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December 12, 2013

By Electronic Mail

Clerk of the Board
California Air Resources Board
1001 I Street, 23rd Floor
Sacramento, California 95812

Re: Proposed Regulation to Govern Commercialization of New Alternative Diesel Fuels (2103 Cal. Reg. Notice Register 1646 (October 25, 2013)

Dear Madam:

Growth Energy, an association of the nation's leading ethanol manufacturers and other companies who serve the nation's need for alternative fuels, is submitting to you the enclosed materials in response to the October 15, 2013, notice of proposed regulatory action to establish rules to govern the commercialization of new alternative diesel fuels.

Growth Energy is a strong supporter of biodiesel fuels, which continue to play an important part in our nation's efforts to achieve energy independence with renewable sources and to address environmental concerns. While we applaud the effort to incentivize greater use of all renewable fuels, including biodiesel, we have several significant concerns about the CARB staff's current regulatory proposal and the regulatory process.

Growth Energy believes that significant but feasible changes must be made to the CARB staff's proposed regulations, because the staff's current proposal does not include all reasonable and feasible methods of mitigating potential increases in emissions of oxides of nitrogen ("NOx"), among other reasons. The required changes to the staff's proposal are explained in the enclosed comment and will facilitate the lawful commercialization and use of biodiesel in California in a manner that fully protects the environment. In addition, the CARB staff has not yet publicly released all the test data and analysis on which it is basing its proposal. The decision to postpone the public hearing until March 2014 affords time for the staff to make full disclosure of all the data and analysis.

Please contact me or David Bearden, our General Counsel, at 605-965-2375 if you have any questions concerning this submission.

Sincerely,

Tom Buis

Tom Buis
CEO, Growth Energy

STATE OF CALIFORNIA

AIR RESOURCES BOARD

PROPOSED REGULATION TO GOVERN THE COMMERCIALIZATION OF NEW ALTERNATIVE DIESEL FUELS

GROWTH ENERGY'S RESPONSE
TO THE NOTICE OF PUBLIC HEARING DATED OCTOBER 15, 2013
2013 CAL. REG. NOTICE REG. 1646 (OCTOBER 25, 2013)

DECEMBER 12, 2013

Executive Summary

These Comments by Growth Energy on the proposed regulation to govern the commercialization of alternative diesel fuels address two main issues: (1) the duty of the Air Resources Board to mitigate potential increases in exhaust emissions of oxides of nitrogen ("NOx") from engines operated on biodiesel fuels, and (2) the analytical and procedural obligations for this rulemaking under the governing statutes.

Growth Energy strongly supports the use of biodiesel to achieve the Nation's environmental and energy independence objectives. As with other elements of California's effort to participate in those national strategies, however, the proposed alternative diesel fuel regulation must avoid having unintended negative environmental consequences, and must be considered carefully and in a manner that permits full and effective public participation. The flaws in the current regulatory proposal for alternative diesel fuels can be readily addressed through feasible mitigation measures, which would put biodiesel in parity with other alternative fuels for which the Board has for many years required risk mitigation through regulation.

As explained in these Comments, a detailed review of the Air Resources Board staff's analysis of the impacts of biodiesel use on NOx emissions, and a reanalysis of the data used by the staff made available to the public, shows that statistically significant increases in NOx emissions must be expected from the use of biodiesel blends of less than ten percent including blends of five percent and lower amounts of biodiesel. Applying the Board's normal precautionary principles, and consistent with the obligations of the California Environmental Quality Act and the Global Warming Solutions Act, the staff's proposed "Significance Level" of ten percent for biodiesel blends should instead be reduced to zero, because the use of biodiesel at any level can be expected to result in increased NOx emissions if not mitigated using reasonable and feasible measures.

These Comments also show that the potential increases in NOx emissions caused by biodiesel use under the proposed regulation are far larger than the NOx levels considered significant enough to require costly mitigation or control measures in the State's two "extreme" areas for ozone nonattainment -- the South Coast Air Basin and the San Joaquin Valley Air Pollution Control District. It would counterproductive, and not consistent with the governing statutes, for the Board to commit itself to measures that will result in NOx emissions increases in order to implement the low-carbon fuel standard under the Global Warming Solutions Act, especially when those increases greatly exceed the levels for which the State's air quality districts currently require mitigation or control of those emissions when they come from other sources.

These Comments also urge the Board to ensure that all comments and data received by the staff in connection with this rulemaking effort, or relied upon in formulating the proposed regulation, be placed in the public rulemaking file, and that sufficient time be allowed to review those materials before the Board considers regulatory action. If the Board directs the staff to address these important issues of public access and transparency -- which are governed by the Administrative Procedure Act -- this regulatory item can be completed in a timely manner.

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Comments of Growth Energy on the Proposed Regulation To Govern the Commercialization of New Alternative Diesel Fuels

Growth Energy respectfully submits these comments on the California Air Resources Board's proposed regulation to govern the commercialization of new alternative diesel fuels (the "proposed ADF regulation"). As explained below, Growth Energy believes that the Board should direct the staff to make revisions in the proposed ADF regulation and cannot adopt the proposed ADF regulation in its current form. The proposed ADF regulation does not require the use of feasible measures that are necessary to mitigate adequately the potential adverse environmental impacts of increased use of biodiesel blends in California.

I. INTRODUCTION AND OVERVIEW

CARB's obligation to examine the impacts of widespread biodiesel usage, and to address potential adverse environmental impacts, have recently been clarified by the California Court of Appeal in *POET LLC, et al. v. California Air Resources Board*, (2013) 218 Cal. App. 4th 681. In that litigation, ARB claimed that it intended to "ensure" that there would be "no" increase in regulated pollutants from Diesel-powered engines in California as a result of the LCFS regulation, and in particular that there would be no increase in exhaust emissions of oxides of nitrogen ("NOx") resulting from the use of biodiesel fuel. 218 Cal. App. 4th at 732.

The CARB staff's proposed approach to the task of NOx mitigation in the proposed ADF regulation falls far short of the claimed metric: whatever the benefits of the proposed ADF regulation for other purposes, the staff's approach will not ***ensure*** that the implementation of the LCFS regulation can cause ***no*** increase in NOx emissions. These comments briefly outline, and the accompanying materials fully explain, the unnecessary environmental risks to the State's efforts to control NOx emissions that the proposed ADF regulation fails to address.[1] Those risks are not based on unqualified speculation, or merely the opinion of Growth Energy; the risks can be demonstrated from the emissions data that the CARB staff has placed in the docket, when those data are evaluated using simple but appropriate statistical tools and methods.[2] Moreover, the increases in NOx emissions, which the CARB staff's data establish, are significant by any contemporary measure: the increases in NOx emissions that the increased use of biodiesel will cause as a result of the LCFS regulation are many times larger than the NOx increases that CARB and regional air quality authorities require to be mitigated. (*See* pp. 18-19 below.)

Addressing the problem of increased NOx emissions is a feasible task, as the Staff Report that accompanies the proposed ADF regulation concedes. Once the risk is established, and the methods of mitigation are determined to be feasible, CARB's task is clear: under the California Environmental Quality Act ("CEQA"), it must require mitigation before it can proceed with regulation.[3]

In this instance, mitigation may impose direct costs on the firms that choose to use biodiesel to comply with the LCFS regulation, and indirect costs on the operators of Diesel engines, but CARB decided nearly five years ago that the benefits of the LCFS regulation overall were worth the costs. In that respect, biodiesel should be treated no differently than the

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[1] In addition to the materials cited below in notes 2 and 4, Growth Energy is also attaching to these comments for inclusion in the rulemaking file -- and for analysis and response by the Board -- its earlier comments on the CARB staff's ADF regulatory proposal, submitted on September 16, 2013. Those comments, and likely many other comments from other parties, were not placed in the rulemaking file when CARB issued its 45-day notice. *See* pp. 13-14 below (requirements of the California Administrative Procedure Act).

[2] *See* R. Crawford, "NOx Emissions Impact of Soy- and Animal-Based Biodiesel Fuels: A Re-Analysis" (Dec. 2013) (hereinafter "Crawford Report"), attached to these Comments as Exhibit A.

[3] *See POET*, 218 Cal. App. 4th at 731-742.

alternative fuels that the LCFS regulation requires for gasoline, which are ethanol, natural gas and electricity.

Instead of requiring the Diesel sector to bear its fair share of the costs of the LCFS regulation through proper environmental mitigation, however, the CARB staff's proposed approach deploys what the Staff Report calls an "Effective Blend Level" concept to exempt biodiesel fuel from any meaningful mitigation requirement.[4] Rather than following the precautionary principles that have constantly guided CARB rulemaking -- which in other contexts sometimes have inclined the Board to require extreme regulatory stringency based on scant evidence of actual harm -- in this one instance, the CARB staff appears intent on risking air quality rather than requiring feasible, if costly to some, mitigation measures. The CARB Staff Report suggests in one place that this deviation from the Board's longstanding regulatory strategy may be necessary to protect the growth of the biodiesel "market."[5] But the CARB staff cites no evidence to support its speculation that the biodiesel "market" is at risk, and there is no evidence of such a risk in the public rulemaking file. Even if such a private market risk existed, however, neither the California Global Warming Solutions Act nor the California Government Code allow CARB to consider factors extrinsic to the statutes in meeting the clean-air goals established by law.[6] The California statutes protect California citizens and air quality, not market entrepreneurs and arbitragers. It is not the proper purpose of any California regulation to

[4] *See* Declaration of James M. Lyons (hereinafter "Lyons Decl."), attached to these Comments as Exhibit B.

[5] *See* Staff Report at 63 (rejecting "immediate" mitigation because "this option has the potential to disrupt or even collapse the burgeoning ADF market by unnecessarily placing overly restrictive requirements that are not warranted by emissions testing"). Tellingly, that portion of the Staff Report has no citations to support the claim.

[6] In its current proposal, the CARB staff is engrafting onto the Global Warming Solutions Act a provision allowing it to avoid mitigation of environmental harm, in order to encourage particular industries or based on general economic preferences. CARB cannot proceed in that fashion. *Cf. Clean Air Constituency v. CARB*, (1974) 11 Cal.3d 801 (CARB lacks authority to establish criteria to govern its actions that are not found in its enabling statutes).

pick "winners" and "losers:" all fuels, including all alternative fuels, must have their environmental risks properly assessed, and when feasible mitigated in full.

The balance of these Comments is divided into two parts. The first part, in Section II below, summarizes the technical analyses contained in the accompanying report of Robert Crawford, a statistician with expertise in evaluation of emissions data, and in the Declaration of James M. Lyons, an expert in automotive air pollution who evaluates the "Effective Blend Level" concept as a method of addressing the risks of increased NOx emissions. Section II also summarizes the relevant portions of the Staff Report dealing with the available mitigation methods and their feasibility. The second part, in Section III below, explains the Board's legal obligations to mitigate the risks of increased NOx emissions presented by biodiesel fuel usage.

II. ENVIRONMENTAL ASSESSMENT OF THE PROPOSED REGULATION

Were the matter ever in any doubt, the Court of Appeal's *POET* decision, which the California Supreme Court has recently declined to review, makes it clear that the Board must take seriously the issue of NOx emissions increases from the increased use of biodiesel in order to comply with the LCFS regulation. CARB has recognized, first in the LCFS regulatory process and more recently in court, that the LCFS regulation will increase the use of biodiesel. The CARB staff now claims in the current ADF rulemaking, however, that emissions testing proves that the use of biodiesel blends containing less than 10 percent biodiesel will not increase NOx emissions. That claim is demonstrably wrong, as Mr. Crawford establishes in his analysis of the available emissions data. (*See* Exhibit A and Section A below.) Because the data do not support the CARB staff's claims that operation of engines on blends below 10 percent biodiesel will not increase NOx emissions, and in fact show the opposite, CARB has a duty to mitigate. The CARB staff's environmental analysis is also unsound in other respects as well, as demonstrated in Mr. Lyons' Declaration. (*See* Exhibit B and Section B below.)

A. Impact of the Proposed Regulation on Exhaust Emissions of Oxides of Nitrogen

Mr. Crawford's report carefully reviews each of the six studies cited in the CARB staff's literature review on biodiesel NOx emissions, as well as CARB's biodiesel characterization study ("Durbin 2011") and the data available from that study. It is important to note at the outset that not all the data from the CARB study has been made available to the public. CARB should publish all of the testing presented in Durbin 2011[7] and any future testing that it sponsors in a complete format that allows for reanalysis, and an opportunity to evaluate those materials prior to the deadline for submission of public comments or CARB's hearing on the approval of the proposed ADF regulation.

Putting aside the CARB staff's failure to make a complete disclosure of the data reflected in Durbin 2011, it is clear that the data from Durbin and the other six studies do not support the CARB staff's conclusion and, indeed, the data refute the staff's conclusion in some instances. These are the salient points from Mr. Crawford's analysis:

- There is ***no evidence*** supporting the staff conclusion that NOx emissions do not increase until the B10 level is reached. Instead, there is consistent and strong evidence that biodiesel increases NOx emissions in proportion to the biodiesel blending percent.

- There is ***clear and statistically significant evidence*** that biodiesel increases NOx emissions at the B5 level in at least some engines for both soy- and animal-based biodiesels.

None of the six studies in the literature measured the NOx emissions impact from biodiesel at blending levels below B10. Only two studies tested a fuel at the B10 level. All

[7] The data should be published in a useable format, and should include (a) the measured emission values for each individual test replication; or (b) averages across all test replications, along with the number of replications and the standard error of the individual tests. The first format (individual test replications) is preferable because that would permit a full examination of the data including effects such as test cell drift over time.

other testing was at the B20 level or higher. Because none tested a B5 (or similar) fuel, the studies do not constitute substantial evidence that NOx emissions are not increased at B5 or other blending levels below B10. Those six studies therefore provide no data or evidence supporting the validity of the staff's claim that biodiesel below B10 does not increase NOx emissions. To the contrary, all of the studies are consistent with the contention that biodiesel increases NOx emissions in proportion to the blending percent. Indeed, two of those six studies present evidence and data that the NOx impact from biodiesel is a continuous effect that is present even at very low blending levels and will increase at higher levels in proportion to the blending percentage.

With regard to the CARB biodiesel characterization report, Mr. Crawford has uncovered the fact that for the three engines for which the CARB staff has published the emission values measured in engine dynamometer testing, all of the data demonstrate that biodiesel fuels significantly increase NOx emissions for both soy- and animal-based fuels by amounts that are proportional to the blending percent. That is true for on-road and off-road engines and for a range of test cycles. When B5 fuels were tested for those engines, NOx emissions were observed to increase. NOx emission increases are smaller at B5 than at higher blending levels and the observed increases for two engines were not statistically significant by themselves based on the pair-wise t-test employed in Durbin 2011. However, the testing for one of the engines (the 2007 MBE4000) showed statistically significant NOx emission increases at the B5 level for both soy- and animal-based blends. The data are sufficient to disprove the staff's contention that biodiesel blends at the B5 level will not increase NOx emissions.

In sum, based on examination of all of the studies cited by CARB as the basis for its proposal to exempt biodiesels below B10 from mitigation, it is clear that the available research points to a very substantial risk, if not a certainty, that both soy- and animal-based biodiesel blends will increase NOx emissions in proportion to their biodiesel content, including at the B5 level. Based on data in the CARB Biodiesel Characterization Report, soy-based biodiesels will increase NOx emissions by about 1% at B5 and 2% at B10, while animal-based biodiesels will increase NOx emissions by about one-half as much: 0.45% at B5 and 0.9% at B10. All of the available research shows that the NOx increases are real and implementation of mitigation measures will be required to prevent increases in NOx emissions due to biodiesel use at blending levels below B10. The available research likewise demonstrates that, to the extent CARB is identifying B10 as a "threshold of significance" under CEQA, (1) the utilization of this threshold is unsupported by the evidence in the record. For the same reasons, and for the reasons discussed in Section III.B below, the utilization of B10 as a "threshold" is contrary to the Legislature's mandate that the regulations should "not interfere with … efforts to achieve and maintain federal and state ambient air quality standards." Cal Health & Safety Code § 38562(b)(4).

B. The "Effective Blend Level" Concept

Mr. Lyons' Declaration builds on the analysis performed by Mr. Crawford and demonstrates that the CARB staff's "effective blend level" concept will operate to exempt biodiesel from any meaningful mitigation, even if biodiesel is causing real-world increases in NOx exhaust emissions from Diesel engines operated in California. Mr. Lyons demonstrates, in particular, that "despite the forecast nine-fold increase in biodiesel use in California from 50 million to 450 million gallons from 2013 to 2023 … the forecast Effective Blend Level of biodiesel decreases to less than zero over virtually all of the period in question." (Lyons Decl. ¶ 14.)

If the fractional coefficients being applied in the "effective blend level" equation (*see* Lyons Decl. ¶¶ 11-12) are incorrect to any significant extent, the environment will not be protected. The CARB staff has apparently selected those coefficients without allowing for the possibility of errors that could understate NOx impacts -- a clear violation of CARB's precautionary norms. The adverse effects will be severe if there is error in the coefficients, because the CARB staff itself recites evidence that the biodiesel market will be concentrated in low-blend biodiesel. (*See* Lyons Decl. ¶¶ 15, 17.) Growth Energy is aware of no other regulatory concept in any CARB program in which mitigation measures required by CEQA depend on a formula that could err as easily as the "effective blend level" equation could.

The mischief in the "effective blend level" coefficients lies in their complexity and the risk of quantitative error. A much simpler but equally fatal analytical flaw, which also violates both sound regulatory policy and the requirements of CEQA, is the failure of the effective blend level calculation to ensure that any NOx increases that require mitigation will be addressed by the use of a mitigation measure in the ***same*** relevant location, and at the ***same*** time, as the NOx increases are occurring. If NOx mitigation does not occur in the same area and at the same time as biodiesel use that increases NOx emissions, the environmental harm presented by those increased NOx emissions will go unmitigated; the adverse impacts of NOx increases are defined by their location, and their severity is greatest at the time when the emissions occur.

As Mr. Lyons points out, the "effective blend level" concept does not fully protect, for example, Los Angeles residents, if NOx increases experienced in the summertime in Los Angeles can be offset by the biodiesel "market" in whole or part by practices that mitigate those emissions in a different season and in another place. (*See* Lyons Decl. ¶¶ 19-20.) The regulation, as proposed by the CARB staff, does nothing even to incentivize, much less require, the biodiesel "market" to deliver mitigation at the time and place it is needed. That may be a result of the CARB staff's conclusion that, as they have written the mitigation rule, it is unlikely that mitigation will ever be required; if so, that simply underscores the weakness of the mitigation rule itself (*see*, *e.g.*, Lyons Decl. ¶¶ 8-10, 15-18). CEQA and its implementing guidelines must be read to require mitigation where and when the adverse effect would otherwise occur. By not accounting for that requirement, the "effective blend level" concept violates CEQA.

Mr. Lyons' Declaration identifies other flaws in the staff proposal that must be addressed. As his Declaration establishes, the data on which CARB relies for its assumption that "new-technology" diesel engines will have lower NOx emissions when operated on biodiesel is inadequate to support the weight it is given by the CARB staff (*see* Lyons Decl. ¶¶ 21-23); that data cannot be treated as substantial evidence to support a regulation that posits lower emissions from such engines. Each of the issues raised in Mr. Lyons' Declaration must be addressed by the Board.

C. Available Mitigation Measures

Mitigation of the risks of NOx increases from biodiesel usage is entirely feasible. The proposed ADF regulation can easily be modified to ensure that the use of biodiesel will not result in increased NOx emissions by setting the "Significance Level" for biodiesel blends at zero -- which is the level that the available data require -- so that mitigation would occur whenever and wherever it should. In addition, CARB must eliminate the use of annual statewide averages for determining the "effective blend levels" and instead use actual blend levels at the batch level. These two changes would require that mitigation be applied to all biodiesel blends in light of the actual amount of biodiesel present in each specific blend.

Appendix 1 to proposed Section 2293.5(c) specifies the three mitigation measures that CARB staff has identified for mitigation of increases in NOx emissions due to biodiesel use. They include (i) addition of di-tert-butyl peroxide to biodiesel blends at a level that varies with the amount of biodiesel in the blend and (ii) blending of low-NOx diesel fuel along with biodiesel into biodiesel blends. Under the staff's proposal, parties responsible for mitigation of increased NOx emissions from biodiesel can choose either of those approaches. They all could be easily applied to any blend containing ten percent or less biodiesel, as well as blends of more than ten percent, if appropriately modified to ensure that there would be no increase in NOx emissions associated with the use of biodiesel. The Staff Report and the rulemaking file contain no significant evidence that such approaches could not be applied at the batch level.

