California's Low Carbon Fuel Standard

(An Update on the California Air Resources Board's Low Carbon Fuel Standard Program)

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Purpose of this Report

On April 23, 2009, the California Air Resources Board (ARB/Board) approved the Low Carbon Fuel Standard (LCFS) for transportation fuels used in California. The LCFS regulation will reduce greenhouse gas (GHG) emissions in California by reducing the carbon intensity of transportation fuels used in the State by an average of 10 percent—measured on a full lifecycle basis—by the year 2020.

This report summarizes the major provisions of the approved LCFS. The Board-approved revisions to the regulation are undergoing public review and as such are subject to change. Staff's proposed regulation, staff report, proposed modifications, Board resolution, and all other rulemaking files for California's LCFS regulation can be found at: http://www.arb.ca.gov/regact/2009/lcfs09/lcfs09.htm. Information on other ongoing activities related to the LCFS can be found at: http://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

Other LCFS or Similar Efforts

An important goal of the LCFS is to establish a durable fuel carbon regulatory template that is capable of being exported to other jurisdictions. The successful implementation of an effective framework in one jurisdiction should hasten the adoption of that framework elsewhere. Without the wider adoption of fuel carbon-intensity standards, fuel producers are free to ship lower-carbon-intensity fuels to areas with such standards, while shipping higher-carbon-intensity fuels elsewhere. The end result of this fuel "shuffling" process is little or no net change in fuel carbon-intensity on a global scale. With a widespread adoption of an LCFS, significant reductions in fuel carbon intensity will begin to be realized on a global scale. It is ARB's intent to continue coordinating California's LCFS program efforts with those of other interested entities.

California is currently the only jurisdiction in the country with an LCFS or similar regulation. Measures similar to the LCFS are under consideration at the regional, national, and international levels. For example, a regional consortium of eleven Northeastern and Mid-Atlantic States has committed to developing an LCFS that is generally based on the same premise as the California LCFS. Significantly, this commitment references California's efforts to develop an LCFS. Under the commitment, the states will seek to draft a Memorandum of Understanding concerning the development of a regional LCFS program, to be forwarded by December 31, 2009, or as soon thereafter as is possible for each state, for consideration by the Governors of each state. The consortium participated in the California's LCFS program development and supported the regulation at the April 2009 public hearing. In July 2009, the

consortium published the results of its own assessment of an LCFS for the Northeastern and Mid-Atlantic states.[1]

Oregon is following California's lead. Oregon Governor Ted Kulongoskii recently signed into law a bill that includes, among other GHG emission reduction measures, an LCFS requirement. The Oregon LCFS must include a full life-cycle analysis of the fuel. The Oregon law requires a 10 percent reduction from 2010 to 2020 in the carbon intensity of a unit of fuel energy. The rules must be adopted by the Environmental Quality Commission by January 1, 2011.

At the federal level, Congress adopted a renewable fuels standard (RFS) in 2005 and strengthened it (RFS2) in December 2007 as part of the Energy Independence and Security Act of 2007 (EISA). It requires that 36 billion gallons of biofuels be sold annually by 2022, of which 21 billion gallons must be "advanced" lower carbon biofuels and the other 15 billion gallons can be corn ethanol. Although the RFS2 requires the production of specified volumes of lower carbon biofuels, the fuel carbon intensity reductions it would achieve in California would be substantially below the reductions the LCFS is designed to achieve. The federal RFS would deliver only about 30 percent of the GHG benefits of the regulation, and does little to incent fuels such as natural gas, electricity or hydrogen. California's LCFS is designed to complement the federal RFS2. The proposed RFS2 regulation is currently undergoing public review.

At the international level, the European Parliament adopted, in December 2008, a package of measures to address climate change throughout the European Union. One of these measures is a revised fuel quality directive. This revised directive requires fuel suppliers to reduce GHG emissions, on a lifecycle basis, by up to 10 percent by 2020. Regarding land use change, the European Commission will have to develop a methodology to measure the GHG emissions that result when crops for biofuel production are grown in areas which have previously been used to grow a food crop and this food crop production then moves to other areas that were previously not in use. The fuel directive also includes provisions to address sustainability of biofuels production.

Concurrent efforts are underway at the Board to establish fuel specifications that will complement the LCFS regulation. The Board has already established fuel specifications for California reformulated gasoline, California ultra-low sulfur diesel fuel, and a number of alternative fuels used in transportation, such as E85 and natural gas. The staff is currently developing specifications for other alternative fuels, such as biodiesel and renewable diesel, and is considering revising other fuel specifications, including natural gas.

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[1] *Introducing a Low Carbon Fuel Standard in the Northeast* is available at : http://www.nescaum.org/documents/lcfs-report-final.pdf

Overview of LCFS Program

California's LCFS will reduce GHG emissions from the transportation sector in California by about 16 million metric tons (MMT) in 2020. These reductions account for almost 10 percent of the total GHG emission reductions needed to achieve the State's mandate of reducing GHG emissions to 1990 levels by 2020. In addition, the LCFS is designed to reduce California's dependence on petroleum, create a lasting market for clean transportation technology, and stimulate the production and use of alternative, low-carbon fuels in California. Governor Schwarzenegger has identified all of these outcomes as important goals for California.

The LCFS is designed to provide a durable framework that uses market mechanisms to spur the steady introduction of lower carbon fuels. The framework establishes performance standards that fuel producers and importers must meet each year beginning in 2011. One standard is established for gasoline and the alternative fuels that can replace it. A second similar standard is set for diesel fuel and its replacements. Each standard is set to achieve an average 10 percent reduction in the carbon intensity of the statewide mix of transportation fuels by 2020.

The standards are "back-loaded"; that is, there are more reductions required in the last five years than the first five years. This schedule allows for the development of advanced fuels that are lower in carbon than today's fuels and the penetration of plug-in hybrid electric vehicles, battery electric vehicles, fuel cell vehicles, and flexible fuel vehicles. Staff anticipates that compliance with the LCFS will be based on a combination of strategies involving lower carbon fuels and more efficient, advanced-technology vehicles.

Reformulated gasoline mixed with corn-derived ethanol at 10 percent by volume and low-sulfur diesel fuel represent the baseline fuels. Lower carbon fuels may be ethanol, biodiesel, renewable diesel, or blends of these fuels with gasoline or diesel as appropriate. Compressed natural gas and liquefied natural gas also may be low-carbon fuels. Hydrogen and electricity are also low-carbon fuels and result in significant reductions of GHGs when used in fuel-cell or electric vehicles due to significant vehicle power train efficiency improvements over conventionally-fueled vehicles. As such, these fuels are included in the LCFS as low-carbon options. Other fuels may be used to meet the standards and are subject to meeting existing requirements for transportation fuels.

The LCFS framework is based on the premise that each fuel has a "lifecycle" GHG emission value that is then compared to a standard.[2] This lifecycle analysis represents the GHG emissions associated with the production, transportation, and use of low-carbon fuels in motor vehicles. The lifecycle analysis includes the direct emissions associated with producing, transporting, and using the fuels. In addition, the lifecycle analysis considers any other effects, both direct and indirect, that are caused by the

[2] For petroleum-based fuels, the lifecycle analysis is also referred to as "well-to-wheels; for fuels produced from crops, the lifecycle analysis is sometimes referred to as "seed-to-wheels."

change in land use or other effects. Land use changes are a significant source of additional GHG emissions for some crop-based biofuels. Therefore, the emissions associated with land use changes were included in the carbon intensity values assigned to those fuels in the regulation. No other significant indirect effects that result in large GHG emissions were identified that would substantially affect the LCFS framework for reducing the carbon intensity of transportation fuels.

The standards are expressed as the carbon intensity of gasoline and diesel fuel and their alternatives. Measured on a lifecycle basis, the carbon intensity represents the equivalent amount of carbon dioxide (CO_2e) emitted from each stage of producing, transporting, and using the fuel in a motor vehicle. Depending on the circumstances, GHG emissions from each step can include carbon dioxide (CO_2), methane, nitrous oxide (N_2O), and other GHG contributors. Moreover, the overall GHG contribution from each particular step is a function of the energy that the fuel contains. Thus, carbon intensity is expressed in terms of grams of CO_2 equivalent per megajoule (g CO_2e/MJ).

Providers of transportation fuels (referred to as regulated parties) must demonstrate that the mix of fuels they supply meet the LCFS intensity standards for each annual compliance period. They must report all fuels provided and track the fuels' carbon intensity through a system of "credits" and "deficits." Credits are generated from fuels with lower carbon intensity than the standard. Deficits result from the use of fuels with higher carbon intensity than the standard. A regulated party meets its compliance obligation by ensuring that the amount of credits it earns (or otherwise acquires from another party) is equal to, or greater than, the deficits it has incurred. Credits and deficits are generally 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 GHG emissions. This determination is made for each year between 2011 and 2020. Credits may be banked and traded within the LCFS market to meet obligations.

