CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD

Proposed Regulations to Implement the Low Carbon Fuel Standard

Comments of Novozymes North America, Inc. for Public Hearing, April 23, 2009

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BEFORE THE
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD

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Proposed Regulations to Implement the Low Carbon Fuel Standard

Novozymes North America, Inc. ("Novozymes") is pleased to submit comments on the California Air Resources Board's ("CARB" or the "Board") proposed regulations to implement the State's Low Carbon Fuel Standard ("LCFS").[1] Novozymes is a world leader in bioinnovation and is the largest producer of industrial enzymes used in the production of both first generation and advanced generation alternative fuels from biomass. Novozymes strongly supports California's goal of achieving significant greenhouse gas ("GHG") emission reductions from transportation fuels.

Novozymes' comments are in two parts. In Part I, we provide overview comments on the LCFS Proposed Regulations and make recommendations to the Board as to how it might further its objectives of reducing the carbon intensity in transportation fuels and accelerating the development of advanced, low-carbon biofuels. In Part II, we comment on specific modeling issues that merit further scientific study and reevaluation of calculations of the carbon intensity of biofuels.

I. Overview and Recommendations

Novozymes shares the objectives of CARB, Governor Schwarzenegger, and Assembly Bill 32, to establish California as a leader in adopting governmental policies to address global warming and to reduce GHG emissions across all major sectors of the State's and the

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[1] Novozymes' Comments refer to proposed regulations in Title 17, new sections 95480-95489, and to the proposed incorporation into such regulations of the specific computer models referred to as CA-GREET and the Global Trade Analysis Project ("GTAP"). *See* Board's Notice of Public Hearing at 1, Feb. 24, 2009. The proposed regulations and the incorporated models are referred to herein collectively as the "Proposed Regulations."

nation's economy. The transportation sector is responsible for a substantial percentage of state-wide (and, indeed, world-wide) GHG emissions due to the ubiquity of gasoline and diesel as transportation fuels. CARB's Low Carbon Fuel Standard ("LCFS") is an important pioneering policy that will transform the transportation sector by encouraging the increased use of alternative low-carbon fuels and vehicles. The urgency of California's policy makes it imperative that the State implement LCFS to take advantage of proven technologies and existing industrial infrastructure that will make possible immediate, cost-effective reductions in carbon intensity. Among the alternatives to fossil fuels considered by the Board, increased production and deployment of biomass-based fuels, such as first- and advanced-generation ethanol, offer the cleanest, most rapid and cost-effective path for California and the nation to achieve meaningful and permanent GHG emission reductions from the transportation sector.

Novozymes commends the Board for its considerable efforts to measure and to compare the carbon intensity of gasoline, as a baseline fuel, and of alternative fuel "pathways," including ethanol from corn, sugar cane, and cellulosic biomass.[2] While the Staff Report's life-cycle approach is conceptually sound for direct GHG emissions from biofuels production, the treatment of indirect GHG emissions gives rise to concerns. More particularly, the Staff Report's analysis of GHG emissions attributed to indirect land use change ("ILUC"), which has been applied exclusively to biofuel pathways, suffers from serious methodological problems. The resulting ILUC penalties that are proposed to be assigned to corn-based, sugar-cane-based, and cellulosic-based ethanol are significantly higher than what Novozymes and the majority of scientists believe is warranted.

The peer review comments provided to CARB underscore the immaturity of ILUC modeling and the lack of scientific validation of the direct and indirect land use data and results

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2 *Proposed Regulation to Implement the Low Carbon Fuel Standard, Volume I: Staff Report Initial Statement of Reasons*, March 5, 2009 ("Staff Report").

relied upon in the Staff Report. For example, John Reilly of MIT notes that the "art" of land use modeling is "in its infancy."[3] He further notes that research "that could establish with confidence [ILUC] emissions is in its infancy."[4] Mr. Reilly also concludes that by relying on a "global economic system model," such as GTAP, for isolating indirect land use changes attributable to a single activity – increased ethanol production – attempts to validate the model from "direct empirical evidence" are "highly confounded" by multiple forces affecting land use change.[5] Mr. Reilly's comments underscore the fact that the Staff Report's ILUC modeling has not been rigorously tested by scientists, nor have its parameter assumptions and results been validated by real world data.

