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Preliminary Review of the ARB Staff Analysis of "Illustrative" Low Carbon Fuel Standard (LCFS) Compliance Scenarios

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As part of the "Low Carbon Fuel Standard 2011 Program Review Report" released on December 8, 2011,[1] the staff of the California Air Resources Board (ARB) included an analysis of the feasibility and cost of compliance with the Low Carbon Fuel Standard (LCFS) targets for the carbon intensity (CI) of gasoline and Diesel fuels and their substitutes. Based on that analysis, ARB staff states the following as conclusions regarding the feasibility and cost of attaining the LCFS CI targets:

1. *ARB Staff believes that regulated parties can meet the targets required under the LCFS.*[2]

2. *…the estimated production costs of gasoline substitute fuels may have little impact on the cost of the LCFS program, but the production costs of alternative diesel fuels could increase costs to the LCFS in the later years of the regulation.*[3]

Based on the above, it appears that ARB staff will report to its Board that compliance with the LCFS targets is feasible and that the cost of that compliance is reasonable.

A review of the ARB analysis, however, indicates that it relies on a suite of optimistic assumptions regarding the availability and cost of low CI fuels that do not appear to be reasonable. Furthermore, an analysis using what appear to be more reasonable alternative assumptions based on analyses and forecasts performed by the U.S. Energy Information Administration (EIA) and the California Energy Commission (CEC) leads to fundamentally different results. As is documented below, this alternative analysis, based on a CEC forecast of biofuel availability in California under the federal Renewable Fuel Standard, indicates that compliance with the LCFS targets will not be feasible beyond 2015.

Similarly, the alternative analysis indicates, based on fuel cost forecasts released by the CEC, that even if ARB's assumptions regarding supply were correct, the cost of LCFS compliance would be substantial. Over the period from 2011 to 2020, these estimates range from about $34 billion to as much $54 billion, depending on which ARB scenario is examined.

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[1] This report is available at *http://www.arb.ca.gov/fuels/lcfs/workgroups/advisorypanel/20111208_LCFS%20program%20review%20report_final.pdf*
[2] Page 95.
[3] Page 112.

Review of ARB Staff's Analysis of Compliance for Gasoline and Gasoline Substitutes

The ARB staff analysis involves 11 "illustrative" LCFS compliance scenarios related to gasoline and gasoline substitutes. Despite stating[4] that these scenarios are *"not predictions or forecasts,"* ARB staff concludes[5]—based in large part on its analysis of the illustrative scenarios—that:

> *…staff believes the illustrative scenarios evaluated show a variety of pathways for the LCFS targets through 2020, even as the standards tighten in the latter years and it becomes more challenging for fuel providers to generate credits.*

As is documented in detail below, however, each of the illustrative LCFS compliance scenarios analyzed by ARB is based on one or more highly optimistic and/or unsupported assumptions regarding the availability of lower carbon intensity (CI) fuels.

Outlined below are the key assumptions used by ARB staff that are examined here, followed by a detailed evaluation of each assumption.

1. The average CI value of corn ethanol supplied to California is assumed to decline from 87.8 gCO_2eq/MJ in 2011 to 66.0 gCO_2eq/MJ in 2020.

2. Ethanol derived from sugarcane is assumed to be available in California as early as 2012 and in volumes as great as 2.73 billion gallons per year. In addition, the average CI value of sugarcane ethanol supplied to California is assumed to decline from 73.4 gCO_2eq/MJ in 2011 to 64 gCO_2eq/MJ in 2020.

3. Cellulosic ethanol is assumed to be available in California as early as 2012 and in volumes as great as 2.35 billion gallons per year. In addition, the average CI value of cellulosic ethanol supplied to California is assumed to be 25.0 gCO_2eq/MJ.

4. Renewable gasoline is assumed to be available in California as early as 2015 and in volumes as great as 0.78 billion gallons per year. In addition, the average CI value of renewable gasoline supplied to California is assumed to be 25.0 gCO_2eq/MJ.

5. Up to 4.6 million flexible-fueled vehicles (FFVs) are assumed to be in operation in California and then assumed, beginning in 2012, to operate no less than 50% and as much as 100% of the time on E85, with the result being an assumed California E85 consumption volume of up to 3.14 billion gallons.

[4] Page 96
[5] Page 102

6. The allowable limit on ethanol in gasoline is raised from 10% by volume to 15%, and all gasoline sold in California beginning in 2016 contains at least 15% ethanol by volume.

Corn Ethanol CI Values: ARB staff assumes that the average (not best) CI value for corn ethanol sold in California will drop from 87.8 gCO_2eq/MJ in 2011 to 66.0 gCO_2eq/MJ in 2020. Given that the indirect land use change value for corn ethanol is 30 gCO_2eq/MJ, this assumption infers a reduction in the direct CI value associated with corn ethanol of almost 50%—from 57.8 to 33.0 gCO_2eq/MJ. Although ARB staff provides no explanation of how it arrived at its assumption regarding the CI of corn ethanol, the only ways in which a large reduction in the direct CI value could be achieved involve some combination of (1) dramatic improvements in process efficiency, (2) extensive use of biomass or other renewable energy sources in the production process, (3) dramatic reductions in GHG emissions associated with corn production, and/or (4) use of only the lowest CI corn ethanol in California.