The regulation provides flexibility for the regulated parties. The regulation is performance-based, and fuel providers have several options. First, they may supply a mix of fuels above and below the standard that, on average, equal the required carbon intensity. Second, they can choose to only provide fuels that have lower carbon intensity than the standard. For example, they may blend low-carbon ethanol into gasoline, or renewable diesel fuel in diesel fuel. Third, they may purchase credits generated by other fuel providers to offset any accumulated deficits from their own production. For example, a fuel provider may choose to purchase credits generated from another fuel provider that has banked credits from using electricity in a plug-in hybrid vehicle. Fourth, a fuel provider may bank excess credits generated in a previous year and use those credits when needed. As the objective is to ensure lower carbon intensity fuels are created and used in the California fuels market, the LCFS does not allow the use of credits, or offsets, generated from outside the transportation fuels market.

The LCFS standards established in the regulation will be periodically reviewed. The first review must be completed and presented to the Board by January 1, 2012, and a second review is required by January 1, 2015. The reviews will be broad in scope, addressing a number of areas, including advances in low carbon fuels and production technologies, advances in fuel-lifecycle assessments, the compliance schedule, an analysis of the air quality impacts, other public health impacts, and the significant economic impacts associated with implementation of the LCFS.

To achieve Governor Schwarzenegger's long term goal of reducing GHG emissions by 80 percent by 2050 (Executive Order S-3-05), the carbon intensity of transportation fuels will need to be substantially decreased over the 2020 target of a 10 percent reduction. Therefore, the staff expects to consider targets for the 2030 timeframe in the subsequent reviews of the LCFS.

Legislative and Policy Directives

The LCFS is supported by a number of legislative and policy directives as presented below:

- **Assembly Bill 32** - In 2006, the Legislature passed and Governor Schwarzenegger signed Assembly Bill (AB) 32, referred to the California Global Warming Solutions Act of 2006. AB 32 required the Board to develop a plan to reduce GHG emissions in California to 1990 levels by 2020. Among other provisions, AB 32 required the Board to identify and adopt discrete early actions in 2007 and to approve a scoping plan in 2008.

- **Executive Order S-06-06** - In April 2006, Governor Schwarzenegger signed an executive order that established targets to increase the production and use of bioenergy, including ethanol and biodiesel fuels made from renewable resources.[3] One of the executive order provisions specified that, by 2020, 40 percent of biofuels used in the State should be produced in the State. The approved regulation supports this goal by requiring the use of low-carbon alternative fuels and stimulating innovation in the production of these low-carbon fuels.

- **Executive Order S-01-07** - In January 2007, Governor Schwarzenegger signed an executive order that established the goal of developing an LCFS to reduce the carbon intensity of transportation fuels by at least 10 percent by 2020 and to consider whether the LCFS should be listed as a discrete early action.[4] In addition, the executive order identified that the LCFS shall apply to all providers of transportation fuels in California, shall be measured on a full fuels cycle basis, and may be met through market-based methods. The approved regulation satisfies the directive of the executive order.

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[3] Executive Order S-06-06 is available at: http://gov.ca.gov/executive-order/183/.
[4] Executive Order S-01-07 is available at: http://gov.ca.gov/executive-order/5172/.

- **AB 32 Discrete Early Action Measures** - In June 2007, the Board approved the LCFS as a discrete early action measure. The proposed regulation is designed to implement this measure. Table 1 summarizes the discrete early action measures, all of which have now been adopted by the Board.

Table 1
Discrete Early Action Measures

Measure	Status	Board Hearing Date	Emission Reductions in 2020 $MMTCO_2e$
Green Ports – Cold Ironing Ships at Ports	Adopted	December 2007	0.2
Reduction of High Global Warming Potential Gases in Consumer Products	Adopted	June 2008	0.2
SmartWay Truck Efficiency	Adopted	December 2008	0.9
Motor Vehicle Air Conditioning Systems: Reduction of Refrigerant Emissions from Non-Professional Servicing	Adopted	January 2009	0.3
Reduction of High Global Warming Gases Used in Semiconductor Operations	Adopted	February 2009	0.2
Sulfur Hexafluoride from the Non-Semiconductor and Non-Utility Applications	Adopted	February 2009	0.1
Vehicles Operating with Under-Inflated Tire Pressure	Adopted	March 2009	0.6
Low Carbon Fuel Standard	Adopted	April 2009	16 *
Landfill Methane Control Measure	Adopted	May 2009	1.0

* Estimated emission reductions based on the "tank-to-wheel" analysis.

- **State Alternatives Fuel Plan** - In November 2007, the California Energy Commission and the Board each approved the "State Alternatives Fuel Plan (Fuels Plan)," required pursuant to Assembly Bill 1007.[5] The Fuels Plan presents strategies and actions California must take to increase the use of alternative non-petroleum fuels. An LCFS was anticipated as part of this Plan. The approved regulation supports and is consistent with the goals of the Fuels Plan.

- **AB 32 Scoping Plan** - In December 2008, the Board approved the AB 32 Scoping Plan to reduce GHG emissions in California to 1990 levels. The Scoping Plan identifies how emission reductions will be achieved from significant GHG sources via regulations, market mechanisms, and other actions.

  The LCFS regulation is listed as one of the key measures in the Scoping Plan and is only one of several motor vehicle and other transportation-related GHG measures identified in the Scoping Plan. Table 2 summarizes the transportation-

[5] The Air Resources Board and the California Energy Commission approved the State Alternatives Fuel Plan in December 2007. The Plan is available at: http://www.energy.ca.gov/ab1007/.

related measures. The potential benefits of the LCFS have been adjusted assuming that these other measures are implemented. In addition, the Scoping Plan also identified that, beginning in 2015, transportation fuels are to be included in the Cap and Trade Program. The ARB staff believes that the LCFS is a complementary program to any Cap and Trade Program.

Table 2
Recommended Transportation-Related Greenhouse Gas Reduction Measures Identified in the Air Resources Board's Scoping Plan

Measure	Description	Emission Reductions Counted Towards 2020 Target ($MMTCO_2e$)
Low Carbon Fuel Standard	Reduce the carbon intensity of transportation fuels used in California by an average of 10 percent	16
California Light-Duty Vehicle Standards	Implement adopted Pavley standard and planned second phase of the program. Align zero-emission vehicle, alternative and renewable fuel and vehicle technology program with climate change goals.	32
Regional Transportation-Related GHG Targets	Develop regional GHG emissions reduction targets for passenger vehicles pursuant to Senate Bill 375.	5
Vehicle Efficiency Measures	Implement light-duty vehicle efficiency measures including properly inflated tires, consideration of minimum fuel-efficient tire standards, and reducing engine load via lower friction oil and reducing the need for air conditioner use.	4.5
Medium/Heavy Duty Vehicles	Adopt medium and heavy-duty vehicle efficiency measure including retrofits to improve the fuel efficiency of heavy-duty trucks by reducing aerodynamic drag and rolling resistance and hybridization of medium-and heavy-duty vehicles.	1.5

In support of an LCFS, University of California (UC) Professors Daniel Sperling and the late Alexander Farrell directed a team of UC colleagues that developed two significant reports that provided an initial framework for the LCFS.[6, 7] These two reports established the technical feasibility of an LCFS, identified many of the significant technical and policy issues, and provided a number of specific recommendations. These comprehensive reports were the backbone of ARB staff's initial efforts to develop the LCFS. While not all of the specific recommendations have been incorporated in the LCFS, all of the recommendations have spurred a vigorous debate on the issues and facilitated the development of ARB staff's proposed regulation.

[6] "A Low Carbon Fuel Standard for California, Part 1: Technical Analysis;" Alexander E. Farrell, UC Berkeley, Daniel Sperling, UC Davis, et al; August 1, 2007
[7] "A Low Carbon Fuel Standard for California, Part 2: Policy Analysis;" Alexander E. Farrell, UC Berkeley, Daniel Sperling, UC Davis, et al; August 1, 2007

Major Provisions of the LCFS Regulation

The basic framework of the LCFS was presented above. The following section provides a more detailed discussion of the LCFS regulation, including major modifications that were approved by the Board in April 2009. As was mentioned earlier, the modifications to the regulation are undergoing public review and as such are subject to change.

Fuels Included in the LCFS

With respect to the fuels, the LCFS applies, either on a compulsory or opt-in basis, to most types of fuels used for transportation in California, including:

- California reformulated gasoline;
- California ultralow-sulfur diesel fuel;
- Compressed or liquefied natural gas;
- Electricity;
- Compressed or liquefied hydrogen;
- Any fuel blend containing hydrogen;
- Any fuel blend containing greater than 10 percent ethanol by volume;
- Any fuel blend containing biomass-based diesel;
- Neat denatured ethanol;
- Neat biomass-based diesel; and
- Any other liquid or non-liquid fuel not otherwise exempted from the regulation.

Fuel Pool Carbon Intensity Standards

The LCFS achieves GHG emission reductions by incrementally reducing the allowable carbon intensity of transportation fuel used in California. The LCFS does not limit the carbon intensity of individual batches or types of fuels, but does require regulated parties to comply with an annual standard for the total amount of fuel they provide. This annual standard is expressed as carbon intensity in g CO_2e/MJ. The allowable carbon intensity of transportation fuels decreases each year, starting in 2011, until the carbon intensities of gasoline and diesel transportation fuels in 2020 are each reduced by 10 percent relative to 2010. Gasoline and diesel follow similar carbon intensity reduction curves from 2011 through 2020 and beyond.