Two other peer reviewers emphasize the large, and scientifically unacceptable, range of uncertainty that surrounds ILUC modeling and results. Linsey Marr of Virginia Tech finds "the largest uncertainties in the estimation of carbon intensities are associated with indirect effects. Relatively speaking, the magnitude of direct effects are much more certain."[6] Valerie Thomas of Georgia Institute of Technology similarly concludes that "the values used to quantify the carbon intensity due to land use change for ethanol from corn and sugarcane are not yet sufficiently developed to be scientifically confirmed; refinement and validation of those quantities is needed."[7] These peer reviewer comments accurately reflect the record already before the Board, which demonstrates the lack of consensus in the scientific community and the

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3 J. Reilly, *Review of Proposed Regulations to Implement the Low Carbon Fuel Standard*, at 7 (Apr. 6, 2009) ("Reilly Comments").

4 *Id.* at 5.

5 *Id.*

6 L. Marr, *Scientific Review of the California Air Resource's Board's Proposal to Implement the Low Carbon Fuel Standard*, at 2 (Mar. 31, 2009).

7 V. Thomas, *Review of Proposed Regulation to Implement the Low Carbon Fuel Standard*, at 3 (undated, posted to CARB website, April 14, 2009).

high level of uncertainty surrounding ILUC modeling and calculations. The Board should also take account of the following evidence in the record:

- Over one hundred scientists have written to Governor Schwarzenegger stating that measurements of indirect land use change associated with biofuels is a "field of science in its nascent stage, [and] is controversial in much of the scientific community."[8]

- A report commissioned by the International Energy Agency Bioenergy Task Force 39, published April 1, 2009 ("2009 IEA Report"), found a wide variance in reported GHG emissions associated with corn-based ethanol production and concluded that "many improvements in both feedstock production and ethanol production efficiencies have not been accurately or fully factored into lifecycle analyses of ethanol's GHG emissions and energy balance."[9]

- A National Academy of Sciences paper found that the complex factors that drive land use change globally "tend to be difficult to connect empirically to land outcomes, typically owing to the number and complexity of the linkages involved."[10]

- The SCOPE workshop of a group of more than 75 scientists from 21 countries that met in Germany in September 2008, has just released its papers and proceedings. The leading paper on measuring GHG emissions from indirect land use change associated with biofuels concludes that "assessment of the GHG implications of land use and land conversion to biofuel crops is a very complex and contentious issue. A complete assessment of the GHG implications would require an accounting [of numerous international activities for which] the present assessment is limited due to the lack of data required to address all of these issues."[11]

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[8] Letter of scientists to Governor Schwarzenegger, *re: Opposed to Selective Enforcement of Indirect Effects in CA LCFS*, March 2, 2009.

[9] IEA News Release accompanying *An Examination of the Potential for Improving Carbon/Energy Balance of Bioethanol,* Apr. 1, 2009.

[10] B. L. Turner, et al., *The Emergence of Land Change Science for Global Environmental Change and Sustainability*, 104 PNAS 52, 20667 (2007).

[11] N.H. Ravindranath et. al., *Greenhouse Gas Implications of Land Use and Land Conversion to Biofuel Crops*, Proceedings of the Scientific Committee on Problems of the Environment (SCOPE), Ch. 6, p. 112-13 (2009).

- The European Union recently decided to postpone inclusion of indirect land use change measures in emerging biofuel regulations, pending completion of a two-year study aimed at gaining a better understanding of indirect land-use change effects on GHG emissions of biofuels.

Novozymes does not contend that ILUC impacts of ethanol pathways are necessarily zero. Rather, the immaturity of ILUC modeling and the questionable basis for assumptions used in connection with the GTAP model (both as to its input parameters and the use of its outputs) provide insufficiently rigorous scientific support for the specific ILUC penalties and carbon intensity values proposed in the Staff Report and Lookup Tables for each ethanol pathway. Novozymes believes that the scientific record before the Board, confirmed by the independent peer review comments, demonstrates that considerably more scientific research and validation is required before the Board has a defensible basis to prescribe absolute levels of ILUC impacts and carbon intensity values for both first generation and advanced generation ethanol.