While it might be reasonable to assume some improvement in the CI value of corn ethanol used in California over time, particularly if price premiums are paid for low CI ethanol, ARB staff needs to provide a basis for any such assumption. There is simply no evidence to support the staff's assumption that the average CI value of up to 1.6 billion gallons of corn ethanol used in California per year will reach anything approaching 66.0 gCO_2eq/MJ. Evidence that contradicts the staff's assumptions, however, can be found in the approximately 90 pathways related to corn ethanol production that are being considered by ARB for incorporation into the LCFS regulation.[6]

The CI values associated with corn and other non-cellulosic grain ethanol pathways submitted to ARB staff under the Method 2A/2B process range from a high of 99.89 gCO_2eq/MJ to a low of 55.56 gCO_2eq/MJ, with most values being in the mid-80s, near the 87.8 average value assumed for 2011. The lowest value of 55.56 gCO_2eq/MJ is from a single plant at which CI values for multiple pathways have been requested. The range of CI values for these pathways at this single plant goes from the low of 55.56 to a high of 77.66 gCO_2eq/MJ. This means that the CI range for the plant in question is highly variable, depending on the feedstock, co-product, and actual process conditions. The next lowest value for corn ethanol from any other pathway at another plant is 73.20 gCO_2eq/MJ, which is more than 10% above the 66.0 gCO_2eq/MJ average value assumed by ARB staff. Clearly, the one plant that might be capable of providing ethanol at or below 66.0 gCO_2eq/MJ ethanol is not going to be capable of supplying volume approaching the 1.6 billion gallons per year assumed by ARB staff. Furthermore, the fact that no other plant has yet been identified that can reach that CI level highlights the highly optimistic nature of the staff's assumption.

Sugarcane Ethanol Availability and CI values: ARB staff assumes that ethanol derived from sugarcane will be available in California as early as 2012 and in volumes as great as 2.73 billion gallons per year, and that the average CI value of sugarcane ethanol supplied to California will decline from 73.4 gCO_2eq/MJ in 2011 to 64 gCO_2eq/MJ in 2020. Again, while ARB staff has provided no basis or support for either of these

[6] See *http://www.arb.ca.gov/fuels/lcfs/2a2b/062411lcfs_apps_sum.pdf*.

assumptions, there is substantial evidence that contradicts ARB's assumptions and highlights how extremely optimistic they are.

First, with respect to the availability of sugarcane ethanol in California, it should be recognized that the only existing source of significant volumes is Brazil. As noted, ARB staff's illustrative scenarios assumed up to 2.73 billion gallons of sugarcane ethanol are used per year in California by 2020. However, the California Energy Commission (CEC) reports that no ethanol has been imported into the U.S. from Brazil since 2009,[7] and that even the Brazilian government forecasts total U.S. imports of only about 0.5 billion gallons by 2020.[8] In addition, EIA forecasts somewhat less than 2 billion gallons of total U.S. ethanol imports in 2020.[9] Given these forecasts from the Brazilian and U.S. governments, it is clearly unlikely that the volumes of sugarcane ethanol assumed by ARB staff will be available in California during the period from 2012 to 2020.

Another factor that has to be accounted for when assessing ARB's assumptions regarding high volume use of sugarcane ethanol in California is cost. Based on the methodology developed by CEC for use in its LCFS compliance analysis,[10] the cost of Brazilian sugarcane ethanol would be expected to be approximately twice the cost of gasoline blendstocks, even under assumptions of high petroleum costs.

Like the assumptions regarding supply, ARB's assumptions regarding decreases in the average CI value of sugarcane ethanol are also unsupported. In contrast to corn ethanol, 15 pathways for Brazilian ethanol are currently being considered by ARB for incorporation into the LCFS regulation.[11] These range from a high of 83.96 gCO_2eq/MJ to a low of 63.94 gCO_2eq/MJ. Absent significant changes in sugarcane ethanol production processes that have not been described by ARB, the staff's assumed average CI value of 64 gCO_2eq/MJ will be realized only if price premiums exist for lower CI sugarcane ethanol in California.

<u>Cellulosic Ethanol Availability and CI Values:</u> ARB staff assumes that cellulosic ethanol will be available in California as early as 2012 and in volumes as great as 2.35 billion gallons per year. In addition, the average CI value of cellulosic ethanol supplied to California is assumed to be 25.0 gCO_2eq/MJ, on average, through 2020.