In addition to conceding the feasibility of the three identified mitigation measures by including them in the proposed ADF regulation, the Staff Report also provides cost estimates for the application of each measure.[8] Absorption of those estimated costs by entities or individuals choosing to use biodiesel is in no way inconsistent with the types of costs that have been imposed by CARB on other California businesses and residents in other regulatory programs. Indeed, the Global Warming Solutions Act gives CARB no choice but to require the regulated parties and their downstream customers to absorb those costs: the Legislature has specifically directed that CARB is to "ensure" that "activities undertaken pursuant to the regulations" adopted to implement the Act -- including the use of biodiesel to comply with the LCFS regulation -- "do not interfere with … efforts to achieve and maintain federal and state ambient air quality standards." Cal. Health & Safety Code § 38562(b)(4).

[8] Those costs are $0.25 per gallon of biodiesel blended for di-tert-butyl peroxide, $1.20 per gallon of biodiesel blended for low-NOx diesel and a one-time expense of between $100,000 and $200,000 for the certification of a biodiesel blend that could then be sold in California in any volume. *See* Staff Report at 59 and *id*. App. C.

In addition to being technically feasible, consistent with costs required by other CARB regulations, the mitigation measures outlined in the Staff Report can be implemented. In some instances, regulated parties would simply have to ensure that steps have been taken to ensure their final blends meet the fuel property specifications associated with the certified blend. Mitigation using di-tert-butyl peroxide or low NOx diesel requires only knowing the amount of biodiesel in the blend and ensuring that the entity performing the blending also be responsible for adding di-tert-butyl peroxide or low NOx diesel to the blend.

The Staff Report claims that "[i]t would be impractical to determine the individual blend level for each gallon of biodiesel blend being sold across the State." The Staff Report continues: "To do so would require the retailers and marketers of biodiesel blends (i.e., the diesel dispensing facilities) to continuously test and determine the biodiesel blend level for each of the approximately 3 billion gallons of on-road diesel fuel sold in California each year."[9] The Staff Report offers no support for that claim, however, and it is contradicted by the overall regulatory experience under the LCFS regulation as well as the data necessary to actually to employ the Effective Blend concept. The LCFS regulation already requires producers of biodiesel sold in California or other entities to which the fuel is transferred to report the volumes of biodiesel to CARB via the Low Carbon Fuel Standard Reporting Tool ("LRT") in order to receive greenhouse gas emission reduction credits. (*See* 17 C.C.R. § 95484(b)(B)(2).) Moreover, in order to employ the Effective Blend concept, data regarding the amount of biodiesel used in blends of five percent or less, as well as the type and volumes of biodiesel used in blends of more than five percent, would be required. Presumably, this data will also be derived from the LRT. The LRT is currently treated by CARB as an accurate source of data regarding biodiesel use in

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[9] Staff Report at 23.

California.[10] The CARB staff regularly publishes quarterly summaries of greenhouse gas credits generated from biodiesel and other fuels under the LCFS.[11]

Given that biodiesel producers must report both their production volumes and production pathways (*e.g.*, soy-based, animal-based, or other) to CARB via the LRT in order to generate greenhouse gas credits under the LCFS regulation, the implementation of NOx mitigation measures involving use of di-tert-butyl peroxide or low NOx diesel under the ADF regulation would be simple and straightforward. All that CARB would have to do is to require entities earning greenhouse gas credits under the LCFS for non-certified biodiesel blends to also report to CARB via the LRT how, when, and where mitigation of the NOx emissions associated with the use of that biodiesel via di-tert-butyl peroxide or low NOx diesel was achieved. Recordkeeping requirements analogous to those that already apply to data reported via the LRT would also apply to mitigation of biodiesel NOx impacts.

By following that approach, CARB staff can both ensure that there are no NOx increases associated with the use of biodiesel in California while simultaneously avoiding any need to involve retailers and marketers of biodiesel in the "impractical" activity described in the Staff Report unless those same retailers and marketers of biodiesel were earning greenhouse gas reduction credits from biodiesel under the LCFS. If the CARB Executive Officer or the staff disagrees with Growth Energy on this point, it is incumbent upon them to explain why and for the Board to give the public an opportunity to respond before CARB weighs the evidence and arguments, because this is an issue involving available and practical mitigation measures under CEQA.

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[10] *See, e.g.*, Staff Report at 30.

[11] The most recent summary for the second quarter of 2013 is available at http://www.arb.ca.gov/fuels/lcfs/20130930_q2datasummary.pdf.

III. THE BOARD'S LEGAL OBLIGATIONS

The Court of Appeal clarified in *POET* that CARB is subject, among other provisions, to sections 15004 and 15352 of the CEQA Guidelines. The Court of Appeal also gave clear instructions about the need to comply with the rulemaking-file requirements of the Administrative Procedure Act. Perhaps most importantly, the Court of Appeal made plain the Board's duty to mitigate, in particular with respect to the subject of NOx exhaust emissions from engines operated on biodiesel. This final section of Growth Energy's comments summarizes the steps that CARB must take to meet its obligations under the governing statutes as clarified by the Court in *POET*, with primary emphasis on the duty to mitigate under CEQA.

A. Procedural and Structural Rulemaking Requirements

CARB must recognize that *any* communications it has received of a factual nature, or data that it has acquired in connection with regulatory action, are not exempt from the requirement to disclose those communications in the public rulemaking file under Gov't Code § 11347.3 (absent a valid and complete demonstration of privilege). *See POET*, 218 Cal. App. 4th at 741-754. At present, the rulemaking file for the ADF proposal cannot possibly be claimed to include all material required for the rulemaking file: Growth Energy knows this, because its own comments of September 16, 2013 (*see* Exhibit C) have not been placed in that file. As noted above, CARB has apparently not made full disclosure of all data relevant to the Durbin emissions study. (*See* p. 5 above.) Likewise, the Staff Report claims that the proposed ADF regulation "is based upon feedback from nearly every corner of the regulated industry as well as other impacted organizations and individuals that are impacted by actions concerning or that regulate the fuels industry."[12] The rulemaking file, when last checked in the week of

[12] Staff Report at 3-4.

December 2, 2013, did not contain any written comments reflecting that “feedback;” those materials should have been in the rulemaking file no later than October 15, 2013, when the public hearing on the proposed ADF regulation was announced. *See* Cal. Gov’t Code § 11347.3(a), (b)(6), (7).

Accordingly, one of the first steps that CARB must take in the current proceeding is to ensure compliance with section 11347.3 of the Government Code, and re-issue a notice of proposed rulemaking to allow 45 days of comment prior to a public hearing at which it would take action on a proposed ADF regulation. If CARB takes this action quickly, there will be no delay in program objections, including reconsideration of the LCFS standards during 2014.

It is also clear from *POET* that, as CEQA and the guidelines direct, there are other reasons why CARB cannot take action with respect to the proposed ADF regulation. *See POET*, 218 Cal. App. 4th at 717-731. If CARB is the decision-maker with respect to the proposed ADF regulation, it must evaluate the environmental issues presented by the staff proposal for itself, and complete the environmental review process required under CEQA and CARB regulations, *before* the Board commits CARB to the proposed ADF regulation. Likewise, the opportunity to participate in the environmental analysis must be adequate -- which in this instance, it is not, in part because not all the relevant data has been publicly released. A comment deadline scarcely 45 days after the staff analysis has been released, when all relevant data have not been provided, will not permit an adequate environmental assessment.

To comply with the procedural requirements of CEQA as confirmed in *POET*, CARB should direct the staff to complete the environmental review process (including full disclosure of the basis for its proposal); prepare a complete rulemaking file; respond to public comment; and publish a Final Statement of Reasons, before considering the proposed ADF regulation on its merits at a subsequent hearing. At that hearing, interested parties should be allowed all the time required to present and to respond to legitimate technical, empirically-based analysis of the environmental issues presented by the proposed ADF regulation. CARB can neither approve the proposed ADF regulation with the record in its current status and at the type of hearing planned for this week, nor defer the environmental assessment to a point after it has committed itself to the proposed regulation, nor delegate any of its CEQA responsibilities identified by the Court of Appeal in *POET*.

B. The Duty to Analyze Potential Impacts and Mitigate Significant Impacts

The importance of NOx emissions control for California air quality is well known and is illustrated, for example, by a June 2012 CARB Report entitled "Vision for Clean Air: A Framework for Air Quality and Climate Planning," prepared in conjunction with the South Coast Air Quality Management District and the San Joaquin Valley Unified Air Pollution Control District.[13] That report addressed potential control strategies that will be required to bring the only two areas of the country designated as being in extreme nonattainment of the National Ambient Air Quality Standard ("NAAQS") for ozone[14] into attainment. In working to identify potential control strategies, these three agencies chose to focus on ways to reduce NOx emissions (and not hydrocarbon emissions) because "NOx is the most critical pollutant for reducing regional ozone and fine particulate matter."[15] The report also identifies diesel-powered heavy-duty vehicles as the largest source of NOx emissions in California, and classifies diesel-powered

[13] *See* CARB, Vision for Clean Air: A Framework for Air Quality and Climate Planning (June 27, 2012) (available at http://www.arb.ca.gov/planning/vision/docs/vision_for_clean_air_public_review_draft.pdf).

[14] *See* http://www.epa.gov/airquality/ozonepollution/designations/2008standards/final/region9f.htm.

[15] *See* Vision for Clean Air at 10.

construction, mining and agricultural equipment as other significant sources of NOx emissions in California.

As indicated above, CEQA requires that mitigation measures must be implemented locally and must be contemporaneous with the emissions events of concern; the type of statewide mitigation concept contained in the Staff Report, unbounded to relevant time intervals, does not comply with CEQA. It is therefore relevant to consider, by way of example, the heavy-duty diesel vehicle NOx emissions inventory for the South Coast and San Joaquin Valley areas during calendar years 2015 and 2020. On-road heavy-duty diesel emission estimates were developed using CARB's latest emission factor modeling software EMFAC2011.[16] The model estimates regional emissions, in tons/day, by vehicle class and model year. Emission estimates were computed for both older vehicles as well as vehicles using what CARB would consider to be NTDEs -- which in this case were assumed to be 2010 and later model-year vehicles. Emissions from off-road construction equipment were estimated using CARB's 2011 In-Use Inventory model.[17] Emissions from agricultural equipment were developed using CARB's OFFROAD2007 model because CARB's regulatory in-use inventory model is still under development for this sector.[18] For construction and agricultural equipment, NTDE vehicles were assumed to be those with engines certified to Tier 4 emission standards. It was assumed Tier 4 engines are used in 2013-and-later model year engines rated at or below 50 HP, 2014-and-later model year engines between 51 and 750 HP, and to 2015-and-later model years for engines

[16] For more information on EMFAC2011 and to download modeling materials, *see* http://www.arb.ca.gov/msei/modeling.htm.

[17] For more information on CARB's off-road model, *see* http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles.

[18] Information about OFFROAD2007 and the pending in-use agricultural sector model can also be found at http://www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles.

above 750 HP. The resulting inventories are presented in Tables 1 and 2 for calendar years 2015 and 2020, respectively.

Table 1

2015 Heavy-Duty NOx Emission Inventories for the South Coast and San Joaquin Valley Air Basins (tons per day)

Air Basin	On-Road		Construction		Agricultural		Total
	Older	NTDE	Older	NTDE	Older	NTDE	
South Coast	117.27	14.91	24.04	0.42	3.92	0.26	160.82
San Joaquin	83.07	15.44	11.85	0.21	26.73	1.86	139.16

Table 2

2020 Heavy-Duty NOx Emission Inventories for the South Coast and San Joaquin Valley Air Basins (tons per day)

Air Basin	On-Road		Construction		Agricultural		Total
	Older	NTDE	Older	NTDE	Older	NTDE	
South Coast	66.53	28.44	20.0	1.8	2.2	0.5	119.47
San Joaquin	32.13	30.33	11.5	1.0	15.0	3.8	93.76

Tables 1 and 2 show that vehicles with NTDEs account for only about 10% of NOx emissions in 2015 and between 25% and 40% of NOx emissions in 2020. Therefore, even if the CARB staff's assertion that biodiesel does not increase emissions from NTDEs were correct, the majority of NOx emissions would still be coming from older engines where, it has been clearly demonstrated, NOx emissions increase with the use of higher biodiesel blends. Applying the estimated NOx increases developed from the available emissions data analyzed by CARB staff (*see* Lyons Decl. ¶ 9, Table 1), and assuming more realistically and conservatively (as CEQA requires) that NTDEs will be affected by biodiesel in the same way as other engines, the overall increases in NOx emissions caused by biodiesel use will be (i) between 0.7 and 1.6 tons per day in 2015 and between 0.5 and 1.2 tons per day in 2020 in the South Coast, and (ii) between 0.6 and 1.4 tons per day in 2015 and between 0.4 and 0.9 tons per day in 2020 in the San Joaquin Valley.

One way to put the magnitude of these potential increases in NOx emissions into context is to compare them with the air quality significance thresholds applied by the South Coast Air Quality Management District[19] and the San Joaquin Valley Air Pollution Control District[20] when evaluating the potential emission impacts of proposed projects in their jurisdictions. In the San Joaquin Valley Air Pollution Control District, the threshold is 10 tons per year while in the South Coast basin, the threshold is 0.0275 tons per day which equals 10 tons per year if daily emissions occurring over the course of the year are equal. The potential 2015 emission increases from the use of five percent biodiesel blends in the South Coast and the San Joaquin Valley are ***25 to 60 times higher*** than the 10-ton-per-year threshold. Even with reductions in diesel NOx emissions by 2020, the potential NOx increases due to biodiesel remains ***15 to 40 times higher*** than the 10-ton-per-year threshold. Potential increases of NOx emissions on such a scale require mitigation at the time and in the place where they will occur. *See POET*, 218 Cal. App. 4th at 740 (under CEQA, "ARB must adopt mitigation measures that minimize the adverse impact" of a potential increase in NOx emissions). Moreover, despite the fact that increases of NOx emissions resulting from the proposed ADF regulation would significantly exceed thresholds adopted by the South Coast Air Quality Management District and the San Joaquin Valley Air Pollution Control District, the ISOR fails to analyze whether the proposed ADF regulation has the potential to conflict with, or obstruct, applicable air quality plans.

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[19] *See* http://www.aqmd.gov/ceqa/handbook/signthres.pdf.

[20] *See* http://www.valleyair.org/transportation/CEQA%20Rules/GAMAQI%20Jan%202002%20Rev.pdf.

There is no question that an increase in biodiesel usage will occur as a result of the LCFS regulation, a measure adopted under the Global Warming Solutions Act. *See POET*, 218 Cal. App. 4th at 700-01. Consequently, under not only CEQA, but also the Global Warming Solutions Act, CARB cannot permit emissions increases from biodiesel of such a magnitude when both the South Coast Air Quality Management District's 2012 Air Quality Management Plan[21] and the San Joaquin Valley's 2013 One Hour Ozone Plan[22] contain control measures intended to reduce NOx emissions by amounts of about the same magnitude as the potential emission increases resulting from biodiesel use at the five percent level. *See* Cal Health & Safety Code § 38562(b)(4) (greenhouse gas control measures such as the LCFS regulation are not to "interfere with … efforts to achieve and maintain federal and state ambient air quality standards.").

IV. CONCLUSION

For the reasons explained above and in the reports and analyses accompanying these Comments, CARB cannot lawfully approve the proposed ADF regulation at this week's public hearing. CARB cannot commit itself now to the proposed ADF regulation and adjourn the important task of environmental assessment to a post hoc process. The available emissions data do not support, and indeed refute, the CARB staff's claim that low-level biodiesel blends are benign. Mitigation is required, and is required at the time and in the places where the NOx emissions increases can be expected to occur. If CARB directs the staff to make straightforward changes in the proposed ADF regulation in a timely manner that will require feasible mitigation

[21] *See* South Coast Air Quality Management District, 2012 Air Quality Management Plan, 2012 AQMP CARB/EPA/SIP Submittal (Dec. 2012) (available at http://www.aqmd.gov/aqmp/2012aqmp/Final/index.html).

[22] *See* http://www.valleyair.org/Air_Quality_Plans/Ozone-OneHourPlan-2013.htm.

measures, there will be no jeopardy to any program objective of the Global Warming Solutions Act or any other CARB project.

Respectfully submitted,

GROWTH ENERGY

EXHIBIT A

NOx Emissions Impact of Soy- and Animal-based Biodiesel Fuels: A Re-Analysis

December 10, 2013

Prepared for:

Sierra Research
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Prepared by:

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NOX EMISSIONS IMPACT OF SOY- AND ANIMAL-BASED BIODIESEL FUELS: A RE-ANALYSIS

prepared for:

Sierra Research, Inc.

December 10, 2013

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NOX IMPACT OF SOY- AND ANIMAL-BASED BIODIESEL FUELS: A RE-ANALYSIS

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1. EXECUTIVE SUMMARY

1.1 Background on the Proposed Rule

The California Air Resources Board (CARB) has proposed regulations on the commercialization of alternative diesel fuel (ADF) that were to be heard at the December 2013 meeting of the Board. The proposed regulations seek to "… create a streamlined legal framework that protects California's residents and environment while allowing innovative ADFs to enter the commercial market as efficiently is possible."[1] In this context ADF refers to biodiesel fuel blends. Biodiesel fuels are generally recognized to have the potential to decrease emissions of several pollutants, including hydrocarbons (HC), carbon monoxide (CO), and particulate matter (PM), but are also recognized to have the potential to increase oxides of nitrogen (NOx) unless mitigated in some way. NOx emissions are an important precursor to smog and have historically been subject to stringent emission standards and mitigation programs to prevent growth in emissions over time. A crucial issue with respect to biodiesel is how to "… safeguard against potential increases in oxides of nitrogen (NOx) emissions."[2]

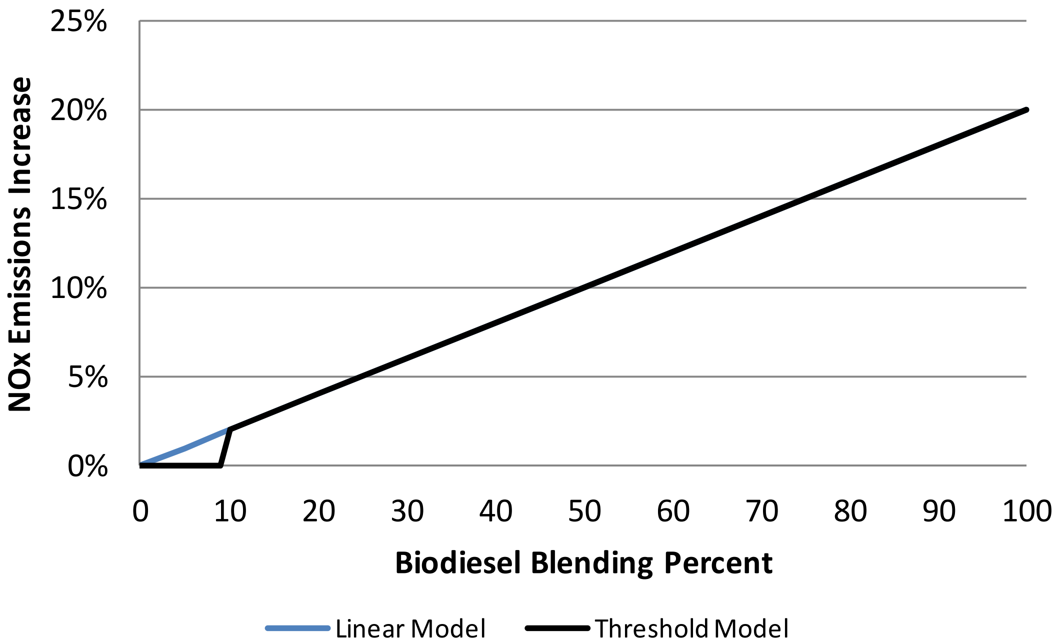
The proposed regulations are presented in the Staff Report: Initial Statement of Reasons (ISOR) for the Proposed Regulation on the Commercialization of New Alternative Diesel Fuels[3] (referenced as ISOR). Chapter 5 of the document describes the proposed regulations, which exempt diesel blends with less than 10 percent biodiesel (B10) from requirements to mitigate NOx emissions:

> There are two distinct blend levels relative to biodiesel that have been identified as important for this analysis. Based on our analysis to date, we have found that diesel blends with less than 10 percent biodiesel by volume (<B10) have no significant increase in any of the pollutants of concern and therefore will be regulated at Stage 3B (Commercial Sales not Subject to Mitigation). However, we have found that biodiesel blends of 10 percent and above (≥B10) have potentially significant increases in NOx emissions, in the absence of any mitigating factors, and therefore those higher blend levels will be regulated under Stage 3A (Commercial Sales Subject to Mitigation).[4]

[1] "Notice of Public Hearing to Consider Proposed Regulation on the Commercialization of New Alternative Diesel Fuels." California Air Resources Board, p. 3. http://www.arb.ca.gov/regact/2013/adf2013/adf2013notice.pdf.
[2] Ibid. p. 3.
[3] "Proposed Regulation on the Commercialization of New Alternative Diesel Fuels. Staff Report: Initial Statement of Reason." California Air Resources Board, Stationary Source Division, Alternative Fuels Branch. October 23, 2013. http://www.arb.ca.gov/regact/2013/adf2013/adf2013isor.pdf.
[4] Ibid, p. 22.

