 billion gallon volume authorized by the Energy Independence and Security Act of 2007 (EISA), it is possible to perform a sensitivity analysis on ethanol production levels. Sensitivity analyses allow the modeler to measure how sensitive model outputs are to variation in the input parameters.

In this case, the goal was to determine whether GHG generation rates (driven by land use changes) vary across a broad possible range of ethanol production levels—whether, for example, an increase in the 1.75- to 10-billion-gallon range generates GHGs at a different rate than an increase in the 10- to 15-billion-gallon range. These runs confirmed that the model predicts that the rate of GHG production is not particularly sensitive to the volume of ethanol being produced[10]. Land use change and GHG generation rates were therefore modeled at the full EISA domestic production volumes of 15 billion gallons per year.

Corn Yield Elasticity: Corn yields (amount of corn produced per acre) varies with corn price. The relationship between price and yield is captured in what is known as the price-yield elasticity. Based on a review of the literature on corn yields, the average yield response in the U.S. was at 0.4. This was the original value chosen for GTAP. However, there is evidence that the corn yield elasticity has been falling over time; the most recent study produced a yield response of 0.27. There are econometric arguments why this might be an overestimate (treatment of time trend) but there are also good reasons why this might be an underestimate (only focuses on fertilizer use). Therefore, the GTAP modelers settled on a price-yield elasticity of 0.25 (for their central case). The interpretation of this parameter is straightforward: an x percent increase in the price of corn, relative to input cost (e.g., fertilizer), will result in a percentage increase in corn yields equal to x times 0.25. The higher the elasticity, the greater the yield increases in response to a price increase. For purposes of testing the sensitivity of the modeled GHG outputs to price-yield elasticity, lower and upper bounds of 0.1 to 0.6 were used for this parameter. The GHG output was decreased by about 49% when the corn yield elasticity was increased from 0.1 to 0.6. As shown in Table 4 below, the GHG emissions are quite sensitive to this parameter, so it is the object of considerable debate. This elasticity is assumed to apply over the medium run (e.g., 3 years). We do not expect to see significant yield changes in response to short run price variations which can be very volatile.

Elasticity of harvested acreage response: This elasticity expresses the extent to which changes occur in cropping patterns as relative land returns change. The change in the number of acres devoted to a specific crop is the product of a land mobility parameter, and a factor expressing that crop’s relative importance (its proportional share of all land rents paid in the region). As the share of agricultural land in the region is devoted to a

[10] The sensitivity of the model to variation in a single input variable is tested by setting all input variables except for the one being tested to their central, or most defensible, values. The test variable is then set to its lowest credible value for one run, and then to its highest credible value for a second run. The variation in the output variable between these two runs constitutes the sensitivity of interest. It is usually expressed in percentage terms.

single crop, rises, the acreage response elasticity falls. The GTAP modelers determined that the upper-bound value of 0.5 is warranted for this parameter (This is the highest value in the FAPRI/CARD files). This value was not included in the current sensitivity analysis.

Elasticity of land transformation across cropland, pasture, and forestry: This parameter functions exactly like the elasticity of harvested acreage response parameter, above. The land use conversions it includes, however, are not restricted to currently cultivated land areas. In addition to agricultural land uses, pasture and forest lands are included. The available evidence indicates that land use changes across agricultural, forest, and pasture cover types are not readily triggered by changes in land costs. Therefore, this parameter was set to the relatively low value of 0.2, based on historical evidence for land cover change in the US over the 1982-1997 period. For the sensitivity analysis, it was varied between 0.1 and 0.3. This variation in the land transformation input variable produced a 30 percent variation in the output variable. As shown in Table 4, the only input variable that produced less output variation was the trade elasticity variable.

Elasticity of crop yields with respect to area expansion: In most parts of the world, a majority of the land that is well-suited to crop production has already been converted to agricultural uses. Therefore, yields on newly converted lands are almost always lower than corresponding yields on existing crop lands. This parameter is equal to the ratio of yields that will be realized from newly converted lands (marginal yields) relative to average yields on acreage previously devoted to that crop. In economic terms, it is the ratio of marginal to average yields within an agro-ecological zone. Although this is a critical input parameter, little empirical evidence exists to guide the modelers in selecting the most appropriate value. Based on the professional judgment of those with experience in this area, the modelers selected a value of 0.66. For purposes of the sensitivity analysis this parameter was varied from 0.25 to 0.75. This input variable produced by far the greatest variation in the output GHG variable: 77 percent.

Trade elasticity: Based on an analysis of bilateral trade data from a variety of nations in the western hemisphere, the GTAP authors estimated the trade elasticities shown in Table 1, below. These elasticities express the elasticity of substitution among imports from all available exporters. These elasticities express the upper bound on the extent to which the importer will respond to a price increase from a given exporter by switching to a different exporter for the more expensive commodity. If a given cereal exporter raises its price by 5 percent, for example, the importer will purchase (at most) 2.6 times 5 percent of its cereal grain imports from a different exporter. The total change is dimished as the exporter’s share of a given market rises. The 2.6 figure is the elasticity value for cereal grains appearing the Table 1. Table 1 also reports the elasticity ranges used in the sensitivity analysis. The sensitivity of the model to these trade elasticities was measured by comparing a run with all elasticities to their lowest values to a run with all elasticities set to their highest value. The results show that GHG output variable changed by only 1.6 percent between these two runs. This is the lowest sensitivity reported in Table 4.