Although the federal Renewable Fuel Standard Regulations ultimately require the production of large volumes of cellulosic biofuels, the failure of cellulosic ethanol supplies to actually develop has led the U.S. EPA to revise the very modest initial RFS volume requirements for 2010 through 2012 downward by a factor of more than 10. The upper bound of the 2012 RFS requirement for total U.S. use of cellulosic biofuels is 0.0126 billion gallons compared to ARB's assumed volumes of up to 2.16 billion gallons

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[7] Page 158, Draft Transportation Energy Forecasts and Analyses for the 2011 Integrated Policy Report, August 2011.
[8] Page 159, Draft Transportation Energy Forecasts and Analyses for the 2011 Integrated Policy Report, August 2011.
[9] Page 84, U.S. Energy Information Administration, Annual Energy Outlook 2011, April 2011.
[10] See *http://www.energy.ca.gov/2011_energypolicy/documents/#11142011* and documents and presentations for the November 14th, 2011 workshop.
[11] See *http://www.arb.ca.gov/fuels/lcfs/2a2b/062411lcfs_apps_sum.pdf.*

in California by 2020. Similarly, EIA forecasts only about 2 billion gallons of total U.S. cellulosic ethanol production in 2020,[12] and even ARB staff acknowledges that its assumed upper limits on the availability of cellulosic ethanol in California imply that essentially all U.S production is consumed in the state.

Again, the diversion of significant amounts of the entire U.S. supply of cellulosic ethanol to California will occur only if there is a large enough price premium paid in California. The CEC methodology described above puts the cost of cellulosic ethanol at about 2.75 times the cost of gasoline blendstocks.

Once again, the basis for ARB staff's assumed CI value for cellulosic ethanol is completely undocumented and no data supporting the assumption are provided. In this case, there are no available CI data for cellulosic pathways being considered by ARB, and the agency itself has not yet published any internal pathway documents regarding cellulosic ethanol CI. It should also be noted that 25.0 gCO_2eq/MJ is in the lower range of values considered by ARB in its analysis of its original "illustrative scenarios" in 2009,[13] and significantly lower than the value of approximately 40 gCO_2eq/MJ assumed by ARB staff in 2009 for cellulosic biofuels produced in order to comply with the federal RFS, the program to which the EIA supply estimates are linked.

Renewable Gasoline Availability and CI Values: ARB staff assumes that renewable gasoline will be available in California as early as 2015 and in volumes as great as 0.78 billion gallons per year by 2020. In addition, the average CI value of renewable gasoline supplied to California is assumed to be 25.0 gCO_2eq/MJ. As with cellulosic ethanol, ARB staff provides no documentation or data to support its assumptions regarding the availability of renewable or "drop in" gasoline and the CI of that fuel. Again, the maximum volume assumed to be available for use in California by ARB staff is approximately equal to the EIA forecast for total U.S. production, and the source of the CI is not linked to any real fuel production pathway or even internal ARB pathway assessment.

FFV Populations and E85 Use: ARB staff assumes that up to 4.6 million FFVs are assumed to be in operation in California by 2020. The staff further assumes that these vehicles operate as much as 100% of the time on E85, which leads to an assumed California E85 consumption volume of up to 3.14 billion gallons.

Turning first to FFVs, data reported by CEC[14] indicate a current California FFV population of about 400,000 vehicles, or roughly one-tenth of that assumed by ARB staff by 2020. CEC also forecasts that the population will grow to about 1.75 million vehicles by 2020, which is still less than half of the maximum value forecast by ARB. However, even the lower CEC forecast appears to be overly optimistic, given that the federal Corporate Average Fuel Economy (CAFE) credits that provide the only current incentive for vehicle manufactures to produce FFVs will be phased out beginning with the 2015 model year and completely eliminated by the 2020 model year. Diminished FFV

[12] Page 84, U.S. Energy Information Administration, Annual Energy Outlook 2011, April 2011.
[13] Table VI-3, CARB LCFS ISOR, March 2009.
[14] See *http://www.energy.ca.gov/2011_energypolicy/documents/2011-11-14_workshop/presentations/Yowell_Weng-Gutierrez_Historic_Demand.pdf* .

production volumes are expected not only due to the elimination of CAFE credits, but also because of the well-known problems associated with certification of FFVs to ARB's Super Ultra-Low Emission Vehicle (SULEV) emission standards, and the fact more vehicles will be required to be certified to SULEV standards under ARB's upcoming LEV III regulation. Overall, there is little reason to expect that the California FFV population will expand to the levels assumed by ARB staff between now and 2020 and, given the direct link between FFV population and potential E85 use, little reason to assume that E85 volumes will reach the levels assumed by ARB staff even before the other limiting factors described below are taken into account.

Turning next to the fraction of time that those FFVs in California could potentially operate on E85, one key factor is the relative cost of gasoline and E85 on an energy-equivalent basis. Unless E85 costs are lower than gasoline costs on a per unit energy basis, FFV owners will choose to operate on gasoline. At present, absent federal ethanol prices subsidies that are scheduled to expire at the end of 2011, the cost of ethanol on a per unit energy basis—without accounting for CI-related price premiums—is higher than that of gasoline. Therefore, large volumes of E85 would not be expected to be used unless there are reductions in ethanol costs relative to gasoline costs.

