DRAFT – FOR DISCUSSION ONLY

Proposed Concept Outline for the California Low Carbon Fuel Standard Regulation

March 2008

California Environmental Protection Agency
AIR RESOURCES BOARD

Purpose of this document

The purpose of this document is to provide a preliminary draft outline of the concepts the ARB staff has developed to date for the California Low Carbon Fuel Standard (LCFS). The outline contains the staff recommendations previously presented in LCFS working groups and workshops but does not address major areas currently under development, including, but not limited to: indirect and direct land use change, sustainability, environmental justice, modeling methodologies, uncertainties and assumptions, multimedia or economic impact analysis.

The intent of this document is to provide stakeholders an opportunity to review and provide input to the proposed LCFS staff recommendations, which are not final and are still under development. Stakeholders are encouraged to provide comments to all sections of this document, particularly those marked with "*Feedback Requested"* in which staff is seeking specific feedback on a section.

All values shown in this report are for illustration purposes only. Specific values to be ultimately proposed by staff are still under development.

Instructions on Submitting Feedback

Please provide your feedback in a separate document containing your name, date, and company letterhead (or equivalent). For each comment, include the section number and name, table number, or figure number to which the comment addresses.

Please submit the document as an email attachment with the subject line "Comments for LCFS Concept Outline" to Christina Zhang-Tillman (czhangti@arb.ca.gov).

All comments received will be posted on the LCFS comments website.

CALIFORNIA LOW CARBON FUEL STANDARD

TABLE OF CONTENTS

1. Applicability of the LCFS

1.a The Low Carbon Fuel Standard (the "LCFS") applies to providers of liquid and non-liquid fuels used for transportation purposes produced or imported into California. These include "conventional fuels" such as RFG ("gasoline") and ULSD ("diesel"), compressed or liquefied natural gas ("natural gas"), liquefied propane gas ("propane"), electricity, compressed or liquefied hydrogen ("hydrogen"), ethanol blends greater than 10 percent by volume ethanol including E85, denatured neat ethanol ("ethanol"), neat biodiesel/biomass-based diesel ("biodiesel/biomass-based diesel"), and blends containing up to 20 percent by volume biodiesel/biomass-based diesel including B5 and B20.

> ***Feedback Requested***
> *Staff is seeking comments on whether hydrogen should be included immediately at the onset of LCFS or be included when a threshold (either quantity or date) is reached. If hydrogen is included, it will be subject to LCFS compliance requirements. However, staff is considering waiving the reporting requirement until such time that the amount of hydrogen used for transportation exceeds a "to-be-determined" amount. If hydrogen is not included immediately but is allowed to opt-in to the LCFS, it will not be subject to reporting but will still be able to generate credits, should it qualify.*

1.b Transportation fuels include fuels used in California for transportation on-road and off-road, off-road equipment, and locomotive applications.

1.c The LCFS does not apply to aviation fuels and marine fuels not regulated by ARB.

1.d Applicability Exemption
An obligated party providing an alternative fuel is not subject to the LCFS compliance and reporting requirement if the aggregate volume of that fuel supplied for transportation use in California is less than "xx" gasoline gallon equivalent per year.

2. Fuel Standards

2.a The LCFS requires a reduction of 10 percent or greater in the average fuel carbon intensity (the "$AFCI$") of transportation fuels in 2020 compared to the baseline year of 2006, with a phase-in period from 2010 through 2019.

2.b The $AFCI$ refers to a volume-averaged carbon intensity value, as calculated by Equation 5.2.1.

2.c The percent reduction refers to a declining carbon intensity standard determined separately for gasoline and diesel. The percent reduction, at minimum of 10 percent, may differ for gasoline and diesel.

2.d For natural gas, propane, electricity, hydrogen, neat ethanol, E85, B5, B20, and neat biodiesel/biomass-based diesel (collectively "alternative fuels") used in transportation, compliance is determined by comparison to either the gasoline or diesel standard, as described in sections 2.3 to 2.8.

2.e All fuel *AFCI* values take into consideration the vehicle efficiency adjustment factors described in section 5.2.d.

2.f The baseline gasoline and diesel *AFCI* values in sections 2.1 and 2.2 are determined from ARB lifecycle analyses using the methodology described in section 5 and default value inputs provided in section 5.3.3.a.

2.1 Standards for Gasoline

2.1.a For gasoline, the baseline *AFCI* could be 92 gCO2e/MJ, which applies at the onset of the regulation in 2010. The carbon intensity resulting from a representative reduction of 10 percent in 2020 would be 83 gCO2e/MJ.

2.1.b The *AFCI* values that must be met in the subsequent years following 2010 are shown in Table 2.1.

Table 2.1. Example LCFS gasoline compliance schedule.
(ALL VALUES SHOWN ARE FOR ILLUSTRATION PURPOSES ONLY)

Year	Gasoline AFCI (gCO2e/MJ)
2010	92
2011	90
2012	89
2013	89
2014	88
2015	87
2016	86
2017	85
2018	84
2019	84
2020+	83

Feedback Requested
The compliance schedule above is, as an initial basis, based on a default Linear Compliance path and is intended solely for discussion. Staff is seeking additional input on the general characteristics of an achievable compliance schedule for gasoline.

Comments should address the factors that could influence the ultimate slope of a compliance path including, but not limited to, the impact of land use change, the availability of low or very low-carbon biofuels in the 2010 to 2015 timeframe, and possible compliance strategies.

2.2 Standards for Diesel

2.2.a For diesel, the baseline *AFCI* could be 71 gCO2e/MJ, which applies at the onset of the regulation in 2010. The carbon intensity resulting from a representative reduction of 10 percent in 2020 would be 64 gCO2e/MJ.

2.2.b The *AFCI* values that must be met in the subsequent years following 2010 are shown in Table 2.2.

Table 2.2. Illustrative LCFS diesel compliance schedule.
(ALL VALUES SHOWN ARE FOR ILLUSTRATION PURPOSES ONLY)

Year	Diesel AFCI (gCO2e/MJ) [a]
2010	71
2011	70
2012	69
2013	68
2014	68
2015	67
2016	66
2017	66
2018	65
2019	65
2020+	64

Feedback Requested
The compliance schedule above is, as an initial basis, based on a default Linear Compliance path and is intended solely for discussion. Staff is seeking additional input on the general characteristics of an achievable compliance schedule for diesel.

Comments should address the factors that could influence the ultimate slope of a compliance path including, but not limited to, the impact of land use change, the availability of low or very low-carbon biofuels in the 2010 to 2015 timeframe, and possible compliance strategies available such as blends of biodiesel/biomass-based diesel up to or greater than 20 percent.

2.3 Standards for Natural Gas

2.3.a For CNG used in a dedicated-fuel, light-duty vehicle or a dedicated-fuel, medium-duty vehicle, the CNG will use the gasoline standard. For CNG used in a dedicated-fuel, heavy-duty vehicle, the CNG will use the diesel standard.

2.3.b For CNG used in a multi-fuel vehicle in which the conventional fuel is gasoline, the CNG will use the gasoline standard. For CNG used in a multi-fuel vehicle in which the conventional fuel is diesel, the CNG will use the diesel standard.

2.3.c For LNG used in a dedicated-fuel, light-duty vehicle or a dedicated-fuel, medium-duty vehicle, the LNG will use the gasoline standard. For LNG used in a dedicated-fuel, heavy-duty vehicle, the LNG will use the diesel standard.

2.3.d For LNG used in a multi-fuel vehicle in which the conventional fuel is gasoline, the LNG will use the gasoline standard. For LNG used in a multi-fuel vehicle in which the conventional fuel is diesel, the LNG will use the diesel standard

[a] The diesel carbon intensity values are adjusted by the vehicle efficiency adjustment factor of 0.78 from the U.C. Report Part I, Table 2-3. Staff is recalculating the base-year carbon intensity number, which could result in a change in the values shown.

2.4 Standards for Propane

2.4.a For LPG used in a dedicated-fuel, light-duty vehicle or a dedicated-fuel, medium-duty vehicle, the LPG will use the gasoline standard. For LPG used in a dedicated-fuel, heavy-duty vehicle, the LPG will use the diesel standard.

2.4.b For LPG used in a multi-fuel vehicle in which the conventional fuel is gasoline, the LPG will use the gasoline standard. For LPG used in a multi-fuel vehicle in which the conventional fuel is diesel, the LPG will use the diesel standard.