Table 1
Trade Elasticity Ranges

Commodity	Elasticity of Substitution Among Imports from Different Sources	Sensitivity Analysis Values	
		1 Standard Deviation below	1 Standard Deviation above
Cereal Grains	2.6	1.5	3.7
Other Grains	9.1	5.1	13.1
Oilseeds	4.9	4.1	5.7
Sugar	5.4	3.4	7.4
Other Agricultural Commodities	4.14	3.14	5.14

Estimating GHG Emissions from Indirect Land Use Changes: The model runs using the parameter values described above produced estimates of the number of hectares of land for each region that experienced changes resulting from the increased cultivation of corn destined for the ethanol industry. Carbon factors were then used to estimate for each land type converted the GHG lost from (a) above ground (occurred at once), (b) below ground (occurred over 5-10 years), and (c) avoided sequestration (occurred continuously in the future years).

Converting Indirect Land Use Change GHG Emissions to Grams per MJ of Ethanol: The three types of GHG estimated losses must be converted to units of grams of CO2 equivalent per megajoule (g CO2e/MJ) of ethanol produced in order to be used in the LCFS. To do this, a time period during which biofuel production is expected to 'offset" indirect land use change emissions must be selected. The time period used for this assessment was 30 years. This approximates the expected lifetime of biofuel facilities that convert corn to ethanol. For this assessment, staff also assumed that emission increases occurring today have equal environmental impacts as emissions decreases that would occur at a future time within a 30 year period.[11]

Based on the GTAP runs and time adjustments described above, the impacts of indirect land use changes caused by the production of ethanol from corn are estimated. The preliminary results for the GHG impacts range from 20 to 88 grams of CO2 equivalent per megajoule (g CO2e/MJ), with the majority of values in the 29 to 40 g CO2e/MJ range. For purposes of this preliminary analysis, ARB staff chose to use the value of 35 g CO2e/MJ as a value in the middle of that range. Table 2 summarizes the results of the GTAP runs that yielded these GHG impact results. The estimated land use changes, in hectares of land, are shown in Table 3.

[11]Note that the method used here to calculate GHG impacts—annualizing unweighted GHG emissions over 30 years—is still under review. ARB staff is evaluating the use of other impact time frames and the possible use of discounting (in keeping with the net present value approach). Discounting gives benefits and impacts occurring in the near term more weight than benefits and impacts that occur in longer term. In addition, analytical time frames up to 100 years are currently under consideration. Staff is seeking comments on this important issue.

Table 2
Detailed GTAP Run Results

	Units	Scenario										
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Baseline Year		2001	2001	2002	2001	2001	2001	2001	2001	2001	2001	2001
Annualization Period	Years	30	30	30	30	30	30	30	30	30	30	30
Incremental Volume	B gal	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25
Key Results												
LUC Term	g/MJ	37	88	20	29	49	57	39	30	36.5	37.1	30
Land Converted	Mill ha											
Total land	mill ha	4.42	8.89	2.94	3.40	6.00	7.26	4.99	3.3	4.5	4.3	4.2
Forest land	mill ha	1.13	3.36	0.40	0.80	1.60	1.94	0.98	1.1	1.2	1.07	0.8
Pasture land	mill ha	3.28	5.53	2.54	2.60	4.40	5.32	4.00	2.2	3.3	3.2	3.4
U.S. Total land	mill ha	1.91	3.85	1.27	1.70	2.20	2.35	2.32	1.25	1.8	2.07	1.6
U.S. Forest land	mill ha	0.77	1.88	0.40	0.70	0.90	0.90	0.89	0.53	0.71	0.85	0.5
U.S. Pasture land	mill ha	1.14	1.97	0.87	1.00	1.30	1.45	1.43	0.72	1.1	1.2	1.1
Economic Parameters												
Productivity of Marginal Land		0.50	0.25	0.75	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.66
Price Yield Elasticity		0.40	0.4	0.4	0.6	0.2	0.1	0.40	0.4	0.4	0.4	0.25
Elasticity of Substitution For Land cover		0.20	0.2	0.2	0.2	0.2	0.2	0.30	0.1	0.2	0.2	0.2
Elasticity of Substitution Crop Areas		0.50	0.5	0.5	0.5	0.5	0.5	0.50	0.5	0.5	0.5	0.5
Trade Elasticity for Crops		central	central	central	central	central	central	central	central	1 st dev above	1 st dev below	central