Another problem with ARB's assumptions is that the agency assumes that all E85 sold in the state will contain 85% ethanol by volume. At present, ARB's specifications for E85[15] require that the fuel contain at least 79% ethanol by volume. However, these specifications also set minimum volatility requirements that cannot be met in general, as ARB acknowledges,[16] by blending of ethanol and California gasoline blendstocks. ARB also has indicated that it will likely propose alignment with ASTM D5798, which allows for a range in ethanol content in "E85" from 51% to 83% by volume, depending on volatility requirements and other factors. Therefore, by assuming 85%, ARB overestimates the amount of ethanol that would actually be consumed by the use of E85 or, alternatively, assumes that a special gasoline blendstock will be produced for E85 in California, which is unlikely.

Finally, there is insufficient retail dispensing infrastructure currently in place in California to support anywhere near the E85 volumes assumed by ARB staff. CEC has reported[17] that the infrastructure required to achieve 1.75 billion gallons of E85 use per year will cost between 1 and 21 billion dollars, and that the infrastructure required to reach the ARB staff's assumed level of approximately 3 billion gallons per year will cost 3 to 102 billion dollars. Obviously, significant lead time would be required to install this infrastructure, and the cost of the investment plus a return on that investment would have to be realized—most likely through increases in the cost of E85, which again is expected to be a viable fuel only if its cost is less than that of gasoline on an energy equivalent basis.

Ethanol Content of Gasoline: ARB staff assumes that the allowable limit on ethanol in gasoline is raised from 10% by volume to 15%, and that all gasoline sold in California

[15] See *http://www.arb.ca.gov/fuels/altfuels/regs/altregs.pdf.*
[16] See *http://www.arb.ca.gov/fuels/altfuels/e85/meetings/meetings.htm.*
[17] Page 99, Draft Transportation Energy Forecasts and Analyses for the 2011 Integrated Policy Report, August 2011.

beginning in 2016 contains at least 15% ethanol by volume. Again, this appears to be an optimistic assumption on the part of ARB staff, and one that is unlikely to be realized. First, at present, the U.S. EPA has granted only a partial waiver for the use of ethanol blends up to E15, which applies only to 2001 and later model year on-road motor vehicles. Therefore, all gasoline marketed in given area, such as the state of California, cannot contain 15% ethanol. Second, as reported by CEC,[18] California is one of many states where existing state laws and regulations restrict the use of ethanol in gasoline to no more than 10% by volume. In order for E15 to be allowed for use in any volumes in California, the following would be required, at a minimum:

1. Extending the 10% ethanol blend limit in §2262 Title 13 CCR to higher ethanol blends, which would require a multimedia evaluation pursuant to California Health and Safety (H&S) Code §43830.8; and

2. Extending the range of the Predictive Model so that it applies to fuels with more than 10% ethanol.

To date, ARB has not initiated the actions that would be required to achieve either of these changes, even for 2001 and later model year vehicles.

Alternative Compliance Analysis Using More Reasonable Assumptions: The alternative compliance analysis was performed using the methodology by ARB staff in evaluating the “illustrative” scenarios, but with the assumption that the supply of biofuel substitutes for gasoline in California in the absence of the LCFS would be equal to EIA’s biofuel supply forecasts[19] multiplied by California’s share of the total U.S. gasoline consumption. This is the same assumption that has been used previously by the CEC[20] to estimate biofuels supplies in California under the federal Renewable Fuel Standard.

The results are shown in Table 1. As shown, the supply of biofuels forecast by EIA and assumed to be available in California during the early years of the LCFS would lead to the generation of LCFS credits. However, by 2015, LCFS compliance could no longer be achieved, and increasing credit deficits would build through 2020.

Also shown in Table 1 are results that reflect the relaxation of ARB’s assumptions regarding decreases in the CI values of certain biofuels over time and instead assume constant CI values. The relaxation of this ARB assumption leads to credit deficits in 2014 and even larger credit deficits thereafter relative to the analysis relaxed only the biofuel supply assumption. Also shown are the credits for the case where CI values remain constant and ARB’s ZEV mandate fails to deliver the significant volumes of electric and fuel cell vehicles. Although relaxing ARB’s assumption regarding the ZEV mandate does not advance the onset of cumulative credit deficits before 2014, it does increase the magnitude of deficits in that year and in subsequent years.