2.5 Standards for Electricity

2.5.a For electricity used in a dedicated-fuel, light-duty vehicle or a dedicated-fuel, medium-duty vehicle, the electricity will use the gasoline standard. For electricity used in a dedicated-fuel, heavy-duty vehicle, or used in truck stop electrification, or used in transportation off-road application, the electricity will use the diesel standard.

2.5.b For electricity used in a plug-in hybrid vehicle in which the conventional fuel is gasoline, the electricity will use the gasoline standard. For electricity used in a plug-in hybrid vehicle in which the conventional fuel is diesel, the electricity will use the diesel standard.

2.6 Standards for Hydrogen

2.6.a For hydrogen used in an internal combustion engine vehicle or a fuel cell vehicle used for light-duty or medium-duty transportation application, the hydrogen will use the gasoline standard.

2.6.b For hydrogen used in an internal combustion engine vehicle or a fuel cell vehicle used for heavy-duty or off-road transportation application, the hydrogen will use the diesel standard.

2.7 Standards for Ethanol

2.7.a For neat ethanol used in a dedicated-fuel or multi-fuel vehicle used for light-duty, medium-duty, or heavy-duty application, the ethanol will use the gasoline standard.

2.7.b For E85 or an ethanol blend greater than 10 percent used in a dedicated-fuel or multi-fuel vehicle used for light-duty, medium-duty, or heavy-duty application, the ethanol blend will use the gasoline standard.

2.8 Standards for Biodiesel/Biomass-Based Diesel

2.8.a For neat biodiesel/biomass-based diesel used in a dedicated-fuel or multi-fuel vehicle used for light-duty, medium-duty, or heavy-duty application, the neat biodiesel/biomass-based diesel will use the diesel standard.

2.8.b For a biodiesel/biomass-based diesel blend up to 20 percent biodiesel/biomass-based diesel used in a dedicated-fuel or multi-fuel vehicle used for light-duty, medium-duty, or heavy-duty application, the biodiesel/biomass-based diesel blend will use the diesel standard.

Table 2.3. Summary of applicable reference standards for LCFS-participating transportation fuels. (LD=light-duty, MD=medium-duty, HD=heavy-duty)

Fuel	Vehicle System	Application	Reference Standard
Gasoline	Dedicated fuel or multi-fuel vehicle	LD, MD, HD	Gasoline
Diesel	Dedicated fuel or multi-fuel vehicle	LD, MD, HD	Diesel
CNG	Dedicated fuel vehicle	LD, MD	Gasoline
	Dedicated fuel vehicle	HD	Diesel
	Multi-fuel vehicle containing gasoline	LD, MD, HD	Gasoline
	Multi-fuel vehicle containing diesel	LD, MD, HD	Diesel
LNG	Dedicated fuel vehicle	LD, MD	Gasoline
	Dedicated fuel vehicle	HD	Diesel
	Multi-fuel vehicle containing gasoline	LD, MD, HD	Gasoline
	Multi-fuel vehicle containing diesel	LD, MD, HD	Diesel
Propane	Dedicated fuel vehicle	LD, MD	Gasoline
	Dedicated fuel vehicle	HD	Diesel
	Multi-fuel vehicle containing gasoline	LD, MD, HD	Gasoline
	Multi-fuel vehicle containing diesel	LD, MD, HD	Diesel
Electricity	Dedicated fuel vehicle	LD, MD	Gasoline
	Dedicated fuel vehicle	HD, truck stop electrification, transportation off-road	Diesel
	Plug-in hybrid vehicle containing gasoline	LD, MD, HD	Gasoline
	Plug-in hybrid vehicle containing diesel	LD, MD, HD	Diesel
Hydrogen	Internal combustion or fuel cell vehicle	LD, MD	Gasoline
	Internal combustion or fuel cell vehicle	HD, transportation off-road	Diesel
Neat ethanol, E85, or blends greater than 10% ethanol	Dedicated fuel or multi-fuel vehicle	LD, MD, HD	Gasoline
Neat biodiesel/biomass-based diesel or blends up to 20% biodiesel/biomass-based diesel	Dedicated fuel or multi-fuel vehicle	LD, MD, HD	Diesel

Feedback Requested
Staff is seeking input on the types of vehicles (and their fuel systems) currently in operation or planned for each fuel category. In addition, staff is seeking input on how to appropriately assign references for fuels used in medium-duty applications.

2.9 Volume Obligation for Ultra Low Carbon Fuel

2.9.a For a given quantity of transportation fuels sold or imported into California, in gasoline gallon equivalent, a percentage of the fuel must be ultra low carbon fuel, to be defined in section 7.

Feedback Requested
Staff is seeking comments on the definition of an ultra low carbon fuel and the concept of a volume obligation for ultra low carbon fuels. Listed below are two

possible approaches:

- By a certain timeframe (i.e. 2015) or when the total volume of transportation fuels reaches "xx" amount, *require "y" percentage of the fuel from an aggregate volume (based on total sales across all LCFS applicable fuels in California) to be ultra low carbon fuels;*

- By a certain timeframe (i.e. 2015) or when the total volume of transportation fuels reaches "xx" amount, an individual obligated party with total sales exceeding "z" volumes will be required to produce "y" percentage of ultra low carbon fuel.

Comments should address, at minimum, whether a volume obligation for ultra low carbon fuels should be included in the LCFS, the appropriate volume requirement, and other approaches staff should evaluate.

3. Compliance and Enforcement

3.1 Compliance Requirements

3.1.a The term "obligated party" refers to the producer, provider, or importer of fuels applicable under the LCFS.

3.1.b An obligated party must submit to ARB periodic compliance reports prepared in accordance with the procedure and reporting frequency described in section 3.3 during the phase-in period of the regulation.

3.1.c <u>Options for compliance</u>
An obligated party must meet at the minimum one of the conditions below to demonstrate compliance with the LCFS.

1. Provide only California fuels that meet the respective standard so that the $AFCI_{reported}^{XD}$ is less than or equal to the $AFCI_{reference}$, as defined in section 4.1;
2. Provide a mix of higher and lower carbon California fuels that on average meet the respective standard;
3. Use previously banked credits in an amount that equals the credit deficit;
4. Acquire credits from other parties who earned credits by exceeding the standard so that the amount of credits acquired equals the credit deficit.

3.1.d <u>Variance provision</u>
If an obligated party cannot demonstrate compliance by meeting the conditions in section 3.1.c due to events "substantially" outside the control of the obligated party, including events such as catastrophic, naturally occurring disasters, the obligated party may submit documentation for variance under the LCFS.

3.1.e <u>Deficit allowance</u>
If an obligated party has a credit deficit for a given compliance period, the obligated party must clear the deficit by the end of the next compliance period ("deficit-clearance period"). During the deficit-clearance period, the obligated party must meet its obligations for that period with sufficient excess credits to clear the deficit.

3.1.f Compliance through fee payment is not allowed.

3.1.g The compliance period is determined on a calendar year (work is in progress to define the actual period).

3.2 Point of Regulation

3.2.a Gasoline
For an obligated party that produces or imports CARBOB into California for the purpose of producing gasoline to be sold as a transportation fuel in California, the point of regulation is the point at which the CARBOB is transferred from the facility at which it was produced or imported. The obligated parties are refiners and importers.

3.2.b For an obligated party that acquires CARBOB and neat ethanol for the purpose of producing gasoline to be sold as a transportation fuel in California, the point of regulation is the point at which the finished gasoline is produced. The obligated parties are refiners and blenders.

3.2.c Diesel
For an obligated party that produces or imports diesel into California to be sold as a transportation fuel in California, the point of regulation is the point at which the diesel is transferred from the facility at which it was produced or imported. The obligated parties are refiners and importers.

3.2.d For an obligated party that acquires diesel for the purpose of producing an alternative fuel to be sold as a transportation fuel in California, the point of regulation is the point at which the finished alternative fuel is produced. The obligated parties are refiners and blenders.

3.2.e Natural gas
For natural gas, the point of regulation is the point at which the fuel is supplied to the vehicle. The obligated parties are fuel providers.

3.2.f Propane
For propane, the point of regulation is the point at which the fuel is supplied to the vehicle. The obligated parties are fuel providers.

3.2.g Electricity
For electricity, the point of regulation is the point at which the fuel is supplied to the vehicle. The obligated parties are fuel providers.

3.2.h Hydrogen
For hydrogen, the point of regulation is the point at which the fuel is supplied to the vehicle. The obligated parties are fuel providers.

Feedback Requested
Staff is seeking input on what entity should be treated as the ‘provider’ for natural gas, propane, electricity, and hydrogen.

