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# The Challenge of Achieving California's Low Carbon Fuel Standard

**Peter Gross**
**Office of Integrated Analysis and Forecasting**
**U.S. Energy Information Administration**

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Author: Peter Gross, peter.gross@eia.doe.gov, (202)586-8822
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On January 12, 2010, the California Air Resources Board (CARB) final rulemaking package for the State's Low Carbon Fuel Standard (LCFS) was approved by the Office of Administrative Law, making it an enforceable regulation. The LCFS rulemaking sets 2010 as a "baseline" year and requires reductions in the carbon intensities (CIs) of both gasoline and diesel transportation fuel types beginning in 2011 and culminating in a 10-percent decrease from the 2010 level by 2020.

California's plan to achieve LCFS compliance has been closely scrutinized by stakeholders [1] and is the subject of intense debate and legal challenge. The compliance scenarios envisioned by CARB to meet the LCFS schedule assume substantial market penetration of battery electric vehicles (BEVs), fuel cell vehicles (FCVs), plug-in hybrid electric vehicles (PHEVs), and the consumption of significant quantities of low-CI ethanol.[2]. Thus, these scenarios require significant use of alternative fuels and vehicles by 2020 that are not now commercially available.

The Energy Information Administration (EIA), in its *Annual Energy Outlook 2010 Early Release Overview* (*AEO2010*) [3], which does not incorporate the LCFS, projects very limited national market penetration for electric and hydrogen vehicles by 2020 [4] due to the incremental costs of these vehicles relative to their conventional counterparts [5]. The outlook for FCV market penetration was studied in a recent EIA report [6], which concluded that barriers associated with hydrogen production and distribution costs—and especially vehicle costs, which will take time to lower given the current state of production technologies—are particularly formidable. EIA's projections suggest that compliance with California's LCFS is unlikely to be aided by the use of hydrogen-fuel vehicle technologies, notwithstanding CARB's assumptions.

Likewise, the development and market penetration of a significant number of BEVs and PHEVs is not assured. The *AEO2010* reference case projects 800,000 such vehicles on the road by 2020[7]. Assuming all of those vehicles were located in California, they would constitute 2.9% percent of the light duty vehicles on the road in California and perhaps a modestly larger percentage of light duty vehicle miles travelled in the State.

The analysis presented in this study assumes the *AEO2010* reference case the projections for PHEVs, BEVs, and FCVs. Thus, it does not account for interaction between a growth in demand for these alternative vehicles induced by the LCFS and a possible supply response of said vehicles. Such an interaction would likely involve a credit system promoting incentives between the utilities, the refineries, and the alternative vehicle consumers which is still undetermined.

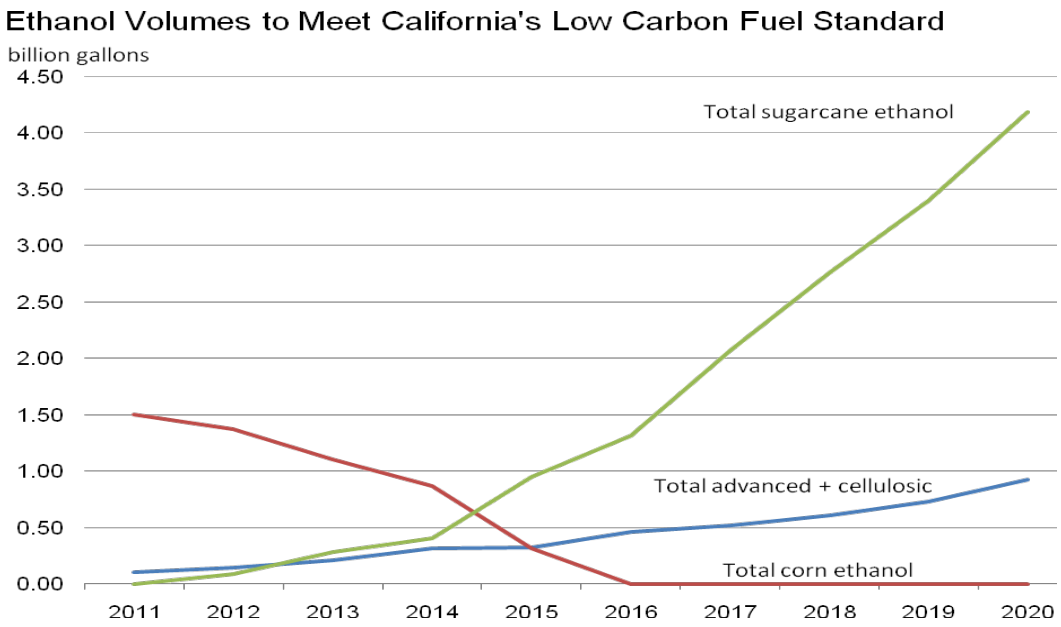
Author: Peter Gross, peter.gross@eia.doe.gov, (202)586-8822