In the LCFS, the carbon intensity for alternative fuels (biofuels, natural gas, hydrogen, electricity) would be judged against either the gasoline or diesel carbon intensity standards, depending on whether the alternative fuel is used for light- or medium-duty vehicles or for heavy-duty vehicles, as specified in the regulation. In each year, the carbon intensity of each fuel is compared to the LCFS standard for that year. Fuels that have carbon intensity levels below the standard generate credits. Fuels with carbon intensity above the standard create deficits. To comply with the LCFS for a given year, a regulated party must show that the total amount of credits equal or exceed the deficits incurred. Excess credits can be banked or sold to other regulated parties.

A graphical representation of the compliance schedules is presented in Figures 1 and 2. Table 3 shows the compliance schedules for gasoline and diesel fuel.

Figure 1

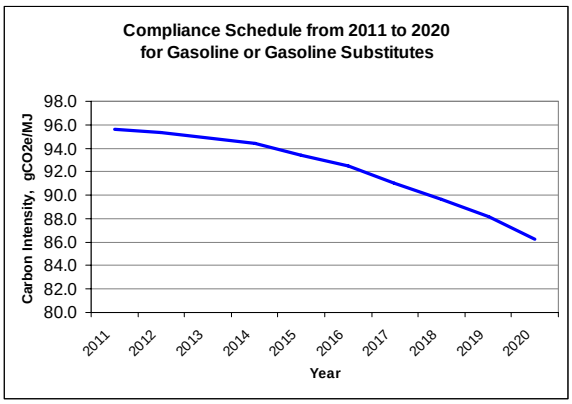

Figure 2

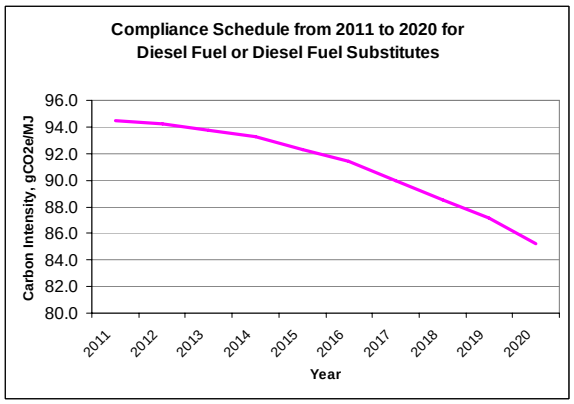

Table 3
LCFS Compliance Schedule

Year	Carbon Intensity for Gasoline and Fuels Substituting for Gasoline (g/MJ)	Gasoline and Fuels Substituting for Gasoline % Reduction	Carbon Intensity for Diesel and Fuels Substituting for Diesel (g/MJ)	Diesel and Fuels Substituting for Diesel % Reduction
2010	Reporting Only			
2011	95.61	0.25%	94.47	0.25%
2012	95.37	0.5%	94.24	0.5%
2013	94.89	1.0%	93.76	1.0%
2014	94.41	1.5%	93.29	1.5%
2015	93.45	2.5%	92.34	2.5%
2016	92.50	3.5%	91.40	3.5%
2017	91.06	5.0%	89.97	5.0%
2018	89.62	6.5%	88.55	6.5%
2019	88.18	8.0%	87.13	8.0%
2020 and subsequent years	86.27	10.0%	85.24	10.0%

Regulated Parties

In general, the regulation places compliance obligations initially on regulated parties that are upstream entities (i.e., producers and importers that are legally responsible for the quality of transportation fuels in California), rather than downstream distributors and fueling stations. However, under specified conditions, the regulated party may be

another entity further downstream that can be held responsible for the carbon intensity of the fuels or blendstocks that they dispense in California. The LCFS specifies the criteria under which a person would be deemed a regulated party for each particular fuel and how the responsibility for complying with the LCFS can be transferred. Table 4 summarizes the regulated parties for each transportation fuel.

Table 4
Regulated Parties Defined in the Low Carbon Fuel Standard

Fuel	Description of the Regulated Party
Gasoline, diesel, and liquid blendstocks (including oxygenates and biodiesel)	The regulated party is the producer or importer of the fuel or blendstocks.
Fossil fuel-derived compressed natural gas (fossil CNG)	The regulated party is generally the utility company, energy service provider, or other entity that owns the fuel dispensing equipment.
Fossil fuel-derived liquefied natural gas (fossil LNG)	The regulated party is the entity that owns the fuel when it is transferred to the fuel dispensing equipment in California.
Other gaseous fuels (biogas/biomethane, hydrogen)	The regulated party will generally be the person who produces the fuel and supplies it for vehicular use.
Electricity	The regulated party will be either the load service entity supplying the electricity to the vehicle or another party that has a mechanism to provide electricity to vehicles and has assumed the LCFS compliance obligation.

Transfer of Compliance Obligations and Regulated Party Status

Certain persons are initially designated as regulated parties who are responsible for all LCFS compliance obligations. Except as provided in the regulation, this status as a regulated party generally remains with the initially designated party even if ownership for the fuel is transferred from one party to another. There are two major exceptions to this general rule. For gasoline and diesel fuel, the compliance obligations would generally transfer to another producer or importer that receives blendstock from the initial regulated party, with provisions for the initial regulated party to retain the compliance obligation if so desired by the affected parties.

The principal rule noted above notwithstanding, the LCFS generally allows the regulated party for a fuel to transfer its compliance obligations by written instrument to another party under specified conditions; the buyer or recipient of the transferred fuel, in turn, becomes the regulated party for that fuel. For a variety of reasons, the transfer of such compliance obligations, along with the potential for generating and selling credits, may be desirable for a company, and the regulation allows such transfers.

Voluntary Opt-In Provisions

The regulation includes an opt-in provision and specific exemptions. The regulation explicitly recognizes that certain alternative fuels have full fuel-cycle, carbon intensities (including power train efficiencies) that inherently meet the compliance standards through 2020. As a result, these fuels may choose an opt-in provision. These fuels are:

- Electricity;
- Hydrogen and hydrogen blends;
- Fossil CNG derived from North American sources;
- Biogas CNG; and
- Biogas LNG.

Parties that opt into the LCFS program will be those parties that expect to generate LCFS credits under the regulation. By opting into the program, a person becomes a regulated party under the LCFS regulation and is required to meet the LCFS reporting obligations and requirements. The provisions for opting into the LCFS are set forth in the regulation.

At the April public hearing, the Board directed staff to work with the California Public Utilities Commission, electric utilities, oil refiners, and other stakeholders to review the provisions applicable to regulated parties for electricity and propose amendments, if appropriate, to the regulation by December 2009.

Exemptions

The proposal initially does not apply to regulated parties providing liquefied petroleum gas (LPG or propane). There are also exemptions for specific applications, including racing fuels, interstate locomotives, ocean-going vessels, aircraft, military tactical vehicles, and military tactical support equipment. These sources account for a small amount of the diesel fuel used in California. However, it is important to note that this exemption does not apply to *intra*state locomotives and commercial harbor craft. These sources are already subject to the California standards for diesel fuel. As such, the diesel fuel used in intrastate locomotives and commercial harbor craft would be treated the same as any other transportation fuel subject to the LCFS.

Progress Reporting and Account Balance Reporting

The LCFS provides for regulated parties to submit quarterly progress reports starting in 2010. These quarterly progress reports are intended to ensure that regulated parties keep track of their ability to comply with the allowable carbon intensity at the end of the annual compliance period. The quarterly reports are required to contain a specified set of information and data, such as carbon intensities, fuel volumes sold or dispensed, fuel transfer information, and other information.

The annual account-balance reporting includes all the information required for the quarterly reporting, along with additional information relating to the total credits and deficits generated during the year or carried over from the previous year; total credits acquired from another party; total credits transferred to other parties; credits generated and banked in the current year; and any deficits to be carried into the next year. All quarterly and annual reporting will be done via a Web-based, interactive form that ARB staff will establish.

Recordkeeping

Regulated parties must maintain specified records in English for a minimum of three years. Upon request by the Executive Officer, regulated parties must provide such records within 48 hours, unless a mutual agreement has been reached on an alternative time period.

Evidence of Physical Pathway

To ensure that low-carbon fuels that are produced outside of California are actually the source of fuels used in the State, regulated parties must establish physical pathway evidence for transportation fuels subject to the LCFS. For each transportation fuel that a regulated party is responsible for under the LCFS, this involves a four-part showing:

- A one-time demonstration that there exists a physical pathway by which the transportation fuel is expected to arrive in California. These demonstrations can be submitted by regulated parties or non-regulated-party fuel producers whose fuels are used by the regulated party. The physical pathway would include any applicable combination of truck delivery routes, rail tanker lines, gas/liquid pipelines, electricity transmission lines, and any other fuel distribution routes that, taken together, accurately account for the fuel's movement from the generator of the fuel, through intermediate entities, to the fuel blender, producer, or importer in California;
- Written evidence, by contract or similar evidence, showing that a specific volume of a particular transportation fuel with known carbon intensity was inserted into the physical pathway as directed by the regulated party;
- Written evidence, by contract or similar evidence, showing that an equal volume of that transportation fuel was removed from the physical pathway by the regulated party for use as a transportation fuel in California; and
- An update to the initial physical pathway demonstration whenever there are modifications to the initially demonstrated pathway.