3.2.i Neat ethanol
For an obligated party that produces or imports neat ethanol into California for the purpose of producing gasoline to be sold as a transportation fuel in California, the point of regulation is the point at which the neat ethanol is transferred from the facility at which it was produced or imported. The obligated parties are refiners and importers.

3.2.j E85 or other ethanol blends greater than 10 percent ethanol
For an obligated party that produces or imports CARBOB into California for the purpose of producing alternative fuels to be sold as a transportation fuel in California, the point of regulation is the point at which the CARBOB is transferred from the facility at which it was produced or imported. The obligated parties are refiners and importers.

3.2.k For an obligated party that acquires CARBOB and neat ethanol for the purpose of producing an alternative fuel to be sold as a transportation fuel in California, the point of regulation is the point at which the finished alternative fuel is produced. The obligated parties are refiners and blenders.

3.2.l Neat biodiesel/biomass-based diesel
For an obligated party that produces or imports neat biodiesel/biomass-based diesel into California for the purpose of producing an alternative fuel to be sold as a transportation fuel in California, the point of regulation is the point at which the biodiesel/biomass-based diesel is transferred from the facility at which it was produced or imported. The obligated parties are refiners and importers.

3.2.m B5, B20 or other biodiesel blends up to 20 percent biodiesel/biomass-based diesel
For an obligated party that produces or imports diesel into California for the purpose of producing an alternative fuel to be sold as a transportation fuel in California, the point of regulation is the point at which the diesel is transferred from the facility at which it was produced or imported. The obligated parties are refiners and importers.

3.2.n For an obligated party that acquires diesel and neat biodiesel/biomass-based diesel for the purpose of producing an alternative fuel to be sold as a transportation fuel in California, the point of regulation is the point at which the finished alternative fuel is produced. The obligated parties are refiners and blenders.

3.3 Tracking and Reporting

3.3.1 Reporting Requirements

3.3.1.a The report submitted for the purpose of compliance must include, at minimum, the requirements outlined in Table 3.1.

3.3.1.b Reporting frequency
An obligated party must submit reports to ARB on a quarterly basis (work is in progress to define the reporting period).

Table 3.1. Reporting requirements for LCFS transportation fuels.

Gasoline & Diesel	Natural Gas	Propane	Electricity	Hydrogen	Ethanol and Biodiesel/Biomass-based diesel
For non-biofuels, work is in progress to determine reporting requirements					▪ Batch number ▪ Fuel type ▪ Fuel quantity ▪ Feedstock type ▪ Feedstock origin ▪ Processing characteristic ▪ The LCFS-Blendstock Average Fuel Carbon Intensity ($BAFCI_i$ in Equation 5.2.1) ▪ Accuracy level ▪ Sustainability information

Feedback Requested
Staff is seeking input on the reporting requirements for natural gas, propane, electricity, and hydrogen.

3.3.2. Procedure for Using Default Values

3.3.2.a ARB will provide the default values for the determination of the LCFS-blendstock average fuel carbon intensity ($BAFCI_i$), as defined in section 5.2.a. Lower level default values, where little is known about the origin of the supply chain, represent more conservative estimates of GHG emissions; higher level default values, where the calculation includes more detailed information, are less conservative.

3.3.2.b Accuracy levels are defined corresponding to type of default value or data used. ARB provides default values in accuracy levels 1 to 4, based on a source-to-wheel fuel life cycle analysis in accordance with section 5. An obligated party may choose to report using different levels of default values.

Table 3.3. Example of accuracy levels for biofuels corresponding to the type of default value or data used.

Type of default value or data	Accuracy level
Fuel type default	1
Feedstock default	2
Processing characteristic default	3
Feedstock & origin default	4
Selected default	5
Actual data	6

3.3.3 Procedure for Using Real Data

3.3.3.a An obligated party with specific information about their fuel pathways may provide additional qualitative or quantitative data to improve the accuracy of their GHG calculation.

3.3.3.b If real data are available, the obligated party may calculate and report its own GHG information using the Software Compliance Tool described in Section 3.4.3. If a portion of the data used in the calculation is based on real data, the accuracy level is 5; if all data used in the calculation is based on real data, the accuracy level is 6.

3.3.4 Tracking Biofuels

3.3.4.a ARB will use the Federal Renewable Identification Number (RIN), defined in Federal Renewable Fuel Standard, to track biofuels.

3.3.4.b ARB will determine the fuel type, feedstock, and processing characteristic information of the RIN based on the biofuel facility registration data from the U.S. EPA.

3.3.4.c Facilities that process multiple feedstocks must provide additional information to segregate fuel batches based on feedstock type. ARB will develop biofuel facility specific default values for the LCFS.

> ***Feedback Requested***
> *Staff is seeking input on a proposed tracking system to accommodate natural gas, propane, and hydrogen. Comments on a proposed tracking system for electricity are currently under staff review.*

3.3.5 Recordkeeping

3.3.5.a An obligated party must keep all of the following records: product transfer documents, copies of all reports submitted to ARB, records related to each fuel transaction, and records used for compliance or credit calculations for the duration of the phase-in period.

3.3.5.b All records and documentation are subject to ARB or 3rd party auditing and verification.

3.4 Certification and Auditing

3.4.1 Verification Protocols

3.4.1.a For default value data submittals (additional details in progress)

3.4.1.b For partial/full real data submittals (additional details in progress)

3.4.2 Certification Procedure

3.4.2.a Third party auditing procedure (additional details in progress)

3.4.3 Software Compliance Tool

3.4.3.a ARB will develop and provide stakeholders a software compliance tool based on ARB source-to-wheel analyses. (additional details in progress)

> ***Feedback Requested***
> *Staff is currently preparing an RFP for the development of a software compliance tool and is seeking input on the design and key software features that will help to streamline the determination of compliance.*

3.5 Violations and Penalty

3.5.a Acts prohibited under LCFS (additional details in progress)

3.5.b Pursuant to Health and Safety Code section 38580 (part of the California Global Warming Solutions Act of 2006), the fuels regulation penalties in Health and Safety Code section 43027 will apply.

3.5.c Any person who violates any prohibition or requirement of the LCFS may be subject to civil penalties for every day of each such violation and the amount of economic benefit or savings resulting from the violation.

4. LCFS Credits

4.a LCFS credits are awarded to fuels demonstrating "over-compliance" such that the reported average fuel carbon intensity value of the fuel, $AFCI_{reported}^{XD}$ in Eqn. 4.1, is less than the corresponding value of the reference fuel, $AFCI_{reference}$ in Eqn.4.1.

4.b For each fuel, credits are determined separately for the portion of the fuel used in light-duty and heavy-duty applications, with the total credit as the sum of the two.

4.c <u>Credit determination frequency</u>
An obligated may submit reports for credit determination on a quarterly basis or on a custom schedule provided to ARB ''xx period" in advance and approved by ARB.

4.d The report submitted for the purpose of documenting credit must include, at minimum, the requirements outlined in Table 3.1.

4.1 Credit Calculation

All calculations shown are for light-duty and heavy-duty applications for the time-being. Analysis is currently underway to determine how to assign a reference standard and how to calculate credit for fuels used in medium-duty applications.

4.1.a LCFS credits are calculated according to the following equations:

$$Credits^{XD}(MMT) = \left(AFCI_{reference} - AFCI_{reported}^{XD}\right)(V^{XD})(C) \qquad (4.1)$$

$$Credits^{TOT}(MMT) = Credits^{LD} + Credits^{HD} \qquad (4.2)$$

where XD ="LD" for light-duty and XD ="HD" for heavy-duty application of the fuel;

$Credits^{XD}(MMT)$ is the amount of LCFS credits awarded (or in deficit) to an obligated party for providing fuels used in light-duty or heavy-duty applications, denominated in units of million metric tonnes ("MMT");

$AFCI_{reference}$ is the average fuel carbon intensity of either the gasoline or diesel reference standard as shown in Tables 2.1 or 2.2, respectively. Table 2.3 shows the applicable reference standard for each fuel system;

$AFCI^{XD}_{reported}$ is the average fuel carbon intensity value reported by an obligated party for fuels used in light-duty or heavy-duty applications, as calculated by Equation 5.2.1;

V^{XD} is the *total* volume of fuel used for light-duty or heavy-duty applications, in gasoline gallon equivalent ("gge"), in a given period. Depending on whether the calculation is done for compliance or credit, a given period corresponds to either the reporting frequency in section 3.3.1.b or to the frequency in which credits are determined, as described in section 4.c.