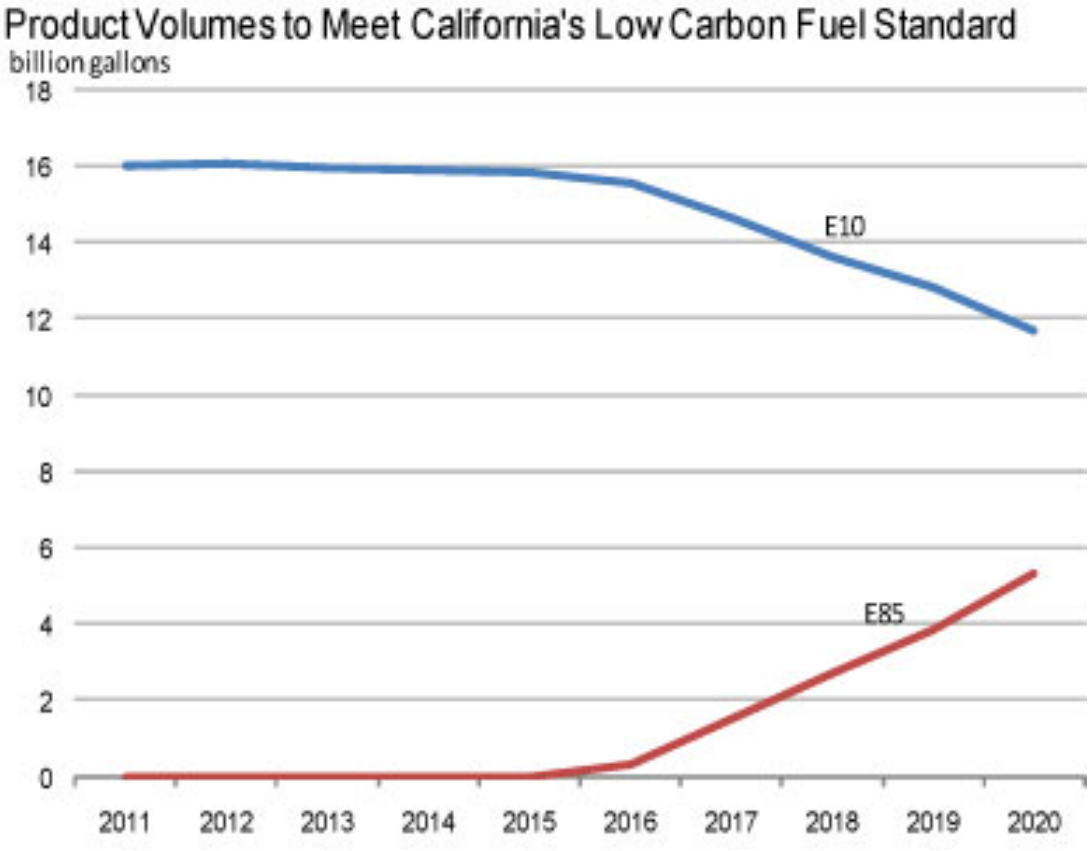
In addition, the *AEO2010* reference case projects that second generation biofuels such as cellulosic ethanol will require more time to reach the quantities that are assumed in CARB's compliance scenarios. This reflects EIA's assessment of the current state of the advanced biofuels industry and the financial and technological hurdles that must be overcome for these fuels to become commercially viable, although CARB is clearly more hopeful on this front [8].