To this end, Novozymes recommends that the Board should undertake further scientific study of the complex models used in making ILUC calculations and that the Board postpone adoption of specific carbon intensity values attributed to land use in its Lookup Tables for corn-based, sugar cane-based and cellulosic ethanol, until a broader scientific consensus is reached. To develop the necessary scientific record, the Board should consider from among the following complementary paths of study. *First*, the Board could direct its staff to convene an expert working group, comprised of scientists and industry experts, tasked with evaluating GTAP and other modeling approaches to account for both direct and indirect land-use change. *Second*, the Board should await the outcome of a proposed rulemaking being undertaken by the U.S. Environmental Protection Agency (EPA), pursuant to federal legislation, to quantify the direct and indirect GHG emissions attributable to different biofuel technologies. The EPA rulemaking process may contribute further scientific studies of ILUC modeling and calculations that the Board could consider. *Third*, the Board should consider requesting the National

Academy of Sciences to appoint a blue-ribbon panel of scientists and industry experts to conduct a rigorous review of ILUC modeling and results. *Fourth*, for whichever path of further scientific studies is chosen, the Board should evaluate the results of those studies, formulate a new proposal for addressing ILUC, submit that proposal to a new panel of peer reviewers with specific relevant expertise,[12] and, then, publish a proposed regulation with new ILUC calculations.

Whichever course is chosen to develop the "art" of ILUC modeling, the Board would then have a sounder scientific basis to incorporate carbon intensity values for all biofuels into binding regulations. Were the Board to adopt prematurely the GTAP model, "as is,"[13] and the proposed ILUC values in the Lookup Tables, there would be serious consequences for the continued development of the biofuels industry. If the Board locks in unvalidated ILUC penalties for first-generation ethanol, a worst-case scenario may be increased demand for foreign oil and less demand for U.S. production of ethanol (and of its feedstocks) – given the fact that even high performance ethanol production facilities could find it difficult to meet carbon-intensity standards proposed for the last five years of the 2011-2020 compliance period. Penalizing first generation producers of ethanol will also impede the rapid deployment of second generation ethanol made from biowaste, since first generation producers are positioned to be the leaders in R&D and production of biofuels from varied sources such as corn stover, biowaste, switchgrass and new non-food crops.

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[12] Several of the peer reviewers of the current proposed regulations, which, of course, covered a much wider range of issues, disclaimed specific expertise on the complex issues of modeling ILUC.

[13] Novozymes notes that the modification of the GTAP Model is described in a separate document (available at CARB's website) made by researchers from the Purdue University. It is unclear how the results of this study has been converted to the indirect land use changes reported in the Staff Report.

For the immediate future, combustion engines will remain the backbone of the U.S. transportation sector. Among the alternative fuels studied in the Staff Report, first and advanced generation ethanol work best with current automotive technology. Thus, in the short-term, the Board should not unduly penalize first-generation ethanol. To position the State's and the nation's transportation sector for the longer term, the Board should establish methodologies that recognize the manifest life-cycle advantages of advanced biofuels.

California is justifiably proud of being a national leader in promoting innovation in alternative fuels and transitioning the state's economy to a much reduced GHG footprint. California's innovative LCFS will likely be a model for other states' and the nation's efforts to reduce GHG emissions from transportation. To that end, the LCFS will establish important price signals for carbon embedded in fuels. These price signals arise from the LCFS credit and debit system under which producers of fuels will accrue tradable credits for exceeding annual carbon intensity targets and incur financial penalties for falling short of annual carbon intensity targets. Since carbon intensity values will become a form of currency, and because calculation of life cycle GHG emissions will be of central importance in other state, federal and international climate change programs, including the federal Renewable Fuels Standard, a possible federal LCFS, and possible federal and international cap and trade (with offsets) programs, it is imperative that the Board not enshrine the Staff Report's immature and unvalidated ILUC methodologies, "as is," in final regulations. Even by postponing for two years or so the incorporation of revised ILUC penalty calculations, the Board would not be compromising its overall objective of reducing GHG emissions.[14]

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[14] With the adoption of more realistic ILUC penalties for biofuels, those fuels could meet the increasingly tighter standards established in the LCFS proposed regulations and, therefore, there would be full realization of the carbon intensity reductions by 2012 or 2013, and in all subsequent compliance years. Novozymes' recommendation for further scientific study does not entail a permanent delay by 2 or 3 years in the start of the LCFS program or its applicability to biofuels.