C is a factor used to convert credits to units of MMT and has the value of[b]

$$(\frac{118MJ}{gge})(\frac{tonne}{1x10^6\,gCO_2e})(\frac{MMT}{1x10^6\,tonne}) = 1.18x10^{-10}\,\frac{(MJ)(MMT)}{(gge)(gCO_2e)};$$

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

4.2 Credit Generation and Banking

4.2.a LCFS credits can be generated beginning 2010.

4.2.b Credits can be banked without expiration or for a duration that is equal to other CA GHG reduction initiatives such as the AB32 program.

4.3 Credit Acquisition and Trading

4.3.a Obligated parties and external 3rd party entities who are not obligated parties under the LCFS may purchase and trade LCFS credits.

Feedback Requested
Staff is seeking comments on whether external 3rd party entities should be allowed to purchase and trade LCFS credit.

4.3.b LCFS credit may be exported for compliance with other CA GHG reduction initiatives including, but not limited to, AB 32 programs.

4.3.c Credits imported from outside the LCFS program including, but not limited to, those from other AB 32 programs, are not allowed.

4.4 Borrowing of Credit

4.4.a Borrowing or the use of credits from future carbon intensity reductions is not allowed.

4.5 Offset Credits

4.5.a Offsets from transportation fuels in sectors not regulated by the LCFS, such as emissions reduction from aviation or non-regulated marine fuels, are not allowed.

[b] 118 MJ/gge is the energy density of gasoline calculated from GREET.

4.5.b Offsets from non-transportation sectors are not allowed.

5. Determination of Carbon Intensity Values

5.a The ARB average fuel carbon intensity values are determined on a source-to-wheel basis with default values provided in section 5.3. Custom values may be submitted for consideration in accordance with section 5.4.

5.b All data compilations submitted by an obligated party for the purpose of demonstrating compliance or documenting credit are subject to ARB review and verification.

5.1 GREET Model

5.1.a ARB will develop, use, and provide a copy of the latest version of a modified ARB GREET model. (The latest version number will be provided when available).

5.2 Calculation of Average Fuel Carbon Intensity

The following sub-sections are intended to provide a conceptual overview of the calculation methods to be used. ***Examples for selected fuels are provided in Appendix A.***

5.2.a The reported average fuel carbon intensity value for light-duty or heavy-duty applications of a fuel is calculated as follows:

$$AFCI_{reported}^{XD}(gCO2e/MJ) = \left(\frac{(BAFCI_{system}) \sum_{j=1to17} (K^j)(V_{system}^j)}{\sum_{j=1to17} V_{system}^j} \right) \qquad (5.2.1)$$

where

$$BAFCI_{system} = \frac{\sum_{i=1}^{n} BAFCI_i V_i}{\sum_{i=1}^{m} V_i} \qquad (5.2.2)$$

$BAFCI_{system}$ is the average fuel carbon intensity of the ‘system’, which can be considered to be the *finished* gasoline, diesel, natural gas, propane, electricity, hydrogen, E85, B5, and B20 that is supplied to the vehicle;

$BAFCI_i$ is the LCFS-blendstock, *i*, average fuel carbon intensity determined by lifecycle analyses using either a) default values provided in section 5.3 or b) custom values calculated in accordance with section 5.4;

Here LCFS-blendstock refers to the blending material(s), each corresponding to a specified fuel pathway similar to those in Appendix B, that contribute to the *finished fuel. For instance, CNG from source A and CNG from source B are considered two separate LCFS-blendstocks to produce the final CNG used in vehicles (see example 1 in Appendix A). For gasoline, corn-ethanol, cellulosic-ethanol, and CARBOB are examples of LCFS-blendstock for gasoline (see example 2 in Appendix A).*

$AFCI_{reported}^{XD}$ is the average fuel carbon intensity value reported by an obligated party for fuels used in light-duty or heavy-duty applications;

XD ="LD" for light-duty and XD ="HD" for heavy-duty application of the fuel;

V_i is the volume of each LCFS-blendstock, in gge;

V_{system}^{j} is the volume of fuel, in gge, used in each fuel-engine combination listed in Table 5.2.2. ($V_{system}^{j} = x^{j}V_{system}$ where x^{j} is the fraction of the total system volume, V_{system}, used in a given fuel-engine combination);

K^{j} is the vehicle efficiency adjustment factor, listed in Table 5.2.2, corresponding to the type of engine in which the fuel is used;

i is the LCFS-blendstock index ;

j is the fuel-engine index in Table 5.2.2 with values ranging from 1 to 17;

n is the total number of LCFS-blendstocks that produce a system;

5.2.b The volume for each fuel under the LCFS must be converted to gge according to the corresponding conversion factor provided in section 5.2.c;

5.2.c For all fuels, volumes denominated in the units shown in Table 5.2.1 must be converted to gge by multiplying by the corresponding conversion factor[c]:

Table 5.2.1 Conversion factors to gasoline gallon equivalent (gge).

Fuel (units)	Conversion Factor
Gasoline (gal)	1.00
Diesel (gal)	1.15
CNG (scf)	0.0084
LNG (gal)	0.67
LPG (gal)	0.76
Electricity (KWh)	32.6
Hydrogen (kg)	1.03
Ethanol (gal)	0.69
Biodiesel/Biomass-based diesel (gal)	1.07

[c] All conversion factors are based on the ratio of energy densities, determined from the lower heating values of fuels, relative to that of gasoline in GREET.

5.2.d ARB will use a vehicle efficiency adjustment factor to take into account differences in engine drive-train efficiencies between vehicles of the same category. The adjustment factor is determined by comparing the fuel economies, in miles per energy, of an alternative fuel vehicle to that of a reference, conventional vehicle.

Table 5.2.2 Illustrative examples of vehicle efficiency adjustment factors for light-duty (LD) and heavy-duty (HD) vehicles with spark ignition (SI) or compression ignition (CI) engines. For hydrogen vehicles, ICE refers to those with internal combustion engines and FC refers to those with fuel cell stacks.

"*j*" in Eqn. 5.2.1	Fuel – Engine Combination	Reference Vehicle	Vehicle Efficiency Adjustment Factor, "K^j" in Eqn. 5.2.1
1	Gasoline / LD / SI	N/a	1.0
2	Diesel / LD / CI	Gasoline	0.89[d]
3	Diesel / HD / CI	N/a	0.89
4	CNG / LD / SI	Gasoline	1.0
5	CNG or LNG / HD / SI	Diesel	1.07[e]
6	CNG or LNG / HD / CI	Diesel	1.07
7	Propane / LD / SI	Gasoline	1.06
8	Propane / HD / SI	Diesel	1.06
9	Propane / HD / CI	Diesel	1.06
10	Electricity / LD / BEV	Gasoline	0.28
11	Electricity / LD / PHEV	Gasoline	0.28
12	Electricity / HD / BEV	Diesel	0.37
13	Electricity / HD / PHEV	Diesel	0.37
14	Hydrogen / LD / ICE	Gasoline	0.77
15	Hydrogen / LD / FC	Gasoline	0.50
16	Hydrogen / HD / ICE	Diesel	0.91
17	Hydrogen / HD/ FC	Diesel	0.67

Feedback Requested
Staff is seeking input on the current vehicle engine types corresponding to light and heavy-duty applications of each fuel.

5.3 Default Value Approach

The following sections outline only the major components of the ARB fuel lifecycle analysis.

5.3.1 Crude Oil

5.3.1.a For all conventional crude oils, a single averaged, default carbon intensity value will be applied.

5.3.1.b For each non-conventional crude oil category, a single averaged, default carbon intensity value will be applied.

5.3.1.c On or after the date the LCFS becomes effective, a non-conventional crude oil

[d] All vehicle efficiency adjustment factors, except the value for diesel, are based on the energy efficiency ratios (EER) from the AB1007 report. For diesel, the adjustment factor is based the fuel economy data of a diesel from EMFAC corrected for the energy densities of gasoline and diesel.
[e] The 1.07 is an average of the CNG/HD value of 1.06 and the LND/HD value of 1.08 in the AB1007 report, which does not distinguish between a CI engine and SI engine. Additional work is in progress to determine values that take into account the CI or SI engine.

provider may submit data to ARB to demonstrate a carbon intensity value that is substantively different than the averaged, default carbon intensity value for that crude oil. Upon ARB review, validation, and approval of the submitted information, the crude oil provider may use in the lifecycle analyses the submitted carbon intensity value instead of the default carbon intensity value for that crude oil.