Existing research on the NOx emission effects of biodiesel has consistently been conducted under the hypothesis that the emission effect will be linearly proportional to the blending percent of neat biodiesel (B100) with the base diesel fuel. The Linear Model that has been accepted by researchers is shown as the blue line in Figure 1-1. The Staff position cited above is that biodiesel fuels do not increase NOx emissions until the fuel blend reaches 10% biodiesel. This so-called Staff Threshold Model departs from the Linear Model that underlies past and current biodiesel research by claiming that NOx emissions do not increase until the biodiesel content reaches 10 percent.

Figure 1-1
Linear and Staff Threshold Models for Biodiesel NOx Impacts



The Staff Threshold model is justified by the statement: "Based on our analysis to date, we have found that diesel blends with less than 10 percent biodiesel by volume (<B10) have no significant increase in any of the pollutants of concern." Other portions of the ISOR state that Staff will track "… the effective blend level on an annual statewide average basis until the effective blend level reaches 9.5 percent. At that point, the biodiesel producers, importers, blenders, and other suppliers are put on notice that the effective blend-level trigger of 9.5 percent is approaching and mitigation measures will be required once the trigger is reached."[5] Until such time, NOx emission increases from biodiesel blends below B10 will not require mitigation.

Section 6 of the ISOR presents a Technology Assessment that includes a literature search the Staff conducted to obtain past studies on the NOx impact of biodiesel in heavy-duty

[5] Ibid, p. 24.

engines using California diesel (or other high-cetane diesel) as a base fuel. Section 6.d presents the results of the literature search with additional technical information provided in Appendix B. The past studies include the Biodiesel Characterization and NOx Mitigation Study[6] sponsored by CARB (referenced as Durbin 2011).

The results of the Staff literature search are summarized in Table 1-1, which has been reproduced from Table 6.1 of the ISOR. For B5 and B20, the data represent averages for a mix of soy- and animal-based biodiesels, which tend to have different impacts on NOx emissions (animal-based biodiesels increase NOx to a lesser extent). For B10, the data represent an average for soy-based biodiesels only. Staff uses the +0.3% average NOx increase at B5 in comparison to the 1.3% standard deviation to conclude:

> Overall, the testing indicates different NOx impacts at different biodiesel percentages. Staff analysis shows there is a wide statistical variance in NOx emissions at biodiesel levels of B5, providing no demonstrable NOx emissions impact at this level and below. At biodiesel levels of B10 and above, multiple studies demonstrate statistically significant NOx increases, without additional mitigation.[7]

Table 1-1
Results of Literature Search Analysis

Biodiesel Blend Level	NOx Difference	Standard Deviation
B5	0.3%	1.3%
B10[a]	2.7%	0.2%
B20	3.2%	2.3%

Source: Table 6.1 of Durbin 2011
Notes:
[a] Represents data using biodiesel from soy feedstocks.

<u>The Staff conclusion is erroneous because it relies upon an apples-to-oranges comparison among the blending levels</u>. Each of the B5, B10, and B20 levels include data from a different mix of studies, involving different fuels (soy- and/or animal-based), different test engines, and different test cycles. The B5 values come solely from the CARB Biodiesel Characterization study, while the B10 values come solely from other studies. The B20 values are a mix of data from the CARB and other studies. The results seen in the table above are the product of the uncontrolled aggregation of different studies that produces incomparable estimates of the NOx emission impact at the three blending levels.

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[6] "CARB Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California: Biodiesel Characterization and NOx Mitigation Study." Prepared by Thomas D. Durbin, J. Wayne Miller and others. Prepared for Robert Okamoto and Alexander Mitchell, California Air Resources Board. October 2011.
[7] ISOR, p. 32.

As will be demonstrated in this report, the Staff conclusion drawn from the data in Table 1-1 is not supported by past or current biodiesel research, including the recent testing program sponsored by CARB. In fact, past and current studies indicate that biodiesel blends at any level will increase NOx emissions in proportion to the blending percent unless specifically mitigated by additives or other measures.

1.2 Summary and Conclusions

The following sections of this report examine the studies cited by CARB one-by-one. As evidenced from this review, it is clear that the data do not support the Staff conclusion and, indeed, the data refute the Staff conclusion in some instances. Specifically:

- There is no evidence supporting the Staff conclusion that NOx emissions do not increase until the B10 level is reached. Instead, there is consistent and strong evidence that biodiesel increases NOx emissions in proportion to the biodiesel blending percent.

- There is clear and statistically significant evidence that biodiesel increases NOx emissions at the B5 level in at least some engines for both soy- and animal-based biodiesels.

Considering each of the six past studies obtained from the technical literature and their data on high-cetane biodiesels comparable to California fuels, we find the following:

1. None of the six studies measured the NOx emissions impact from biodiesel at blending levels below B10. Only two studies tested a fuel at the B10 level. All other testing was at the B20 level or higher. Because none tested a B5 (or similar) fuel, none of them can provide direct evidence that NOx emissions are not increased at B5 or other blending levels below B10.

2. These studies provide no data or evidence supporting the validity of the Staff's Threshold Model that biodiesel below B10 does not increase NOx emissions. In fact, all of the studies are consistent with the contention that biodiesel increases NOx emissions in proportion to the blending percent.

3. Two of the studies present evidence and arguments that the NOx impact from biodiesel is a continuous effect that is present even at very low blending levels and will increase at higher levels in proportion to the blending percentage.

Considering the CARB Biodiesel Characterization report, we find that:

4. For the three engines where CARB has published the emission values measured in engine dynamometer testing, all of the data demonstrate that biodiesel fuels significantly increase NOx emissions for both soy- and animal-based fuels by amounts that are proportional to the blending percent. This is true for on-road and off-road engines and for a range of test cycles.

5. Where B5 fuels were tested for these engines, NOx emissions were observed to increase. NOx emission increases are smaller at B5 than at higher blending levels and the observed increases for two engines were not statistically significant by themselves based on the pair-wise t-test employed in Durbin 2011.[8] However, the testing for one of the engines (the 2007 MBE4000) showed statistically significant NOx emission increases at the B5 level for both soy- and animal-based blends.

By itself, the latter result is sufficient to disprove the Staff's contention that biodiesel blends at the B5 level will not increase NOx emissions.

Based on examination of all of the studies cited by CARB as the basis for its proposal to exempt biodiesels below B10 from mitigation, it is clear that the available research points to the expectation that both soy- and animal-based biodiesel blends will increase NOx emissions in proportion to their biodiesel content, including at the B5 level. CARB's own test data demonstrate that B5 will significantly increase NOx emissions in at least some engines.

Based on data in the CARB Biodiesel Characterization report, soy-based biodiesels will increase NOx emissions by about 1% at B5 (and 2% at B10), while animal-based biodiesels will increase NOx emissions by about one-half as much: 0.45% at B5 (and 0.9% at B10). All of the available research says that the NOx increases are real and implementation of mitigation measures will be required to prevent increases in NOx emissions due to biodiesel use at blending levels below B10.

Finally, we note that CARB has not published fully the biodiesel testing data that it relied on in support of the Proposed Rule and thereby has failed to adequately serve the interest of full public disclosure in this matter. The CARB-sponsored testing reported in Durbin 2011 is the sole source of B5 testing cited by CARB as support for the Proposed Rule. Durbin 2011 publishes only portions of the measured emissions data in a form that permits re-analysis; it does not publish any of the B5 data in such a form. It has not been possible to obtain the remaining data through a personal request to Durbin or an official public records request to CARB and, to the best of our knowledge, the data are not otherwise available online or through another source.

CARB should publish all of the testing presented in Durbin 2011 and any future testing that it sponsors in a complete format that allows for re-analysis. Such a format would be (a) the measured emission values for each individual test replication; or (b) averages across all test replications, along with the number of replications and the standard error of the individual tests. The first format (individual test replications) is preferable because that would permit a full examination of the data including effects such as test cell drift over time. Such publication is necessary to assure that full public disclosure is achieved and that future proposed rules are fully and adequately informed by the data.

[8] As discussed in Section 3.3, the pair-wise t-test is not the preferred method for demonstrating statistical significance.

1.3 Review of 2013 CARB B5 Emission Testing

In December 2013, after the release of the ISOR and in response to an earlier Public Records Act request, CARB released a copy of new CARB-sponsored emission testing conducted by Durbin and others at the University of California CE-CERT[9]. The purpose of the study was "… to evaluate different B5 blends as potential emissions equivalent biodiesel fuel formulations for California."[10] Three B5 blends derived from soy, waste vegetable oil (WVO), and animal biodiesel stocks were tested on one 2006 Cummins ISM 370 engine using the hot-start EPA heavy-duty engine dynamometer cycle. A preliminary round of testing was conducted for all three fuels followed by emissions-equivalent certification testing per 13 CCR 2282(g) for two of the fuels. As noted by Durbin: "[t]he emissions equivalent diesel certification procedure is robust in that it requires at least twenty replicate tests on the reference and candidate fuels, providing the ability to differentiate small differences in emissions."[11]

Soy and WVO B5 Biodiesel

The B5-soy and B5-WVO fuels were blended from biodiesel stocks that were generally similar to the soy-based stock used in the earlier CARB Biodiesel Characterization Study (Durbin 2011) with respect to API gravity and cetane number. In the preliminary testing, the two fuels "…showed 1.2-1.3% statistically significant [NOx emissions] increases with the B5-soy and B5-WVO biodiesel blends compared to the CARB reference fuel."[12] The B5-WVO fuel caused the smaller NOx increase (1.2%) and was selected for the certification phase of the testing. There, it "… showed a statistically significant 1.0% increase in NOx compared to the CARB reference fuel"[13] and failed the emissions-equivalent certification due to NOx emissions.

Animal B5 Biodiesel

The B5-animal derived fuel was blended from an animal tallow derived biodiesel that was substantially different from the animal based biodiesel used in the earlier Durbin study, and was higher in both API gravity and cetane number. The blending response for cetane number was also surprising, in that blending 5 percent by volume of a B100 stock (cetane number 61.1) with 95% of CARB ULSD (cetane number 53.1) produced a B5 fuel blend with cetane number 61.

In preliminary testing, the B5-animal fuel showed a small NOx increase which was not statistically significant, causing it to be judged the best candidate for emissions-equivalent certification. In the certification testing, it "…showed a statistically

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[9] "CARBB5 Biodiesel Preliminary and Certification Testing." Prepared by Thomas D. Durbin, G. Karavalakis and others. Prepared for Alexander Mitchell, California Air Resources Board. July 2013. This study is not referenced in the ISOR, nor was it included in the rule making file when the hearing notice for the ADF regulation was published in October 2013.
[10] Ibid, p. vi.
[11] Ibid, p. viii.
[12] Ibid, p. 8.
[13] Ibid, p. 9.

significant 0.5% reduction in NOx compared to the CARB reference fuel"[13] and passed the emissions-equivalent certification. The NOx emission reduction for this fuel blend appears to be real for this engine, but given the differences between the blendstock and the animal based biodiesel blendstock used in the earlier Durbin study it is unclear that it is representative for animal-based biodiesels in general..

Summary

The conclusions drawn in the preceding section are not changed by the consideration of these new emission testing results. For plant-based biodiesels (soy- and WVO-based), the new testing provides additional and statistically significant evidence that B5 blends will increase NOx emissions at the B5 level. The result of decreased NOx for the B5 animal-based blend stands out from the general trend of research results reviewed in this report. However:

- The same result – reduced NOx emissions for some fuels and engines – has sometimes been observed in past research, as evidenced by the emissions data considered by CARB staff in ISOR Figure B.3 (reproduced in Figure 2.1 below). As shown, some animal-based B5 and B20 fuels reduced NOx emissions while others increased NOx emissions with the overall conclusion being that NOx emissions increase in direct proportion to biodiesel content of the blends and that there is no emissions threshold.

- Increasing cetane is known to generally reduce NOx emissions and has already been proposed by CARB as a mitigation strategy for increased NOx emissions from biodiesel[14]. The unusual cetane number response in the blending and the high cetane number of the B5-animal fuel may account for the results presented in the recently released study.

Considering the broad range of plant- and animal-based biodiesel stocks that will be used in biodiesel fuels, we conclude that the available research (including the recently released CARB test results) indicates that unrestricted biodiesel use at the B5 level will cause real increases in NOx emissions and that countermeasures may be required to prevent increases in NOx emissions due to biodiesel use at blending levels below B10.

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[14] For example, see Durbin 2011 Section 7.0 for a discussion of NOx mitigation results through blending of cetane improvers and other measures.

2. CARB LITERA TURE REVIEW

The Staff ISOR explains that the Appendix B Technology Assessment is the basis for CARB's conclusion that biodiesels below B10 have no significant impact on NOx emissions. The assessment is based on data from seven studies (identified in Table 2-1) that tested high-cetane diesel fuels. The first study (Durbin 2011) is the Biodiesel Characterization Study that was conducted for CARB, while the others were obtained through a literature search.

Tab le 2-1
List of Studies f rom High -Cetane Liter ature Sear ch

Primary Author	Title	Published	Year
Durbin	Biodiesel Mitigation Study	Final Report Prepared for Robert Okamoto, M.S. and Alexander Mitchell, CARB	2011
Clark	Transient Emissions Comparisons of Alternative Compression Ignition Fuel	SAE 1999-01-1117	1999
Eckerle	Effects of Methyl Ester Biodiesel Blends on NOx Emissions	SAE 2008-01-0078	2008
McCormick	Fuel Additive and Blending Approaches to Reducing NOx Emissions from Biodiesel	SAE 2002-01-1658	2002
McCormick	Regulated Emissions from Biodiesel Tested in Heavy-Duty Engines Meeting 2004 Emissions	SAE 2005-01-2200	2005
Nuszkowski	Evaluation of the NOx emissions from heavy duty diesel engines with the addition of cetane improvers	Proc. I Mech E Vol. 223 Part D: J. Automobile Engineering, 223, 1049-1060	2009
Thompson	Neat fuel influence on biodiesel blend emissions	Int J Engine Res Vol. 11, 61-77.	2010

Source: Table B.2 of Durbin 2011

Figure 2-1 reproduces two exhibits from Appendix B that show increasing trends for NOx emissions with the biodiesel blending level. Based on the slopes of the trend lines,

Figure 2-1
NOx Emission Increases Observed in Biodiesel Research Cited in Staff ISOR

Figure B.2: NOx Impact of Soy Biodiesel Blended in High Cetane Base Fuel

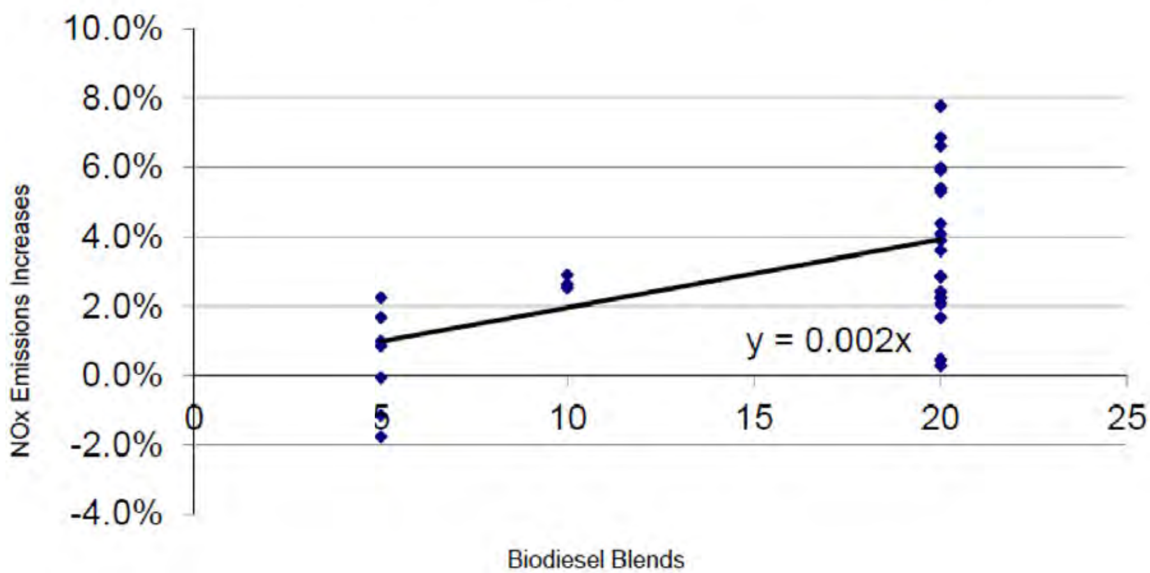
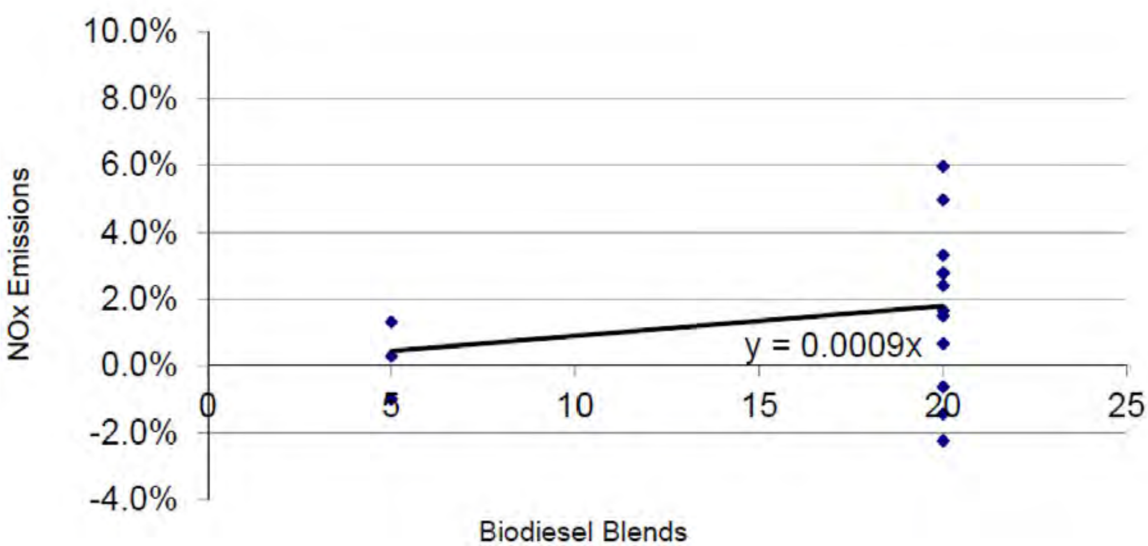


Figure B.3: NOx Impact of Animal Biodiesel Blended in High Cetane Base Fuel



Source: Figures B.2 and B.3 of Appendix B: Technology Assessment soy-based biodiesels are shown to increase NOx emissions by approximately 1% at B5, 2% at B10, and 4% at B20. Animal-based biodiesels are shown to increase NOx emissions by about one-half as much: 0.45% at B5, 0.9% at B10, and 1.8% at B20. Although there is substantial scatter in the results, these data do not appear to support the Staff Threshold Model that biodiesel does not increase NOx emissions at B5 but does so at B10.

We will examine the Durbin 2011 study at some length in Section 3. In this section, we look at each of the other studies cited by the Staff to find out what the studies say about NOx emissions impacts at and below B10.