II. Comments on Methodological Issues

In the remainder of its Comments, Novozymes will address specific methodological issues that should benefit from further rigorous scientific study of ILUC modeling.

1. GTAP is highly sensitive to modeling assumptions and parameters that have not been validated.

The GTAP model is a highly complex global macroeconomic model that was designed to show the directional impacts of certain policies and economic factors on the global economy. However, the model was not designed specifically for land use modeling nor to measure the precise extent to which increased biofuel production in the United States would cause land conversion (or of what kind of land) in other countries to make up for supposedly lost U.S. food production. For this purpose, GTAP is entirely dependent upon assumptions used to set the model's parameters. Among these assumptions and parameters are macroeconomic assumptions about many agricultural variables, such as elasticities of crop yields and rates of transformation of less-intensively used land to food production. In addition, the GTAP model was originally designed with a single land type and did not account for biofuels specifically. This omission has required the staff to adapt the model, although the underlying assumptions for doing so have not been clearly set forth in the Report. There is, thus, considerable uncertainty about the basis to support each of these key parameters in GTAP.

In light of these uncertainties, one would expect the Staff Report to present an extensive sensitivity analysis of each of the assumptions underlying the GTAP parameters. While the Staff Report refers to some sensitivity results, it does not present sufficient details to enable validation of the GTAP modeling. A benefit of the further study that Novozymes recommends is that extensive sensitivity analyses can be performed, which should inform the selection of parameters in the GTAP model. The entire process can be transparent to the cross-section of scientists involved in the study process.

In addition, the Staff Report evidently made adjustments in various data inputs to and outputs from the GTAP model. For example, the Staff Report acknowledges the sensitivity of results to assumptions about crop yield elasticities, land-use transformation elasticities, and trade elasticities. The Staff Report adjusted elasticity values used as inputs in the model from those the staff had previously proposed to use. Moreover, since the Staff Report used 2001 agricultural data, it had to make an ad hoc adjustment for subsequent changes in land use up to 2007. Yet, the Staff Report does not build in further experience curve effects for any of the elasticities it uses. Instead, the model freezes inputs at current levels and does not account for dynamic improvements in a wide range of land uses. Nor does the Staff Report reconcile the GTAP model inputs with extensive data on actual land use patterns experienced in the recent growth of U.S. corn production dedicated as an ethanol feedstock. Each of these modeling adjustments demonstrates the imprecision of the GTAP model, the limitations of available data inputs, and the role of simplifying assumptions.

As the peer review of Mr. John Reilly concluded, discerning the effects of U.S. biofuel production on international land use patterns from available macroeconomic data is "highly confounding." Although the GTAP model offers insights in the direction of broad economic changes caused by ethanol production, the model is not well suited to make the precise measurements of ILUC impacts attributed to U.S. production of ethanol for use in transportation fuel. Substantial additional empirical analysis is needed to justify the parameters and data used in making GTAP calculations. Given this level of scientific uncertainty, the Board should use caution before adopting ILUC models and calculations that may be counterproductive to the Board's worthy goals.

2. Annualizing the one-time GHG impact from land conversion

GTAP calculates the extent of indirect land use change, e.g. from grasslands or forest to crop production, and the amount of GHG emissions associated with such change in use. This land use change occurs only once with respect to any steady state increase in U.S. ethanol production, as the converted land will re-sequester carbon once ethanol production stops (in accordance with the *ceteris paribus* or "everything-else-equal" assumption).[15] The Staff Report converted the one-time change in the stock of ILUC emissions into an annual flow amount of ILUC emissions associated with the increase in U.S. biofuel production. This conversion required the staff to divide the total amount of ILUC emissions yielded by GTAP by an arbitrarily determined number of years of production of the biofuels.[16] Staff selected 30 years.