Feedback Requested
Staff is seeking input on what value above the averaged, default value is considered to be 'substantive' and whether the credits should be allowed..

5.3.1.d ARB may perform periodic review of crude oil carbon intensity values incorporated in the CARBOB lifecycle analysis.

5.3.2 Refinery Efficiency

5.3.2.a A single averaged, default refinery efficiency value will be applied for all refineries.

5.3.2.b On or after the date the LCFS becomes effective, an obligated party may submit data to demonstrate any improvements in the refinery efficiency that is substantive compared to the averaged, default refinery efficiency value. The improvements do not include those already mandated by other emissions reduction regulations. Upon ARB review, validation, and approval of the submitted information, ARB will provide credits for the improvement towards compliance with both the gasoline and diesel standards.

Feedback Requested
Staff is seeking input on what value above the averaged, default refinery efficiency value is considered to be a 'substantive' improvement. Additionally, if an obligated party makes a substantive improvement through the use of, for instance, co-generation technology, staff is seeking input on whether credits should be allowed. If credits are allowed, the input should also address how the credits are to be awarded. Credits may be awarded as follows:

- *Credits under the LCFS;*
- *Credits under AB32;*
- *Credits under both the LCFS and AB32;*

5.3.3 Input values

5.3.3.a ARB will provide a table of input values, similar to those in Appendix C, to be used for the ARB GREET model.

5.3.4 Co-Products

5.3.4.a ARB will provide the methodology to calculate co-product values.

5.3.4.b Example default values are provided in Appendix D.

5.3.5 Land Use Change

5.3.5.a The portion of the LCFS-blendstock average fuel carbon intensity value attributed to land use changes must be estimated using the ARB's latest greenhouse gas land use change methodology. (Land use change values will be provided when available).

5.3.5.b Values from the land use change methodology will be used as input to the ARB GREET model.

5.3.6 Sustainability

5.3.6.a LCFS will include sustainability criteria consistent with those in the federal Renewable Fuel Standard section 210.

5.4 Custom Value Approach

5.4.a If an obligated party has data different from the ARB default values, data may be submitted to ARB for review and, should approval be granted, the obligated party is permitted to use the submitted data in substitute for the default input values in section 5.3.3.

6. Program Review

6.a ARB will conduct, no later than January 1, 2012, periodic reviews of the LCFS program in all major areas including, but not limited to: lifecycle analysis, land use change, sustainability, uncertainty, policy design, compliance and regulatory process, economic impact, environmental justice, and multimedia evaluation.

7. Definitions

The following terms are not all inclusive and are for illustration purposes only. Definitions are still under development.

3rd party purchasers
ARB GREET model
Average Fuel Carbon Intensity (AFCI)
Biodiesel
Biomass-based diesel
Carbon dioxide equivalent
Co-products
Conventional crude oil
Fuel 'system'
Gasoline gallon equivalent (gge)
Greenhouse gas
Land use change
Lifecycle analysis
Non-conventional crude oil
Renewal Identification Number (RIN)
Ultra low carbon fuels

APPENDIX A. Sample Calculations

Example 1: CNG

CNG producer A is providing fuel for light-duty and heavy-duty transportation use in CA. The CNG is produced by the same process but comes from

A = Within California and
B = Outside of California

In the heavy-duty category, the fuel is used in spark-ignited and compression-ignited engines.

Sample calculation:

The following figure illustrates the possible fuel-engine combination(s).

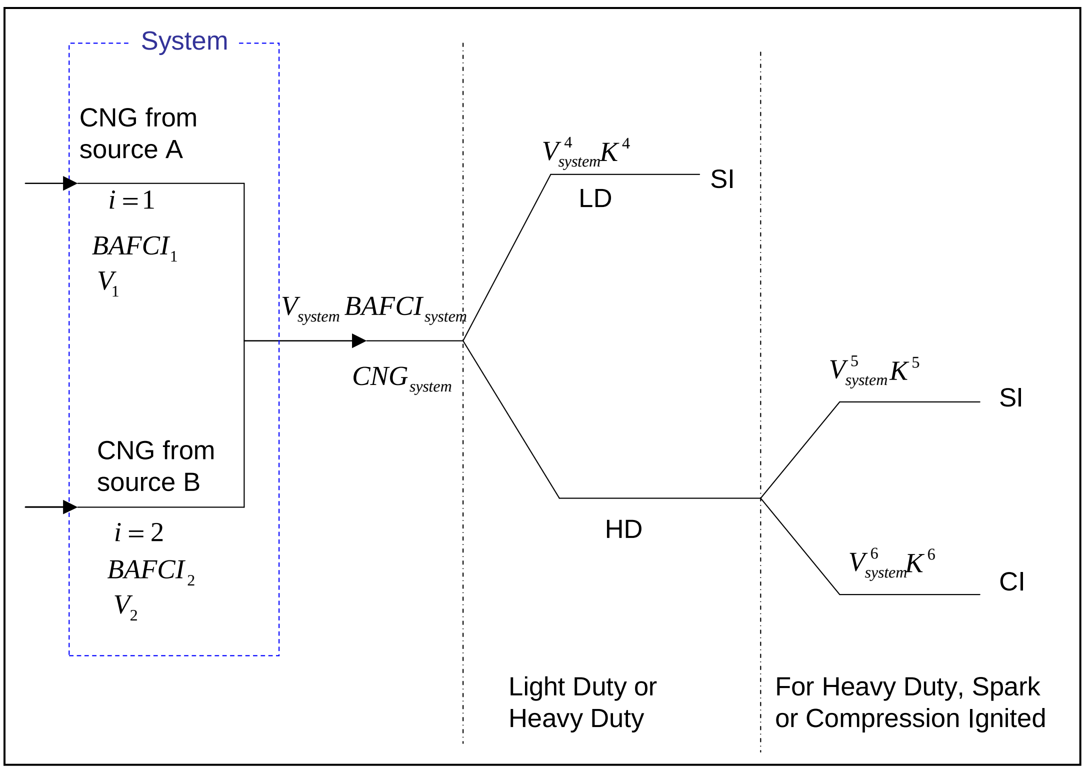

Figure A.1. Illustrative diagram of the fuel-engine combinations used to calculate the corresponding LCFS average fuel carbon intensities for natural gas. In this example, the natural gas comes from two difference sources and is used for light-duty (LD) and heavy-duty (HD) applications. The calculations take into account the engine efficiency adjustment factor (K^j) and the volume (V^j_{system}) of fuel used in each engine type, spark-ignited (SI) or compression-ignited (CI).

First, define the system as indicated in Figure A.1.

Let

i =1 = CNG from source A (corresponding to CNG pathway 1)
i =2 = CNG from source B (corresponding to CNG pathway 2)

These correspond to LCFS-blendstocks for CNG.

The *j* values in Table 5.2.2 are *j*=4, 5, and 6 corresponding to Vehicle Efficiency Adjustment Factors of K^4, K^5 and K^6 for CNG/LD/SI, CNG/HD/SI, and CNG/HD/CI, respectively.

Determine the volume of fuel used in each engine type.

$$V_{system} = V_1 + V_2$$

$V^4_{system} = x^4 V_{system}$ where x^4 is the fraction of fuel used for CNG/LD/SI and
$V^5_{system} = x^5 V_{system}$ where x^5 is the fraction of fuel used for CNG/HD/SI and
$V^6_{system} = x^6 V_{system}$ where x^6 is the fraction of fuel used for CNG/HD/CI.

Using the ARB GREET fuel pathways similar to those in Appendix B, the LCFS-blendstock average carbon fuel intensity value, $BAFCI_i$, for each CNG LCFS-blendstock is determined. The overall $BAFCI$ of the system is determined by

$$BAFCI_{system}(gCO2e/MJ) = \frac{(BAFCI_1)(V_1) + (BAFCI_2)(V_2)}{V_1 + V_2}$$

The AFCI for light-duty use is

$$AFCI^{LD}_{reported}(gCO2e/MJ) = (BAFCI_{system})(K^4)$$

The AFCI for heavy-duty use is

$$AFCI^{HD}_{reported}(gCO2e/MJ) = \frac{BAFCI_{system}\left[(K^5)(V^5_{system}) + (K^6)(V^6_{system})\right]}{V^5_{system} + V^6_{system}}$$

The overall credits received (or in deficit) for CNG used in light-duty and heavy-duty application, according to Eqn. 4.1, are

$$Credits^{LD}(MMT) = \left(AFCI_{gasoline} - AFCI^{LD}_{reported}\right)(V^4_{system})(C)$$ and

$$Credits^{HD}(MMT) = \left(AFCI_{diesel} - AFCI^{HD}_{reported}\right)(V^5_{system} + V^6_{system})(C)$$

Where $Credits^{TOT} = Credits^{LD} + Credits^{HD}$ is the total credit received (or in deficit) for the fuel provider.