2.1 Review of Literature Cited in the ISOR

The Staff literature search sought and selected testing that used fuels with cetane levels comparable to California diesel fuels; the Staff does not, however, list those fuels or provide the data that support the tables and figures in Appendix B of the ISOR. Therefore, we have necessarily made our own selection of high-cetane fuels in the course of reviewing the studies. The key testing and findings of each study are summarized below, with a specific focus on what they tell us about NOx emission impacts at B10 and below.

2.1.1 Clark 1999

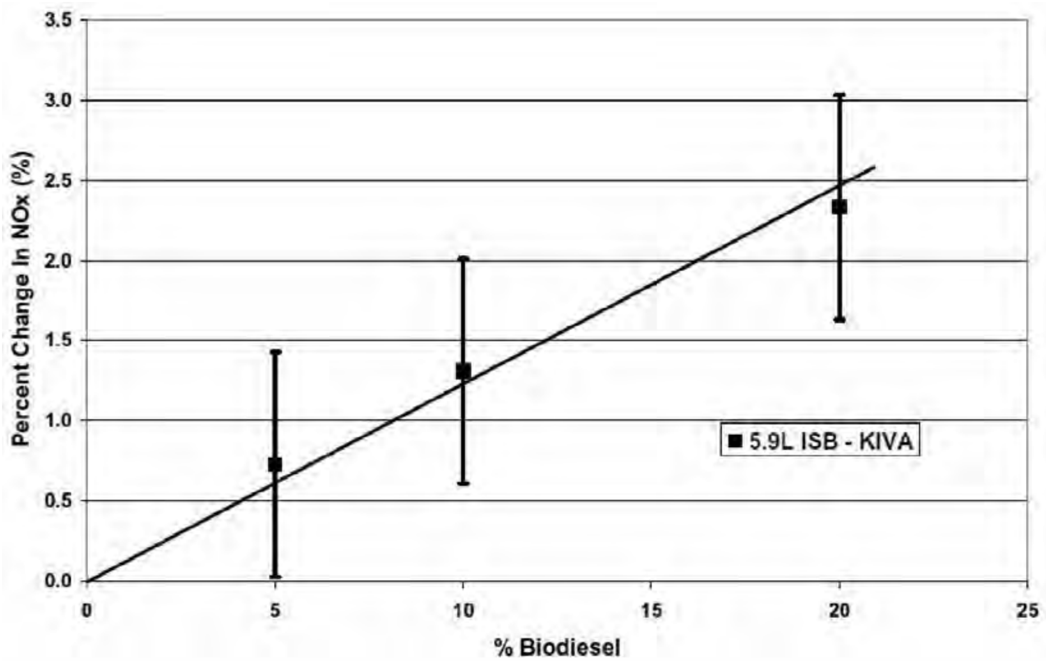
This study tested a variety of fuels on a 1994 7.3L Navistar T444E engine. Of the high-cetane base fuels, one base fuel (Diesel A, off-road LSD) was blended and tested at levels of B20, B50, and B100. NOx emissions were significantly increased for all of the blends. The other base fuel (CA Diesel) was tested only as a base fuel. Its NOx emissions were 12% below that of Diesel A, making it is unclear whether Diesel A is representative of fuels in CA. This study conducted no testing of the NOx emissions impact from biodiesels at the B10 level or below.

2.1.2 Eckerle 2008

This study tested low and mid/high-cetane base fuels alone and blended with soy-based biodiesel at the B20 level. The Cummins single-cylinder test engine facility was used in a configuration representative of modern diesel technology, including cooled EGR. Testing was conducted under a variety of engine speed and load conditions. FTP cycle emissions were then calculated from the speed/load data points. The test results show that B20 blends increase NOx emissions compared to both low- and high-cetane base fuels. This study conducted no testing of the NOx emissions impact from biodiesels at the B10 level or below.

The study notes that two other studies "show that NOx emissions increase nearly linearly with the increase in the percentage of biodiesel added to diesel fuel." Eckerle's Figure 21 (reproduced below as Figure 2-2) indicates a NOx emissions increase at B5, which is the basis for the statement in the abstract that "Results also show that for biodiesel blends containing less than 20% biodiesel, the NOx impact over the FTP cycle is proportional to the blend percentage of biodiesel." The authors clearly believe that biodiesel fuels have NOx emission impacts proportional to the blending percent at all levels including B5.

Figure 2-2
Impact of Biodiesel Blends on Percent NOx Change for the 5.9L ISB Engine Operation Over the FTP Cycle



Source: Figure 21 of Eckerle 2008

2.1.3 McCormick 2002

This study tested low- and mid-cetane base fuels alone and blended with soy- and animal-based biodiesel at the B20 level. The testing was conducted on a 1991 DDC Series 60 engine using the hot-start U.S. heavy-duty FTP. NOx emission increases were observed for both fuels at the B20 level. Mitigation of NOx impacts was investigated by blending a Fisher-Tropsch fuel, a 10% aromatics fuel and fuel additives. This study conducted no testing of the NOx emissions impact from commercial biodiesels at the B10 level or below.

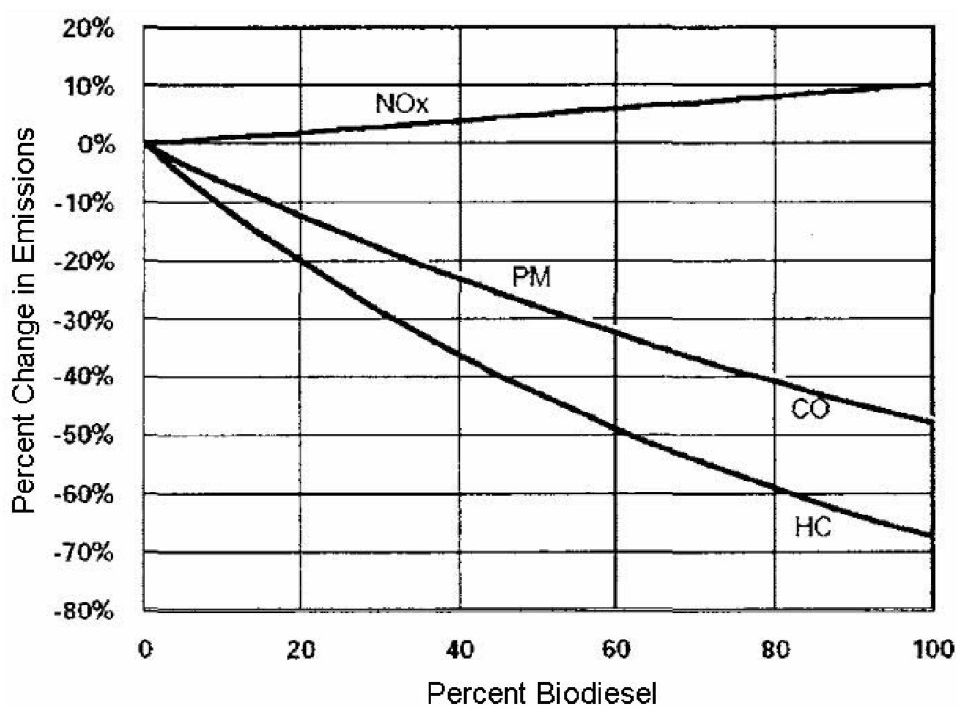
This study also tested a Fisher-Tropsch (FT) base fuel blended at the B1, B20, and B80 levels. Although the very high cetane number (≥75) takes it out of the range of commercial diesel fuels, it is interesting to note that the study measured higher NOx emissions at the B1 level than it did on the FT base fuel and substantially higher NOx emissions at the B20 and B80 levels. While the B1 increase was not statistically significant given the uncertainties in the emission measurements (averages of three test runs), it is clear that increased NOx emissions have been observed at very low blending levels.

2.1.4 McCormick 2005

This study tested blends of soy- and animal-based biodiesels with a high-cetane ULSD base fuel at B10 levels and higher. Two engines were tested – a 2002 Cummins ISB and a 2003 DDC Series 60, both with cooled EGR. The hot-start U.S. heavy-duty FTP test cycle was used. The majority of testing was at the B20 level with additional testing at the B50 and B100 levels. One soy-based fuel was tested at B10. The study showed NOx emission increases at B10, B20, and higher levels. The study also investigated mitigation of NOx increases. This study conducted no testing of the NOx emissions impact from biodiesels below the B10 level.

The authors present a figure (reproduced as Figure 2-3) in their introduction that shows their summary of biodiesel emission impacts based on an EPA review of heavy-duty engine testing. It shows NOx emissions increasing linearly with the biodiesel blend percentage.

Figure 2-3
Trend in HC, CO, NOx and PM Emissions with Biodiesel Percent



Source: McCormick 2005

2.1.5 Nuszkowski 2009

This study tested five different diesel engines: one 1991 DDC Series 60, two 1992 DDC Series 60, one 1999 Cummins ISM, and one 2004 Cummins ISM. Only the 2004 Cummins ISM was equipped with EGR. All testing was done using the hot-start U.S. heavy-duty FTP test cycle. The testing was designed to test emissions from fuels with and without cetane-improving additives. Although a total of five engines were tested, the base diesel and B20 fuels were tested on only two engines (one Cummins and one DDC Series 60) because there was a limited supply of fuel available. NOx emissions increased on the B20 fuel for both engines. A third engine (Cummins) was tested on B20 and B20 blended with cetane improvers to examine mitigation of NOx emissions. This study conducted no testing of the NOx emissions impact from biodiesels at the B10 level or below.

2.1.6 Thompson 2010

This study examined the emissions impacts of soy-based biodiesel at the B10 and B20 levels relative to low-cetane (42), mid-cetane (49), and high-cetane (63) base fuels using one 1992 DDC Series 60 engine. The emissions results were measured on the hot-start U.S. heavy-duty FTP cycle. The study found that NOx emissions were unchanged (observed differences were not statistically significant) at B10 and B20 levels for the low- and mid-cetane fuels. NOx emissions increased significantly at B10 and B20 levels for the high-cetane fuels. This study conducted no testing of the NOx emissions impact from biodiesels at levels below B10.

2.2 Conclusions Based on Studies Obtained in Literature Search

From the foregoing summary of the studies cited by Staff, we reach the conclusions given below.

1. None of the six studies measured the NOx emissions impact from commercial-grade biodiesel at blending levels below B10, and only two studies tested a fuel at the B10 level. All other testing was at the B20 level or higher. Because none tested a B5 (or similar) fuel, none is capable of providing direct evidence regarding NOx emissions at B5 or other blending levels below B10.

2. These studies provide no data or evidence supporting the validity of Staff's Threshold Model that biodiesel below B10 does not increase NOx emissions. In fact, all of the studies are consistent with the contention that biodiesel increases NOx emissions in proportion to the blending percent.

3. Two of the studies present evidence and arguments that the NOx impact from biodiesel is a continuous effect that is present even at very low blending levels and will increase at higher levels in proportion to the blending percentage. One study tested a Fischer-Tropsch biodiesel blend at B1 and observed NOx emissions to increase (but not by a statistically significant amount).

###

3. CARB BIODIESEL CHARACTERIZATION STUDY

3.1 Background

CARB sponsored a comprehensive study of biodiesel and other alternative diesel blends in order "… to better characterize the emissions impacts of renewable fuels under a variety of conditions."[15] The study was designed to test eight different heavy- duty engines or vehicles, including both highway and off-road engines using engine or chassis dynamometer testing. Five different test cycles were used: the Urban Dynamometer Driving Schedule (UDDS), the Federal Test Procedure (FTP), and 40 mph and 50 mph CARB heavy-heavy-duty diesel truck (HHDDT) cruise cycles, and the ISO 8178 (8 mode) cycle. Table 3-1 (reproduced from Table ES-1 of Durbin 2011) documents the scope of the test program. Because the Staff relied only on engine dynamometer testing in its Technology Assessment, only the data for the first four engines (shaded) are considered here.

Table 3-1
A Breakdown of the Test Engines for the Different Categories of Testing

2006 Cummins ISM[a]	Heavy-duty on-highway	Engine dynamometer	
2007 MBE4000	Heavy-duty on-highway	Engine dynamometer	
1998, 2.2 liter, Kubota V2203-DIB	Off-road	Engine dynamometer	
2009 John Deere 4.5 L	Off-road	Engine dynamometer	
2000 Caterpillar C-15	Heavy-duty on-highway	Chassis dynamometer	Freightliner chassis
2006 Cummins ISM	Heavy-duty on-highway	Chassis dynamometer	International chassis
2007 BME4000	Heavy-duty on-highway	Chassis dynamometer	Freightliner chassis
2010 Cummins ISX15	Heavy-duty on-highway	Chassis dynamometer	Kenworth chassis

Source: Table ES-1 of Durbin 2011, page xxvi
Notes:
[a] Data for the first four engines (shaded) are considered in this report.

[15] Durbin 2011, p. xxiv.

The original goal of this report was to subject all of the NOx emission testing in Durbin 2011 to a fresh re-analysis. However, it was discovered that Durbin 2011 did not report all of the data that were obtained during the program and are discussed in the report. The chassis dynamometer testing was conducted at the CARB Los Angeles facility. Emission results for the chassis dynamometer testing are presented in tabular and graphical form, but the report does not contain the actual emissions test data. For the engine dynamometer testing, some of the measured emission values are not reported even though the emission results are reported in tabulated or graphical form. Requests for the missing data were directed to Durbin in a personal request and to CARB through an official records request. No information has been provided in response and we have not been able to obtain the missing data from online or other sources.

For this report, we have worked with the data in the forms that are provided in Durbin 2011 as being the best-available record of the results of the CARB study. Because Staff used only data obtained in engine dynamometer testing, the analysis presented in this report has done the same. Nevertheless, the results of the chassis dynamometer testing are generally supportive of the results and conclusions presented here. Durbin 2011 notes:

> "… The NOx emissions showed a consistent trend of increasing emissions with increasing biodiesel blend level. These differences were statistically significant or marginally significant for nearly all of the test sequences for the B50 and B100 fuels, and for a subset of the tests on the B20 blends."[16]

Durbin notes that emissions variability was greater in the chassis dynamometer testing, which leads to the sometimes lower levels of statistical significance. There was also a noticeable drift over time in NOx emissions that complicated the results for one engine.

3.2 Data and Methodology

Table 3-2 compiles descriptive information on the engine dynamometer testing performed in Durbin 2011. The experimental matrix involves four engines, two types of biodiesel fuels (soy- and animal-based), and up to four test cycles per engine. However, the matrix is not completely filled with all fuels tested on all engines on all applicable test cycles. The most complete testing is for the ULSD base fuel and B20, B50, and B100 blends. There is less testing for the B5 blend, and B5 is tested using only a subset of cycles. For this reason, we first examine the testing for ULSD, B20, B50, and B100 fuels to determine the overall impact of biodiesels on NOx emissions. We then examine the more limited testing for B5 to determine the extent to which it impacts NOx emissions.

This examination is limited by the form in which emissions test information is reported in Durbin 2011. A complete statistical analysis can be conducted only for the two on-road engines for which Appendices G and H of Durbin 2011 provide measured emissions, and for a portion of the testing of the Kubota off-road engine for which Appendix I provides

[16] Durbin 2011, p. 126.

Table 3-2
Experimental Matrix for Heavy-Duty Engine Dynamometer Testing Reported in Durbin 2011

Engine	Biodiesel Type	Fuels Tested	Test Cycles	Notes
On-Road Engines				
2006 Cummins ISM	Soy	ULSD, B20, B50, B100, B5	UDDS, FTP, 40 mph, 50 mph	B5 tested on 40 mph and 50 mph cruise cycles
	Animal	ULSD, B20, B50, B100, B5	UDDS, FTP, 50 mph	B5 tested only on FTP.
2007 MBE4000	Soy	ULSD, B20, B50, B100, B5	UDDS, FTP, 50 mph	B5 tested only on FTP.
	Animal	ULSD, B20, B50, B100, B5		B5 tested only on FTP.
Off-Road Engines				
1998 Kubota V2203-DIB	Soy	ULSD, B20, B50, B100, B5	ISO 8178 (8 Mode)	none
	Animal	Not tested		
2009 John Deere	Soy	ULSD, B20, B50, B100	ISO 8178 (8 Mode)	B5 not tested
	Animal	ULSD, B20, B5		none

measured emissions. The data needed to support a full re-analysis consist of measured emissions on each fuel in gm/hp-hr terms, which are stated in Durbin 2011 as averages across all test replications along with the number of replications and the standard error of the individual tests. With this information, the dependence of NOx emissions on biodiesel blending percent can be determined as accurately as if the individual test values had been reported and the appropriate statistical tests for the significance of results can be performed.

Regression analysis is used as the primary method of analysis. For each engine and test cycle, the emission averages for each fuel are regressed against the biodiesel blending percent to determine a straight line. The regression weights each data point in inverse proportion to the square of its standard error to account for differences in the number and reliability of emission measurements that make up each average. The resulting regression line will pass through the mean value estimated from the data (i.e., the average NOx emission level at the average blending percent), while the emission averages for each fuel may scatter above and below the regression line due to uncertainties in their measurement. The slope of the line estimates the dependence of NOx emissions on the blending percentage.

Where the data points closely follow a straight line and the slope is determined to be statistically significant, one can conclude that blending biodiesel with a base fuel will increase NOx emissions in proportion to the blending percent. The regression line can then be used to estimate the predicted emissions increase for a given blending percent. The predicted emissions increase is the value one would expect on average over many measurements and is comparable to the average emissions increase one would expect in a fleet of vehicles.

The same level of analysis is not possible for the testing on B5 fuel, which is reported as a simple average for the on-road engines and is not reported at all for the off-road engines. For the B5 fuel, Durbin 2011 presents emission test results in a tabulated form where the percentage change in NOx emissions has been computed compared to ULSD base fuel. This form supports the presentation of results graphically, but it does not permit a proper statistical analysis to be performed. Specifically, the computation of percentage emission changes will perturb the error distribution of the data, by mixing the uncertainty in measured emissions on the base fuel with the uncertainties in measured emissions on each biodiesel blend, and it can introduce bias as a result of the mixing. Further statistical analysis of the computed percent values should be avoided because of these problems. Therefore, a more limited trend analysis of the NOx emissions data for B5 and the John Deere engine is conducted.

3.3 2006 Cummins Engine (Engine Dynamometer Testing)

Table 3-3 shows the NOx emission results for the 2006 model-year Cummins heavy-duty diesel engine based on a re-analysis of the data for this report. As indicated by highlighting in the table, the relationship between increasing biodiesel content and increased NOx emissions for soy-based biodiesel is statistically significant at >95% confidence level[17] in all cases. For the animal-based biodiesel, the relationship is statistically significant at the 92% confidence level for the UDDS cycle, the 94% confidence level for the 50 mph cruise, and the >99% confidence level for the FTP cycle.

For the soy-based fuels, the R^2 statistics show that the emissions effect of biodiesel is almost perfectly linear with increasing biodiesel content over the range B20, B50, and B100. Although not as high for the animal-based fuels (because the emissions effect is smaller and measurement errors are relatively larger in comparison to the trend), the R^2 statistics nevertheless establish a linear increase in NOx emissions with increasing biodiesel content over the same range. The linearity of the response with blending percent is well supported by the many NOx emissions graphs contained in Durbin 2011.

The table also gives the estimated NOx emission increases for B5 and B10 as predicted by the regression lines. For soy-based fuels, the values are 1% for B5 (range 0.8% to 1.3% depending on the cycle) and 2% for B10 (range 1.6% to 2.6% depending on cycle).

[17] A result is said to be statistically significant at the 95% confidence level when the p value is reported as $p \leq 0.05$. At the $p \leq 0.01$ level, a result is said to be statistically significant at the 99% confidence level, and so forth.

Table 3-3 Re-Analysis for 2006 Cummins Engine (Engine Dynamometer Testing) Model: NOx = A + B · BioPct Using ULSD, B20, B50, and B100 fuels							
Biodiesel Type	Test Cycle	R^2	Intercept A	BioPct Slope B		Predicted NOx Increase for B5	Predicted NOx Increase for B10
			Value	Value	p value	Pct Change	Pct Change
Soy-based							
	UDDS	0.997	5.896	0.0100 [a]	0.001	0.8%	1.7%
	FTP	0.995	2.024	0.0052	0.003	1.3%	2.6%
	40 mph	1.000	2.030	0.0037	<0.0001	0.9%	1.8%
	50 mph	0.969	1.733	0.0028	0.016	0.8%	1.6%
Animal-based							
	UDDS	0.847	5.911	0.0021 [b]	0.080	0.2%	0.4%
	FTP	0.981	2.067	0.0031	0.001	0.7%	1.4%
	50 mph	0.887	1.768	0.0011	0.058	0.3%	0.6%

Notes:
[a] Blue highlight indicates result is statistically significant at the 95% confidence level or better.
[b] Orange highlight indicates result is statistically significant at the 90% confidence level or better.