Based upon *AEO2010* projections for the limited commercial availability of alternative fuels and vehicles over the next ten years, the analysis below explores one possible option for compliance with California's LCFS: the import of large amounts of sugarcane ethanol. In early 2006, the Natural Resources Defense Council examined the potential for compliance with the California LCFS through market penetration of a (comparatively) modest number of FCVs (200,000) [9] and the use of ethanol in the form of both E10 and E85 [10] although the sources of ethanol were unspecified in this study.

Figures 1A and 1B display the projected ethanol and product supplies to meet the California LCFS target while Figure 1B shows the E85 volumes needed to absorb all of this ethanol [11]. The underlying assumption made is that E10 with increasing use of available low-CI ethanol is the fuel of choice, but that it must be phased out in favor of E85 as the LCFS schedule becomes more stringent towards 2020 (culminating in a reduced average fuel CI of 86.27 gCO2eq/MJ). This gradual phasing in of E85 is plausible given the cost to build up the necessary infrastructure for dispensing E85. By 2020 roughly 20 percent of the 9,000-plus retail stations in the State would have to be converted to allow dispensing of E85. (Currently, there are only a handful of E85 stations in California.) In addition, with E85 making up one-third of the State's total fuel pool in Figure 1B, roughly one-third of the vehicles in California in 2020 would have to be flex-fuel vehicles (FFVs).

Author: Peter Gross, peter.gross@eia.doe.gov, (202)586-8822




Critical to meeting the LCFS target is how much low-CI alternative fuels (cellulosic ethanol, electricity, hydrogen, and natural gas) California is able to utilize. The availability of low-CI fuels (and in some cases the vehicles that use them) could be limited by competition with other States

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that have plans to implement their own LCFS policies. In particular, Oregon [12] and the States that have joined the Northeast States Center for a Clean Air Future (NESCCAF) [13] have announced their intention to pursue LCFS policies similar to California's.

The *AEO2010* reference case projects that the total supply of cellulosic ethanol (both imported and domestic) nationwide will be only 1.6 billion gallons in 2020 (including roughly 1 billion gallons produced domestically [14]). Based on this projection and the additional assumption that California receives 37 percent of the low-CI fuel available nationally, consistent with its share of total fuel consumption among states with current or planned LCFS policies, the ethanol and ethanol blend projections shown in Figures 1A and 1B reflect the use of 0.58 billion gallons of low-CI cellulosic ethanol within California[15]. If LCFS policies in California (and possibly other states) increased the national availability of choice low-CI fuels, or if California could use a larger share of the national pool of choice low-CI fuels, then somewhat less E85 and sugarcane ethanol would be needed to meet the LCFS target.

The specific fuel types used in the above projections and their respective CIs are shown in Table 1. The value shown in Table 1 for California Reformulated Blendstock for Oxygenate Blending (CARBOB) represents the baseline CI for California gasoline (E10 State-wide) in 2010. It should be noted that the singular use of biofuels to achieve the LCFS schedule is reinforced by CARB rules because conventional approaches that might be taken by refineries to reduce their CI are excluded from the calculation of future reductions in fuel CIs [16].

**Table 1. Carbon Intensities Assumed for Fuels**
(Grams Carbon Dioxide Equivalent per Megajoule)

| Fuel | Assumed Carbon Intensity |
|---|---|
| Cellulosic ethanol[a] | 21.3 |
| Sugarcane ethanol[b] | 58.4 |
| Advanced renewable ethanol[c] | 47.93 |
| Corn ethanol[d] | 95.66 |
| CARBOB[e] | 95.86 |
| Natural gas for CNG vehicles[f] | 67.70 |
| Electricity for BEV and PHEV[g] | 41.37 |
| Hydrogen for FCV[h] | 42.74 |