Example 2: CA Reformulated Gasoline

Refiner A uses conventional crude oil as the feedstock for CARBOB that is mixed with ethanol from corn and cellulosic materials. All gasoline is used in light-duty applications.

Sample calculation:

The following figure illustrates the possible fuel-engine combination(s).

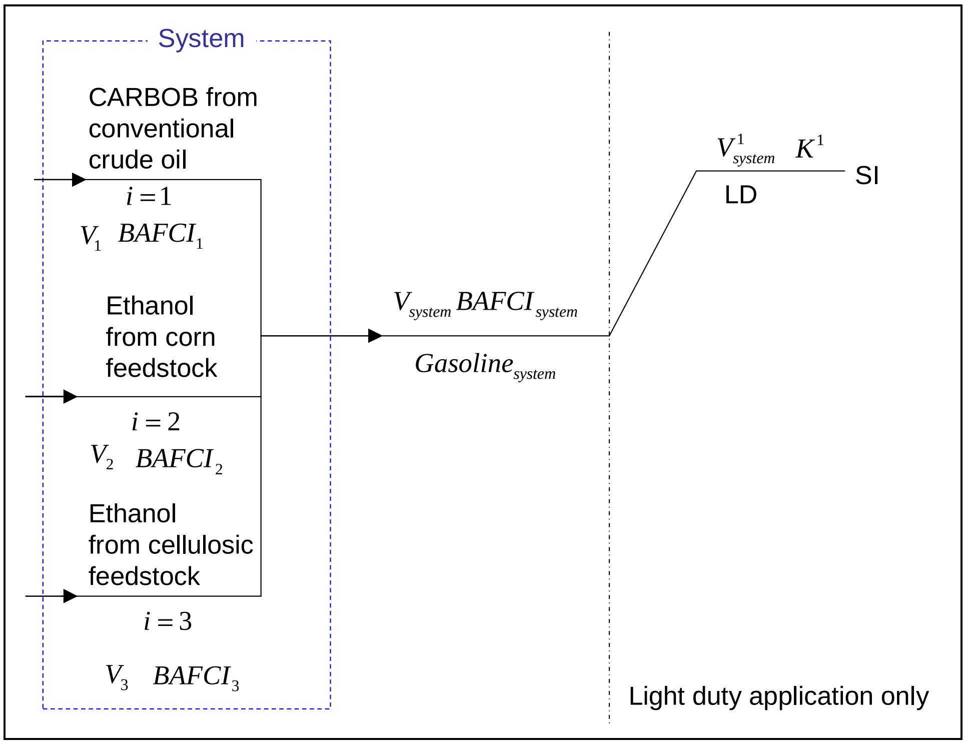

Figure A.2. Illustrative diagram of the fuel-engine combination used to calculate the corresponding LCFS average fuel carbon intensities for CA reformulated gasoline. In this example, only conventional crude oil is considered. The ethanol used for oxygenate blending comes from two different feedstocks, corn and cellulosic materials.

First, define the system as indicated in Figure A.2.

Let

i =1 = CARBOB from conventional crude oil
i =2 = ethanol from corn feedstock
i =3 = ethanol from cellulosic feedstock

These correspond to LCFS-blendstocks for gasoline.

The *j* value in Table 5.2.2 is *j*=1 corresponding to Gasoline/LD/SI with Vehicle Efficiency Adjustment Factor of $K^1 = 1.0$.

Using the ARB GREET fuel pathways similar to those in Appendix B, the LCFS-blendstock average carbon fuel intensity value, $BAFCI_i$, for each gasoline LCFS-blendstock is determined. The overall $BAFCI$ of the system is determined by

$$BAFCI_{system}(gCO2e/MJ) = \frac{(BAFCI_1)(V_1) + (BAFCI_2)(V_2) + (BAFCI_3)(V_3)}{V_1 + V_2 + V_3}.$$

The AFCI for gasoline is

$$AFCI^{LD}_{reported}(gCO2e/MJ) = (BAFCI_{system})(1.0)$$

In this case, $V_{system} = V_1 + V_2 + V_3 = V^1_{system}$, is the amount of finished gasoline used for light-duty transportation application.

The overall credit received (or in deficit) for gasoline used in light-duty application, according to Eqn. 4.1, is

$$Credits^{LD}(MMT) = \left(AFCI_{gasoline} - AFCI^{LD}_{reported}\right)(V_{system})(C)$$

Where $Credits^{TOT} = Credits^{LD}$

is the total credit received (or in deficit) for the fuel provider.

Example 3: Hydrogen

Producer A is providing hydrogen for light-duty and heavy-duty transportation use in CA. For each category, the fuel is used in hydrogen internal combustion and fuel cell vehicles. The hydrogen is produced from electrolysis using electricity from CA grid.

Sample calculation:

The following figure illustrates the possible fuel-engine combination(s).

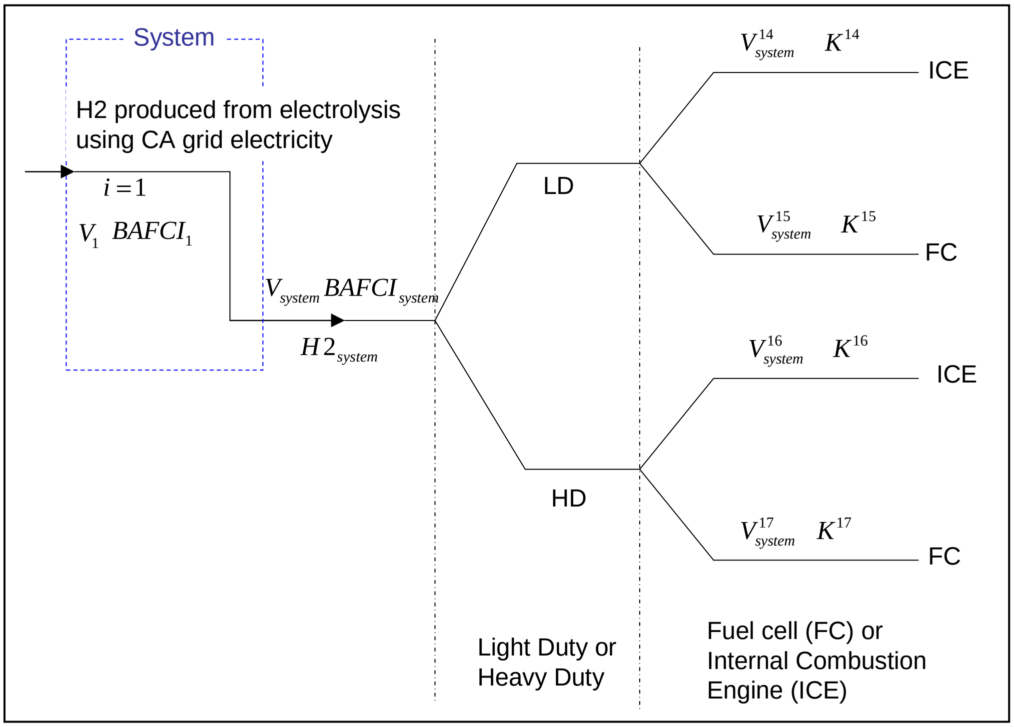

Figure A.3. Illustrative diagram of the fuel-engine combination used to calculate the corresponding LCFS average fuel carbon intensities for hydrogen produced from electrolysis using CA grid electricity. The fuel is used in light-duty and heavy-duty internal combustion (ICE) and fuel cell (FC) vehicles.

First, define the system as indicated in Figure A.3.

Let

i =1 = H2 produced from electrolysis using electricity from CA grid

This corresponds to the LCFS-blendstock for hydrogen.

The *j* values in Table 5.2.2 are *j*=14, 15, 16, and 17 corresponding to Vehicle Efficiency Adjustment Factors of K^{14}, K^{15} K^{16} and K^{17} for H2/LD/ICE, H2/LD/FC, H2/HD/ICE and H2/HD/FC, respectively.

Determine the volume of fuel used in each engine type.