Provisions Governing Credits and Deficits and Reconciliation of Shortfalls

Detailed equations and calculations are specified in the regulation for a regulated party to use in calculating its total deficits and credits within each compliance period. A regulated party will meet its annual compliance requirements if its credit balance, at the end of the compliance year, is greater than or equal to zero. Conversely, a regulated

party is in deficit and may be in violation if its credit balance is less than zero at the end of a compliance year.

A regulated party whose credit balance is less than zero at the end of a compliance year is in deficit and may be in violation of the LCFS, depending on the magnitude of the shortfall. Shortfalls are categorized into two main categories. First, a regulated party that ends a compliance year with a significant credit balance shortfall, determined on a percentage basis, will be in violation of the LCFS and subject to a notice of violation and penalties commensurate with the size of the violation. In addition, the regulated party must reconcile and remedy the shortfall within a specified period of time. By contrast, a regulated party that ends a compliance year with a relatively small shortfall (i.e., shortfall is 10 percent or less) will be required to reconcile the shortfall within the following year.

It should be noted that two or more consecutive years in a shortfall will be treated the same as a substantial credit balance shortfall, irrespective of the shortfall's size. A regulated party may generate credits on a quarterly basis, and unused credits may be banked without expiration. There is no prohibition against retiring or exporting LCFS credits to other GHG reduction initiatives, but importing credits from such external programs into the LCFS program is not allowed. A non-regulated third party is prohibited from buying, selling, or trading LCFS credits unless the regulated party that owns the credits is exporting such credits for compliance with other GHG reduction initiatives.

At the April public hearing, the Board directed staff to work with electric utilities, environmental advocates, and other stakeholders to further evaluate the feasibility of generating credits for electricity used in nonroad transportation sources, such as new categories and applications of electric forklifts and other similar nonroad vehicles and equipment, and propose amendments, if appropriate, to the regulation by December 2009.

Determination of Carbon Intensity Values

Within the LCFS framework, the GHG emissions associated with a fuel are referred to as that fuel's "carbon intensity." Carbon intensities are calculated under the LCFS on a full lifecycle basis and are determined in two parts. The first part represents all of the direct emissions associated with producing, transporting, storing, and using the fuel. The second part considers any other effects, both direct and indirect, that are caused by the change in land use or other market-mediated effects.

Direct Emissions

The direct emissions are determined by calculating the amount of GHG emissions emitted per unit of energy for each of the steps in the fuel pathway. For example, these steps may involve the following for the production of ethanol:

- Farming practices (e.g., frequency and type of fertilizer used);
- Crop yields;
- Harvesting of the crop;
- Collection and transportation of the crop;
- Type of fuel production process;
- Fuel used in the production process (e.g. coal/CNG/biomass);
- Energy efficiency of the production process;
- The value of the co-products generated (e.g. distillers grain);
- Transport and distribution of the fuel; and
- Combustion of the fuel in vehicles.

To assess the direct GHG emissions, staff used the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation model (GREET). This model was modified for use in California (CA-GREET) as the primary method for calculating carbon intensity values for various transportation fuels. The CA-GREET model is essentially a very large spreadsheet that performs accounting of GHG emissions. The CA-GREET model incorporates many specific numeric values that allow for the calculation of the lifecycle GHG emissions associated with producing, transporting, and using various fuels. Staff used CA-GREET to develop specific carbon intensities for a number of different pathways. For some fuels, multiple pathways were developed that represent differences in how and where the fuel is produced.

Indirect Land Use Changes

To assess the GHG emissions from land use changes, staff uses a global trade model (Global Trade Analysis Project – GTAP) to estimate the GHG emissions impact. In general, the model evaluates the worldwide land use conversion associated with the production of crops for fuel production. When land is converted to agricultural uses, much of the carbon stored in that land is released to the atmosphere. The amount of carbon released depends primarily on the type of vegetation and soil present. Multiplying the area of the land converted times an emission factor specific to the type of land that is converted results in an estimate of the GHG emissions impacts of land conversions.

Based on the work done to date, staff identified indirect land use changes as a significant source of additional GHG emissions for some crop-based biofuels, and included the emissions associated with these changes in the carbon intensity values assigned to those fuels in the LCFS. An indirect land use change impact is initially triggered when an increase in the demand for a crop-based biofuel begins to drive up prices for the necessary feedstock crop. This price increase causes farmers to devote a

larger proportion of their cultivated acreage to that feedstock crop. Supplies of the displaced food and feed commodities subsequently decline, leading to higher prices for those commodities. The lowest-cost way for many farmers to take advantage of these higher commodity prices is to bring non-agricultural lands into production. These land use conversions release the carbon sequestered in soils and vegetation. The resulting carbon emissions constitute the "indirect" land use change impact of increased biofuel production.

The magnitude of this impact, however, has been questioned by some renewable fuel producers. Land use change is driven by multiple factors. Because the tools for estimating land use change are few and relatively new, some producers argue that land use change impacts should be excluded from carbon intensity values pending the development of better estimation techniques. Based on its work with university land-use-change researchers, however, ARB staff concluded that the land use impacts of crop-based biofuels are significant, and must be included in LCFS fuel carbon intensities. To exclude them would allow fuels with carbon intensities that are similar to gasoline and diesel fuel to function as low-carbon fuels under the LCFS. This would delay the development of truly low-carbon fuels, and jeopardize the achievement of a 10 percent reduction in fuel carbon intensity by 2020.

To help address indirect land use issues, the Board, at the April public hearing, directed staff to convene an expert workgroup to assist staff in refining and improving the land use and indirect effect analysis of transportation fuels and to return to the Board no later than January 1, 2011, with regulatory amendments or recommendations, if appropriate, on approaches to address issues identified. Staff is to coordinate this effort with similar efforts by the U.S. EPA, European Union, and other agencies pursuing a low carbon fuel standard.

Furthermore, staff is to work with interested stakeholders to develop criteria and a list of specific biofuel feedstocks that are expected to have no or inherently negligible land use effects on carbon intensity and to propose amendments, if appropriate, to the regulation resulting from this analysis by December 2009. Certainly, indirect land use change will also be part of the 2011 and 2014 periodic review of the LCFS.

Other Indirect Effects

Staff identified no other significant effects that result in large GHG emissions that would substantially affect the LCFS framework for reducing the carbon intensity of transportation fuels. In addition, stakeholders have not provided any quantitative analysis that demonstrates that these impacts are significant. Some providers of crop-based biofuels continue to maintain, however, that significant market-mediated indirect effects other than land use change are likely to exist. Staff will continue to work with interested parties to identify and measure such effects. The expert workgroup will evaluate this issue, and its findings will be part of the report to the Board by January 1, 2011, and also included as part of the 2011 and 2014 reviews.

Carbon Intensity Values

The regulation has several different methods for establishing carbon intensities. With these different methods, no transportation fuel is excluded from the LCFS unless specifically exempted.

The first method, referred to as Method 1, establishes carbon intensity (CI) default values for specific fuels and pathways. The CI values are established in two Lookup Tables in the regulation: one table is for gasoline and fuels that substitute for gasoline, and one table is for diesel and fuels that substitute for diesel. Regulated parties may choose to use the quantified pathways to calculate credits and deficits. The Lookup Tables reflect those fuel pathways that ARB staff has completed to date. The pathways that are completed are summarized in Table 5.

Note that these pathways do not represent all of the possible pathways for producing fuels. Staff continues to develop carbon intensity values and has released preliminary values for a number of other pathways or is developing carbon intensities for additional pathways. The regulation establishes that the Executive Officer may approve subsequent amendments to the Lookup Table after a specified public process. Table 6 summarizes the pathways where preliminary numbers have been developed or that are currently under development. Following a formal public rulemaking process as identified in the regulation, the Executive Officer may approve additional carbon intensity values to be added to the Lookup Table.