Table 3
Land Use Conversion Results

Land Conversion Location	Middle Estimate Results (millions of hectares)	Range (millions of hectares)
USA—All Lands	1.6	1 to 4.8
Forest land subtotal	0.5	
Pasture land subtotal	1.1	
Worldwide—All Lands	4.2	2.3 to 14.6
Forest land subtotal	0.8	
Pasture land subtotal	3.4	

4. Discussion of Sensitivity Analysis Results and Model Precision

As Table 4 shows, the GTAP land-use change results for ethanol are most sensitive to variation in the two crop-yield-related parameters. Changing the elasticity of corn yields on existing crop lands from 0.1 to 0.6 decreases the GHG impact by about 49%. The variable describing expected yields on former forest and pasture lands has the greatest effect on GHG impacts, however: an increase in that variable from 0.25 to 0.75 reduces the GHG impact by about 77 percent. The model is less sensitive to the elasticity of land transformation across cropland, pasture, and forestland: a change from 0.1 to 0.3 in that input variable increases the GHG impact by about 30 percent. The input variable with least effect on GHG impacts is trade elasticity: a change from one standard deviation below the central value to one standard deviation above that value produces only about a 1.6 percent drop in GHG impacts.

Staff will continue to work with UCB, Purdue, and other stakeholders to better define each of the input variables, particularly those to which the model is most sensitive.

Table 4
Sensitivity Analysis Results

Input variable	Input Variable Ranges		Output Variable Ranges (grams of CO_2 Equivalent per megajoule)		
	Low Value	High Value	From Low Input Value	From High Input Value	% Change
Corn Yield Elasticity	0.1	0.6	57	29	-49%
Elasticity of harvested acreage response	0.5	0.5	Was Not Subjected To Sensitivity Analysis		
Elasticity of land transformation across cropland, pasture and forest land	0.1	0.3	30	39	30%
Elasticity of crop yields with respect to area expansion	0.25	0.75	88	20	-77%
Trade elasticity	1 Std. Dev. Below	1 Std. Dev. Above	37.1	36.5	-2%

Appendix B

Use of the Energy Economy Ratio Factor in the LCFS Regulation

The Low Carbon Fuel Standard (LCFS) regulation will include the use of factors to recognize the fact that some fuels and vehicles are more energy efficient than others. The more energy efficient fuels and vehicles will travel more miles per unit of energy input to the vehicle, thus resulting in less fuel consumption and CO_2 emissions. Total emissions are dependent on both the emissions per unit of energy consumed and the fuel economy of the vehicle. This dependence can be illustrated with the following formula:

grams CO_2/mile=grams CO_2/MJ x MJ/mile

Because the LCFS standard is in units of mass per energy (gCO_2e/MJ), and not in units of mass per mile (gCO_2e/mile), the standard would not recognize the benefits of more energy efficient fuels and vehicles without the inclusion of an additional factor that represents the fuel economy.

For example, the wells-to-wheels CO_2 emissions from electric vehicles, in units of grams of CO_2 per megajoule of energy delivered to the vehicle, are generally higher than for gasoline vehicles. However, electric vehicles have much greater fuel economy (i.e., lower MJ/mi). As a result of their much lower per mile energy consumption, electric vehicles emit much less greenhouse gases than gasoline vehicles on a per mile basis, even though they emit more per unit of energy consumed. An LCFS regulation based only on the emissions per energy consumed would not recognize the benefits of electric vehicles without the inclusion of a factor that can be used to place the emissions from electric vehicles on a per mile basis.

For purposes of the LCFS, staff has adopted the term “Energy Economy Ratio,” or EER, to refer to the factor that is used to account for differences in energy efficiency among different types of fuels and vehicles. The term EER was used by TIAX, Inc., in its study for the California Energy Commission pursuant to the requirements of AB1007. The term EER has proved to be convenient index by which to measure energy efficiency differences between different types of fuels and vehicles. The use of the EER in the LCFS allows the use of the per energy emission metric (i.e., gCO_2/MJ), but in a manner that can be used to give an indication of total emissions (i.e., gCO_2/mile).

How is the EER Calculated?

The EER is defined as the ratio of the number of miles driven per unit energy consumed for a fuel of interest to the miles per energy for a reference fuel. For purposes of the LCFS, the reference fuel is gasoline for light duty vehicles, and diesel for heavy duty vehicles. Thus, the EER for light duty vehicles for a given fuel is defined as the ratio of the miles driven per energy consumed for that fuel to the miles driven per energy consumed for a comparable vehicle using gasoline. The EER for heavy duty vehicles is the same ratio with reference fuel being diesel. Therefore, the EER for gasoline is always 1.0 for light duty vehicles and 1.0 for diesel for heavy duty vehicles. The values for the number of miles driven per unit energy used are calculated based on data or estimates of fuel economy, in units of miles per gallon, and the energy density of the fuel, in units of energy (Btu or Joules) per gallon.