For animal-based fuels, the values are approximately one-half as large: 0.4% for B5 (range 0.2% to 0.7%) and 0.8% for B10 (range 0.4% to 1.4%). These predicted increases are statistically significant to the same degree as the slope of the regression line from which they are estimated. That is, the NOx increases predicted by the regression line for soy-based fuels are statistically significant at the 95% confidence level (or better) on all cycles and the predicted NOx increases for animal-based fuels are statistically significant at the 90% confidence level (or better) on all cycles and at the >99% confidence level for the FTP.

Because the limited data on B5 were not used to develop the regression lines for each cycle, and no test data on B10 are available, use of the lines to make predictions for B5 and B10 depends on their linearity over the range between ULSD and B20. Based on the R^2 statistics and the graphs in Durbin 2011, the slopes observed between ULSD and B20 are the same as the slopes observed between B20 and B100 for each of the test cycles. We believe that the linearity of the response with blending percent for values over the range ULSD to B100 would be accepted by the large majority of researchers in the field, as would the use of regression analysis to make predictions for B5 and B10.

The Durbin 2011 report takes a different approach for determining the statistical significance of NOx emission increases for each fuel. For each fuel tested, it computes a percentage change in emissions for NOx (and other pollutants) relative to the ULSD base fuel. It then determines the statistical significance of each observed change using a conventional t-test for the difference of two mean values (2-tailed, 2 sample equal variance t-test). The t-test is conducted on the measured emission values before the percentage emission change is computed.

The t-test would be the appropriate approach for determining statistical significance if only two fuels were tested. However, it is a simplistic approach when three or more fuels are tested because it is applied on a pair-wise basis (B5 vs. ULSD, B20 vs. ULSD, etc.) and does not make use of all of the data that is available. It will have less power than the regression approach to detect emission changes that are real. This limitation is in one direction, however, in that the test is too weak when 3 or more data points are available, but a finding of statistical significance is valid when it occurs. As long as the linear hypothesis is valid, the regression approach should be the preferred method for analysis and for the determination of whether biodiesel blending significantly increases NOx emissions.

Because emission changes will be smallest for B5 (because of the low blending volume), the pair-wise t-test is most likely to fail to find statistical significance at the B5 level. In cases where the pair-wise t-test for B5 says that the emission change vs. ULSD is not statistically significant – but slope of the regression line is statistically significant – the proper conclusion is that additional B5 testing (to improve the precision of the emission averages) would likely lead to the detection of a statistically significant B5 emissions change using the t-test. In this case, the failure to find statistical significance using the t-test is not evidence that B5 does not increase NOx emissions.

For this engine, soy-based B5 was tested on the 40 mph and 50 mph cruise cycles and animal-based B5 was tested on the FTP. To examine this matter further, Table 3-4 reproduces NOx emission results reported in Tables ES-2 and ES-3 of Durbin 2011. Soy-based B5 was shown to increase NOx emissions on the 40 mph cruise cycle, but not on the 50 mph cruise cycle. Animal-based B5 was shown to increase NOx emissions on the FTP. Durbin 2011 noted (p. xxxii) that "[t]he 50 mph cruise results were obscured, however, by changes in the engine operation and control strategy that occurred over a segment of this cycle." Therefore, we discount the 50 mph cruise results and do not consider them further. Neither of the remaining B5 NOx emission increases (for the 40 mph Cruise and FTP cycles) were found to be statistically significant using the t-test, although the 40 mph cruise result for soy-based fuels comes close to being marginally significant (it would be statistically significant at an 86.5% level). The NOx emission increases at higher blending levels were found have high statistical significance (>99% confidence level).

This format, used throughout Durbin 2011 to report emission test data and to show the effect of biodiesel on emissions, is subject to an important statistical caveat. The percent changes are computed by dividing the biodiesel emission values by the emissions measured for the ULSD base fuel. Therefore, measurement errors in the ULSD measurement are blended with the measurement errors for each of the biodiesel fuels. The blending of errors in each computed percent change can bias the apparent trend of emissions with increasing biodiesel content. As will be shown in Section 3.3.2, we can see this problem in the animal-based B5 test data for this engine.

Table 3-4 Percentage Change in NOx Emissions for Biodiesel Blends Relative to ULSD: 2006 Cummins Engine (Engine Dynamometer Testing)						
	Soy-based Biodiesel				Animal-based Biodiesel	
	40 mph Cruise		50 mph Cruise		FTP	
	NOx % Diff	p value	NOx % Diff	p value	NOx % Diff	p value
B5	1.7%	0.135	-1.1%	0.588	0.3%	0.298
B20	3.9% [a]	0.000	0.5%	0.800	1.5%	0.000
B50	9.1%	0.000	6.3%	0.001	6.4%	0.000
B100	20.9%	0.000	18.3%	0.000	14.1%	0.000

Source: Table ES-2 and ES-3 of Durbin 2011, p. xxviii
Notes:
[a] Blue highlight indicates result is statistically significant at the 95% confidence level or better based on the pair-wise t-test.

3.3.1 NOx Impact of Soy-based Biodiesel at the B5 Level

Figures 3-1a and 3-1b display the trend of NOx emissions with blending percent for the soy-based biodiesel on the 40 mph cruise cycle. Figure 3-1a plots the percentage increases as reported by Durbin 2011 in contrast to two different analytical models for the relationship:

- The Linear Model shown by the blue line; and
- The Staff Threshold model (black line), in which the NOx emission change is zero through B9 and then increases abruptly to join the linear model.

In Figure 3-1a, the linear model is an Excel trendline for the computed percent changes. While the data violate a key assumption for the proper use of regression analysis, this approach is the only way to establish a trendline given the form in which Durbin 2011 tabulates the data and presents the results of its testing.

Figure 3-1b plots the actual measured emission values in g/bhp-hr terms in contrast to the same two analytical models. Here, the linear model line is determined through a proper use of regression analysis, in which each emission average in g/bhp-hr terms is weighted inversely by the square of its standard error, using the data for ULSD, B20, B50 and B100 (i.e., excluding the B5 data point). In the case of this engine and biodiesel fuel, both forms of assessment show generally the same trend for NOx emissions as a function of blending percent. Although the NOx emission increases for B5 may fail the t-test for significance, emissions are increased at B5 and the B5 data point is fully consistent with the Linear Model. The Threshold model is clearly a less-satisfactory representation of the test data.

Figure 3-1a
Durbin 2011 Assessment: 40 mph Cruise Cycle NOx Emissions Increases for Soy-Biodiesel Blends (2006 Cummins Engine)

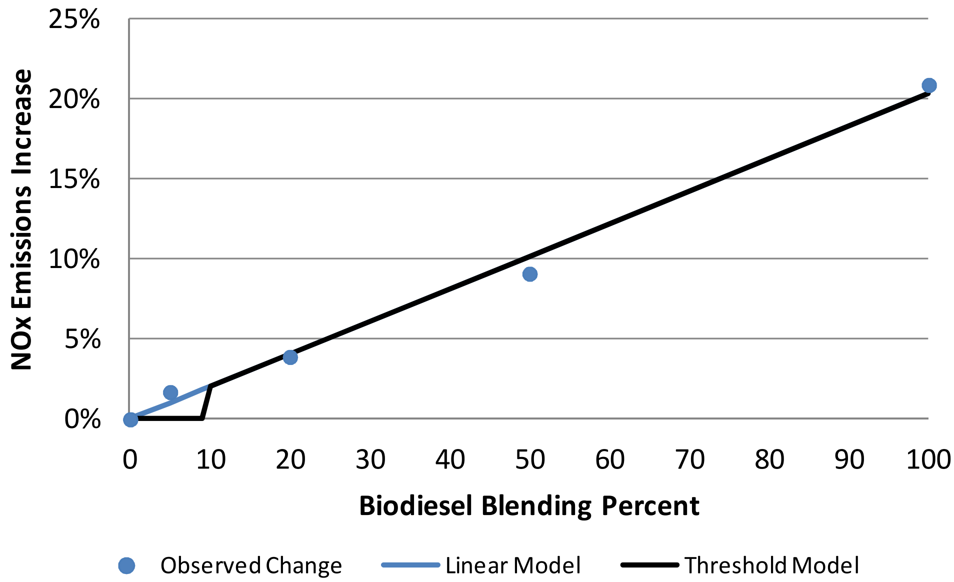
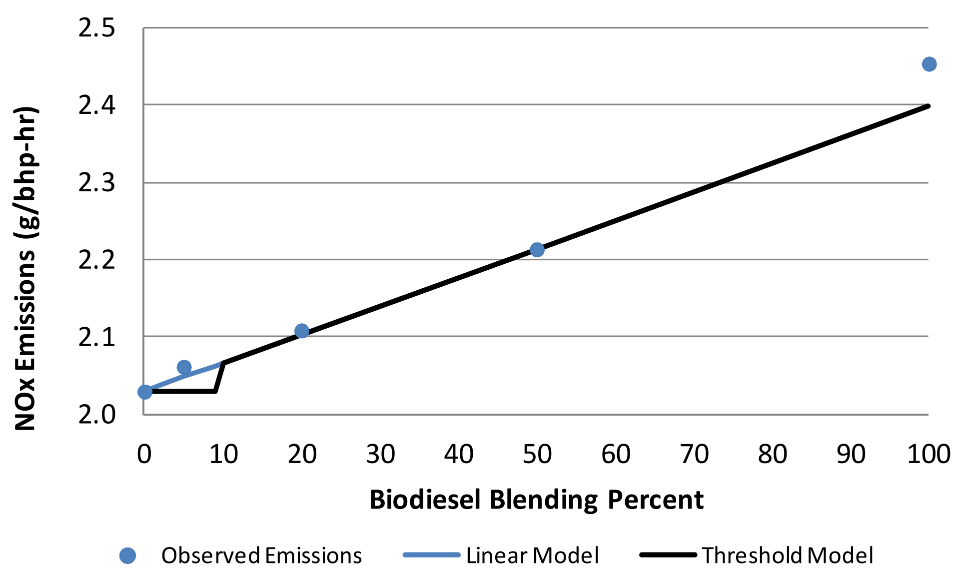


Figure 3-1b
Re-assessment of 40 mph Cruise Cycle NOx Emissions Increases for Soy-Biodiesel Blends (2006 Cummins Engine)



Note that the slope of the trendline (Figure 3-1a) is greater than the slope of the regression line (Figure 3-1b). In the latter figure, the B100 data point stands above the regression line, which passes below it. The regression line (but not the trendline) is fit in a manner that accounts for the uncertainties in each data point, so that the line will pass closer to points that have smaller uncertainties and farther from points that have greater uncertainties. For these data, the B100 data point has the largest uncertainty (±0.026 g/bhp-hr) followed by the B20 data point (±0.025 g/bhp-hr). The other three data points (ULSD, B5, and B50) have uncertainties less than ±0.001 g/bhp-hr. The B20 data point happens to fall on the line, but the B100 data point is found to diverge above. Because the regression analysis can account for the relative uncertainties of the data points, it provides a more accurate and reliable assessment of the impact on NOx emissions.

3.3.2 NOx Impact of Animal-based Biodiesel at the B5 level

Figures 3-2a and 3-2b display the trend of NOx emissions with blending percent for the animal-based biodiesel on the FTP test cycle as reported by Durbin 2011 and as re-assessed in this report using regression analysis, respectively. As Figure 3-2a shows, the NOx percent change values reported by Durbin 2011 appear to follow the Staff Threshold model in that NOx emissions are not materially increased at B5, but are increased significantly at B20 and above. As a result, the blue trendline in the figure (fit from the B20, B50 and B100 data points) has a negative intercept.

Figure 3-2b paints a very different picture from the data. Here, the ULSD and B5 data points stand above the weighted regression line (blue) developed from the data for ULSD, B20, B50 and B100. In the data used to fit the regression line, the ULSD data point has the largest uncertainty (±0.013 g/bhp-hr) while the other three data points (B20, B50, and B100) have uncertainties of ±0.002 g/bhp-hr (one case) and ±0.001 g/bhp-hr (two cases). Considering all of the data, the B5 data point has the second highest uncertainty (±0.007 g/bhp-hr). The regression line closely follows a linear model with a high R^2 (0.981) considering the weighted errors, while the ULSD and B5 points lie above it.

Because the ULSD data point is subject to more uncertainty and appears to be biased high compared to the regression line, the NOx percent changes computed by Durbin 2011 are themselves biased. The trendline result in Figure 3-2a that appeared to be supportive of the Staff Threshold model now appears to be the result of biases in the ULSD and B5 emission averages.

Two important conclusions can be drawn from the foregoing:

1. Accurate and reliable conclusions regarding the impact of B5 on NOx emissions cannot be drawn from the computed percent changes that are reported in Durbin 2011. Nor can accurate and reliable conclusions be drawn from visual inspection of graphs that present such data. Weighted regression analysis of the measured emission values (g/bhp-hr terms) must be performed so that the uncertainties in emissions measurements can be fully accounted for.

2. When a weighted regression analysis is performed using the testing for this engine, there is no evidence that supports the conclusion that B5 blends will not increase NOx emissions. In fact, the data are consistent with the conclusion that biodiesel increases NOx emissions in proportion to the blending percent.

Figure 3-2a
Durbin 2011 Assessment: FTP NOx Emissions Increases for Animal-based Biodiesel Blends (2006 Cummins Engine)

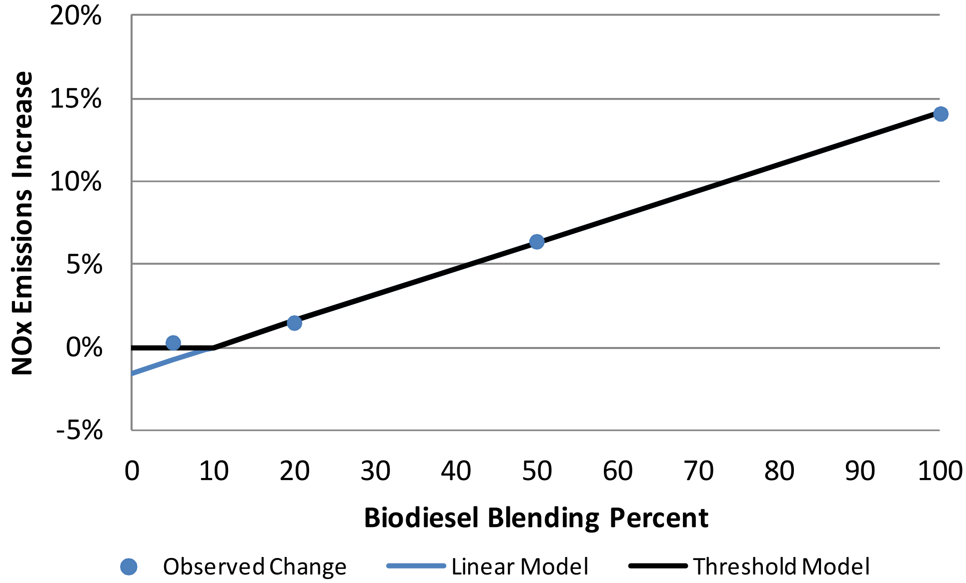
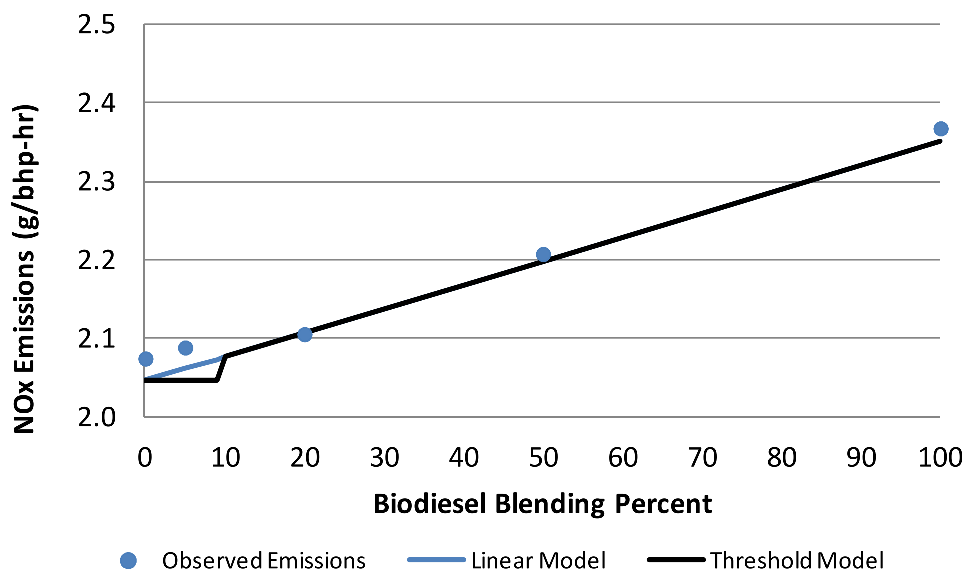


Figure 3-2b
Re-assessment of FTP NOx Emissions Increases for Animal-based Biodiesel Blends (2006 Cummins Engine)



3.4 2007 MBE4000 Engine (Engine Dynamometer Testing)

To analyze the data for the 2007 MBE4000 engine, it has proved necessary to remove two data points, one for the soy-based B20 fuel on the 50 mpg cruise cycle and one for the animal-based B50 fuel on the FTP test cycle:

- Appendix H reports the 50 mph cruise emission average for soy-based B20 to be 0.014 ± 0.020 g/bhp-hr. This value is implausible and wholly inconsistent with the NOx emission change of +6.9% reported in Table ES-4 of Durbin 2011, which would imply a NOx emission average of 1.21*1.069 = 1.30 g/bhp-hr.

- Appendix H reports the FTP emission average for the animal-based B50 fuel to be 2.592 ± 0.028 g/bhp-hr, which stands well above the other test data on animal-based biodiesel. This value is also inconsistent with the NOx emission change of +12.1% reported in Table ES-4 of Durbin 2011, which would imply a NOx emission average of 1.29*1.121 = 1.45 g/bhp-hr.

We believe these reported values are affected by typographical errors and have deleted them from the dataset used here.

With these corrections, Table 3-5 shows the results of the NOx emissions analysis for the 2007 model-year MBE4000 heavy-duty diesel engine. As indicated by highlighting in the table, the relationship between increasing biodiesel content and increased NOx emissions is statistically significant at >99% confidence level in two cases for soy-based biodiesel (the UDDS and FTP cycles) and at the 90% confidence level in one case (the 50 mph cycle). For the animal-based biodiesel, the relationship is statistically significant at the 96% confidence level for the UDDS cycle, the 98% confidence level for the FTP cycle, and >99% confidence level for the 50 mph cycle.

Durbin 2011 again notes a problem with the 50 mph cruise test results, saying (p. xxxii) that "[the NOx] trend was obscured, however, by the differences in engine operation that were observed for the 50 mph cruise cycle." Therefore, we will focus the discussion on the UDDS and FTP results.

For the soy-based fuels, the R^2 statistics show that the emissions effect of biodiesel is almost perfectly linear with increasing biodiesel content over the range from ULSD to B20, B50, and B100 for all cycles (including the 50 mph cruise). That is, the NOx emissions increase between ULSD and B20 shares the same slope as the NOx emissions increase between B20 and B100. For the animal-based biodiesel, the R^2 statistics also establish a linear increase in NOx emissions with increasing biodiesel content over the same range. The linearity of the response with blending percent is also well supported by the many NOx emissions graphs contained in Durbin 2011.