$V_{system} = V_1$

$V^{14}_{system} = x^{14} V_{system}$ where x^{14} is the fraction of fuel used for H2/LD/ICE and
$V^{15}_{system} = x^{15} V_{system}$ where x^{15} is the fraction of fuel used for H2/LD/FC and
$V^{16}_{system} = x^{16} V_{system}$ where x^{16} is the fraction of fuel used for H2/HD/ICE and
$V^{17}_{system} = x^{17} V_{system}$ where x^{17} is the fraction of fuel used for H2/HD/FC.

Using the ARB GREET fuel pathways similar to those in Appendix B, the LCFS-blendstock average carbon fuel intensity value, $BAFCI_i$, for the selected H2 LCFS-blendstock is determined. The overall $BAFCI$ of the system is determined by

$$BAFCI_{system}(gCO2e/MJ) = (BAFCI_1)$$

The AFCI for light-duty use is

$$AFCI^{LD}_{reported}(gCO2e/MJ) = \frac{(BAFCI_{system})\left[(K^{14})(V^{14}_{system}) + (K^{15})(V^{15}_{system})\right]}{V^{14}_{system} + V^{15}_{system}}$$

The AFCI for heavy-duty use is

$$AFCI^{HD}_{reported}(gCO2e/MJ) = \frac{BAFCI_{system}\left[(K^{16})(V^{16}_{system}) + (K^{17})(V^{17}_{system})\right]}{V^{16}_{system} + V^{17}_{system}}$$

The overall credits received (or in deficit) for hydrogen used in light-duty and heavy-duty applications, according to Eqn. 4.1, are

$$Credits^{LD}(MMT) = \left(AFCI_{gasoline} - AFCI^{LD}_{reported}\right)(V^{14}_{system} + V^{15}_{system})(C)$$ and

$$Credits^{HD}(MMT) = \left(AFCI_{diesel} - AFCI^{HD}_{reported}\right)(V^{16}_{system} + V^{17}_{system})(C)$$

Where $Credits^{TOT} = Credits^{LD} + Credits^{HD}$ is the total credit received (or in deficit) for the fuel provider.

APPENDIX B. Example Fuel Pathways

Possible Feedstock-Fuel Pathways to be considered for calculating carbon intensities for the LCFS

	FEEDSTOCK	PROCESS	LOCATION	OTHER	FUEL
CRUDE	CRUDE (light and heavy)	REFINING	49 States		CARBOB
	CRUDE (light and heavy)	REFINING	CALIFORNIA		CARBOB
	CRUDE (light and heavy)	REFINING	OVERSEAS		CARBOB
	TAR SANDS	REFINING	N.AMERICA		CARBOB
	CRUDE (light and heavy)	REFINING	49 States		ULSD
	CRUDE (light and heavy)	REFINING	OVERSEAS		ULSD
	CRUDE (light and heavy)	REFINING	CALIFORNIA		ULSD
	CRUDE (light and heavy)	REFINING	49 States		LPG
	TAR SANDS	REFINING	N.AMERICA		ULSD
	CRUDE	REFINING	CALIFORNIA		LPG
NATURAL GAS	NATURAL GAS	PROCESSING	OUTSIDE CA		LPG
	NATURAL GAS	PROCESSING	OUTSIDE CA		CNG
	NATURAL GAS	PROCESSING	OUTSIDE CA		LNG
	NATURAL GAS	PROCESSING	CALIFORNIA		LNG
	NATURAL GAS	PROCESSING	OUTSIDE CA	LNG	CNG
	NATURAL GAS	FISCHER-TROPSCH	OUTSIDE CA		FT DIESEL
	NATURAL GAS	COMBUSTION	CALIFORNIA		ELECTRICITY
	NATURAL GAS	COMBUSTION	OUTSIDE CA		ELECTRICITY
	NATURAL GAS	REFORMING	CALIFORNIA	20% RPS	LIQUID H2
	NATURAL GAS	REFORMING	CALIFORNIA	100% RPS	LIQUID H2
	NATURAL GAS	REFORMING	CALIFORNIA	PIPELINE	LIQUID H2
CORN	CORN (grown in mid-west)	DRY MILLING	49 States	NG	ETHANOL
	CORN (grown in mid-west)	DRY MILLING	CALIFORNIA	NG	ETHANOL
	CORN (grown in mid-west)	WET MILLING	49 States	NG	ETHANOL
	CORN (grown in mid-west)	DRY MILLING	49 States	COAL	ETHANOL
	CORN (grown in mid-west)	WET MILLING	49 States	COAL	ETHANOL
	CORN (grown in mid-west)	WET MILLING	49 States	Ave. electricity	ETHANOL
	CORN (grown in mid-west)	DRY MILLING	49 States	Ave. electricity	ETHANOL
	CORN (grown in mid-west)	DRY MILLING	49 States	BIOMASS	ETHANOL
	CORN (grown in mid-west)	DRY MILLING	49 States	BIOMASS + COAL	ETHANOL
	SUGARCANE	PROCESSING	BRAZIL	Ave. electricity	ETHANOL
BI	SOYBEAN	ESTERIFICATION	OVERSEAS		BIODIESEL
	PALM OIL	ESTERIFICATION	INDONESIA		BIODIESEL

O/RENEWABLE					
	RAPE SEED/MUSTARD	ESTERIFICATION	CALIFORNIA		BIODIESEL
	CANOLA	ESTERFICATION	CALIFORNIA		BIODIESEL
	CANOLA	THERMAL	CALIFORNIA		RENEWABLE DIESEL
	WASTE (MEAT PROCESSING)	THERMAL	CALIFORNIA		RENEWABLE DIESEL
	WASTE (MEAT PROCESSING)	THERMAL	49 States		RENEWABLE DIESEL
LG	LANDFILL GAS	PROCESSING	CALIFORNIA		HYDROGEN
	LANDFILL GAS	COMBUSTION	CALIFORNIA		ELECTRICITY
WASTE	AG WASTE	PROCESSING	CALIFORNIA		ETHANOL
	AG WASTE	PROCESSING	49 States		ETHANOL
	MUNI. WASTE	PROCESSING	CALIFORNIA		ETHANOL
	MUNI WASTE	GASIFICATION	CALIFORNIA		FT DIESEL
	MUNI WASTE	COMBUSTION	CALIFORNIA		ELECTRICITY
BIOMASS	BIOMASS	GASIFICATION	CALIFORNIA		LIQUID H2
	BIOMASS	GASIFICATION	CALIFORNIA		HYDROGEN
	BIOMASS	COMBUSTION	CALIFORNIA		ELECTRICITY
	BIOMASS	GASIFICATION	CALIFORNIA		FT DIESEL
	BIOMASS (POPLAR)	CELLULOSIC	CALIFORNIA		ETHANOL
	FOREST RESIDUE	CELLULOSIC	CALIFORNIA		ETHANOL
	SWITCHGRASS	CELLULOSIC	CALIFORNIA		ETHANOL
	PETROLEUM COKE	GASIFICATION	CALIFORNIA		HYDROGEN
	PETROLEUM COKE	COMBUSTION	49 States		ELECTRICITY
COAL	COAL	COMBUSTION	49 States		ELECTRICITY
	COAL	PROCESSING	49 States		FT DIESEL
ELEC	ELECTRICITY	ELECTROLYSIS	49 States		HYDROGEN
	ELECTRICITY	ELECTROLYSIS	CALIFORNIA	CA Grid	HYROGEN
	ELECTRICITY	ELECTROLYSIS	CALIFORNIA	70% RPS	HYDROGEN
NUC	NUCLEAR	PROCESSING	49 States		ELECTRICITY
	NUCLEAR	PROCESSING	CALIFORNIA		ELECTRICITY
WIND	WIND POWER	GENERATION	49 States		ELECTRICITY
	WIND POWER	GENERATION	CALIFORNIA		ELECTRICITY

SOLAR	SOLAR	GENERATION	CALIFORNIA		ELECTRICITY
	SOLAR	GENERATION	49 States		ELECTRICITY

APPENDIX C. Example GREET Input Values[6]

CaRFG Pathway Input Values for GREET **PRELIMINARY DRAFT**

Scenerio: Average Crude Oil to CA refineries to make CARBOB, blended with 5.7% (by wt.) Midwest Corn Ethanol for CaRFG

Parameters	Units	Values	Note
WTP Efficiency		77.90%	Calculated by 1,000,000/(1,000,0000 + Total Energy input for CaRFG)
Conversion Factor to CO_2 equivalent			
CO_2		1	
CH_4		23	
N_2O		296	
VOC		0	
CO		0	
Crude Recovery			
Efficiency (assumed)		96.8%	Crude Recovery for 2010
% Energy Contributions			
Crude		1%	
Residual Oil		1%	
Conv Diesel		15%	
Conventional Gasoline		2%	
NG		61.90%	
Electricity		19%	
Feed Loss crude recovery		0.1%	
Crude Transport Assumptions to CA refineries			
Pipeline shares		42%	42% by pipeline to CA
Pipeline distance	miles	150	One way
Pipeline Energy Intensity	Btu/mile-ton	253	
Crude Transport Assumptions to US refineries			
Pipeline shares		100%	
Pipeline distance	miles	750	One way
Pipeline Energy Intensity	Btu/mile-ton	253	
Feed Loss		1.000062	
CaRFG Refining			
Refining Efficiency		84.50%	CaRFG Refining for year 2010
% Energy Contributions to Refinery by feed			
Residual Oil		6%	
NG		40%	
Electricity		4%	
Still Gas		50%	
Transportation Assumption for CARBOB feed to the refineries			

[6] This is for CaRFG WTT GREETv.94 calculations for the year 2010. Values change based on year, fuel, and GREET version.