The following example illustrates a calculation of the EER for light duty diesel vehicles. The energy content (lower heating value) of California diesel is about 127,464 Btu per gallon (134.5 MJ per gallon), and for California RFG it is about 111,289 Btu per gallon (117.4 MJ per gallon). The average fuel economy for light duty diesel vehicles certified in the United States in the past few years is about 27.1 miles per gallon. The average fuel economy for the gasoline versions of these vehicles is about 20.4 miles per gallon. Using these values, the miles per energy for the diesel vehicles is about 0.201 miles per MJ (27.1/134.5), while for gasoline vehicles it is about 0.174 miles per MJ (20.4/117.4). Therefore, the EER for light duty diesel passenger vehicles is:

Miles per energy diesel / Miles per energy gasoline = 0.174/0.201 = 0.86.

The EER is calculated in a similar manner for other fuels. Where available, fuel economies from the U.S. EPA’s fuel economy guide were used to calculate EERs. If fuel economy data was not published in the EPA’s fuel economy guide for a particular fuel, data from other sources was used. If no data could be found on fuel economies for a given fuel, the EERs published in the TIAX report for the CEC pursuant to the AB1007 requirements was used.

<u>How is the Adjustment Factor Used?</u>

The EER can be used as a factor to adjust the wells-to-wheels carbon intensity values that are produced from life-cycle emissions models such as GREET in order to reflect differences in fuel economy among different types of fuels. As mentioned above, the gram per MJ metric does not give a complete indication of total greenhouse gas emissions because it neglects the effect of vehicle fuel economy on total emissions. Making an adjustment to the wells-to-wheels emissions in the gram per MJ metric with the EER has the effect of including differences in fuel economy. Making this adjustment provides a complete indication of the relative difference in total wells-to-wheels emissions among different types of fuels. If the gram CO2 per MJ values output by GREET are divided by the EER for a particular fuel and vehicle, the resulting quotient will give an indication of the total emissions for that fuel and vehicle relative to the reference fuel that was used to calculate the EER.

An example for electric vehicles illustrates this. For average California electricity generation, the carbon intensity value produced by GREET for electric vehicles is about 105 grams CO2 per MJ. For gasoline vehicles using California reformulated gasoline, the carbon intensity is about 96 grams CO2 per MJ. These values indicate that, on the basis of energy delivered to the vehicle and consumed, gasoline vehicles have higher greenhouse gas emissions than electric vehicles. However, assuming electric vehicles have an EER of 4.1, these vehicles would travel about 4.1 times as many miles as gasoline vehicles for the same energy consumption. If the energy economy for light-duty gasoline vehicles is 0.174 miles per MJ, the energy economy for light-duty electric vehicles can be calculated from the formula:

EER = miles per MJ electricity/miles per MJ gasoline

The energy economy for electric vehicles is about 4.1 x 0.174 = 0.713 miles per MJ.

Total per mile CO2 emissions for both gasoline and electricity can be calculated from the following formula:

gram CO2/mile = gram CO2/MJ x MJ/mile

For gasoline cars: gram CO2/mile = 96 x (1/0.174) = 552

For electric cars: gram CO2/mile = 105 x (1/0.713) = 147

This calculation shows that total CO2 emissions for light-duty gasoline cars are about 3.8 times the total CO2 emissions from electric cars.

This result can also be demonstrated by applying the EER for electric vehicles directly to carbon intensity value for electricity produced by the GREET model. The carbon intensity value for electric vehicles can be divided by the EER for electricity as follows to give an adjusted carbon intensity value for electric cars:

105 gCO2/MJ / 4.1 = 25.6 gCO2/MJ for light-duty electric vehicles

The result of this calculation can be combined with the carbon intensity value for gasoline vehicles produced by GREET to show that total CO2 emissions for light-duty gasoline vehicles are about 3.8 times the total CO2 emissions from electric vehicles.

96 gCO2/MJ for gasoline vehicles / 25.6 gCO2/MJ for electric vehicles = 3.8

The above calculation shows that dividing the carbon intensity values produced by GREET by the EER for a given fuel type gives an adjusted carbon intensity value that can be compared to the carbon intensity value for the reference fuel (gasoline for light duty and diesel for heavy duty) to give a ratio of total CO2 emissions. The EER values can thus be used to compare the total CO2 emissions from different types of fuels and vehicles without having to calculate gram per mile values. This allows the metric of grams CO2 per MJ to be used in the LCFS regulation, which is a much more convenient metric for regulatory and enforcement purposes than the gram per mile metric.

It is necessary to use the EER in the LCFS for setting carbon intensity standards; for calculating credits for over compliance and for inherently lower carbon intensity fuels that are not subject to the regulation; and for purposes of projecting the amount of energy that will be used in the transportation sector for various numbers of different types of vehicles that will be used.

While the EERs are calculated using data on fuel economy, they are applied to the total wells-to-wheels carbon intensity values produced by GREET, and not only to the tank-to-wheels emissions. For a fuel with a greater energy efficiency or fuel economy, less of the fuel will be burned to travel a given distance. Because less of the fuel will be burned, less of the fuel will have to be produced and distributed. The energy savings of the fuel with higher fuel economy will be translated to the entire fuel production and distribution process therefore lowering the entire wells-to-wheels carbon intensity for the fuel.