Table 3-5 Re-Analysis for 2007 MBE4000 Engine (Engine Dynamometer Testing) Model: NOx = A + B · BioPct Using ULSD, B20, B50, and B100 fuels							
Biodiesel Type	Test Cycle	R^2	Intercept A	BioPct Slope B		Predicted NOx Increase for B5	Predicted NOx Increase for B10
			Value	Value	p value	Pct Change	Pct Change
Soy-based							
	UDDS	0.989	2.319	0.0090 [a]	0.005	4.6%	9.1%
	FTP	0.998	1.268	0.0049	0.006	2.5%	5.0%
	50 mph	0.979	1.198	0.0054 [b]	0.092	2.7%	5.5%
Animal-based							
	UDDS	0.913	2.441	0.0036	0.044	2.0%	4.0%
	FTP	0.999	1.288	0.0038	0.020	2.5%	5.0%
	50 mph	0.994	1.205	0.0049	0.003	2.5%	5.0%

Notes:
[a] Blue highlight indicates result is statistically significant at the 95% confidence level or better.
[b] Orange highlight indicates result is statistically significant at the 90% confidence level or better.

The table also gives the estimated NOx emission increases for B5 and B10 as predicted by the regression lines. For soy-based fuels, the values are ~3.5% for B5 (range 2.5% to 4.6% depending on the cycle) and ~7.5% for B10 (range 5.0% to 9.1% depending on cycle). For animal-based fuels, the values are approximately two-thirds as large: ~2.3% for B5 (range 2.0% to 2.5%) and ~4.5% for B10 (range 4.0% to 5.0%). The predicted increases are statistically significant to the same degree as the slope of the regression line from which they are estimated. That is, the predicted NOx increases are statistically significant at the >99% confidence level for soy-based fuels on the UDDS and FTP cycles and at the >95% confidence level for animal-based fuels on all cycles. The predicted NOx increase is statistically significant at the 90% confidence level for soy-based fuels on the 50 mph cruise cycle.

For this engine, soy- and animal-based B5 were tested on the FTP. Table 3-6 reproduces the NOx emission results reported in Tables ES-4 and ES-5 of Durbin 2011. While there are caveats on use of the pair-wise t-test, the FTP test data for this engine show NOx emissions at the B5 level for both soy- and animal-based fuels that are statistically significant at the 99% confidence level (or better) in this case. That is, the test data for this engine as reported by Durbin 2011 refute the Staff Threshold Model that biodiesel blends below B10 do not increase NOx emissions.

Table 3-6 Percentage Change in NOx Emissions for Biodiesel Blends Relative to ULSD: 2007 MBE4000 Engine (Engine Dynamometer Testing)				
	Soy-Based Biodiesel FTP		Animal-Based Biodiesel FTP	
	NOx % Diff	p value	NOx % Diff	p value
B5	0.9% [a]	0.007	1.3%	0.000
B20	5.9%	0.000	5%	0.000
B50	15.3%	0.000	12.1	0.000
B100	38.1%	0.000	29%	0.000

Source: Table ES-4/5 of Durbin 2011, p. xxix
Notes:
[a] Blue highlight indicates result is statistically significant at the 95% confidence level or better based on pair-wise t-test.

Figures 3-3a and 3-3b below compare the FTP data for this engine to the regression line representing the linear model (blue) and the Staff Threshold model (black) for both soy- and animal-based biodiesel. In both cases, the regression line was developed using the data for ULSD, B20, B50, and B100 (i.e., excluding the B5 data point). For both soy- and animal-based biodiesels, the data point for B5 falls on the established line, while the Staff Threshold model is inconsistent with the data. For this engine, it is clear that soy- and animal-based biodiesels increase NOx emissions at all blending levels.

Figure 3-3a
Re-assessment of FTP Cycle NOx Emissions Increases for Soy-based Biodiesel Blends (2007 MBE4000 Engine)

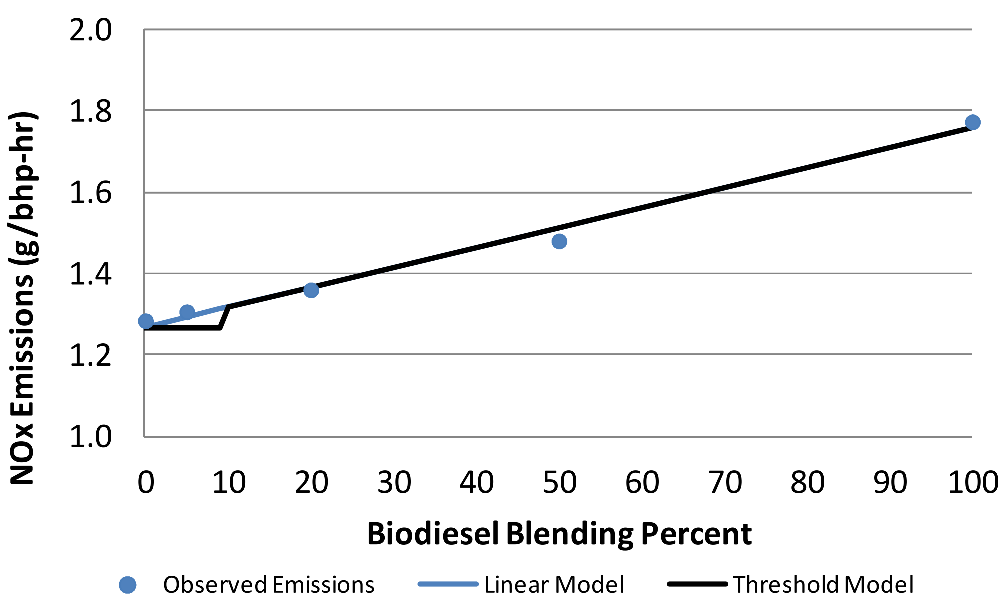
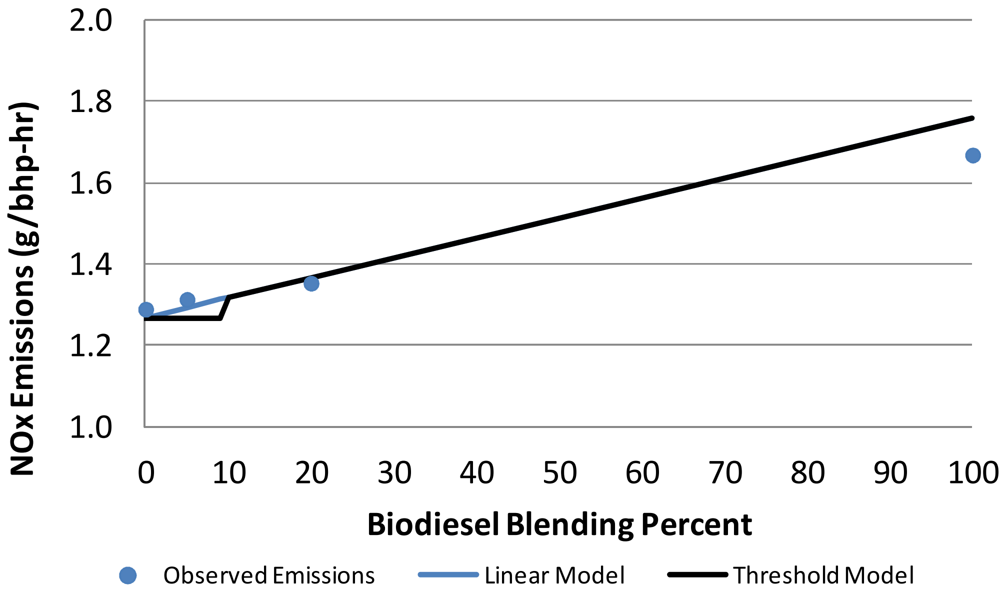


Figure 3-3b
Re-assessment of FTP Cycle NOx Emissions Increases for Animal-based Biodiesel Blends (2007 MBE4000 Engine)



3.5 1998 Kubota TRU Engine (Engine Dynamometer Testing)

The 1998 Kubota V2203-DIB off-road engine was tested on the base fuel (ULSD) and soy-based biodiesel at four blending levels (B5, B20, B50, B100) in two different series using the ISO 8178 (8-mode) test cycle. Appendix I reports the measured emissions data only for the first series (ULSD, B50, B100). Using this subset of data, Table 3-7 summarizes the results of the re-analysis for this engine.

As for the other engines, the results of the analysis demonstrate the following:

- The high R^2 statistic shows that the emissions effect of biodiesel is almost perfectly linear over the range B50 and B100. That is, the slope from ULSD to B50 is the same as the slope from B50 to B100. The slope of the regression line is statistically significant at the 99% confidence level.

- NOx emissions are estimated to increase by 1.0% at the B5 level and by 2.1% at the B10 level. These estimated NOx emission increases are statistically significant to the same high degree as the regression slope on which they are based.

Table 3-7 Re-Analysis for 1998 Kubota V2203-DIB Engine (Engine Dynamometer Testing) Model: NOx = A + B · BioPct Using ULSD, B50, and B100 fuels							
Biodiesel Type	Test Cycle	R^2	Intercept A	BioPct Slope B		Predicted NOx Increase for B5	Predicted NOx Increase for B10
			Value	Value	p value	Pct Change	Pct Change
Soy-based	ISO 8178	0.999	12.19	0.0256 [a]	0.01	1.0%	2.1%

Notes:
[a] Blue highlight indicates result is statistically significant at the 95% confidence level or better.

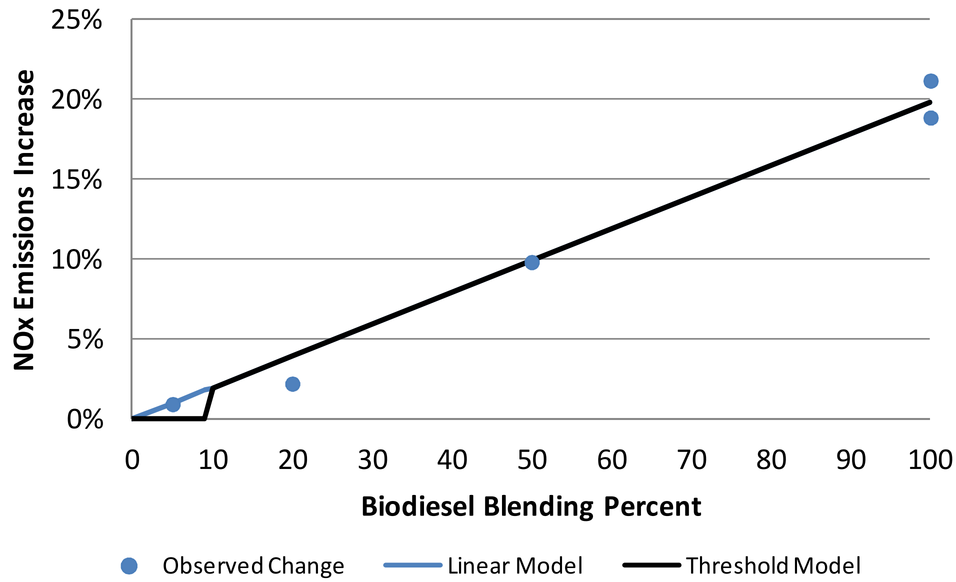
The second test series involved ULSD, B5, B20, and B100 fuels. Measured emissions data are not given in Appendix I, so we must work with the calculated percent changes in NOx emissions tabulated in Durbin 2011. Table 3-8 reproduces the NOx emission results reported in Table ES-8 of Durbin 2011 for the two test series. For the second test series, biodiesel at the B5 level increased NOx emissions, but the result fails the pair-wise t-test for statistical significance. The NOx emission increase at the B20 level was statistically significant at the 90% confidence level, and the increase at the B100 level was statistically significant at the >99% confidence level. The significance determinations use the pair-wise t-test, which is subject to caveats, but this is the only method available to gauge significance because re-analysis of the computed percentage changes is not possible.

Table 3-8 Percentage Change in NOx Emissions for Biodiesel Blends Relative to ULSD: 1998 Kubota TRU Engine (Engine Dynamometer Testing)				
	Soy-Based Biodiesel Series 1 ISO 8178		Soy-Based Biodiesel Series 2 ISO 8178	
	NOx % Diff	p value	NOx % Diff	p value
B5	Not tested		0.97%	0.412
B20	Not tested		2.25% [a]	0.086
B50	7.63% [b]	0.000	Not tested	
B100	13.76%	0.000	18.89%	0.000

Source: Table ES-8 of Durbin 2011, p. xxxviii
Notes:
[a] Orange highlight indicates result is statistically significant at the 90% confidence level or better based on pair-wise t-test.
[b] Blue highlight indicates result is statistically significant at the 95% confidence level or better based on pair-wise t-test

Figure 3-4 displays the trend of NOx emissions with blending percent for the first and second test series combined. As the figure shows, the available data points scatter around the trendline determined from the emission change percentages (not from regression analysis). The B20 data point falls below the trend line while the two B100 data points bracket the trend line. It is not possible to explain the divergence of the B20 data point

Figure 3-4
Durbin 2011 Assessment: ISO 8178 Cycle NOx Emissions Increases for Soy-based Biodiesel Blends (1998 Kubota Engine, Test Series 1 and 2 Combined)



because the emissions data for the second test series are not published in Durbin 2011. The B5 data point clearly supports the Linear Model and is inconsistent with the Staff Threshold Model.

3.6 2009 John Deere Off-Road Engine (Engine Dynamometer Testing)

The only information on the 2009 John Deere off-road engine comes from the tabulation of calculated percentage emission changes. Table 3-9 reproduces these data from Table ES-7 of Durbin 2011. For the soy-based biodiesel, NOx emissions are significantly increased at the B20 and higher blend levels. The increase for B20 is statistically significant at the 90% confidence level and the increases for B50 and B100 are statistically significant at the >99% confidence level based on the pair-wise t-test. A soy-based B5 fuel was not tested.

Table 3-9 Percentage Change in NOx Emissions for Biodiesel Blends Relative to ULSD: 2009 John Deere Engine (Engine Dynamometer Testing)				
	Soy-Based Biodiesel ISO 8178		Animal-Based Biodiesel ISO 8178	
	NOx % Diff	p value	NOx % Diff	p value
B5	Not tested		-3.82	0.318
B20	2.82% [a]	0.021	-2.20	0.528
B50	7.63%	0.000	Not tested	
B100	13.76%	0.000	4.57	0.000

Source: Table ES-7 of Durbin 2011, p. xxxviii
Notes:
[a] Blue highlight indicates result is statistically significant at the 95% confidence level or better based on pair-wise t-test.

For animal-based biodiesel, the testing shows the unusual result that B5 and B20 appear to decrease NOx emissions, while B100 increases NOx. The B5 and B20 decreases are not statistically significant, while the B100 increase is statistically significant at the >99% confidence level. Durbin 2011 concludes:

> The animal-based biodiesel also did not show as great a tendency to increase NOx emissions compared to the soy-based biodiesel for the John Deere engine, with only the B100 animal-based biodiesel showing statistically significant increases in NOx emissions.[18]

Durbin 2011 does not discuss these results further and does not note any problems in the testing, making further interpretation of the results difficult. Figure 8-1 of Durbin 2011 presents the NOx results for this engine with error bars. First, we note that the figure appears to suggest that NOx emissions were increased on the B20 fuel in contradiction to the table above. Second, it is clear that the error bars are large enough that no difference in NOx emissions can be detected among ULSD, B5, and B20 fuels. Overall, this result could be consistent with the Staff Threshold Model through B5, but the failure to detect a NOx emission increase at B20 is not. Without further information, it is not possible to determine whether the result seen here is a unique response of the John Deere engine to animal-based biodiesel or is the result of a statistical fluctuation or an artifact in the emissions data.

3.7 Conclusions

The Biodiesel Characterization report prepared by Durbin et al. for CARB is an important source of information on the NOx emissions impact of biodiesel fuels in heavy-duty engines. It is the sole source of information on the NOx impact of B5 blends cited in the ISOR. When the engine dynamometer test data are examined for

[18] Durbin 2011, p. xx.

the three engines for which emissions test data have been published, we find clear evidence that biodiesel increases NOx emissions in proportion to the blending percent. Where B5 fuels were tested for these engines, NOx emissions are found to increase above ULSD for both soy- and animal-based blends in all three engines and by statistically significant amounts in one engine.

Specifically, a re-analysis of the NOx emissions test data demonstrates the following:

1. For the 2006 Cummins engine, biodiesel fuels are found to significantly increase NOx emissions for both soy- and animal-based blends by amounts that are proportional to the blending percent. This result indicates that biodiesels will increase NOx emissions at blending levels below B10. When B5 fuels were tested, NOx emissions were observed to increase but by amounts that fail to reach statistical significance according to the pair-wise test.[19] Graphical analysis demonstrates that NOx emissions measured for B5 fuels are consistent with the Linear Model, but not the Staff Threshold Model.

2. For the 2007 MBD4000 engine, biodiesel fuels are found to significantly increase NOx emissions for both soy- and animal-based blends by amounts that are proportional to the blending percent. This result indicates that biodiesels will increase NOx emissions at blending levels below B10. When B5 fuels were tested, NOx emissions were observed to increase and by amounts that are found to be statistically significant using the pair-wise t-test.[13] <u>This result alone is sufficient to disprove the Staff Threshold Model</u>. Graphical analysis demonstrates that NOx emissions measured for B5 fuels are consistent with the Linear Model, but not the Staff Threshold Model.

3. For the 1998 Kubota TRU (off-road) engine, soy-based biodiesel fuels are found to significantly increase NOx missions. Animal-based biodiesel was not tested. When a soy-based B5 fuel was tested, NOx emissions were observed to increase but by amounts that fail to reach statistical significance according to the pair-wise test.[13] Graphical analysis demonstrates that NOx emissions measured for B5 fuels are consistent with the Linear Model, but not the Staff Threshold Model.

The measured emissions test data for the other off-road engine (2009 John Deere) are not contained in the Durbin 2011 report and CARB has not made them publicly available. Thus, a re-analysis was not possible. Based on the tables and figures in Durbin 2011, soy-based biodiesel fuels were shown to significantly increase NOx emissions at B20 levels and higher, but B5 was not tested. Testing of animal-based blends shows no change in NOx emissions at B5 and B20 levels, but B100 is shown to significantly increase NOx emissions. Durbin 2011 discusses this result only briefly, and it is unclear what conclusions can be drawn from it.

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[19] As discussed in Section 3.3, the pair-wise t-test is not the preferred method for demonstrating statistical significance.

APPENDIX A

RESUME OF ROBERT W. CRAWFORD

Education

1978 Doctoral Candidate, ScM. Physics, Brown University, Providence, Rhode Island
1976 B.A. Physics, Pomona College, Claremont, California

Professional Experience

1998-Present Independent Consultant

Individual consulting practice emphasizing the statistical analysis of environment and energy data with an emphasis on how data and statistics are properly used to make scientific inferences. Mr. Crawford provides support on statistical, data analysis, and modeling problems related to ambient air quality data and emissions from mobile and stationary sources.

Ambient Air Quality and Mobile Source Emissions – Mr. Crawford has worked with Sierra Research on elevated ambient CO and PM concentrations in Fairbanks AK and Phoenix AZ, including the effect of meteorological conditions on ambient concentrations, the relationship of concentrations to source inventories, and the use of non-parametric techniques to infer source location from wind speed and direction data. Ongoing work is employing Principal Components Analysis to elucidate the relationship between meteorology and $PM_{2.5}$ concentrations in Fairbanks. In the past year, this work led to creation of the AQ Alert System, a tool used by air quality staff to track $PM_{2.5}$ monitor concentrations during the day and to prepare AQ alerts over the next 3 days based on the meteorological forecast.

In past work for Sierra, he has also conducted studies of fuel effects on motor vehicle emissions for Sierra. For CRC, he determined the relationship between gasoline volatility and oxygen content on tailpipe emissions of late model vehicles at FTP and cold-ambient temperatures. For SEMPRA, he determined the relationship between CNG formulation and tailpipe emissions of criteria pollutants and a range of air toxics. Other work has included the design of vehicle surveillance surveys and determination of sample sizes, development of screening techniques similar to discriminant functions to improve the efficiency of vehicle recruitment, the analysis of vehicle failure rates measured in inspection & maintenance programs, and the statistical evaluation of data collected on freeway speeds using automated sensors.

Stationary Source Emissions – Over the past 5 years, Mr. Crawford has worked with AEMS, LLC on EPA's MACT and CISWI rulemakings for Portland Cement plants, in which significant issues related to data quality, data reliability, and emissions variability are evident. Key issues include the need to properly account for uncertainty and emissions variability in setting emission standards. He also supported AEMS in the current EPA rulemaking on reporting of greenhouse gas emissions from semiconductor facilities, where the proper characterization of emission control device performance was a key issue. He is currently supporting AEMS in a regulatory process to re-determine emission standards for an industrial facility where the new standard will be enforced by continuous emissions monitoring (CEMS). At issue is how to set the standard in such a way that there will be no more than a small, defined risk that 30-day emission averages will exceed the limitations while emissions remain well-controlled .