The selection of any "amortization" or "annualization" period is entirely arbitrary and the resulting ILUC penalty is highly sensitive to the length of such period. Had the staff selected a 15-year period, the annualized ILUC effects would have doubled. Had the staff selected a 60-year period, the annualized ILUC effects would have been reduced by 50 percent. Indeed, were one to assume that ethanol production levels remained constant indefinitely, the one-time ILUC increase in GHG emissions could be spread over an infinite period, effectively justifying a *de minimis* ILUC penalty. The Staff Report adduces no basis for the selected annualization period or the annualization method. Further study is needed to justify the appropriate annualization period and method for assigning ILUC impacts to increased U.S. biofuels production.

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15 The staff assumed 90 percent of above-ground carbon is released in one year, and the majority of below-ground carbon is released in five years, with a slower release over the next 15 years. See Staff Report, App. C-4 at C-17. The Staff Report acknowledges that some studies may show that a higher percentage of converted forestland may be sequestered in permanent wood products, such as furniture, rather than combusted. This would be an appropriate parameter to revisit during the expert scientific review of ILUC modeling.

16 *See id.*, at IV-47 and Apps. C3-C5.

A further arbitrariness is introduced when considering the possibility that, after a period of years, biofuels incentives may be eliminated and biofuels production (and consumption of food crops) may drop back to non-LCFS levels. With any such reduction in biofuels production, there should be a corresponding "release" or "reversion" of land to native vegetation or less intensive use. Just as the original increase in biofuels production is assumed to cause an increase in GHG emissions due to more intensive use of some land somewhere in the world, a release or reversion of the land should cause a corresponding reduction in GHG emissions. The Staff Report acknowledges that the end of LCFS credits could induce release or reversion of land, which should result in a reduction, if not complete reversal, of the ILUC GHG impacts originally attributed to increased U.S. biofuels production. This reversal will depend upon the extent and the time periods over which regeneration of the original land cover is assumed to occur. Despite recognition of possible land reversion when LCFS credits are phased out, the Staff Report makes no adjustment in its annualization of ILUC impacts for the possible or likely release or reversion of land and its concomitant reduction in ILUC impacts over the appropriate period.

Novozymes suggests that, in future studies, experts should carefully assess the sensitivity of ILUC calculations to the assumed annualization period and the likelihood of land reversion during that period. Indeed, since the IPCC has adopted a 100-year time horizon for measuring the climate impact of different types of GHG emissions, Novozymes believes that the Board should consider the appropriateness of using such an extended time horizon.

3. Adjust baseline case for marginal gasoline source.

The LCFS requires the Board to achieve annual reductions in carbon intensity measured against a baseline or reference scenario in which there is continued reliance on gasoline and diesel fuels. The Staff Report calculated the carbon intensity of California gasoline

(CARBOB) based on the carbon intensity of the average rather than the marginal source of crude oil delivered to California refineries. The Staff Report used an assumption that crude oil recovered in California represented 40 percent of the all crude delivered to California refineries. The Staff Report's reliance on the average carbon intensity of delivered crude oil stocks masks market mediated impacts. That is, in the current market, marginal crude oil supplies are being obtained from sources like shale and tar sands in Canada. Such supplies have much heavier carbon intensity than other supplies of crude oil delivered to California.

Novozymes believes that the LCFS reference case should be based on the carbon intensity of the marginal supplies of oil that would be displaced by the LCFS policies mandating lower carbon fuels. The size of California's oil market is sufficiently large that LCFS, when implemented, should have a depressive effect on crude oil prices in California and world-wide. This should have the marginal effect of displacing the most expensive sources of crude oil, which may happen to be carbon-heavy tar sands from Canada. The Staff Report's approach dilutes this price mediated effect by calculating the reference case carbon intensity value of gasoline using the *average* supplies of crude oil delivered to California refineries. Consistent with its incorporation of market-mediated effects in calculating ILUC, the Board should consider requiring that staff measure the carbon intensity of CARBOB using the *marginal* supplies of crude oil on the world market for determining the reference case carbon intensity value. Recalibrating the reference case's carbon intensity will better reflect the GHG reductions achieved by biofuels.