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[18] Page 99, Draft Transportation Energy Forecasts and Analyses for the 2011 Integrated Policy Report, August, 2011.
[19] See *http://www.eia.gov/forecasts/aeo/index.cfm*
[20] *http://www.energy.ca.gov/2011_energypolicy/documents/2011-11-14_workshop/presentations/Schremp-RFS2.pdf*

Table 1 Cumulative California LCFS Credit Balance for Gasoline and Substitutes Under the RFS2 Based on EIA Supply Forecasts (Thousands of Metric Tons)										
Case	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EIA Share	569	1177	1442	1258	-129	-2648	-6941	-12916	-20515	-30206
EIA Share with Constant CI	569	806	337	-884	-3562	-7614	-13715	-21794	-31774	-44160
EIA Share with Constant CI and Failed ZEV Mandate	555	719	105	-1330	-4370	-8923	-15676	-24583	-35645	-49390

Compliance Costs Using CEC Assumptions: Assuming that one or more of ARB's "illustrative" scenarios, which were designed to show LCFS compliance, are actually feasible, the question becomes what the cost implications are for California. As noted previously, ARB concludes based on its analysis that *"…the cost of producing lower CI alternative fuels to comply with the LCFS is unlikely to drive a significant cost change in the gasoline fuel mix over the 2011-2020 time horizon."*[21] However, if one substitutes fuel cost data developed by the CEC[22] for ARB's assumptions one arrives at very different conclusion.

In estimating biofuel costs using the CEC data, each fuel's total cost is the sum of the fuel's commodity cost plus a CI premium. The fuel commodity costs and the carbon intensity premiums were taken from reference 22 for the "High LCFS Price Forecast" data set. The costs for gasoline and gasoline substitutes that were estimated on a volumetric, as opposed to a gasoline gallon equivalent, basis using the CEC data and CI premium methodology are shown in Table 2. These costs are considerably higher than those assumed by ARB staff. For example, ARB's 2011 cost estimate for Brazilian sugar cane ethanol adjusted to a gallon of ethanol basis is $1.90 compared to the $3.93 derived from the CEC data and methodology.

The biofuel costs derived from the CEC data and methodology were then used to estimate compliance costs for the 11 ARB "illustrative" scenarios. These results are shown in Table 3. Note that these cost estimates do not account for changes in new vehicle prices for vehicles capable of using alternative fuels or costs associated with the development of alternative fuel refueling infrastructure, both of which would increase the estimated LCFS compliance costs.

[21] Page 129
[22] See *http://www.energy.ca.gov/2011_energypolicy/documents/index.html#11142011* and Excel Spreadsheet labeled "2011-11-14_Biofuel_Values.xls.

Table 2 **Estimated Costs of Gasoline and Substitutes** **Based on CEC Data and Methodologies** **(cents per gallon excluding taxes)**										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CARBOB	306	306	319	332	341	345	347	349	350	351
Midwest Ethanol	233	234	246	260	271	281	291	302	313	325
Cellulosic Ethanol	520	520	557	593	627	661	697	732	764	799
Brazilian Sugarcane Ethanol	393	393	413	434	450	462	474	486	497	508
Cellulosic Gasoline (Drop-In)	625	625	664	705	737	772	805	837	867	897

The LCFS compliance cost estimates developed by Sierra for biofuels alone for each of the ARB illustrative scenarios are presented in Table 3. As shown, the total compliance costs for the gasoline scenarios over the period from 2011 to 2020 based on the CEC data and methodology range from about $22 to as much as $42 billion dollars.

Table 3 **Estimated Annual Incremental LCFS Compliance Costs** **for ARB Gasoline Scenarios Relative to RFS2** **(Based on CEC Cost Data; billions of $)**											
Scenario	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
1	0.0	0.1	0.3	0.8	2.2	4.4	5.4	6.9	9.2	12.1	41.5
2	0.0	0.0	0.2	0.4	1.3	2.6	4.0	6.2	9.2	11.2	35.2
3	0.0	-0.1	-0.1	0.1	1.3	2.2	4.0	6.2	8.2	10.3	32.2
4	0.0	0.1	0.2	0.4	1.3	2.2	3.4	4.9	6.6	8.9	28.0
5	0.0	-0.1	-0.1	0.2	0.8	1.5	2.7	3.9	5.4	7.4	21.6
6	0.0	-0.1	-0.1	0.2	1.0	1.5	2.9	4.5	6.4	9.4	25.6
7	0.0	-0.1	-0.1	0.2	1.0	1.4	2.7	4.2	6.2	9.0	24.5
8	0.0	-0.1	-0.1	0.1	0.8	1.2	2.4	3.8	5.7	7.8	21.7
9	0.0	-0.1	-0.1	0.2	0.8	1.7	3.0	4.5	6.4	9.0	25.4
10	0.0	-0.1	-0.1	0.1	0.7	1.6	3.1	4.6	6.5	8.9	25.3
11	0.0	-0.1	-0.1	0.2	0.9	1.9	3.2	4.8	6.9	9.4	27.0

Review of ARB Staff's Analysis of Compliance for Diesel and Diesel Substitutes

ARB staff has published an analysis of five "illustrative" LCFS compliance scenarios related to Diesel fuel and Diesel substitutes. As discussed above with respect to the gasoline scenarios, ARB staff concludes based on its analysis of these scenarios that compliance with the LCFS targets is feasible at a reasonable cost. However, as with the gasoline scenarios, each of the illustrative LCFS Diesel compliance scenarios is based on one or more highly optimistic and/or unsupported assumptions regarding the availability of lower CI fuels.