Table 5
Fuel Pathways Completed for Use in the LCFS

Fuel Pathway	Description of the Pathway
CARBOB (California Reformulated Gasoline Blendstock for Oxygenate Blending)	1 average pathway based on the average crude oil used in California refineries
CaRFG (California Reformulated Gasoline)	1 specific pathway combining CARBOB and a blend of an average Midwestern corn ethanol and California corn ethanol to meet a 3.5% oxygen content by weight (approximately 10% ethanol).
Ethanol from Corn	13 different specific pathways that reflect different options that are used to produce ethanol from corn. (2 pathways are proposed regulatory modifications currently subject to public review.)
Ethanol from Sugarcane	3 specific pathways for producing ethanol from Brazilian sugarcane, one using average production processes only, one that includes mechanized harvesting and electricity co-product credit, and one with electricity co-product credit but not mechanized harvesting. (2 pathways are proposed regulatory modifications currently subject to public review.)
Electricity	2 specific pathways representing average and marginal electricity used in California.
Hydrogen	5 specific pathways reflecting different options to produce hydrogen as a fuel. (1 pathway is a proposed regulatory modification currently subject to public review.)
ULSD (Ultra Low Sulfur Diesel)	1 average pathway based on the average crude oil used in California refineries.
Compressed Natural Gas	4 specific pathways reflecting different options to produce compressed natural gas as a fuel. (1 pathway is a proposed regulatory modification currently subject to public review.)
Liquefied Natural Gas	9 pathways, including North American NG liquefied in California, imported LNG re-gasified and re-liquefied in California or not, and dairy digester biogas and landfill gas from in-state. (All pathways are proposed regulatory modifications currently subject to public review.)
Biodiesel	2 specific pathways for conversion of waste oils (used cooking oil) to biodiesel (fatty acid methyl esters- FAME. (Proposed regulatory modification currently subject to public review.)
Renewable Diesel	2 specific pathways for conversion of tallow to renewable diesel. (Proposed regulatory modification currently subject to public review.)

Table 6
Fuel Pathways Under Development for Use in the LCFS

Fuel Pathway	Description of the Pathway
Ethanol from Cellulosic Material	Farmed trees using a fermentation process.
	Agriculture waste
	Forest waste
Biodiesel	Midwest soybeans to soy oil for conversion to biodiesel (fatty acid methyl esters - FAME)
	Palm oil from South East Asia for conversion to biodiesel (FAME)
Renewable Diesel	Midwest soybeans to soy oil for conversion to renewable diesel.
Liquefied Natural Gas	Onsite biogas energy production.

Under specified conditions, regulated parties may also obtain Executive Officer approval to either modify the CA-GREET model inputs to reflect their specific processes (Method 2A) or to generate an additional fuel pathway using CA-GREET (Method 2B). For both Method 2A and 2B, there is a scientific defensibility requirement for the regulated party to meet before the Executive Officer can approve new values. For Method 2A, there is an additional provision that requires a substantial change in the carbon intensity (5 g CO_2e/MJ decrease in source-to-tank CI) relative to the analogous value calculated for that pathway under Method 1.

For CARBOB, gasoline, and diesel fuel, the quantified carbon-intensity values in the Lookup Table are based on the average carbon intensity of crude oils used in California refineries. There are specific provisions for determining carbon-intensity values of crude oils of higher carbon intensity than this average. Examples of these crude oils may include certain crude oils produced from oil sands or oil shale.

By contrast, for CARBOB, gasoline, and diesel fuel made from high-carbon-intensity crude oil, the regulated party would be required to use the carbon intensity value, if any, which is specified in the Lookup Table for that particular pathway. If there is no carbon intensity value specified for a particular high-carbon-intensity crude oil, the regulated party could use Method 2B (with Executive Officer approval) to generate an additional pathway for this type of crude.

Alternately, the regulated party could use the standard Lookup Table value for CARBOB, gasoline, or diesel for fuel derived from non-high-carbon-intensity crude oil, but only if the regulated party can demonstrate to the Executive Officer that its crude production and transport carbon-intensity value has been reduced to a specified level and meets other specified criteria. To this end, staff is proposing that any regulated

party using a high-carbon-intensity crude oil (> 15 g CO_2e/MJ) brought into California that is not already part of the California baseline crude mix, such as crude oil from oil sands, would have to report and use the actual carbon intensity for that crude oil unless the party demonstrates that it has reduced the crude oil's carbon intensity below 15 g CO_2e/MJ using carbon capture and sequestration (CCS) or other method. Upon this demonstration, the regulated party would be permitted to use the average carbon intensity value for the California baseline crude mix (i.e., crude oils currently used in California refineries).

The Executive Officer or Board approves a carbon intensity value proposed pursuant to Method 2A or 2B through a formal public hearing held per the California Administrative Code. The pathway application and supporting documentation, except the information that the applicant identifies as consisting of trade secrets, are subject to public disclosure. The applicant must identify information it considers to be trade secrets in its Method 2A or 2B application. The Executive Officer shall treat the trade secrets identified by the applicant in accordance with 17 CCR §§ 91000-91022 and the California Public Records Act (Government Code section 6250 et seq.).

In deciding on what information to designate as secret, however, applicants must consider the public nature of the rulemaking process. New sub-pathways can be approved only if enough information is available publicly to justify that approval. Once a sub-pathway is approved and added to the Lookup Table, other regulated parties may use the new pathway to report their fuel carbon intensities if they can demonstrate that the new pathway best describes their processes. Such use by other regulated parties is unrestricted.

Staff has committed to continuing its efforts to improving the CI values and will report back to the Board by the end of 2009 with additional information. These efforts include:

- Working with interested stakeholders to prepare guidelines to assist regulated parties in determining the data, documentation, and other information needed to support the expeditious development of carbon intensity values for new or modified fuel pathways,[8]
- Developing a prioritized list for new specialized fuel pathways and a schedule for developing these pathways, and
- Working with interested stakeholders to develop an informal screening process for assessing the carbon intensity of new or modified fuel pathways.

Determination of Vehicle Efficiency Adjustment Factors

In calculating the credits and deficits, factors are used to recognize the fact that some vehicle propulsion systems are more energy efficient than others. The more energy efficient systems will travel more miles per unit of energy input to the vehicle, thus

[8] On August 4, 2009, staff posted at http://www.arb.ca.gov/fuels/lcfs/newfuelpathwaysguidance.pdf a draft concept paper for public review entitled "Establishing New Fuel Pathways under the California Low Carbon Fuels Standard Procedures and Guidelines for Regulated Parties."

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.

For example, the well-to-wheel CO_2 emissions from electric vehicles, in units of g CO_2e/MJ of energy delivered to the vehicle, are generally higher than for gasoline vehicles. However, electric vehicles require much less energy to travel a specified distance. As a result of their much lower per mile energy consumption, electric vehicles emit less greenhouse gases than gasoline vehicles on a per mile basis, even though they emit more per unit of energy consumed.

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 EER is defined as the ratio of the number of miles driven per unit energy consumed for a fuel of interest to the miles driven per unit energy for a reference fuel. For purposes of the LCFS, the reference fuel is gasoline for light- and medium-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. Therefore, the EER for gasoline is always 1.0 for light- and medium-duty gasoline-powered vehicles; similarly, the EER for diesel is always one for diesel-fueled heavy-duty vehicles.

In general, the values for the number of miles driven per unit energy used are 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. However, for advanced technology or emerging vehicles such as battery electric vehicles (BEV), plug-in hybrid electric vehicles (PHEV), fuel cell vehicles (FEV), and heavy-duty compressed natural gas (CNG) or liquefied natural gas (LNG) vehicles, the data are relatively limited. Therefore, the staff has provided EER values that are to be used until such time that there is more robust data available to better establish the EER. Table 7 presents the EERs specified in the regulation.

Tables 8 and 9 present the adjusted carbon intensities for gasoline and fuels that substitute for gasoline, and diesel and fuels that substitute for diesel, respectively. Note that the carbon intensities in the tables have been adjusted with the EERs in Table 7 to reflect vehicular power train efficiencies. As there will only be a limited number of these advanced vehicles available in the first few years of the LCFS, the amount of credits generated is not likely to be significantly affected. Staff is committed to review and update these and other EERs as soon as more robust data become available, as well as develop EERs for other vehicles such as internal combustion engines using hydrogen.

Table 7
EER Values for Use in the Low Carbon Fuel Standard

Light- and Medium Duty Applications (Fuels Used in Vehicles Substituting for Gasoline Vehicles)		**Heavy-Duty/Off-Road Applications (Fuels Used in Vehicles Substituting for Diesel Vehicles)**	
Fuel/Vehicle Combination	**EER Values Relative To Gasoline**	**Fuel/Vehicle Combination**	**EER Values Relative to Diesel**
Gasoline (including 6% and 10% ethanol blends) Used In Gasoline Vehicles or 85% Ethanol/15% Gasoline Blends Used In Flexible Fuel Vehicles	1.0	Diesel Fuel Used in A Diesel Vehicle or Biomass-Based Diesel Blends	1.0
Compressed Natural Gas Used in Spark-Ignited Vehicles	1.0	Compressed or Liquefied Natural Gas Used in a Heavy-Duty Spark Ignited or Compression Ignition Engine	0.9
Electricity Used in a Battery Electric or Plug-In Hybrid Electric Vehicle	3.0	Electricity Used in a Battery Electric or Plug-In Hybrid Electric Heavy-Duty Vehicle	2.7
Hydrogen Used in a Fuel Cell Vehicle	2.3	Hydrogen Used in a Heavy Duty Vehicle	1.9

Table 8
Adjusted Carbon Intensity Values
for Gasoline and Fuels that Substitute for Gasoline