EER Values for Other Fuels

The EER values for other fuels are calculated in the same manner as for diesel. With the exception of diesel, the energy efficiency data for other fuels were obtained from a study by TIAX, LLC. The energy efficiency for diesel was calculated using the fuel economy values used by the University of California in its report “A Low Carbon Fuel Standard for California” and the energy densities used in GREET. TIAX, under contract to the California Energy Commission (CEC), performed a full fuel cycle assessment of carbon emissions as part of the CEC’s requirements under Assembly Bill 1007 (AB 1007). TIAX evaluated the energy efficiency for a number of fuels, and reported the energy efficiency in terms of an Energy Efficiency Ratio (EER), which is the ratio of the miles per energy, for a fuel of interest, to the miles per energy for a reference fuel. Fuel light-duty vehicles, TIAX used gasoline as the reference fuel. For heavy-duty vehicles, diesel was used as the reference fuel. Because the EER is calculated using units of miles per energy, while the adjustment factor is based on units of energy per mile, the adjustment factor is just the inverse of the EER. The table below shows EERs for different fuels and vehicles. The data presented here is preliminary. Staff is requesting comments on the underlying data used to calculate the EERs.

EER Values Used in the LCFS

Fuel	Vehicle Type	Engine Type	EER	Source
Gasoline	LD	SI	1.00	1
Diesel	LD	CI	1.12	1
Diesel	HD	CI	1.12	1
FFV (E85)	LD	SI	0.98	1
FFV (E85)	HD	SI	0.98	1
CNG	LD	SI	1.00	1
CNG or LNG	HD	SI	0.94	2
CNG or LNG	HD	CI	0.94	2
Propane	LD	SI	1.00	2
Propane	HD	SI	0.94	2
Propane	HD	CI	0.94	2
Electricity	LD	BEV	4.1	2,3
Electricity	LD	PHEV	4.1	2,3
Electricity	HD	BEV	2.7	2,3
Electricity	HD	PHEV	2.7	2,3
Hydrogen	LD	ICE	1.3	2
Hydrogen	LD	FC	2.2	2
Hydrogen	HD	ICE	1.2	2,3
Hydrogen	HD	FC	1.9	2,3

Abbreviations:
HD – heavy-duty vehicle
LD – light-duty vehicle
SI – spark-ignited engine
CI – combustion-ignited engine
BEV – battery electric vehicle
PHEV – plug-in hybrid electric vehicle
ICE – internal combustion engine
FC – fuel cell vehicle

Sources:
1) U.S. EPA Fuel Economy Guide
2) TIAX Report to the California Energy Commission for AB 1007
3) ARB Mobile Source Division staff

As the table shows, adjustment factors vary not only with the type of fuel, but with the type of vehicle and type of engine in which the fuel is used. Some caution should be used in comparing the EERs and the adjustment factors for the non-diesel and non-gasoline fuels. Because the EERs for heavy-duty vehicles use the diesel energy efficiency as the reference fuel and the EERs for the light-duty vehicles use gasoline as the reference fuel, the EERs and adjustment factors for heavy-duty vehicles are not directly comparable to the EERs and adjustment factors for the light-duty vehicles. For example, the EER for CNG of 1.00 for light-duty vehicles cannot be directly compared to the EER for CNG of 0.94 for heavy-duty vehicles because the 1.00 EER used the energy efficiency of gasoline as a reference, while the 0.94 EER used the energy efficiency of diesel as the reference.

Appendix C

Compliance Scenarios
Year-By-Year Results

This appendix presents the year-by-year results for the seven compliance scenarios: four for gasoline and fuels substituting for gasoline and three for diesel and fuels substituting for diesel fuel.

In summary, the seven scenarios are listed below.

Gasoline and Fuels that Substitute for Gasoline

Scenario 1: Increasing volumes of RFS-compliant ethanol through 2015, then gradual decline to 2020 as advanced renewable fuels replace the RFS-compliant ethanol. Conventional corn ethanol gradually decreases to zero in 2017. Gradual increases in the number of FFVs using E85. The number of advanced vehicles (BEV, PHEV, FCVs) using electricity or hydrogen as a fuel increases to about 560,000 vehicles in 2020. This volume is consistent with the penetration schedule in the 2008 ARB ZEV regulation.

Scenario 2: Similar to Scenario 1 except that RFS-compliant ethanol is replaced with cellulosic ethanol, advanced renewable ethanol, and sugarcane ethanol.

Scenario 3: Similar to Scenario 2 except that the number of advanced vehicles is increased from 560,000 vehicles to 1 million vehicles in 2020. In turn, the number of FFVs using E85 in 2020 and the amount of cellulosic ethanol, advanced renewable ethanol, and sugarcane ethanol are reduced.

Scenario 4: Similar to Scenario 3 except the number of advanced vehicles is increased to 2 million vehicles in 2020.