Outlined below are the key assumptions used by ARB staff that are examined here.

1. On a volume-average basis, the biodiesel content of Diesel fuel sold in California is assumed to exceed the B5 level by 2014 and reach the B20 level by 2017.

2. Volumes of biodiesel available in California are assumed to be as much as 770 million gallons per year by 2020.

3. In some scenarios, the average CI value associated with soy derived biodiesel supplied to California is assumed to drop from 83.3 to 79 gCO_2eq/MJ.

4. Biodiesel produced from used cooking oil is assumed to be available in California as early as 2014, in volumes as great as 425 million gallons per year.

5. Biodiesel produced from canola and corn is assumed to be available in California as early as 2015, in volumes as great as 123 million gallons per year. Furthermore, the average CI value of canola-based biodiesel is assumed in some scenarios to be as low as 56.27 gCO_2eq/MJ, and the average CI of biodiesel derived from corn oil is assumed to average 5 gCO_2eq/MJ.

6. Drop-in renewable Diesel fuel is assumed to be available in California as early as 2016, in volumes of up to 71 million gallons per year, with a CI value of 35 gCO_2eq/MJ. Renewable Diesel fuel from tallow is assumed to be available in California as early as 2014, in volumes of up to 35 million gallons per year, with a CI value of 29.49 gCO_2eq/MJ.

Average Biodiesel Levels: ARB staff assumes that biodiesel accounts for more than 5% of all Diesel fuel sold in California beginning in 2014 and 20% beginning in 2017. No basis is provided to support either the assumption of blends greater than B5 entering the market or the timing of that entry.

While it might seem reasonable to assume that the fraction of biodiesel sold in California will increase under the LCFS, there are a number of issues that will have to be resolved if Diesel fuel sold in California is to contain more than 5% biodiesel. As the California Environmental Protection Agency (Cal EPA) reports,[23] these issues include the following:

1. Need to complete the ongoing multimedia assessment as required under California Health and Safety Code section 43830.8;

2. Lack of ARB regulations establishing specifications for biodiesel blends above 5% and the potential need to offset increased NOx emissions;

3. Lack of State Water Resources Control Board regulations for tank leak testing and other requirements; and

4. Lack of ASTM specifications, FTC labeling, and advertising requirements for biodiesel blends above B20.

In addition, many Diesel vehicles are not warranted for operation on biodiesel blends above B5.[24]

Given the above, ARB staff's assumptions that the average level of biodiesel used in California will be above 5% by 2014 and that it will reach the 20% level by 2017 are highly optimistic. Clearly, general availability of blends above the B5 level will require considerable effort on the part of ARB and other state agencies, and will be limited by the fact that many vehicles are not warranted for operation at levels above B5.

<u>Biodiesel Availability:</u> In addition to the assumptions discussed above regarding average biodiesel blend levels, ARB staff assumes that total biodiesel consumption in California will reach 148 million gallons in 2013 and will increase to 770 million gallons by 2020. No support is provided by ARB staff to demonstrate that these assumptions are reasonable.

In contrast, total U.S. biodiesel supply forecast by EIA[25] for 2013 is about 1 billion gallons and about 1.6 billion gallons in 2020. Therefore, ARB is assuming that California's biodiesel supply will be greater than its proportional share of total U.S. production based on Diesel fuel consumption, and that the California supply will amount to as much as 50% of total U.S. biodiesel production.

Although ARB staff has not provided a basis for these assumptions, there is no reason to expect the biodiesel supply in California will reach the assumed levels unless there is a large enough price premium.

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[23] See *http://www.calepa.ca.gov/biofuels/Guidance.pdf.*
[24] See "Identification and Review of State/Federal Legislative and Regulatory Changes Required for the Introduction of New Transportation Fuels," Sierra Research Report No. SR2010-08-01, August 2010.
[25] See *http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2011&subject=0-AEO2011&table=24-AEO2011&region=0-0&cases=ref2011-d020911a*.

CI Value of Soy Derived Biodiesel: ARB staff assumes in certain cases that the average CI value of soy derived biodiesel supplied in California decreases from 83.3 to 79 gCO_2eq/MJ. No explanation is provided by ARB staff to support this change. While the change may appear to be small, one first has to recognize that the indirect land use component of the CI value is 62 gCO_2eq/MJ. The means that the direct CI value is being assumed to drop by about 20% from 21.3 to 17 gCO_2eq/MJ. Again, given the lack of documentation provided by CARB staff, it is unclear what assumptions are involved in this change and how reasonable they are.

Availability of Biodiesel Derived from Used Cooking Oil: ARB staff assumes that biodiesel produced from used cooking oil will be available in California as early as 2014, in volumes as great as 425 million gallons per year. No documentation is provided by ARB staff to support the assumed volumes of used cooking oil biodiesel.