Fuel	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)		
		Direct Emissions	Land Use or Other Indirect Effect	Total
Gasoline	CARBOB – based on the average crude oil delivered to California refineries and average California refinery efficiencies	95.86	0	95.86
Ethanol from Corn	Midwest average; 80% Dry Mill; 20% Wet Mill; Dry DGS	69.40	30	99.40
	California average; 80% Midwest Average; 20% California; Dry Mill; Wet DGS; NG	65.66	30	95.66
	California; Dry Mill; Wet DGS; NG	50.70	30	80.70
	Midwest; Dry Mill; Dry DGS, NG	68.40	30	98.40
	Midwest; Wet Mill, 60% NG, 40% coal	75.10	30	105.10
	Midwest; Wet Mill, 100% NG[1]	64.52	30	94.52
	Midwest; Wet Mill, 100% coal[1]	90.99	30	120.99
	Midwest; Dry Mill; Wet, DGS	60.10	30	90.10
	California; Dry Mill; Dry DGS, NG	58.90	30	88.90
	Midwest; Dry Mill; Dry DGS; 80% NG; 20% Biomass	63.60	30	93.60
	Midwest; Dry Mill; Wet DGS; 80% NG; 20% Biomass	56.80	30	86.80
	California; Dry Mill; Dry DGS; 80% NG; 20% Biomass	54.20	30	84.20
	California; Dry Mill; Wet DGS; 80% NG; 20% Biomass	47.44	30	77.44
Ethanol from Sugarcane	Brazilian sugarcane using average production processes	27.40	46	73.40
	Brazilian sugarcane with average production process, mechanized harvesting and electricity co-product credit[1]	12.40	46	58.40
	Brazilian sugarcane with average production process and electricity co-product credit[1]	20.40	46	66.40
Compressed Natural Gas	California NG via pipeline; compressed in CA	67.70	0	67.70[2]
	North American NG delivered via pipeline; compressed in CA	68.00	0	68.00[2]
	Landfill gas (bio-methane) cleaned up to pipeline quality NG; compressed in CA	11.26	0	11.26[2]
	Dairy Digester Biogas to CNG[1]	13.45	0	13.45[2]

Liquefied Natural Gas	North American NG delivered via pipeline; liquefied in CA using liquefaction with 80% efficiency[1]	83.13	0	83.13
	North American NG delivered via pipeline; liquefied in CA using liquefaction with 90% efficiency[1]	72.38	0	72.38
	Overseas-sourced LNG delivered as LNG to Baja; re-gasified then re-liquefied in CA using liquefaction with 80% efficiency[1]	93.37	0	93.37
	Overseas-sourced LNG delivered as LNG to CA; re-gasified then re-liquefied in CA using liquefaction with 90% efficiency[1]	82.62	0	82.62
	Overseas-sourced LNG delivered as LNG to CA; no re-gasification or re-liquefaction in CA[1]	77.50	0	77.50
	Landfill Gas (bio-methane) to LNG liquefied in CA using liquefaction with 80% efficiency[1]	26.31	0	26.31
	Landfill Gas (bio-methane) to LNG liquefied in CA using liquefaction with 90% efficiency[1]	15.56	0	15.56
	Dairy Digester Biogas to LNG liquefied in CA using liquefaction with 80% efficiency[1]	28.53	0	28.53
	Dairy Digester Biogas to LNG liquefied in CA using liquefaction with 90% efficiency[1]	17.78	0	17.78
Electricity	California average electricity mix	124.10	0	41.37[3]
	California marginal electricity mix of natural gas and renewable energy sources	104.71	0	34.90[3]
Hydrogen	Compressed H_2 from central reforming of NG (includes liquefaction and re-gasification steps)	142.20	0	61.83[4]
	Liquid H_2 from central reforming of NG	133.00	0	57.83[4]
	Compressed H_2 from central reforming of NG (no liquefaction and re-gasification steps) [1]	98.80	0	42.96[4]
	Compressed H_2 from on-site reforming of NG	98.30	0	42.74[4]
	Compressed H_2 from on-site reforming with renewable feedstocks	76.10	0	33.09[4]

[1] Pathway is proposed modification currently subject to public review.
[2] Adjusted by an EER factor of 1.0 to account for no power train efficiency improvements over gasoline engines.
[3] Adjusted by an EER factor of 3.0 to account for power train efficiency improvements over gasoline engines.
[4] Adjusted by an EER factor of 2.3 to account for power train efficiency improvements over gasoline engines.

Table 9
Adjusted Carbon Intensity Values for Diesel and Fuels that Substitute for Diesel

Fuel	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)		
		Direct Emissions	Land Use or Other Indirect Effect	Total
Diesel	ULSD – based on the average crude oil delivered to California refineries and average California refinery efficiencies	94.71	0	94.71
Biodiesel	Pathways for conversion of Midwest soybeans to biodiesel (fatty acid methyl esters -FAME)	[pending GTAP analysis]		
	Conversion of waste oils (Used Cooking Oil) to biodiesel (fatty acid methyl esters -FAME) where "cooking" is required[1]	15.84	0	15.84
	Conversion of waste oils (Used Cooking Oil) to biodiesel (fatty acid methyl esters -FAME) where "cooking" is not required[1]	11.76	0	11.76
Renewable Diesel	Pathways for conversion of Midwest soybeans to renewable diesel	[pending GTAP analysis]		
	Conversion of tallow to renewable diesel using higher energy use for rendering[1]	39.33	0	39.33
	Conversion of tallow to renewable diesel using lower energy use for rendering[1]	19.65	0	19.65
Compressed Natural Gas	California NG via pipeline; compressed in CA	67.70	0	75.22[2]
	North American NG delivered via pipeline; compressed in CA	68.00	0	75.56[2]
	Landfill gas (bio-methane) cleaned up to pipeline quality NG; compressed in CA	11.26	0	12.51[2]
	Dairy Digester Biogas to CNG[1]	13.45	0	14.94[2]
Liquefied Natural Gas	North American NG delivered via pipeline; liquefied in CA using liquefaction with 80% efficiency[1]	83.13	0	92.37[2]
	North American NG delivered via pipeline; liquefied in CA using liquefaction with 90% efficiency[1]	72.38	0	80.42[2]
	Overseas-sourced LNG delivered as LNG to Baja; re-gasified then re-liquefied in CA using liquefaction with 80% efficiency[1]	93.37	0	103.74[2]
	Overseas-sourced LNG delivered as LNG to CA; re-gasified then re-liquefied in CA using liquefaction with 90% efficiency[1]	82.62	0	91.80[2]
	Overseas-sourced LNG delivered as LNG to CA; no re-gasification or re-liquefaction in CA[1]	77.50	0	86.11[2]

	Landfill Gas (bio-methane) to LNG liquefied in CA using liquefaction with 80% efficiency[1]	26.31	0	29.23[2]
	Landfill Gas (bio-methane) to LNG liquefied in CA using liquefaction with 90% efficiency[1]	15.56	0	17.29[2]
	Dairy Digester Biogas to LNG liquefied in CA using liquefaction with 80% efficiency[1]	28.53	0	31.70[2]
	Dairy Digester Biogas to LNG liquefied in CA using liquefaction with 90% efficiency[1]	17.78	0	19.76[2]
Electricity	California average electricity mix	124.10	0	45.96[3]
	California marginal electricity mix of natural gas and renewable energy sources	104.71	0	38.78[3]
Hydrogen	Compressed H_2 from central reforming of NG (includes liquefaction and re-gasification steps)	142.20	0	74.82[4]
	Liquid H_2 from central reforming of NG	133.00	0	70.00[4]
	Compressed H_2 from central reforming of NG (no liquefaction and re-gasification steps) [1]	98.80	0	52.00[4]
	Compressed H_2 from on-site reforming of NG	98.30	0	51.74[4]
	Compressed H_2 from on-site reforming with renewable feedstocks	76.10	0	40.05[4]

[1] Pathway is proposed modification currently subject to public review.
[2] Adjusted by an EER factor of 0.9 to account for power train efficiency losses compared to diesel engine
[3] Adjusted by an EER factor of 2.7 to account for power train efficiency improvements over heavy-duty diesel engines
[4] Adjusted by an EER factor of 1.9 to account for power train efficiency improvements over heavy-duty diesel engines

Other Board Directives to Staff

The Board, when approving the LCFS for adoption in April 2009, directed staff to accomplish several other tasks, namely:

- Develop, as appropriate, a fee schedule, credit-trading provisions, and guidelines for establishing CI for additional fuels by December 2009;
- Evaluate, as part of the development of the cap-and trade regulation identified in ARB's AB 32 Scoping Plan, whether (1) displacing petroleum transportation fuels with electricity leads to a cross-sector shift in GHG compliance obligations and assesses the effect of any such shift, including the impacts on electricity use as a transportation fuel and attendant price signals on consumers; and (2) consider as part of the ongoing activities associated with AB 32 how the LCFS regulation, a broader cap-and-trade regulation, and other programs established pursuant to the AB 32 Scoping Plan should work together to ensure that the use of electricity as a transportation fuel is appropriately encouraged consistent with the goals of AB 32; and
- Report back to the Board on rulemakings conducted to (1) establish or revise CIs and pathways or revise incorporated GREET model with newer versions,

(2) revise Energy Economy Ratios, and (3) revise the list of opt-in low carbon fuels.