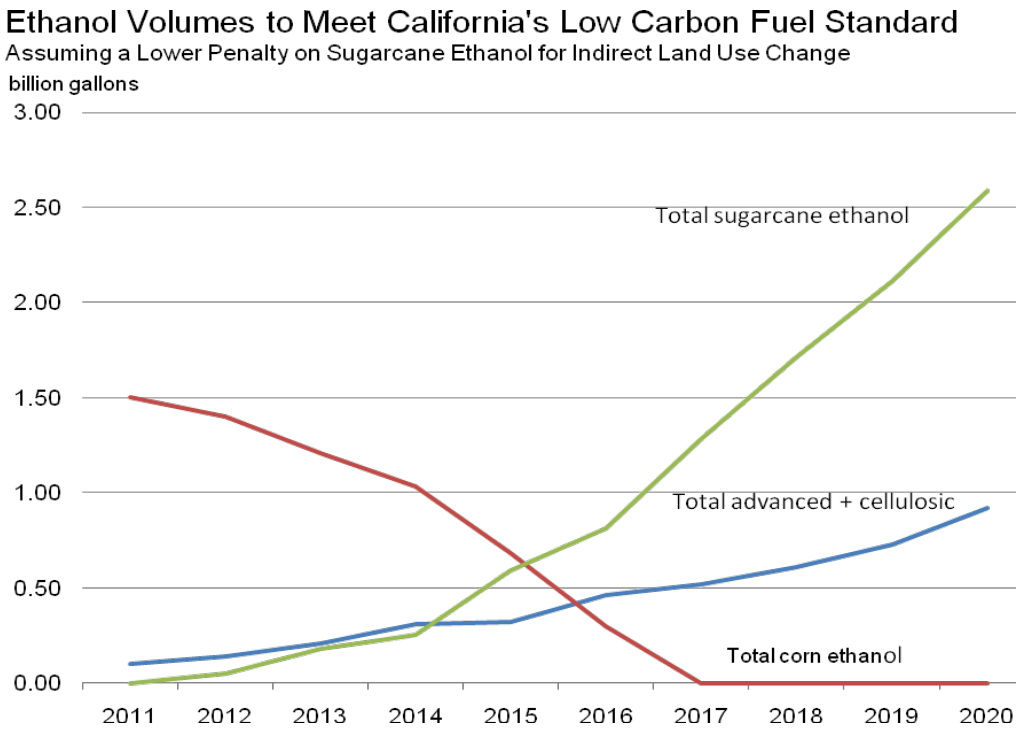
[a]According to the most recent CARB update on the LCFS program, the process of converting cellulosic materials to ethanol still is under development (see CARB, *California's Low Carbon Fuel Standard* (October 2009), Tables 5 and 6, pp. 17-18, http://www.arb.ca.gov/fuels/lcfs/100609lcfs_updated_es.pdf. Thus, in order to assign a value for its carbon intensity, the average of two values from earlier analyses published by CARB on ethanol from farmed trees (CARB, *Detailed California-Modified GREET Pathway for Cellulosic Ethanol from Farmed Trees by Fermentation* [February 27, 2009], http://www.arb.ca.gov/fuels/lcfs/022709lcfs_trees.pdf) and from forest waste (CARB, *Detailed California-Modified GREET Pathway for Cellulosic Ethanol from Forest Waste* [February 27, 2009], http://www.arb.ca.gov/fuels/lcfs/022709lcfs_forestw.pdf) is used here.
[b]See CARB, *California's Low Carbon Fuel Standard* (October 2009), Table 8, p. 22, http://www.arb.ca.gov/fuels/lcfs/100609lcfs_updated_es.pdf. Note that the lowest CI was chosen, representing a