Diesel Fuel and Fuels that Substitute for Diesel Fuel

Scenario 1: The first scenario is based on a diversification of the liquid fuel pool using available low-carbon-intensity fuels.

Scenario 2: The second scenario includes not only a variety of liquid fuels, but also CNG vehicles penetrating the fleet.

Scenario 3: Diesel Compliance Scenario 3 increases the compliance options by expanding Diesel Scenario 2 to include Heavy Duty PHEVs (HD PHEVs).

Tables 1a through 7a present the year-by-year results. Tables 1b through 7b show how each fuel generates debits and credits in the year 2020.

Table 1a
Year-by-Year Analysis of Compliance Scenarios
for Gasoline and Fuels that Substitute for Gasoline
Scenario 1

Year	CI of CaRFG	FFVs (millions)	BEV, PHEV, and FCVs (millions)	Conv. Corn EtOH (Bgal)	Low-CI Corn EtOH (Bgal)	RFS Low-CI Corn EtOH (Bgal	Cell. EtOH (Bgal)	Adv. Renew. EtOH (Bgal)	Sugar Cane EtOH (Bgal)	Total EtOH (Bgal)	Total CARBOB (Bgal)	%E85	vol % EtOH
2010	96.70	0	0.003	1.24	0.30	0	0	0	0	1.54	13.9	0	10.0
2011	96.46	0	0.004	1.18	0.31	0.05	0	0	0	1.53	13.8	0	10.0
2012	96.22	0	0.03	1.02	0.30	0.20	0	0	0	1.52	13.6	0	10.0
2013	95.97	0	0.05	0.86	0.30	0.34	0	0	0	1.50	13.5	0	10.0
2014	95.49	0	0.08	0.50	0.30	0.68	0	0	0	1.48	13.3	0	10.0
2015	94.52	0.2	0.14	0.30	0.30	0.80	0	0.19	0	1.59	13.2	1.0	10.8
2016	93.07	0.4	0.19	0	0.30	0.88	0	0.50	0	1.68	12.9	2.0	11.5
2017	91.38	0.8	0.26	0	0.30	0.61	0	0.99	0	1.90	12.7	4.0	13.0
2018	89.45	1.3	0.35	0	0.30	0.32	0	1.51	0	2.13	12.3	6.4	14.8
2019	87.51	1.9	0.46	0	0.30	0.12	0	2.01	0	2.43	12.0	9.2	16.9
2020	86.55	2.15	0.56	0	0.30	0	0	2.24	0	2.54	11.8	10.4	17.7

Table 1b
Year 2020 Credits and Debits for Each Fuel
Scenario 1

	CaRFG Debit[1]	Electricity Credit	Cellulosic EtOH Credit	Adv. Renew. EtOH Credit	Sugar Cane EtOH Credit	H_2 Credit	Net MMT CO2e-All Fuels
Emission Reductions (MMT CO2/yr)	-13.5	1.4 (10%)	0 (0%)	12.0 (89%)	0 (0%)	0.1 (1%)	0

Table 2a
Year-by-Year Analysis of Compliance Scenarios
for Gasoline and Fuels that Substitute for Gasoline
Scenario 2

Year	CI of CaRFG	FFVs (millions)	BEV, PHEV, and FCVs (millions)	Avg. Corn EtOH (Bgal)	Low-CI Corn EtOH (Bgal)	RFS Low-CI Corn EtOH (Bgal)	Cell. EtOH (Bgal)	Adv. Renew. EtOH (Bgal)	Sugar Cane EtOH (Bgal)	Total EtOH (Bgal)	Total CARBOB (Bgal)	%E85	vol % EtOH
2010	96.7	0	0.003	1.24	0.30	0	0	0	0	1.54	13.9	0	10.0
2011	96.5	0	0.004	1.20	0.30	0	0	0	0.03	1.53	13.7	0	10.0
2012	96.2	0	0.03	1.10	0.30	0	0	0	0.11	1.51	13.6	0	10.0
2013	96.0	0	0.05	1.04	0.30	0	0.04	0	0.12	1.50	13.5	0	10.0
2014	95.5	0	0.08	0.89	0.30	0	0.13	0	0.16	1.48	13.3	0	10.0
2015	94.5	0.2	0.14	0.68	0.30	0	0.27	0	0.34	1.59	13.2	1.0	10.8
2016	93.1	0.4	0.19	0.36	0.30	0	0.42	0.15	0.45	1.68	12.9	2.0	11.5
2017	91.4	0.8	0.26	0.08	0.30	0	0.61	0.30	0.61	1.90	12.7	4.0	13.0
2018	89.4	1.6	0.35	0	0.30	0	0.64	0.76	0.61	2.31	12.2	7.9	15.9
2019	87.5	2.4	0.46	0	0.30	0	0.64	1.21	0.61	2.76	11.8	11.6	19.0
2020	86.5	2.8	0.56	0	0.30	0	0.64	1.40	0.61	2.95	11.5	13.4	20.4