Executive Officer Review and Multimedia Evaluations

The regulation requires two reviews of the LCFS implementation. The first review must be completed and presented to the Board by January 1, 2012, and a second review is required by January 1, 2015. The reviews will be broad in scope, addressing a number of areas, including advances in low-carbon fuels and production technologies, advances in fuel-lifecycle assessments, the compliance schedule, an analysis of the air quality impacts, other public health impacts, and significant economic impacts associated with implementation of the LCFS.

The ARB will establish an LCFS Advisory Panel by July 1, 2010, to assist staff with the periodic review process. The Panel participants will include representatives of the California Energy Commission; the California Public Utilities Commission; fuel providers; storage and distribution infrastructure owner/operators; consumers; engine and vehicle manufacturers; environmental justice organizations; environmental groups; academia; public health; and other stakeholders and government agencies.

Pursuant to Health and Safety Code (H&S) section 43830.8(a), the Board may not adopt a regulation that establishes a specification for a motor vehicle fuel unless a multimedia evaluation for the regulation undergoes the review process specified in the statute. However, this multimedia requirement does not apply if the regulation does not establish a motor-vehicle fuel specification. Based on its assessment, staff has determined that the LCFS regulation, by itself, does not establish a motor-vehicle fuel specification and therefore does not trigger a multimedia evaluation requirement under H&S section 43830.8(i).

While the LCFS, by itself, does not establish motor-vehicle fuel specifications, we expect that as new, lower-carbon intensity fuels are developed over time, ARB may need to establish fuel specifications to allow the sale of such fuels in California. In those cases, we anticipate the need to conduct multimedia evaluations for the specific fuels. Indeed, ARB has a multimedia evaluation already underway for biodiesel and renewable diesel. Staff expects to propose motor vehicle fuel specifications for biodiesel and renewable diesel to the Board by mid-2010. Similar multimedia evaluations may be needed if ARB amends the specifications for 85 percent ethanol gasoline (E-85) and adopts a new biobutanol fuel specification. Therefore, the LCFS contains provisions relating to multimedia evaluations which, when applicable, would be conducted pursuant to H&S section 43830.8.

Enforcement Mechanisms

The ARB is developing a secure on-line LCFS Reporting Tool (LRT) to support the reporting requirements of fuels and other data to the State. ARB plans to have the LRT available for use in early 2010. The LCFS mandates that all regulated parties report

required data on a quarterly and annual basis. The LRT will be a secure, web-based data collection and report generation application designed to accommodate submittal of all required information and help regulated parties meet their reporting obligations.

To accommodate special circumstances, the regulation allows the Executive Officer to enter into an enforceable written protocol with a regulated party that allows the party to comply with the recordkeeping, reporting, and demonstration of physical pathway requirements in the LCFS under mechanisms equivalent to those specified in the regulation.

ARB will review the reports submitted via the LRT for completeness and accuracy, evaluate the data in the reports to determine if the regulated party is in compliance with the requirements of the regulation, conduct field investigations and audits of the regulated parties to verify and validate the information submitted in the reports, prepare and issue notices of violation, meet with violators for the purpose of mutual settlement, and participate in litigation if necessary.

Penalties and other remedies for violations of regulations adopted pursuant to AB 32, which includes the LCFS, are set forth in H&S section 38580 et. seq. These include injunctive relief under H&S section 41513 and criminal and civil penalties under H&S 42400 et seq. and H&S 43025 et seq. Further, H&S section 43029 provides additional penalties designed to eliminate the economic benefits gained from a regulated party's noncompliance.

H&S section 43031(b) states that in determining the amount assessed, the court, the Attorney General, or the state board, in reaching any settlement, shall take into consideration all relevant factors. Those factors include, but are not limited to: (1) the extent of harm to the public health, safety and welfare caused by the violation; (2) the nature and persistence of the violation, including the magnitude of the excess emissions; (3) the compliance history of the defendant, including the frequency of past violations; (4) The preventive efforts taken by defendant, including the record of maintenance and any program to ensure compliance; (5) the innovative nature and the magnitude of the effort required to comply, and the accuracy, reproducibility, and repeatability of the available test methods; (6) the efforts to attain, or provide for, compliance; (7) the cooperation of the defendant during the course of the investigation and any action taken by the defendant, including the nature, extent, and time of response of any action taken to mitigate the violation; and (8) for the person who owns a single retail service station, the size of the business.

Environmental Analysis

The environmental analysis of the LCFS regulation focused on significant decreases in the GHG emissions that would result from the regulation. These reductions would result from production and use of lower-carbon transportation fuels in California and changes in the vehicle fleet composition due to new, lower-carbon fuels being available to the transportation fuel pool. Staff estimated the GHG emissions reductions for the

combustion of transportation fuels to be about 16 MMT CO_2e by 2020. Staff also estimated GHG reductions for the full fuel lifecycle, including fuel production through combustion, of 23 MMT CO_2e in 2020. These reductions account for a 10 percent reduction of the GHG emissions from the use of transportation fuel. These reductions compare to the expected three percent reduction in GHG emissions if only the federal RFS2 requirements were met.

The LCFS regulation is expected to result in no additional adverse impacts to California's air quality due to emissions of criteria and toxic air pollutants. Based on the best available data, there may be a benefit in further reducing criteria air pollutants from the 2020 projected vehicle fleet.

New Potential Biofuel Facilities

To meet the LCFS and the proposed federal RFS2, new biofuel production facilities may be built in California. Staff estimates a total of thirty facilities producing corn ethanol (6), cellulosic ethanol (18), and biodiesel (6) could be operational by 2020 based on an assessment of the availability of feedstock material. Biofuel production on a commercial scale will require development of new technologies as well as the continued use of improved conventional technology with crop-derived feedstocks. Non-crop feedstocks could include biomass wastes from municipal solid wastes, agriculture wastes, waste oils, and forestry. Staff estimated criteria pollutant emissions for the production of biofuels, the collection of feedstock, and delivery of the finished biofuel.

The major criteria pollutant emissions are associated with the additional biorefinery truck trips. As part of the analysis, the staff analyzed the localized diesel PM impacts and localized facility emissions impacts.

Staff conducted a health risk assessment to estimate the potential cancer risk associated with newly established biorefineries based on the facility specific emission inventory and air dispersion modeling predictions. The estimated potential cancer risk levels are associated with onsite diesel PM emissions from three co-located prototype biorefinery facilities. The area with greatest impact was estimated to be the area surrounding the facility fence lines with a potential cancer risk of over 0.4 chances in a million. The health risk assessment also examined combined onsite and offsite emissions of the three prototype biofuel facilities. The area with the greatest impact was estimated with a potential cancer risk of about five chances in a million.

Staff also quantified seven non-cancer health impacts associated with the change in exposure to PM2.5 emissions due to the possible construction and operation of 24 new biofacilities in California. The analysis shows that the statewide health impacts of the emissions associated with these facilities are approximately 20 premature deaths; seven hospital admissions; and 314 cases of asthma, acute bronchitis and other lower respiratory symptoms.

Staff does not anticipate either a decrease or increase in the emissions from petroleum refineries, power plants, or corn ethanol facilities over the 2010 baseline. The capacity of the State's electric system in 2020 will be sufficient to support 1.8 million electric vehicles due to the 33 percent renewable portfolio standard and off-peak charging.

Also included in the environmental analysis is an examination of other environmental impacts of the LCFS on water quality and use, agricultural resources, biological resources, geology and soils, hazardous materials, mineral resources, and solid waste, among others.

The emissions estimated for the biofuel production facilities reflect the use of the cleanest energy conversion technologies and air pollution control technologies. ARB staff recommends that the emissions associated with the production of low-carbon fuels be fully mitigated consistent with local district and California Environmental Quality Act (CEQA) requirements.

To provide additional information for local districts and to inform the CEQA process, ARB staff is committed to developing a guidance document, in consultation with the local air districts, regulated parties, environmental advocates, public health experts, and other stakeholders, to provide information on the best practices available to assess and mitigate air quality impacts from these types of facilities. ARB staff plans to present the guidance document to the Board by December 2009.

At the April public hearing, the Board directed staff to participate in the environmental review of projects in California that are directly related to the production, storage, and distribution of transportation fuel subject to the LCFS program. This effort is to be coordinated with the local air districts; lead agencies for the preparation of environmental impact reports to comply with CEQA; companies proposing to build new production, storage, and distribution facilities; and environmental and community representatives.

Sustainability and Renewable Biomass

Sustainability provisions will ensure that the LCFS regulation does not adversely impact the ability to continue the use of biofuels and other low carbon intensity fuels in the future. One of the most critical sustainability components, addressing land use change, is part of the LCFS regulation. To address other sustainability components, both environmental and socioeconomic, will require national and international cooperation.

At the April public hearing, the Board directed staff, in coordination with the Interagency Forest Work Group, appropriate state agencies, environmental advocates, regulated parties, and other interested stakeholders, to develop and present a workplan to the Board in December 2009 for developing sustainability provisions to be used in implementing the LCFS. The sustainability provisions deemed feasible and appropriate by the Executive Officer must be finalized no later than December 2011.