Author: Peter Gross, peter.gross@eia.doe.gov, (202)586-8822

fuel pathway that includes mechanized harvesting and bagasse-fired cogeneration.
[c]"Advanced renewable ethanol" refers to ethanol fuel pathways that have not yet been defined (see CARB, *California's Low Carbon Fuel Standard: Final Statement of Reasons* [December 2009], http://www.arb.ca.gov/regact/2009/lcfs09/lcfsfsor.pdf, p. 519). In its *Staff Report: Initial Statement of Reasons* (CARB, *Proposed Regulation to Implement the Low Carbon Fuel Standard, Vol. I, Staff Report: Initial Statement of Reasons* [March 5, 2009], http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol1.pdf, Table VI-3, p. VI-7), CARB defines advanced renewable ethanol as coming from forest waste; however, in the *AEO2010* projections it is included in the cellulosic ethanol category. Therefore, it will be assumed that "Advanced renewable ethanol" is on par with ethanol grouped as "Advanced Biofuels" under the Renewable Fuels Standard 2 (RFS2) of the Energy Independence and Security Act of 2007 and thus has a CI equal to 50 percent of the baseline fuel (which is assumed here to be California's 2010 gasoline baseline).
[d]CARB, *California's Low Carbon Fuel Standard* (October 2009), Table 8, p. 22.
[e]"CARBOB" refers to "California Reformulated Blendstock for Oxygenate Blending," which is blended with ethanol to produce emissions-compliant fuel. See CARB, *California's Low Carbon Fuel Standard* (October 2009), Table 8, p. 22.
[f]Value assumes non-renewable (as opposed to land-fill) natural gas sources. See Table 6 of Table 6 of http://www.arb.ca.gov/regact/2009/lcfs09/lcfsfsor.pdf
[g]CI here assumes average California mix of electricity sources and takes into account the "energy efficiency ratio" (EER) for better electric car use of energy over a conventional vehicle. See Table ES-8 of "Proposed Regulation to Implement the Low Carbon Fuel Standard vol. 1" (http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol1.pdf)

[h]CI here assumes compressed hydrogen source is steam methane reforming (SMR) and takes into account the superior energy efficiency of a FCV over a conventional vehicle. See Table ES-8 of "Proposed Regulation to Implement the Low Carbon Fuel Standard vol. 1" (http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol1.pdf)

The CI values presented in Table 1 reflect the indirect land-use change (ILUC) penalties assumed for biofuels in the CARB rulemaking. The ILUC numbers are particularly important, because the pathways to LCFS compliance are highly sensitive to the ILUC penalties. For example, CARB has assigned an ILUC penalty of 46 gCO2eq/MJ to sugarcane ethanol. If that value were reduced by half, the projections for LCFS compliance would change dramatically, as shown in Figures 2A and 2B.

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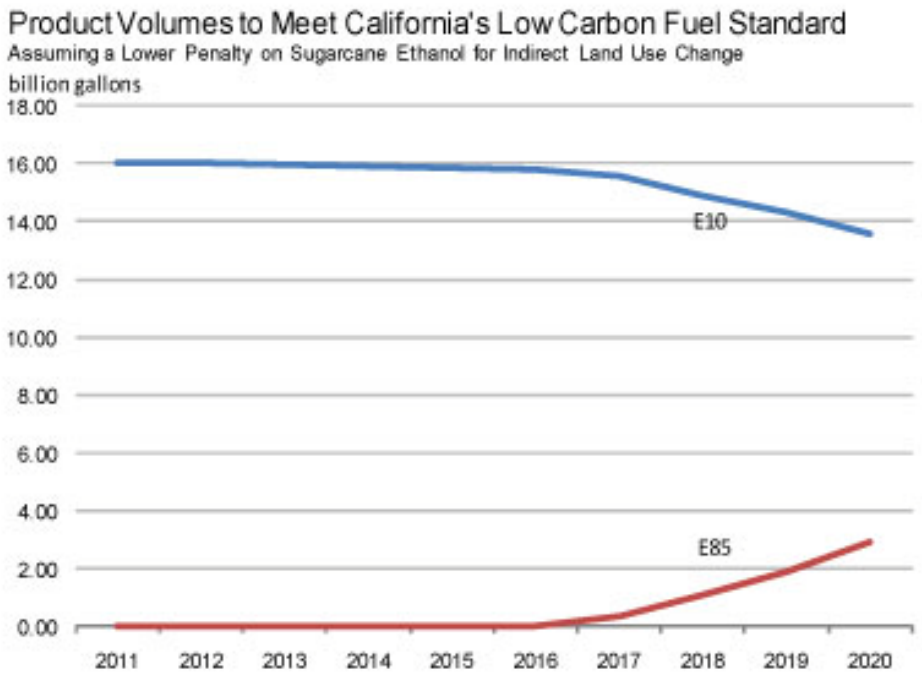


Comparison of Figures 1A, 1B and 2A, 2B shows significant differences in their projections for sugarcane ethanol demand and E85 supply in 2020. When the ILUC penalty for sugarcane ethanol is reduced by 50 percent, the California LCFS requirements are easier to achieve, although certain infrastructure investments still would be needed.