In contrast to the ARB staff's estimates, EIA[4] forecasts that total U.S. biodiesel production from used cooking oil (also known as "yellow grease") will reach only 84 million gallons per year. The EIA forecast implies that ARB staff is assuming that additional sources of used cooking oil biodiesel will be created in the U.S., that the supply from those sources will total approximately four times the supply that EIA forecasts will be available, and that all of that biodiesel will be made available in California. Absent any explanation for the staff's assumptions, they appear to be unreasonable based on the available information from EIA.

Availability of Biodiesel from Canola and Corn Oil: ARB staff assumes that biodiesel derived from canola will be available as early as 2015, in volumes of up to 115 million gallons per year, and at average CI values as low as 56.27 gCO_2eq/MJ. The staff also assumes that biodiesel derived from corn oil will be available beginning as early as 2015, in volumes of up to 38 million gallons per year, at an average CI value of 5 gCO_2eq/MJ. Again, no documentation supporting the assumed availability of these fuels is provided by ARB staff, and the projected CI values for biodiesel derived from canola require additional unsupported assumptions.

As noted, no basis has been presented for ARB's assumptions regarding canola-derived biodiesel supply in California. Furthermore, at present EIA is not forecasting significant supplies of canola-derived biodiesel. With respect to the CI value assumed for canola-derived biodiesel, the base value of 62.99 gCO_2eq/MJ is taken directly from an ARB staff assessment.[26] However, ARB staff also assumes in some scenarios that this value drops to 56.27 gCO_2eq/MJ. Given that the indirect CI value for canola-derived biodiesel is 31 gCO_2eq/MJ, this implies a reduction of about 20% in direct emissions. Given the sources of direct greenhouse gas emissions associated with biodiesel production from canola, it is unclear how ARB staff believes the reduction in direct emissions will be achieved.

Similarly, EIA is not currently forecasting significant biodiesel production from corn oil, and the 5 gCO_2eq/MJ assumes that all of the corn oil used to produce biodiesel is

[26] See *http://www.arb.ca.gov/fuels/lcfs/2a2b/internal/121410lcfs-canola-bd-sum.pdf.*

obtained from plants engaged in ethanol production.[27] Again, the reasonableness of the ARB staff's assumptions is clearly questionable at best.

Availability of Renewable Drop-in and Tallow Derived Renewable Diesel and Assumed CI Values: ARB assumes that "drop-in" renewable Diesel fuel will be available as early as 2016, in volumes of up to 71 million gallons per year. No basis is provided for either of these assumptions. Although EIA forecasts significant volumes of unspecified "liquids" from biomass, the assumed 71 million gallons of drop in renewable Diesel would amount to the total amount of renewable gasoline and Diesel forecast produced in the U.S. in 2020. Further, no explanation is provided by ARB staff to support the assumed 35 gCO_2eq/MJ CI value.

ARB staff assumes that renewable Diesel fuel derived from tallow will be available beginning as early as 2014, in volumes of up to 40 million gallons per year. Again, no basis is provided for the supply assumptions, which appear to be questionable—although EIA does forecast significant volumes of biodiesel derived from tallow (or "white grease"), it does not forecast this feedstock to be a source of renewable Diesel.

With respect to ARB's assumed average CI value of 29.49 gCO_2eq/MJ for tallow-derived renewable Diesel, this value is the average of two values in the existing LCFS "Look Up Table": 39.33 gCO_2eq/MJ for higher energy rendering, and 19.65 gCO_2eq/MJ for lower energy rendering.[28] No explanation is provided, however, as to why this averaging is appropriate, and there is no apparent basis for assuming that 50% of supply would come from either of the two pathways.

Alternative Compliance Analysis Using More Reasonable Assumptions: The alternative compliance analysis was performed using the methodology by ARB staff in evaluating the "illustrative" scenarios but with the assumption that the supply of biofuel substitutes for Diesel in California in the absence of the LCFS would be equal to EIA's biofuel supply forecasts multiplied by California's share of the total U.S. Diesel consumption. Again, this is the same assumption that has been used previously by the CEC[29] to estimate biofuels supplies in California under the federal Renewable Fuel Standard.

The results are shown in Table 4. As shown, the supply of biofuels forecast by EIA and assumed to be available in California during the early years of the LCFS would lead to the generation of LCFS credits; by 2016, however, LCFS compliance could no longer be achieved, and increasing credit deficits would build through 2020. It is important to also note that the credits estimated to be available in 2014 and 2015 from Diesel compliance are not sufficient to offset the credit deficits shown for gasoline compliance in Table 1. Therefore, under the EIA share assumptions LCFS non-compliance is forecast to occur in the 2014 to 2015 timeframe.