In addition, staff will work with the Interagency Forest Work Group, the California Natural Resources Agency, the California Energy Commission, the California Department of Forestry and Fire Protection, the U.S. Forest Service, the U.S. EPA, environmental advocates, regulated parties, and other stakeholders to further develop definition and safeguards for the use of “biomass” and “renewable biomass,” and propose amendments to the LCFS regulation, if appropriate, by December 2009. As part of this effort staff will consider the specific effects of incentivizing the use of forest biomass from public and private lands, the greenhouse gas emissions from different fuel pathways on public and private lands, and the additional protections, if any, necessary to ensure the sustainable and environmentally beneficial use of such forest biomass, with the goal of certifying pathways for the use of forest biomass.

Environmental Justice

The ARB is committed to making the achievement of environmental justice an integral part of the LCFS. As such, staff seeks to develop tools to ensure that the regulation does not disproportionately impact low-income and minority communities, does not interfere with the attainment and maintenance of ambient air quality standards, and considers overall societal benefits (such as diversification of energy resources). As part of ongoing AB 32 analysis, ARB staff is developing a screening method for geographically representing emission densities, air quality exposure metrics, and indicators of vulnerable populations, as an evaluation aide for already adversely impacted communities.

Economic Analysis

For the economic analysis of the LCFS, staff estimated the costs of producing the petroleum-based fuels—gasoline and diesel—and the costs of producing the lower-carbon-intensity transportation fuels that could be used in combination with petroleum fuels to meet the LCFS. Staff applied these costs to possible compliance scenarios for both diesel fuel and gasoline. Each of these possible scenarios includes an assumed mix of fuels that satisfies the LCFS reduction targets.

Staff estimated that the displacement of petroleum-based fuels with lower-carbon-intensity fuels will result in an overall savings in the State, as much as $11 billion from 2010 -2020. These savings may be realized by the biofuel producers as profit, or some of the savings may be passed on to the consumers. Should the savings be entirely passed on to consumers, it would represent less than three percent of the total cost of a typical gallon of transportation fuel ($0 - $0.08/gal).

Staff understands that the economic analysis of the LCFS is greatly affected by future oil prices and the actual production costs and timing of lower-carbon-intensity alternative fuels. Economic factors, such as tight supplies of lower-carbon intensity fuels or a lengthy economic downturn keeping crude demand and hence prices down, could result in overall net costs, not savings, for the LCFS.

Staff determined that approximately 24 new biorefineries could be built in California based on an assessment of potential feedstocks. Biofuel producers are expected to eventually recoup their costs through the sale of lower-carbon-intensity fuels, while consumers should see no significant changes in fuel prices to some savings. In addition to liquid fuels, such as ethanol and biodiesel, other lower carbon-intensity fuels, including electricity, hydrogen, and compressed natural gas (CNG) may be used to meet the requirements of the LCFS.

The regulatory action would not affect small businesses because: (1) most, if not all, regulated parties are expected to be relatively large businesses, and (2) small businesses (generally the fueling station owners and operators) would presumably invest in equipment that dispenses LCFS-compliant fuel with the expectation that the costs of such an investment would be recouped through sales of such fuels.

Staff conducted the economic analyses considering all costs of production and distribution of alternative transportation fuels, which, as mentioned above, resulted in overall savings to the State. Staff then recognized that the federal Renewable Fuel Standard (RFS2) will bring significant quantities of ethanol to California, and that the infrastructure required to meet the mandates of RFS2 is essentially the same infrastructure necessary to meet the potential ethanol requirements of the LCFS; therefore, nearly all of the ethanol-related infrastructure costs can be attributed to RFS2.

The RFS2 and the LCFS regulation will result in a shift of capital from the petroleum sector to the agricultural, chemical, electricity, and natural gas sectors. This redistribution of capital among these sectors is essential to the success of the LCFS and RFS2. The diversification of California's transportation fuels, which requires a shift of capital from the petroleum sector, is consistent with well-established national and State policies.

The regulation would create costs to the State in the form of lost transportation-fuel taxes, including excise taxes and sales tax. Although there would be no estimated fiscal impact for the first three years of the regulation, staff estimates the potential loss of annual state tax revenue to be $80 million to $370 million in 2020—the year of greatest impact—depending on compliance path(s) chosen. For local government, the impact of sales tax on transportation fuels from implementing the potential compliance scenarios could either create revenue or result in a revenue loss, depending on the compliance path(s) chosen. The impacts to local sales taxes would be location specific. Although there would be no fiscal impact for the first three years of the regulation, staff estimates a potential range of impacts in annual local sales tax revenue of -$51 million to +$2 million from 2013 – 2020.

Evaluation of Alternatives

Staff evaluated several alternatives to the Regulation. Two of the more significant alternatives are presented below.

1. Take no action at the State level and, instead, defer to the Federal Renewable Fuels Standard. The federal RFS is an important complementary strategy to California's RFS. However, the federal RFS would deliver only about 30 to 40 percent of the GHG benefits of the regulation, and does little to incentivize the development of fuels such as natural gas, electricity, or hydrogen.

2. Implement a gasoline standard only. The LCFS includes separate standards for gasoline and the low carbon fuels that can replace it, and for diesel fuel and its replacements. The Western States Petroleum Association has advocated a gasoline standard only approach to allow for a simpler implementation of the regulation in the early years. ARB does not support this approach. A comprehensive approach from the beginning will allow for the development of a more robust credit market and will provide greater certainty on future expectations. Fuel producers will need to consider overall approaches to providing low carbon transportation fuels. Given the fact that the compliance requirements are substantially less in the early years should provide fuel producers adequate time to develop appropriate compliance options. In addition, failure to include diesel will result in a loss of approximately 20 percent of the LCFS benefits.

Public Process for LCFS Regulation Development

To support regulatory development, ARB staff initially formed four workgroups to help develop specific provisions or address specific issues. These workgroups are summarized below:

- Policy and Regulatory Workgroup – This workgroup was designed to be the overarching workgroup that would bring together the various overarching issues and address policy considerations. In addition, this workgroup was designed to develop the specific regulatory language.
- Lifecycle Analysis Workgroup – The lifecycle analysis is the heart of the LCFS and was one of the most challenging aspects. This workgroup was designed to be the primary method of vetting results and discussing approaches to the lifecycle analysis.
- Compliance and Enforcement Workgroup – Identifying how the compliance and enforcement mechanisms would be established was the focal point of this workgroup.
- Economic and Environmental Workgroup – The objective of this workgroup was to discuss the economic and environmental analysis.

In practice, the workgroups evolved into a series of public workshops with topics designed to cover the range of issues expected. All of the workgroup meetings were public. The announcements were posted on the ARB website and distributed through a list serve that included over 6,000 recipients. All materials presented at the workshops were also posted on the ARB website. Almost all of the meetings were telecast, available by teleconference, or both. In all, ARB staff held a total of 15 public

workshops to support the development of the LCFS. The dates of the workshops and the materials presented at each workshop are available on the ARB website.[9]

In cooperation with Argonne National Laboratories and the California Energy Commission, the ARB staff hosted two special public training sessions on the CA-GREET model used to develop carbon intensities for the various fuel pathways. These sessions, held in the first quarter of 2008, were designed to provide stakeholders with a basic understanding of how the CA-GREET model worked. Training materials on these training sessions is also posted on the ARB website. Additional and very detailed hands-on training for about 10 stakeholders and agency personnel were also provided in the first quarter of 2008.

The ARB staff has also participated in over 200 individual meetings with various stakeholders, supported by numerous individual telephone calls. All comments submitted through the entire process are posted on the ARB website.[10] Over 200 individual comment letters were submitted either in response to the public workshops or to raise specific issues. In addition, the website contains a number of supporting documents that were related to the development of the LCFS.

Staff released its proposed regulation and the Initial Statement of Reasons (Staff Report) for public comment on March 6, 2009. Over 200 comments were received during the 45-day public review period. In addition 40 written comments and 90 oral testimonies were received during the Board Hearing on April 23, 2009.[11] The Board approved staff's proposed regulation, with modifications, after considering all comments received.

The Board-approved modifications are undergoing public review. At the end of the public review period, the Executive Officer will adopt the regulations with modifications as may be appropriate in light of the comments received, unless further consideration of the regulation by the Board is warranted in light of those comments.

Staff must summarize and respond to all written and oral comments received by the Board on the proposed regulatory text during the formal rulemaking process. These responses are included in the Final Statement of Reasons (FSOR), which is submitted to the Office of Administrative Law (OAL) for review as part of the rulemaking process. In addition, the FSOR will provide the rationale for the modifications made to the originally proposed regulatory text as a result of public comment and any staff analysis conducted after staff issued the Initial Statement of Reasons (ISOR, or "Staff Report"). Once approved by OAL, the regulation is filed with the Secretary of State, after which it becomes part of California's Code of Regulations. Staff expects the LCFS regulation to be effective by the end of 2009.

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[9] The dates and materials from the ARB workshops are presented at: http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings.htm.
[10] All comments are posted at the following ARB website: http://www.arb.ca.gov/fuels/lcfs/lcfscomm.htm.
[11] All written comments received during the 45-day review period are posted at the following ARB website: http://www.arb.ca.gov/regact/2009/lcfs09/lcfs09.htm.