4. Static inputs to CA-GREET model should be modified to reflect dynamic improvements in the "experience curves"

a. Energy efficiency of ethanol plants. The energy efficiency of ethanol plants has been specified in the CA-GREET model using fixed historical data, without adjustment for

efficiency improvements.[17] The 2009 IEA Report documents how "energy efficiency at ethanol plants has increased steadily over time."[18] This has also been empirically documented by Adam Liska et al. in *Improvement in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of Corn-Ethanol* (Yale, 2008).

The IEA Report found that energy requirements for ethanol have been reduced by 16% for each doubling of production.[19] The IEA Report documents an "experience curve" from which further gains in refinery energy efficiency can be reasonably expected and calculated through extrapolation.[20] The Staff Report Lookup Tables are based on historic data (which in some cases were extrapolated to 2007 from 2001 data), without adjustment for reasonably expected efficiency gains that will occur continuously in the future. This static approach biases the calculation of carbon intensity values for corn-based ethanol and should be corrected by staff.

b. Credit for distillers grains and solubles. The Staff Report recognized that corn ethanol plants should be credited with GHG emission reductions attributable to the co-production of valuable distillers grains and solubles ("DGS"). DGS displaces the use of corn and other meal as animal feed, thereby reducing the life-cycle consumption of corn attributable to ethanol production. The Staff Report uses the value of 1.0 for the displacement ratio used to calculate the co-product credit[21], but recent studies done by Argonne National Laboratories and the University of Minnesota, as well as an International Energy Agency report, have determined the

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17 *Detailed California-Modified GREET Pathway for Corn Ethanol v. 2.1,* California Environmental Protection Agency, CARB, February 29, 2009 at 67-68.

18 2009 IEA Report at 24.

19 *Id.*

20 *See id.* at Figure 3-13, p.25.

21 Staff Report at IV-12 and Appendix C-11. *See also* CA. GREET Corn Model at 58. Displacement ratio is the ratio of the amount of corn displaced by 1 unit of distiller grains with solubles (DGS).

credit to be significantly higher.[22] The University of Minnesota study states that the CA-GREET model not only underestimates the use of DGS animal feed (a major assumption influencing the value of the displacement ratio), but inadequately identifies the sources on which its assumption relies.[23] A University of Nebraska study published on March 31, 2009, further documents the prevalence of unreported and outdated sources used in calculating the co-production credit in the CA-GREET model.[24] Again, the use of historic data to fix carbon intensity values in a Lookup Table inherently overstates the carbon intensity of corn ethanol.

While Proposed Regulations Method 2A could allow producers to present updated data on the co-product credit for DGS, the Proposed Regulations appear to limit new data to that which "accurately reflects the conditions *specific to the regulated party's* production and distribution process."[25] Thus, whereas the Lookup Tables are based upon industry-wide data, the Proposed Regulations hold producers to use of their own actual data in seeking permission to use Method 2A. The Proposed Regulations do not seem to include a procedure for producers to incorporate updated industry-wide data to modify inputs to the CA-GREET model. This too unjustifiably biases the Proposed Regulations against corn ethanol. The Board should consider a

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22 The University of Minnesota study determined the DGS displacement ratio to be 1.244. Shurman, Jerry, *Analysis of Current Feeding Practices of Distiller's Grains with Solubles in Livestock and Poultry Feed Relative to Land Use Credits Associated with Determining the Low Carbon Fuel Standard for Ethanol.* Department of Animal Science, University of Minnesota, March 25, 2009 ("2009 UMN Study") at 9. An updated Argonne National Laboratory study calculated the ratio to be approximately 1.27. Salil Arora, May Wu, and Michael Wang, *Update of Distillers Grains Displacement Ratios for Corn Ethanol Life-Cycle Analysis.* Center for Transportation Research, Energy Systems Division, Argonne National Laboratory, September 2008 ("2008 ANL Study") at 13. The commissioned IEA study reports an updated displacement ratio value of 1.28 (1 kg of distiller grains and solubles replaces 0.68 kg of corn and 0.6 kg of soybean meal). 2009 IEA Report at 26.