Table 2b
Year 2020 Credits and Debits for Each Fuel
Scenario 2

	CaRFG Debit	Electricity Credit	Cellulosic EtOH Credit	Adv. Renew. EtOH Credit	Sugar Cane EtOH Credit	H_2 Credit	Net MMT CO2e-All Fuels
Emission Reductions (MMT CO2/yr)	-13.2	1.6 (12%)	2.6 (19%)	7.3 (54%)	1.6 (12%)	0.1 (1%)	0

Table 3a
Year-by-Year Analysis of Compliance Scenarios for Gasoline and Fuels that Substitute for Gasoline
Scenario 3

Year	CI of CaRFG	FFVs (millions)	BEV, PHEV, and FCVs (millions)	Avg. Corn EtOH (Bgal)	Low-CI Corn EtOH (Bgal)	RFS Low-CI Corn EtOH (Bgal)	Cell. EtOH (Bgal)	Adv. Renew. EtOH (Bgal)	Sugar Cane EtOH (Bgal)	Total EtOH (Bgal)	Total CARBOB (Bgal)	%E85	vol % EtOH
2010	96.7	0	0.006	1.24	0.30	0	0	0	0	1.54	13.9	0	10.0
2011	96.5	0	0.007	1.21	0.30	0	0	0	0.02	1.53	13.7	0	10.0
2012	96.2	0	0.026	1.10	0.30	0	0	0	0.11	1.51	13.6	0	10.0
2013	96.0	0	0.04	1.01	0.30	0	0	0	0.19	1.50	13.5	0	10.0
2014	95.5	0	0.08	0.87	0.30	0	0.06	0.03	0.22	1.48	13.3	0	10.0
2015	94.5	0.1	0.09	0.70	0.30	0	0.14	0.14	0.25	1.53	13.2	0.5	10.3
2016	93.1	0.2	0.30	0.41	0.30	0	0.27	0.28	0.31	1.57	12.9	1.0	10.8
2017	91.4	0.5	0.43	0.19	0.30	0	0.31	0.62	0.30	1.72	12.7	2.5	11.9
2018	89.4	1.0	0.56	0	0.30	0	0.30	1.07	0.30	1.97	12.4	5.0	13.7
2019	87.5	1.8	0.72	0	0.30	0	0.30	1.45	0.30	2.37	11.9	8.9	16.6
2020	86.5	2.0	1.00	0	0.30	0	0.30	1.53	0.30	2.43	11.6	9.8	17.3

Table 3b
Year 2020 Credits and Debits for Each Fuel
Scenario 3

	CaRFG Debit	Electricity Credit	Cellulosic EtOH Credit	Adv. Renew. EtOH Credit	Sugar Cane EtOH Credit	H_2 Credit	Net MMT CO2e-All Fuels
Emission Reductions (MMT CO2/yr)	-13.9	2.9 (22%)	1.3 (10%)	8.2 (61%)	0.8 (6%)	0.1 (1%)	0

Table 4a
Year-by-Year Analysis of Compliance Scenarios for Gasoline and Fuels that Substitute for Gasoline
Scenario 4

Year	CI of CaRFG	FFVs (millions)	BEV, PHEV, and FCVs (millions)	Avg. Corn EtOH (Bgal)	Low-CI Corn EtOH (Bgal)	RFS Low-CI Corn EtOH (Bgal	Cell. EtOH (Bgal)	Adv. Renew. EtOH (Bgal)	Sugar Cane EtOH (Bgal)	Total EtOH (Bgal)	Total CARBOB (Bgal)	%E85	vol % EtOH
2010	96.7	0	0.01	1.24	0.30	0	0	0	0	1.54	13.9	0	10.0
2011	96.5	0	0.02	1.22	0.30	0	0	0	0.01	1.53	13.7	0	10.0
2012	96.2	0	0.04	1.13	0.30	0	0	0	0.08	1.51	13.6	0	10.0
2013	96.0	0	0.08	1.09	0.30	0	0	0	0.10	1.49	13.4	0	10.0
2014	95.5	0	0.17	0.96	0.30	0	0.06	0.03	0.12	1.47	13.3	0	10.0
2015	94.5	0	0.39	0.83	0.30	0	0.10	0.05	0.18	1.46	13.1	0	10.0
2016	93.1	01	0.60	0.55	0.30	0	0.24	0.13	0.27	1.49	12.8	0.5	10.4
2017	91.4	0.2	0.85	0.26	0.30	0	0.37	0.26	0.34	1.53	12.6	1.0	10.8
2018	89.4	0.4	1.12	0	0.30	0	0.37	0.59	0.34	1.60	12.3	2.1	11.5
2019	87.5	0.8	1.56	0	0.30	0	0.37	0.74	0.34	1.75	11.9	4.1	12.8
2020	86.5	0.9	2.00	0	0.30	0	0.37	0.82	0.34	1.83	11.6	4.6	13.6