Transportation by ocean tanker		80%	
Distance	miles	5750	
Transportation by pipeline		20%	20% directly by pipeline
Distance	miles	50	
Distribution by truck		99.40%	
Distance	miles	50	
Feed loss by T&D		5.87%	
Corn Farming			
Assumption for Corn Production			
Corn energy use	Btu/bu	22500	
Corn harvest	lbs/bu	56	
Corn transp. by truck farm to stack	miles	10	Energy Intensity 2199 Btu/mile-ton
Corn transp. by truck stack to plant	miles	50	Energy Intensity 1713 Btu/mile-ton
Fertilizer Use			
Nitrogen	g/bu	420	
NH_3			
Production Efficiency		82.4%	
Shares in Nitrogen Production		70.7%	
Transport by ocean tanker	miles	3000	48 Btu/mile-ton for O-D and 43 Btu/mile-ton reverse
by rail	miles	750	370 Btu/mile-ton
by barge	miles	400	403 Btu/mile-ton
from plant to bulk center	miles	0	
from bulk center to mixer	miles	50	
from mixer to farm	miles	30	
Urea			
Feedstock input	tons	0.567	
Production Efficiency		46.7%	
Shares in Nitrogen Production		21.1%	
Transport by ocean tanker	miles	5200	48 Btu/mile-ton for O-D and 43 Btu/mile-ton reverse
by rail	miles	750	
by barge	miles	400	
from plant to bulk center	miles		by barge and ocen tanker
from bulk center to mixer	miles	50	1142 Btu/mile-ton by truck
from mixer to farm	miles	30	2199 Btu/mile-ton by truck
Amonium Nitrate			
Production Efficiency		35%	
Shares in Nitrogen Production		8%	
Transport by ocean tanker	miles	3700	Energy Intensity 27 Btu/mile-ton O-D, and 24 reverse
by barge	miles	400	Energy Intensity 403 Btu/mile-ton
by rail	miles	750	Energy Intensity 370 Btu/mile-ton
from plant to bulk center	miles		
from bulk center to mixer	miles	50	
from mixer to farm	miles	30	
P_2O_5	g/bu	149	
H_3PO_4			
Feedstock input	tons	n/a	
H_2SO_4			
Feedstock input	tons	2.674	
P Rock			
Feedstock input	tons	3.525	
P_2O_5 Transportation			
Transport by ocean tanker	miles	3000	
by barge	miles	400	
by rail	miles	750	

K_2O	g/bu	174	
Transport by ocean tanker	miles	3900	
by barge	miles	400	
by rail	miles	750	
from plant to bulk center	miles		
from bulk center to mixer	miles	50	
from mixer to farm	miles	30	
$CaCO_3$	g/bu	1,202	
Transport by Truck	miles	50	
Herbicide	g/bu	8.1	
Transport by ocean tanker	miles	4,000	
by barge	miles	400	
by rail	miles	750	
from plant to bulk center	miles		
from bulk center to mixer	miles	50	
from mixer to farm	miles	30	
Insecticide	g/bu	0.68	
Transport by ocean tanker	miles	4,000	
by barge	miles	400	
by rail	miles	750	
from plant to bulk center	miles	0	
from bulk center to mixer	miles	50	
from mixer to farm	miles	30	
% of Energy contribution fertilizer production			
Diesel fuel		38.3%	
Gasoline		12.3%	
Natural gas		21.5%	
LPG		18.8%	
Electricity		9%	
Feed loss			
Land Use			
EtOH Production			
Dry mill (shares of total)		80%	
Dry EtOH Yield	gal/bushel	2.72	
Energy use for Dry EtOH	Btu/gal	36,000	
% Energy of Coal used for dry mill		9%	
% Energy of NG used for dry mill		81.5%	
Electricity used for dry mill		9.5%	
Wet mill (shares of total)		20%	
Wet EtOH Yield	gal/bushel	2.62	
Energy use for Wet EtOH		45,970	
% Energy of Coal used for wet mill		40%	
% Energy of NG used for wet mill		60%	
Transportation and Distribution			
EtOH transp. by truck		70%	
Distance	miles	40	
EtOH distr. by truck		100%	
Distance	miles	50	
Fuels Properties			
Fuels Specifications	**LHV (Btu/gal)**	**Density (g/gal)**	
Crude	129,670	3,205	

RO	140,353	3,752	
Conv Diesel	128,450	3,167	
Conv Gasoline	116,090	2,819	
CaRFG	111,289	2,828	
CARBOB	113,300	2,767	
NG	111,520	2,651	
EtOH	76,330	2,988	
Still Gas	128,590		
Energy Content Contribution for CaRFG			
CARBOB		96.4%	
EtOH		3.6%	
Transportation			
Cargo Load Capacities			
Ocean Tanker	tons		
Crude		250,000	
Gasoline		150,000	
Corn		n/a	
Ethanol		80,000	
Barge	tons		
Crude		150,000	
Gasoline		20,000	
Corn		20,000	
Ethanol		20,000	
Heavy Heavy-Duty Truck	tons		
Crude		25	
Gasoline		25	
Corn		15	
Ethanol		25	
Rail			
Ethanol	gallons	25,000	

APPENDIX D. Example Co-Product Values

Sample excerpt from co-products spreadsheet located on http://arb.ca.gov/fuels/lcfs/lcfs.htm

Corn Ethanol and Soy Biodiesel Life Cycle GHG Emissions and Co-Product Credit Based on GREET 1.8a Methodology for Target Year 2010

Co-product credit results are shown in tables below the table of inputs and intermediate calculations on the GREET Corn EtOH and GREET Soy Diesel tabs

- This workbook uses the GREET 1.8a framework to calculate the emission credit for dry and wet mill corn ethanol using the displacement method and soy biodiesel co-product credits using allocation by energy intensity.
- Dry distillers grains and solubles (DDGS) from dry mill corn ethanol production is assumed to displace feed corn and soy bean meal in equal proportions. We assume 1 gal EtOH yields 6.4 lbs DDGS (range of estimates 5.34-6.4) The 6.4 lbs of DDGS/gal displaces 3.2 lbs soy bean meal and 3.2 lbs feed corn (EPA RIA).
- The soy diesel co-product (soy bean meal and glycerin) credits are based on percentage allocation between soy oil and these co-products, shown at the top of the *GREET Corn EtOH* tab. Allocations are GREET defaults, based on Ahmed et al. (1994)
- GREET assumption: 85% of DDGS displaces feedcorn and soy bean meal and 15% is allocated to new markets.
- The workbook takes advantage of GREET input values and structure by using intermediate process energy and emission results to calculate credits on a g/gal fuel basis for each component of the fuel pathway.
- The main inputs are highlighted in yellow and are located at the top of each sheet.
- The *Ag Inputs* tab is used for calculating the co-product credit for N-in Urea for CGM and CGF (WM corn ethanol)
- **References:**

  - US EPA, 2007, "Regulatory Impact Analysis: Renewable Fuel Standard Program," Assessment and Standards Division, Office of Transportation and Air Equality, US Environmental Protection Agency, EPA420-R-07-004
  - Ahmed, I. et al., 1994, "How Much Energy Does it Take to Make a Gallon of Soy Diesel?" prepared by the Institute for Local Self-Reliance for the National Soy Diesel Development Board