Advanced Combustion Research – In recent work for Oak Ridge National Laboratory, Mr. Crawford conducted a series of statistical studies on the fuel consumption and emissions performance of Homogenous Charge Compression Ignition (HCCI) engines. One of these studies was for CRC, in which fuel chemistry impacts were examined in gasoline HCCI. In HCCI, the fuel is atomized and fully-mixed with the intake air charge outside the cylinder, inducted during the intake stroke, and then compressed to the point of spontaneous combustion. The timing of combustion is controlled by heating of the intake air. If R&D work can demonstrate a sufficient understanding of how fuel properties influence engine performance, the HCCI combustion strategy potentially offers the fuel economy benefit of a diesel engine with inherently lower emissions.

1979-1997 Energy and Environmental Analysis, Inc., Arlington, VA. Director & Partner (from 1989).

Primary work areas: Studies of U.S. energy industries for private and institutional clients emphasizing statistical analysis, business planning and computer modeling/forecasting. Responsible for the EEA practice area that provided strategic planning and forecasting services to major energy companies. Primary topical areas included: U.S. energy market analysis and strategic planning; gas utility operations; and natural gas supply planning.

U.S. Energy Market Analysis

During 1995-1997, Mr. Crawford directed EEA's program to provide comprehensive energy supply and demand forecasting for the Gas Research Institute (GRI) in its annual Baseline Projection of U.S. Energy Supply and Demand. Services included: development of U.S. energy supply, demand, and price forecasts; sector-specific analyses covering energy end-use (residential, commercial, industrial, transportation), electricity supply, and natural gas supply and transportation; and the preparation of a range of publications on the forecasts and energy sector trends.

From 1989 through 1997, he directed the use of EEA's Energy Overview Model in strategic planning and long-term market analysis for a client base of major energy producers, pipelines, and distributors in both the United States and Canada. The Energy Overview Model was used under his direction as the primary analytical basis for the 1992 National Petroleum Council study The Potential for Natural Gas in the United States. Mr. Crawford also provided analysis for clients on a wide range of other energy market issues, including negotiations related to an LNG import project intended to serve U.S. East Coast markets. This work assessed the utilization and economic value of seasonal gas deliverability in order to develop LNG pricing formulas and evaluate the project's viability.

Other topical areas of work during his period of employment with EEA include:

Gas Load Analysis and Utility Operations – Principal investigator in a multi-year research program for the Gas Research Institute (GRI) that examined seasonal gas loads, utility operations, and the implications for transmission and storage system reliability and capacity planning.

Gas Transmission and Storage – Principal investigator for a study of industry plans for expansion of underground gas storage capacity in the post-Order 636 environment, including additions of depleted-reservoir and salt-formation storage, an engineering analysis of capital and operating costs for the projects, and unbundled rates for new storage services.

Natural Gas Supply Planning – Mr. Crawford was EEA's senior manager and lead analyst on gas supply planning issues for both pipeline and distribution companies, which included technical and analytic support in development and justification of gas supply strategies; and identification of optimal seasonal supply portfolios for Integrated Resource Planning proceedings.

Transportation Systems Research

Mr. Crawford also had extensive experience in motor vehicle fuel economy and emissions while at EEA. He participated for five years in a DOE research program on fuel economy, with emphasis on the evaluation of differences between laboratory and on-road fuel economy. His work included analysis of vehicle use databases to understand how driving patterns and ambient (environmental) conditions influence actual on-road fuel economy. He also developed a software system to link vehicle certification data systems to vehicle inspection and testing programs and participated in a range of studies on vehicle technology, fuel economy, and emissions for DOE, EPA, and other governmental agencies.

SELECTED PUBLICATIONS (emissions and motor vehicle-related topics)

Statistical Assessment of $PM_{2.5}$ and Meteorology in Fairbanks, Alaska: 2013 Update. Crawford and Dulla. Prepared for the Alaska Department of Environmental Conservation. (forthcoming).

Statistical Assessment of $PM_{2.5}$ and Meteorology in Fairbanks, Alaska. Crawford and Dulla. Prepared for the Alaska Department of Environmental Conservation. March 2012.

Principal Component Analysis: Inventory Insights and Speciated $PM_{2.5}$ Estimates. Crawford. Presentation at Air Quality Symposium 2011, Fairbanks and North Star Borough, Fairbanks, AK. January 2011.

Influence of Meteorology on $PM_{2.5}$ Concentrations in Fairbanks Alaska: Winter 2008-2009. Crawford. Presentation at Air Quality Symposium 2009, Fairbanks and North Star Borough, Fairbanks, AK. July 2009.

Analysis of the Effect of Fuel Chemistry and Properties on HCCI Engine Operation: A Re-Analysis Using a PCA Representation of Fuels. Bunting and Crawford. 2009. Draft Report (CRC Project AFVL13C)

The Chemistry, Properties, and HCCI Combustion Behavior of Refinery Streams Derived from Canadian Oil Sands Crude. Bunting, Fairbridge, Mitchell, Crawford, et al. 2008. (SAE 08FFL 28)

The Relationships of Diesel Fuel Properties, Chemistry, and HCCI Engine Performance as Determined by Principal Components Analysis. Bunting and Crawford. 2007. (SAE 07FFL 64).

Review and Critique of Data and Methodologies used in EPA Proposed Utility Mercury MACT Rulemaking, prepared by AEMS and RWCrawford Energy Systems for the National Mining Association. April 2004.

PCR+ in Diesel Fuels and Emissions Research. McAdams, Crawford, Hadder. March 2002. ORNL/TM-2002/16.

A Vector Approach to Regression Analysis and its Application to Heavy-duty Diesel Emissions. McAdams, Crawford, Hadder. November 2000. ORNL/TM-2000/5.

A Vector Approach to Regression Analysis and its Application to Heavy-duty Diesel Emissions. McAdams, Crawford, Hadder. June 2000. (SAE 2000-01-1961).

Reconciliation of Differences in the Results of Published Shortfall Analyses of 1981 Model Year Cars. Prepared by Energy and Environmental Analysis, Inc. for the U.S. Department of Energy under Contract DE-AC01-79PE-70045. October 1985

Short Test Results on 1980-1981 Passenger Cars from the Arizona Inspection and Maintenance Program. Darlington, Crawford, Sashihara. August 1984.

Seasonal and Regional MPG as Influenced by Environmental Conditions and Travel Patterns. Prepared by Energy and Environmental Analysis, Inc. for the U.S. Department of Energy under Contract DE-AC01-79PE-70045. March 1983.

Comparison of EPA and On-Road Fuel Economy – Analysis Approaches, Trends, and Impacts. McNutt, Dulla, Crawford, McAdams, Morse. June 1982. (SAE 820788)

Regionalization of In-Use Fuel Economy Effects. Prepared by Energy and Environmental Analysis, Inc. for the U.S. Department of Energy under Contract DE-AC01-79PE-70032. April 1982.

1985 Light-Duty Truck Fuel Economy. Duleep, Kuhn, Crawford. October 1980. (SAE 801387)

PROFESSIONAL AFFILIATIONS

Member, Society of Automotive Engineers.

HONORS AND AWARDS

2006 Barry D. McNutt Award for Excellence in Automotive Policy Analysis. Society of Automotive Engineers.

US Patent 7018524 (McAdams, Crawford, Hadder, McNutt). Reformulated diesel fuels for automotive diesel engines which meet the requirements of ASTM 975-02 and provide significantly reduced emissions of nitrogen oxides (NO_x) and particulate matter (PM) relative to commercially available diesel fuels.

US Patent 7096123 (McAdams, Crawford, Hadder, McNutt). A method for mathematically identifying at least one diesel fuel suitable for combustion in an automotive diesel engine with significantly reduced emissions and producible from known petroleum blend stocks using known refining processes, including the use of cetane additives (ignition improvers) and oxygenated compounds.

###

EXHIBIT B

BEFORE THE
CALIFORNIA AIR RESOURCES BOARD

In re:	)
	)
Proposed Regulation on the Commercialization of Alternative Diesel Fuels (Public Hearing Scheduled for March 20, 2014)	)
	)

Declaration of James M. Lyons

I, James M. Lyons, declare and state as follows:

1. I am an engineer with training and expertise in motor vehicle fuels, automotive emissions control, and automotive air pollution. I am a Senior Partner of Sierra Research, Inc. ("Sierra"), an environmental consulting firm located at 1801 J Street, Sacramento, California. Sierra specializes in research and regulatory matters pertaining to air pollution control, and does work for both governmental and private sector clients. I have been employed at Sierra Research since 1991. I received a B.S. degree in Chemistry from the University of California, Irvine, and a M.S. Degree in Chemical Engineering from the University of California, Los Angeles. Before joining Sierra in 1991, I was employed by the State of California in the Mobile Source Division of the California Air Resources Board ("CARB").

I. Introduction, Qualifications, and Materials Considered

2. I have prepared this Declaration and the analysis it contains for Growth Energy. I hold the opinions expressed in this Declaration with a reasonable degree of engineering and scientific certainty. I plan to request an opportunity to testify before CARB at the public hearing scheduled for this matter, so that I may answer any questions concerning my opinions and the analysis and sources on which I have based those opinions. I also request that CARB review and

respond to each part of the analysis and opinions presented in this Declaration before deciding what action to take on the CARB staff's proposed alternative diesel fuel ("ADF") regulation.

3. During my career, I have worked on many projects related to the following areas: (1) the assessment of emissions from on- and non-road mobile sources, including ships and locomotives; (2) analyses of the unintended consequences of regulatory actions; and (3) the feasibility of compliance with air quality regulations. I have also studied how the use of biodiesel fuels can influence exhaust emissions of oxides of nitrogen ("NOx") when used in vehicles and engines operated in California, and I have prepared and filed declarations regarding that issue in *POET LLC et al. v. California Air Resources Board*, an action in which I was a co-petitioner.

4. I have testified as an expert under state and federal court rules in cases involving CARB regulations for gasoline, Stage II vapor recovery systems and their design, combustion chamber system design, and issues related to emissions from heavy-duty vehicles and engines. While at Sierra I have acted as a consultant on automobile air pollution control matters for CARB and other governmental organizations. I am a member of the American Chemical Society and the Society of Automotive Engineers and have co-authored nine peer-reviewed monographs concerned with automotive emissions, including greenhouse gases and their control. In addition, over the course of my career, I have conducted peer-reviews of numerous papers related to a wide variety of issues associated with pollutant emissions and air quality. My résumé is attached as Attachment A.

5. I have reviewed a report being filed along with this Declaration by Growth Energy that has been prepared by Mr. Robert Crawford of Rincon Ranch Consulting, entitled *NOx Emissions Impact of Soy- and Animal-based Biodiesel Fuels: A Re-Analysis* (December

2013). I have also studied the CARB Initial Statement of Reasons ("ISOR" or "Staff Report") released to support the proposed ADF regulation, and the studies cited in the ISOR that are pertinent to Mr. Crawford's analysis. The additional materials I have considered to prepare this Declaration are identified as references.

6. Mr. Crawford's report examines the empirical basis for the CARB staff's claims that the use of biodiesel in California is unlikely to warrant environmental mitigation, and that the use of biodiesel blends below the ten percent blend level (B10) in California pursuant to the proposed ADF regulation will not result in increases in NOx emissions.

7. Mr. Crawford's report applies generally accepted methods of data analysis and demonstrates expertise in the subject-matter of the report; Mr. Crawford is an expert in the field in which he opines in his report; and his report is the type of analysis on which experts in the field of automotive emissions control rely.

II. Analysis and Opinions

A. Increases in NOx Emissions from Biodiesel Blends Below B10

8. As explained in detail in Mr. Crawford's report, a proper statistical analysis of the available emissions data relied upon by CARB staff in developing the proposed ADF regulation demonstrates that statistically significant increases in NOx emissions will result from biodiesel blends that contain less than ten percent biodiesel, including at the five percent level (B5) and below. In addition, Mr. Crawford's report demonstrates that NOx emissions increase in direct proportion of the amount of biodiesel in a blend and there is not, as CARB staff claims, a "threshold" below which biodiesel use in a blend will not increase NOx emissions. Given this, as I explain below in more detail, CARB staff should be proposing a Significance Level of zero, rather than ten percent, for biodiesel. Given the issues identified with the CARB staff analysis of

biodiesel impacts on NOx emissions by Mr. Crawford, CARB has no credible scientific basis upon which to adopt the ADF regulation as proposed with the biodiesel Significance Level set at ten percent.

9. CARB staff presents, in Figures B.2 and B.3 of the ISOR, regressions of all the available emissions data considered by CARB staff in developing the proposed ADF regulation. Based on Mr. Crawford's findings, the slopes of these regression lines can be used to calculate the increases in NOx emissions expected from the use of soy- and animal-based biodiesel as a function of biodiesel content in the blend. The values calculated for soy- and animal-based biodiesel at selected blends levels over the range from one percent to twenty percent are shown in Table 1.

Table 1
Expected Increases In NOx Emissions from Biodiesel Use Based on Available Emissions Data Considered by CARB Staff

Biodiesel Blend Level %	Percentage Increase in NOx Emissions	
	Soy-Based	Animal-Based
1	0.2	0.09
2	0.4	0.18
3	0.6	0.27
4	0.8	0.36
5	1	0.45
10	2	0.90
20	4	1.80

10. As shown in Table 1, the magnitude of the NOx increase for animal-based biodiesel is approximately half that observed for soy-based biodiesel. As also shown in Table 1, the emissions data considered by CARB show that increases in NOx emissions between about one and two percent occur at the proposed B10 significance threshold.

B. The "Effective Blend Level" Concept Provides No Assurance Against Increases in NOx Emissions Due to Biodiesel Use

11. The proposed ADF regulation relies on a concept called the "Effective Blend Level" (EB) for biodiesel to determine when mitigation would be required. The formula proposed by CARB staff for calculating the Effective Blend Level for biodiesel is found in proposed Section 2293.6(a) and is reproduced below.

$$EB = 100 \times \left[\frac{NBV - 0.5LN - 0.73RD - VM - 0.55AB}{TCV}\right]$$

As specified in Section 2293.6(a), the above formula is to be used to compute an annual average statewide value for the Effective Blend Level relative to the total volume of fuel used in compression ignition engines excluding alternative fuels such as natural gas and liquefied petroleum gas ("TCV") in the state during that year.

12. The calculation begins with establishing the net volume of biodiesel of all types used in California *excluding biodiesel used in blends of five percent or less* (NBV) — a step that has no scientific basis, as demonstrated by Mr. Crawford's analysis, and that, on its own, completely invalidates the use of the EB metric for the intended purpose. The NBV value is then further reduced by subtracting 50% of the volume of low NOx Diesel (LN) used statewide and 73% of the volume of renewable Diesel used statewide. The remainder is then further reduced by subtracting the volume of biodiesel of all types used in blends where steps have been taken to voluntarily mitigate NOx increases (VM) and then again by subtracting 55% of the volume of animal-based biodiesel (AB) to account for the smaller magnitude of the NOx emission increases observed with that fuel.[1] The final value is then divided by TCV (i.e., the total volume of fuel

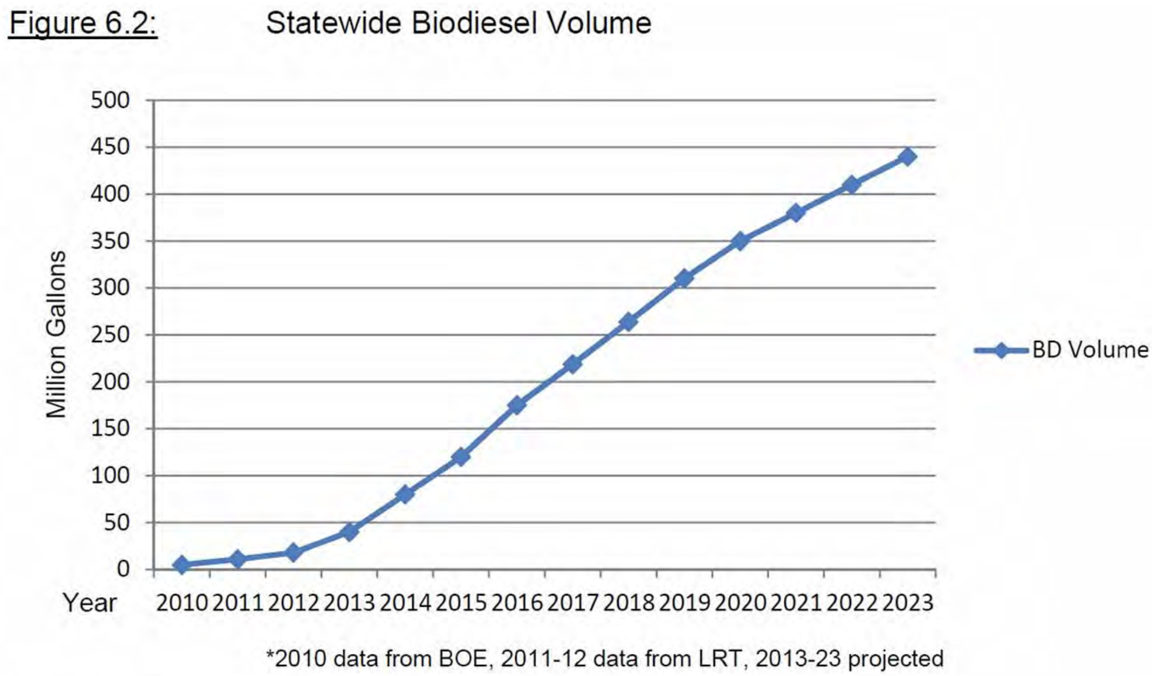
1 Those voluntary mitigation measures are assumed to have been taken before the so-called "Significance Level" is reached and mitigation would be required under the staff's proposal. *See* ¶ 13.

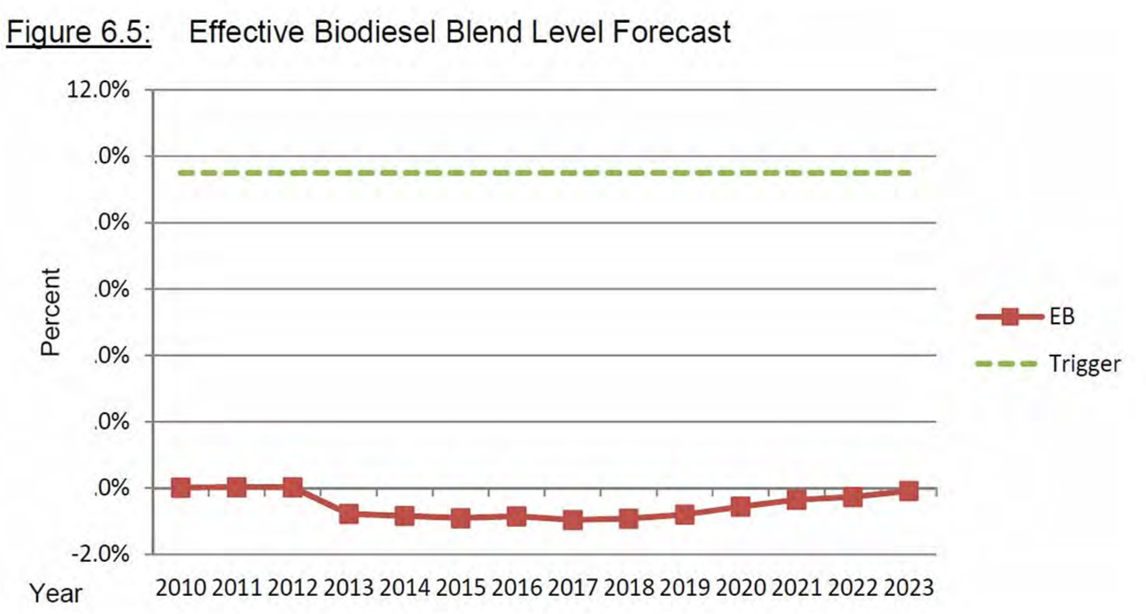
used in compression ignition engines excluding alternative fuels such as natural gas and liquefied petroleum gas in the state during that year) and multiplied by 100 to yield the Effective Blend Level on a percentage basis.