Table 4b
Year 2020 Credits and Debits for Each Fuel
Scenario 4

	CaRFG Debit	Electricity Credit	Cellulosic EtOH Credit	Adv. Renew. EtOH Credit	Sugar Cane EtOH Credi	H_2 Credit[1]	Net MMT CO2e-All Fuels
Emission Reductions (MMT CO2/yr)	-12.9	5.8 (45%)	1.6 (12%)	4.5 (35%)	0.8 (6%)	0.2 (2%)	0

Table 5a
Year-by-Year Analysis of Compliance Scenarios
for Diesel Fuels and Fuels that Substitute for Diesel Fuel
Scenario 5

Year	% Reduc.	HD CNG (Veh. and %)	HD PHEVs (Veh. and %)	Conv. Biodiesel (M gal/yr)	Adv. Renew. Diesel (Mgal/yr)[1]	Total Diesel (M gal/yr)	Bio. and Renew. % of Diesel
2011	0.3	0	0	5	11	3,847	0.4
2012	0.5	0	0	10	21	3,937	0.8
2013	0.8	0	0	16	33	4,029	1.2
2014	1.3	0	0	28	56	4,121	2.0
2015	2.3	0	0	52	102	4,213	3.7
2016	4.0	0	0	89	173	4,294	6.1
2017	5.5	0	0	133	261	4,401	9.0
2018	7.5	0	0	184	363	4,496	12.2
2019	9.5	0	0	240	471	4,592	15.4
2020	10.0	0	0	260	510	4,689	16.4

Table 5b
Year 2020 Credits and Debits for Each Fuel
Scenario 5

	Conven. Diesel	CNG	Electricity	Conv. Biodiesel	Adv. Renew Diesel	Net MMT CO2e-All Fuels
Emission Reductions	-5.2	0 (0%)	0 (0%)	0.6 (12%)	4.6 (88%)	0.0

Table 6a
Year-by-Year Analysis of Compliance Scenarios for Diesel Fuels and Fuels that Substitute for Diesel Fuel
Scenario 6

Year	% Reduc.	HD CNG (Veh. and %)	HD PHEVs (Veh. and %)	Conv. Biodiesel (M gal/yr)	Adv. Renew. Diesel (M gal/yr)	Total Diesel (M gal/yr)	Bio. and Renew. % of Diesel
2011	0.3	0	0	6	11	3,847	0.4
2012	0.5	0	0	12	22	3,937	0.9
2013	0.8	0	0	18	33	4,029	1.3
2014	1.3	2,000 (0.3%)	0	27	52	4,109	1.9
2015	2.3	3,400 (0.5%)	0	50	96	4,193	3.5
2016	4.0	5,200 (0.8%)	0	85	164	4,263	5.8
2017	5.5	7,000 (1.0%)	0	128	246	4,361	8.6
2018	7.5	12,800 (1.8%)	0	176	340	4,423	11.7
2019	9.5	16,600 (2.3%)	0	231	443	4,498	15.0
2020	10.0	18,300 (2.5%)	0	250	480	4,585	15.9

Table 6b
Year 2020 Credits and Debits for Each Fuel
Scenario 6

	Conven. Diesel	CNG	Electricity	Conv. Biodiesel	Adv. Renew Diesel	Net MMT CO2e-All Fuels
Emission Reductions	-5.1	0.2 (4%)	0 (0%)	0.5 (10%)	4.4 (86%)	0.0

Table 7a
Year-by-Year Analysis of Compliance Scenarios
for Diesel Fuels and Fuels that Substitute for Diesel Fuel
Scenario 7

Year	% Reduc.	HD CNG (Veh. and %)[1]	HD PHEVs (Veh. and %)[1]	Conv. Biodiesel (M gal/yr)	Adv. Renew. Diesel (Mgal/yr)[2]	Total Diesel (Mgal/yr)	Bio. and Renew. % of Diesel
2011	0.3	0	0	6	11	3,847	0.4
2012	0.5	0	0	12	22	3,937	0.9
2013	0.8	0	0	18	33	4,029	1.3
2014	1.3	2,600 (0.38%)	900 (0.13%)	25	49	4,102	1.8
2015	2.3	4,600 (0.68%)	1,600 (0.23%)	50	90	4,180	3.3
2016	4.0	7,700 (1.1%)	2,500 (0.4%)	85	154	4,238	5.6
2017	5.5	12,000 (1.7%)	4,000 (0.55%)	129	232	4,317	8.4
2018	7.5	15,900 (2.1%)	5,000 (0.7%)	187	330	4,391	11.8
2019	9.5	20,000 (2.8%)	6,500 (0.9%)	238	428	4,450	15.0
2020	10.0	21,900 (3.0%)	7,300 (1.0%)	250	450	4,533	15.4

Table 7b
Year 2020 Credits and Debits for Each Fuel
Scenario 7

	Conven. Diesel	CNG	Electricity	Conv. Biodiesel	Adv. Renew Diesel	Net MMT CO2e-All Fuels
Emission Reductions	-4.9	0.2 (4%)	0.2 (4%)	0.5 (10%)	4.0 (82%)	0.0