23 2009 UMN Study at 10.

24 Kenneth G. Cassman and Adam J. Liska, *Memo to the California Air Resources Board: Transparency and Documentation are needed for Parameter Assumptions and Underlying Data in the Life Cycle Assessment.* Nebraska Center for Energy Science Research, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, March 31, 2009 at 8.

25 *See* Prop. Regs., § 95486(c)(1) (emphasis added).

modification to Method 2A, which would allow producers and others to make a showing that the Lookup Tables need to be updated to reflect dynamic changes in the value of DGS co-production.

c. Agricultural parameters. The CA-GREET life-cycle model incorporates crop yields and fertilizer requirements as inputs to calculate the carbon intensity of corn-based ethanol. Again, the Staff Report's Lookup Tables are based on static, historical data for such direct land use effects. Just as in the case of energy efficiency in ethanol production, the 2009 IEA Report has documented an experience curve that shows corn yields have increased by 0.113 tons/ha/year and nitrogen requirements have decreased at the rate of 0.10 kg N/ton/year, based on fifty year trends.[26] The 2009 IEA Report also documents an experience curve improvement in fuel consumption needed to produce and to transport the crops. The CA-GREET model contains no projected improvements in land-use efficiency with respect either to corn yields or nitrogen requirements or improvements in fuel efficiency. This static feature of the model and the resulting Lookup Tables again bias GHG intensity values for the corn-based ethanol pathway. Moreover, Method 2A does not expressly contemplate modification of the input data to CA-GREET based solely on updated industry-wide data, as opposed to producer specific data.

The CA-GREET model also includes a parameter for direct land-use carbon emissions attributable to N_2O releases incident to tilling the soil and the use of fertilizer. The 2009 IEA Report documents that a "significant portion of the GHG emissions in the ethanol life-cycle arises from the category of land use emissions."[27] The methods for calculating N_2O emission factors are complex and dependent upon modeling assumptions. The IEA Report shows how improvements in tillage practices or fertilizer applications could have significant

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26 2009 IEA Report at 19-20 and Figures 3-7 and 3-8.

27 2009 IEA Report at 29.

effects upon calculated direct land-use emissions.[28] The CA-GREET model assumes a static value for direct land-use emissions. As with the other parameters, there is no adjustment factor for future improvements in land use and Method 2A of the Proposed Regulations does not expressly authorize the use of industry-wide data on land use to supplant the data inputs in CA-GREET.

In summary, the Board should consider directing staff to incorporate dynamic improvements in many land-use variables, as well as revising Method 2A to allow modification of the Lookup Table values. Novozymes has not attempted to identify all of the parameters and variables of the CA-GREET and GTAP modeling that should be revised to reflect continuous improvements and changes in land use and in ethanol production. Novozymes recommends the Board consider the treatment of the many issues identified in other scientific studies submitted to the staff, including the memorandum of February 27 from Liska and Cassmann, et al., and comments filed on behalf of UNICA (with special reference to the dynamic changes in Brazilian land use that are not captured in the Staff Report), RFA and Growth Energy. Incorporating experience curves that annually revise input values will provide a more realistic measure of the carbon intensity of the dynamic ethanol industry.

CONCLUSION

Novozymes is a world leader in development of new biotechnologies that offer the most cost-effective means of reducing GHG emissions in transportation fuels. Novozymes' enzymes are critical components of emerging new biofuel pathways, such as cellulosic ethanol. The Board can advance deployment of these emerging technologies by modifying the Proposed Regulations to ensure that absolute values of carbon intensity and indirect land-use adjustment factors are calculated using robust, scientifically defensible models that have been rigorously

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28 *Id.*

reviewed by expert scientific panels. Novozymes would also welcome the Board's renewed commitment to further analysis of complex and controversial ILUC models, as well as to modification of input parameters to better reflect dynamic, industry-wide improvements in lessening carbon intensity at different phases of the life-cycle production of ethanol.

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