A focus on the sensitivity of the LCFS compliance results to different ILUC penalties is of significant real-world interest given differences between the U.S. Environmental Protection Agency (U.S. EPA) and CARB in their life cycle analysis (LCA) of emissions from various biofuels. Under the recently-issued U.S. EPA rules for the Federal Renewable Fuels Standard 2, the lifecycle emissions for the key motor gasoline fuel substitutes such as corn, sugarcane, and cellulosic ethanol are significantly lower than those estimated by CARB[17]. The U.S. EPA stated that these values are evolving as more is learned about biofuels production pathways and feedstocks, especially with respect to indirect land use. Although California is under no obligation to adopt the CI values developed in the recent U.S. EPA rulemaking, even lower amounts of sugarcane ethanol would be needed to fulfill the LCFS targets than is shown in Figure 2A if it were ultimately to do so.

Author: Peter Gross, peter.gross@eia.doe.gov, (202)586-8822

The high degree of sensitivity of the fuel requirements implied by the LCFS to the ILUC penalty parameter that is so uncertain and controversial is quite noteworthy from both infrastructure planning and policy perspectives. It should be noted, however, that the high CI value assigned to corn ethanol—largely as a result of a penalty of 30 gCO2eq/MJ for ILUC—does not alter the implied E85 requirement presented in Figure 1B, since corn ethanol is fully displaced beyond 2016. Even if the ILUC penalty were excluded altogether, corn ethanol still would be displaced in favor of sugarcane ethanol, and the projected E85 volume in Figure 1B would be the same.

Another point of controversy is whether the large volumes of sugarcane ethanol needed for LCFS compliance would in fact be available to the State of California. The Brazilian Sugarcane Industry Association (UNICA) projects that 4.1 billion gallons of sugarcane ethanol per year could be available for export by 2020 [18]; even if California were able to procure 100 percent of that export volume, the LCFS compliance schedule still would not be met in 2020.

Based on the analysis described here, successful compliance with California's LCFS may seem to be an unattainable goal; however, the analysis is subject to a number of caveats. For example, because the California LCFS was not assumed to be implemented in the *AEO2010* modeling (and most likely not in the UNICA study), the projections did not capture an increase in demand for low-CI fuels under the LCFS, which would spur more production of advanced renewable ethanol, both in the United States and perhaps in Brazil. On the other hand, it is unlikely that the incremental production of advanced ethanol could provide for billions of gallons of additional production in the LCFS time frame, even if new "advanced renewable" ethanol pathways with lower CIs were ratified by CARB.

**Footnotes**

[1]State of California, Environmental Protection Agency, Air Resources Board, *California's Low Carbon Fuel Standard: Final Statement of Reasons* (December 2009), http://www.arb.ca.gov/regact/2009/lcfs09/lcfsfsor.pdf.

[2]California Environmental Protection Agency, Air Resources Board, *Proposed Regulation to Implement the Low Carbon Fuel Standard, Vol. II, Appendices* (March 5, 2009), Appendix E, "Supporting Documentation for the Compliance Scenarios," http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol2.pdf.

[3]Energy Information Administration, *Annual Energy Outlook Early Release Overview*, DOE/EIA-0383(2009) (December 2009), http://www.eia.doe.gov/oiaf/aeo/overview.html.

Author: Peter Gross, peter.gross@eia.doe.gov, (202)586-8822

[4]Energy Information Administration, Supplemental Tables to the *Annual Energy Outlook 2010* (December 2009), Table 64. Transportation Fleet Car and Truck Stock by Type and Technology, http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C1925.

[5]The production cost of the vehicle is also balanced with the projected fuel costs as well. See Energy Information Administration, *Annual Energy Outlook 2009*, DOE/EIA-0383(2009) (March 2009), "Economics of Plug-In Hybrid Electric Vehicles," pp. 31–36, http://www.eia.doe.gov/oiaf/archive/aeo09/pdf/0383(2009).pdf.