[27] See *http://www.arb.ca.gov/fuels/lcfs/2a2b/internal/121410lcfs-cornoil-bd.pdf*
[28] See *http://www.arb.ca.gov/fuels/lcfs/121409lcfs_lutables.pdf*
[29] *http://www.energy.ca.gov/2011_energypolicy/documents/2011-11-14_workshop/presentations/Schremp-RFS2.pdf*

Table 4 Cumulative California LCFS Credit Balance for Diesel and Substitutes Under the RFS2 Based on EIA Supply Forecasts (Thousands of Metric Tons)										
Case	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EIA Share	352	607	669	516	51	-797	-2366	-4703	-7830	-12052

Compliance Costs Using CEC Assumptions: The same CEC-based biofuel cost data and methodology discussed above were also applied to the Diesel scenarios. The costs obtained for Diesel fuel are presented in Table 5. Again, the costs derived from the CEC data are significantly higher than those assumed by ARB staff in its analysis.

Table 5 Estimated Costs of Diesel and Substitutes Based on CEC Data and Methodologies (cents per gallon excluding taxes)										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CARB Diesel	304	304	317	330	339	342	345	347	348	348
Midwest Soybean Biodiesel	499	499	522	546	564	574	582	591	597	602
Midwest Soybean Biodiesel Lower CI	499	499	522	547	566	577	588	599	607	616
UCO Biodiesel	555	555	608	657	709	767	832	896	956	1023
Canola Oil Biodiesel	519	519	553	585	615	640	667	692	714	736
Canola Oil Biodiesel Lower CI	519	519	553	587	618	646	676	704	730	757
Corn Oil Biodiesel	564	564	622	675	733	799	874	948	1018	1096
Renewable Diesel – Tallow	553	553	604	652	702	757	820	882	939	1003
Renewable Diesel – Drop-In	653	653	704	752	799	847	901	952	1000	1051

The biofuel costs derived from the CEC data and methodology were then used to estimate compliance costs for the 5 ARB "illustrative" scenarios for Diesel fuel. These results are shown in Table 6. Note that these costs do not include costs for natural gas vehicles or the cost savings that ARB staff assumes will result from the use of compressed natural gas as a Diesel substitute. As the CEC has indicated,[30] most compressed natural gas is used in urban transit buses and that will continue to be the case into the future even under the ARB scenarios. As this use would occur without or without the LCFS, it is not treated here as providing a "cost savings" created by the LCFS. The LCFS credits provided by compressed natural gas use are reflected, however, in the compliance cost estimates, and the required use of biofuels assumed by ARB staff is also assumed here.

The LCFS compliance cost estimates developed by Sierra for biofuels alone for each of the five ARB illustrative Diesel scenarios are presented in Table 6. As shown, the total compliance costs over the period from 2011 to 2020 based on the CEC data and methodology range total about $12 billion.

Table 6
Estimated Annual Incremental LCFS Compliance Costs for ARB Diesel Scenarios Relative to RFS2 (Based on CEC Cost Data; billions of $)

Scenario	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
1	-0.2	-0.2	0.1	0.4	0.6	1.1	1.7	2.1	2.6	3.4	11.7
2	-0.2	-0.2	0.1	0.4	0.6	1.1	1.8	2.2	2.7	3.6	12.2
3	-0.2	-0.2	0.1	0.4	0.6	1.1	1.8	2.2	2.7	3.5	12.0
4	-0.2	-0.2	0.1	0.4	0.6	1.1	1.8	2.2	2.7	3.6	12.0
5	-0.2	-0.2	0.1	0.4	0.6	1.1	1.8	2.2	2.7	3.6	11.9

Assessment of EIA Share Assumption

As noted above, the feasibility of LCFS compliance was evaluated using the assumption that California would receive a share of EIA forecast biofuels equal to the share of total U.S. gasoline and Diesel supplied to California. Based on that assumption, compliance with the LCFS is forecast to be feasible only through 2014 or 2015.

Although it is not clear what proportion of total U.S. biofuel production will be available to California from 2011 to 2020, the validity of the assumption that the supply will be proportional to California's use of gasoline and Diesel fuel can be evaluated for 2011. As shown in Tables 1 and 4, the estimated LCFS credits from the EIA share assumption for 2011 amount to 921,000 metric tons of CO_2 equivalent emissions. This can be compared to the actual LCFS credits that ARB staff reports[31] have been generated through the end of the third quarter of 2011. The actual credits total only 450,000 metric tons compared to the 921,000 estimated by Sierra. Assuming another 150,000 metric tons are generated

[30] Page 82, Draft Transportation Energy Forecasts and Analyses for the 2011 Integrated Policy Report, August, 2011.
[31] Page 104.

in the fourth quarter, this puts the annual total at 600,000 metric tons or only about 65% of the credits estimated by Sierra. This suggests that the actual supply of biofuels in California in 2011 is lower than that based on EIA share assumption or that the CI values associated with the biofuels supplied to the state are higher than estimated by ARB staff. This result supports the EIA share assumption and calls into question ARB's assumptions that biofuel supply in California will far exceed that forecast.