[6]Energy Information Administration, *The Impact of Increased Use of Hydrogen on Petroleum Consumption and Carbon Dioxide Emissions*, SR/OIAF-CNEAF/2008-04 (August 2008), http://www.eia.doe.gov/oiaf/servicerpt/hydro/pdf/oiafcneaf(08)04.pdf.

[7]Projection for year 2020 which includes light duty stock and transportation fleet vehicle stock alternative fuel cars and light trucks from supplemental Tables 58 and 64 (http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C1375 and http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls#set3.1118a!C1925).

[8]Renee Littaua of CARB fuels section says that CARB projects "24 new potential biofuel facilities in California by 2020, including 18 new cellulosic ethanol and six new biodiesel facilities". See Ethanol Producer Magazine, "Setting Boundaries with the Low Carbon Fuel Standard" (April 2010).

[9]The California Approach: *Overview of the Global Warming Solutions Act (AB 32) and Strategies to Reduce Transportation Emissions* (January 2006), http://cta.ornl.gov/trbenergy/trb_documents/Handout%20CA%20GHG%20Trans.pdf.

[10]Even if the EPA granted the E15 waiver as petitioned by Growth Energy, California may not allow mid-level blends given past concerns over emissions related to ethanol.

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[11]The assumptions behind the computed ethanol fuel volumes are: (1) E85 penetration occurs after the "E10 option" has been exhausted, that is, after all ethanol in E10 is the lowest carbon form (cellulosic and/or sugarcane/advanced renewable). If corn ethanol were not fully displaced, even more E85 would be needed. (2) E85 composition is 74 percent ethanol and 26 percent gasoline, consistent with EIA assumptions for average (over seasonal temperatures) E85 composition. (3) The cellulosic and advanced ethanol supplies are limited in the *AEO2010* projection as noted in the text, but no inherent limit is placed on the imported sugarcane ethanol supply for the purposes of the results shown here. (4) Carbon intensity reduction benefits from electricity, natural gas, and hydrogen are factored in.

[12]Oregon Low Carbon Fuel Advisory Committee, "Advisory Committee Meeting 1, November 3, 2009, Agenda Item A, Nov. 3rd Draft Meeting Notes," http://www.deq.state.or.us/aq/committees/docs/decemberLCF/itemA.pdf.

[13]See Northeast States Center for a Clean Air Future (NESCCAF), *Introducing a Low Carbon Fuel Standard in the Northeast: Technical and Policy Considerations* (July 2009), http://www.nescaum.org/documents/lcfs-report-final-200909-rev-final.pdf. The NESCCAF States are Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, and Maryland.

[14]This quantity is well below the level of cellulosic ethanol assumed in California's LCSF compliance scenarios; however, EIA's recent assessment of the state of the industry, including evaluations of the current state of the cellulosic ethanol industry and financial climate, points to a significant delay in the commercialization of cellulosic biofuels. For detailed projections from the *AEO2010 Early Release* reference case, see Table A17, "Renewable Energy Consumption by Sector and Source," http://www.eia.doe.gov/oiaf/aeo/excel/aeotab_17.xls.

[15]The same assumption is used for domestically produced advanced ethanol, which the *AEO2010* projects to be 0.94 billion gallons in 2020 for the entire United States.

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[16]See, *California's Low Carbon Fuel Standard: Final Statement of Reasons* (December 2009), http://www.arb.ca.gov/regact/2009/lcfs09/lcfsfsor.pdf, pp. 170, 226, 228 and 229, where stakeholders BP and Shell in particular bring up the issue of CARB's not allowing credits for refinery efficiency improvements in the LCFS program. CARB's reasons for the restriction include its goal of stimulating "more fundamental changes to the transportation fuel pool, moving towards fuels that meet the much lower carbon intensities needed to meet long-term GHG emission goals," its plan not to "double count" refinery emissions reductions that will be credited in the broader AB 32 cap and trade program, and its premise that any changes in refinery efficiency less than 1 gCO2eq/MJ would be too onerous from an administrative point of view to monitor for individual refineries.

[17]http://www.regulations.gov/search/Regs/home.html#documentDetail?R=0900006480ac93f2

[18]Agrievolution 2008, "The Silent Tsunami: The Food Crisis and How To Solve It" (May 2008), http://www.agrievolution.com/atti/brasile_02.ppt.

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