13. As specified in proposed Section 2293.5(c)(4), mitigation of NOx increases associated with biodiesel would be required only when the value of EB reaches 9.5 percent, which is 95% of the 10% Significance Level proposed for biodiesel.

14. There are a number of specific problems with the concept and calculation of the predicted Effective Blend Level that create the potential for significant increases in NOx emissions to result from the use of biodiesel in California; these are explained in detail below and should be addressed by CARB. As an initial matter, however, the overall problem with the EB concept will allow massive increases in the amount of biodiesel used in California without requiring any mitigation of the associated increase in NOx emissions. This can be seen readily by comparing CARB staff's projections of biodiesel use in California (Figure 6.2 of the ISOR) with CARB staff's projections regarding the Effective Blend Level for biodiesel (Figure 6.5 of the ISOR). Those two figures are reproduced below in Figure 1. As can been seen, despite the forecast nine-fold increase in annual biodiesel use in California from 50 million to 450 million gallons from 2013 to 2023 shown in Figure 6.2 of the ISOR, the forecast Effective Blend Level of biodiesel **decreases** to less than zero over virtually all of the period in question — meaning that, under the CARB staff's proposal, no mitigation of the increase in NOx emissions in California from biodiesel use will ever occur. CARB needs to confront and eliminate the EB concept from the staff's proposal, in light of this very simple demonstration of why the EB concept will not protect the environment against increases in NOx emissions.

Figure 1. CARB Biodiesel Forecasts





Source: CARB Initial Statement of Reasons. Note that Figure 6.5 is reproduced directly from the ISOR, which is missing some increments on the y-axis.

15. Next, CARB needs to modify the proposed ADF regulation in order to address CARB staff's faulty assumption that biodiesel blends of up to five percent will have no impact on NOx emissions. With respect to five percent blends, CARB staff states on page ES-3 of the Staff

Report that “biodiesel used in blends at B9 or below, including the B5 (B0 to B5) in predominant use today, does not increase NOx.” The Staff Report also attempts to justify the exclusion of five percent blends from the EB calculation by arbitrarily excluding these blends from the ADF regulation. That assertion is undercut by the Staff Report’s frank and correct admission on page 51 that “[g]iven the significant price premium for higher biodiesel blends such as B20 or B100, it is highly unlikely that operators of heavy-duty, legacy diesel fleets would opt to use the more expensive, higher biodiesel blends when comparable, lower cost conventional CARB diesel or B5 blends are readily available.”

16. As noted above, Mr. Crawford’s analysis demonstrates that statistically significant increases in NOx emissions will occur from the use of five percent biodiesel blends and, as Table 1 shows, the available emissions data relied upon by CARB staff indicate that at the five percent blend level, biodiesel use is expected to increase NOx emission by between about 0.5 and one percent. There is no doubt that unmitigated NOx emission increases of this magnitude have the potential to create significant adverse environmental impacts in areas of California with severe air quality problems.

17. It is also important for CARB to understand the import of the staff’s prediction that biodiesel blends of five percent or less will be the primary means by which biodiesel will be used in California. As the Staff Report states on page 30:

> Staff has communicated with many of the stations that sell biodiesel as well as the major terminal operators in the state, and has found that the vast majority of the biodiesel currently being sold in California and expected to be sold in the future is sold as blends of B5 or less.

The fact that most biodiesel used in California will be sold as blends of five percent biodiesel or less, coupled with the fact that – as Mr. Crawford has explained – the available data show statistically significant increases in NOx emissions from such blends, means that biodiesel use in

California under the proposed ADF regulation will result in unmitigated increases in NOx emissions. Again, the critical nature of the CARB staff's invalid assumption about the NOx impacts of blends at or below five percent simply cannot be ignored by CARB.

18. Even if it were correct that blends of B5 and less have no impact on NOx emissions, the EB calculation double-counts for the supposedly benign effect of those blends, and therefore makes mitigation even more unlikely. This can be illustrated by noting that CARB staff estimates that 450 million gallons per year of biodiesel will be used in California in 2023. (See Figure 6.2 of the Staff Report.) A recent California Energy Commission forecast[2] for total Diesel use in California in 2023 is about 4 billion gallons. On that basis, and without discounting for low NOx, renewable Diesel, or voluntary mitigation, the actual Effective Blend Level would be 11.25 percent and mitigation would be required for at least some biodiesel blends under the proposed ADF. Under CARB staff's approach, however, if a substantial portion of that biodiesel — for example, 50 percent — is five percent or lower blends, the Effective Blend Level drops to 5.6 percent and no mitigation of any kind is required for any biodiesel blends. That result is clearly incorrect, and the EB calculation must be modified to include, rather than exclude, B5 blends.

19. Another fundamental problem with the proposed EB calculation is that it is based on annual statewide average fuel use. NOx emissions have local and immediate impacts on air quality, with the questions of when and where they occur in the state being of critical importance with respect to the significance of those impacts. It follows directly that mitigation of NOx increases associated with biodiesel use must occur in the same area at the same time if air quality

[2] See *http://www.energy.ca.gov/2011publications/CEC-600-2011-007/CEC-600-2011-007-SD.pdf* .

impacts are to be avoided. However, the EB completely fails to provide this assurance because CARB staff has either (1) ignored that reductions in NOx emissions from mitigation must take place at the same time and in the same area as NOx increases from biodiesel use, or (2) without support from anything in the rulemaking file, assumed that mitigation will occur in the same area and at the same time as the increases in NOx emissions.

20. To illustrate the problems the EB creates for mitigation, consider, for example, that under the proposed ADF regulation, increases in NOx emissions could occur from trucks operating on biodiesel in Los Angeles during August and exacerbate already high ambient ozone levels in that area. In turn, this increase in NOx emissions could be "mitigated" by reductions in NOx emissions from trucks operating on renewable diesel in the San Francisco area during December, when high ozone levels are not a problem. In this example, the EB concept would allow residents of Los Angeles to suffer adverse environmental impacts while the residents of San Francisco would realize no environmental benefit. Clearly the approach to mitigation designed into the EB concept by CARB staff makes no sense.

C. CARB Staff's Assumption that Biodiesel Use Will not Increase Emissions from New Technology Diesel Engines Is Not Adequately Supported

21. In the Staff Report, CARB staff makes frequent statements regarding the impact of biodiesel on NOx emissions from "new technology diesel engines" (or "NTDEs"). For example, on page ES-3 of the ISOR, the staff states categorically that "use of biodiesel in 2010-compliant engines and other so-called 'New Technology Diesel Engines' does not increase NOx, regardless of the biodiesel blend level." Only one reference, Lammert et al.,[3] is provided in the staff report

[3] Lammert, M., McCormick, R., Sindler, P. and Williams, A., "Effect of B20 and Low Aromatic Diesel on Transit Bus NOx Emissions Over Driving Cycles with a Range of Kinetic Intensity," *SAE Int. J. Fuels Lubr.* 5(3):2012,

(Continued…)

to support this and other, analogous, statements by CARB staff. As CARB staff acknowledges, this single study involved chassis dynamometer testing of only two urban buses with NTDEs, with both engines being the same model produced by the same manufacturer. The extrapolation of that limited testing to the entire population of heavy-duty Diesel vehicles with NTDEs used in different applications and with different engine designs produced by a number of different manufacturers is simply not credible or reliable.

22. In addition, the CARB staff fails to acknowledge the following statement made by the authors of the Lammert study about the measurement of NOx emissions: "For much of the cycle[,] NOx would be at or near the detection limit of the laboratory equipment which resulted in a 95 percent confidence interval that was high relative to the value of the cycle emissions." That effect, which can be clearly seen in Figures 10 and 11 of the Lammert study, renders the claim that there was no statistically significant increase in NOx emissions observed from the use of biodiesel in NTDEs an artifact attributable to the lack of sensitivity of the NOx measurement instrumentation used in the study.

23. In sum, the CARB staff's unequivocal statements regarding the impact of biodiesel on NOx emissions from all vehicles with NTDEs is simply not reasonable based on data from (1) a single study that (2) that tested only two urban buses equipped with the same engine and (3) used instrumentation that was, at best, barely able to measure NOx emissions from the test vehicles in general, and clearly was not sensitive enough to reliably detect changes in NOx emissions due to use of different fuels. Nothing else in the rulemaking file supports the CARB staff's claim that there will not be increased NOx emissions from the use of biodiesel in NTDEs.

I declare under penalty of perjury under the laws of California that the foregoing is true and correct to the best of my knowledge and belief.

Executed this __12th__ day of December 2013 at Sacramento, California.

James M. Lyons

ATTACHMENT A

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research

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Résumé

James Michael Lyons

Education

1985, M.S., Chemical Engineering, University of California, Los Angeles

1983, B.S., Cum Laude, Chemistry, University of California, Irvine

Professional Experience

4/91 to present — Senior Engineer/Partner/Senior Partner
Sierra Research

Primary responsibilities include oversight and execution of complex analyses of the emission benefits, costs, and cost-effectiveness of mobile source air pollution control measures. Mr. Lyons has developed particular expertise with respect to the assessment of control measures involving fuel reformulation, fuel additives, and alternative fuels, as well as accelerated vehicle/engine retirement programs, the deployment of advanced emission control systems for on- and non-road gasoline- and Diesel-powered engines, on-vehicle evaporative and refueling emission control systems, and Stage I and Stage II service station vapor recovery systems. Additional duties include assessments of the activities of federal, state, and local regulatory agencies with respect to motor vehicle emissions and reports to clients regarding those activities. Mr. Lyons has extensive litigation experience related to air quality regulations, product liability, and intellectual property issues.

7/89 to 4/91 — Senior Air Pollution Specialist
California Air Resources Board

Supervised a staff of four professionals responsible for identifying and controlling emissions of toxic air contaminants from mobile sources and determining the effects of compositional changes to gasoline and diesel fuel on emissions of regulated and unregulated pollutants. Other responsibilities included development of new test procedures and emission standards for evaporative and running loss emissions of hydrocarbons from vehicles; overseeing the development of the state plan to control toxic emissions from motor vehicles; and reducing emissions of CFCs from motor vehicles.

4/89 to 7/89	Air Pollution Research Specialist California Air Resources Board

Responsibilities included identification of motor vehicle research needs; writing requests for proposals; preparation of technical papers and reports; as well as monitoring and overseeing research programs.

9/85 to 4/89	Associate Engineer/Engineer California Air Resources Board

Duties included analysis of vehicle emissions data for trends and determining the effectiveness of various types of emissions control systems for both regulated and toxic emissions; determining the impact of gasoline and diesel powered vehicles on ambient levels of toxic air contaminants; participation in the development of regulations for "gray market" vehicles; and preparation of technical papers and reports.

Professional Affiliations

American Chemical Society
Society of Automotive Engineers

Selected Publications (Author or Co-Author)

"Review of CARB Staff Analysis of 'Illustrative' Low Carbon Fuel Standard (LCFS) Compliance Scenarios," Sierra Research Report No. SR2012-02-01, prepared for the Western States Petroleum Association, February 20, 2012.

"Review of CARB On-Road Heavy-Duty Diesel Emissions Inventory," Sierra Research Report No. SR2010-11-01, prepared for The Ad Hoc Working Group, November 2010.

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"Technical Review of EPA Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis for Non-GHG Pollutants," Sierra Research Report No. SR2010-05-01, prepared for the American Petroleum Institute, May 2010.

"Effects of Gas Composition on Emissions from Heavy-Duty Natural Gas Engines," Sierra Research Report No. SR2010-02-01, prepared for the Southern California Gas Company, February 2010.

"Effects of Gas Composition on Emissions from a Light-Duty Natural Gas Vehicle," Sierra Research Report No. SR2009-11-01, prepared for the Southern California Gas Company, November 2009.

“Technical Review of 2009 EPA Draft Regulatory Impact Analysis for Non-GHG Pollutants Due to Changes to the Renewable Fuel Standard,” Sierra Research Report No. SR2009-09-01, prepared for the American Petroleum Institute, September 2009.

“Effects of Vapor Pressure, Oxygen Content, and Temperature on CO Exhaust Emissions,” Sierra Research Report No. 2009-05-03, prepared for the Coordinating Research Council, May 2009.

“Technical Review of 2007 EPA Regulatory Impact Analysis Methodology for the Renewable Fuels Standard,” Sierra Research Report No. 2008-09-02, prepared for the American Petroleum Institute, September 2008.

“Impacts of MMT Use in Unleaded Gasoline on Engines, Emission Control Systems, and Emissions,” Sierra Research Report No. 2008-08-01, prepared for McMillan Binch Mendelsohn LLP, Canadian Vehicle Manufacturers’ Association, and Association of International Automobile Manufacturers of Canada, August 2008.

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“Evaluation of California Greenhouse Gas Standards and Federal Energy Independence and Security Act – Part 1: Impacts on New Vehicle Fuel Economy,” SAE Paper No. 2008-01-1852, Society of Automotive Engineers, 2008.

“Basic Analysis of the Cost and Long-Term Impact of the Energy Independence and Security Act Fuel Economy Standards,” Sierra Research Report No. SR 2008-04-01, April 2008.

“The Benefits of Reducing Fuel Consumption and Greenhouse Gas Emissions from Light-Duty Vehicles,” SAE Paper No. 2008-01-0684, Society of Automotive Engineers, 2008.

“Assessment of the Need for Long-Term Reduction in Consumer Product Emissions in South Coast Air Basin,” Sierra Research Report No. 2007-09-03, prepared for the Consumer Specialty Products Association, September 2007.

“Summary of Federal and California Subsidies for Alternative Fuels,” Sierra Research Report No. SR2007-04-02, prepared for the Western States Petroleum Association, April 2007.

“Analysis of IRTA Report on Water-Based Automotive Products,” Sierra Research Report No. SR2006-08-02, prepared for the Consumer Specialty Projects Association and Automotive Specialty Products Alliance, August 2006.

“Evaluation of Pennsylvania’s Implementation of California’s Greenhouse Gas Regulations on Criteria Pollutants and Precursor Emissions,” Sierra Research Report No. SR2006-04-01, prepared for Alliance of Automobile Manufacturers, April 12, 2006.

"Evaluation of New Jersey's Adoption of California's Greenhouse Gas Regulations on Criteria Pollutants and Precursor Emissions," Sierra Research Report No. SR2005-09-03, prepared for the Alliance of Automobile Manufacturers, September 30, 2005.

"Evaluation of Vermont's Adoption of California's Greenhouse Gas Regulations on Criteria Pollutants and Precursor Emissions," Sierra Research Report No. SR2005-09-02, prepared for the Alliance of Automobile Manufacturers, September 19, 2005.

"Assessment of the Cost-Effectiveness of Compliance Strategies for Selected Eight-Hour Ozone NAAQS Nonattainment Areas," Sierra Research Report No. SR2005-08-04, prepared for the American Petroleum Institute, August 30, 2005.

"Evaluation of Connecticut's Adoption of California's Greenhouse Gas Regulations on Criteria Pollutants and Precursor Emissions," Sierra Research Report No. SR2005-08-03, prepared for the Alliance of Automobile Manufacturers, August 26, 2005.

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"Operation of a Pilot Program for Voluntary Accelerated Retirement of Light-Duty Vehicles in the South Coast Air Basin," Sierra Research Report No. SR01-05-02, prepared for California Air Resources Board, May 2001.

"Comparison of Emission Characteristics of Advanced Heavy-Duty Diesel and CNG Engines," Sierra Report No. SR01-05-01, prepared for Western States Petroleum Association, May 2001.

"Analysis of Southwest Research Institute Test Data on Inboard and Sterndrive Marine Engines," Sierra Report No. SR01-01-01, prepared for National Marine Manufacturers Association, January 2001.

"Institutional Support Programs for Alternative Fuels and Alternative Fuel Vehicles in Arizona: 2000 Update," Sierra Report No. SR00-12-04, prepared for Western States Petroleum Association, December 2000.

"Real-Time Evaporative Emissions Measurement: Mid-Morning Commute and Partial Diurnal Events," SAE Paper No. 2000-01-2959, October 2000.

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"Benzene/Aromatic Measurements and Exhaust Emissions from Gasoline Vehicles," Paper No. 89-34B.4, presented at the 82nd Annual Meeting of the Air and Waste Management Association, Anaheim, CA, June 1989.

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EXHIBIT C

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America's Ethanol Supporters

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September 16, 2013

By Electronic Mail

Alexander Mitchell
Floyd Vergara
California Air Resources Board
Stationary Source Division
1001 I Street
Sacramento, California 95812

Re: Comments Regarding CARB's Alternative Diesel Fuels Rulemaking

Dear Sirs:

Growth Energy, an organization of ethanol producers and supporters, has a number of concerns with the Alternative Diesel Fuels (ADF) Regulations currently under development by the staff of the California Air Resources Board (CARB) which were the subject of a September 5th workshop held in Sacramento. These concerns, which are described in detail below, focus on the treatment of biodiesel and biodiesel blends currently being proposed by CARB staff. Overall, the provisions of the proposed ADF regulations would allow for the widespread use of biodiesel and biodiesel blends in California without adequately mitigating the resulting increases in emissions of oxides of nitrogen (NOx). The treatment being proposed by CARB staff for biodiesel and biodiesel blends is unacceptable in that it will result in adverse air quality impacts and violates several of the "underlying principles" in the February 15, 2013, CARB White Paper concerning its conceptual approach to the regulation of alternative diesel fuels, including:[1]

1. Protection of public health;
2. Preservation or improvement of air quality; and
3. Reliance on the best scientific knowledge available.

Given the above, Growth Energy urges CARB staff to revise the proposed ADF regulations to eliminate the potential for biodiesel use in California to result in increased emissions, degraded air quality and adverse impacts on public health.

[1] See page 3 of CARB's White Paper "Discussion of Conceptual Approach to Regulation of Alternative Diesel Fuels", February 15, 2013 which is available at http://www.arb.ca.gov/fuels/diesel/altdiesel/20130212ADFRegConcept.pdf

1. The Proposed ADF Regulation Incorrectly Ignores Increases in NOx Emissions Associated with Use of Biodiesel Blends

As currently drafted, the proposed ADF regulation fails to require any mitigation for increases in NOx emissions associated with the use of biodiesel until total biodiesel usage in the state amounts to at least 10% of all fuel used in diesel engines in California on an annual basis.[2] While the potential for increased NOx emissions due to this arbitrarily established "significance level" for biodiesel use is discussed in Section 2 below, its basic premise appears to be an assumption that there are no NOx emissions associated with the use of biodiesel blends at or below the B10 level. In support of the inaccurate assumption that there is some threshold level below which biodiesel use will not increase emissions, CARB cites its White Paper, which states:[1]

> *Furthermore, for purposes of this rulemaking B5 blends will be considered a legal California diesel fuel with no emissions mitigation required.*

This arbitrary threshold is not supported by any data or analysis, and we are unaware of any published analysis of emissions test data that supports the assumptions that there are no increases in NOx emissions at either the B5 or up to the B10 levels.

In contrast, a preliminary analysis of data from CARB's most recently funded biodiesel testing program[3] demonstrates that NOx emissions would increase significantly at the B5 and B10 levels in at least some engines and for some biodiesel types. Here, the term "significant" means both that the NOx increase is statistically significant and that it is large enough to be of concern. Although the fact that CARB has not made all of the emissions data from this testing program publically available makes analysis difficult, results of a preliminary analysis are shown in Table 1 below for a 2006 model-year Cummins heavy-duty diesel engine. As shown, the relationship between increasing biodiesel content and increased NOx emissions is statistically significant at the 95% confidence level in all cases for soy-based biodiesel and at the 90% confidence level or better for animal-based biodiesel.

Further, the R^2 statistics for soy-based fuels show that the emissions effect of biodiesel is almost perfectly linear with increasing biodiesel content. Although not as high because the emissions effect is smaller and measurement errors are relatively larger in comparison to the trend, the R^2 statistics for the animal-based fuels also clearly establish a linear increase in NOx emissions with increasing biodiesel content. Because the slope or the regression equations are statistically significant in all cases and the R^2 statistics are high, there is no evidence in the data for the Cummins engine of the "threshold effect" that CARB staff claims which purports that biodiesel content has to reach the B5 or B10 level before NOx emissions begin to increase.

[2] See slide 18 of the staff presentation for the September 5th workshop which is available at http://www.arb.ca.gov/fuels/diesel/altdiesel/20130905ADFWorkshopPresentation.pdf
[3] Available at http://www.arb.ca.gov/fuels/diesel/altdiesel/20111013_CARB%20Final%20Biodiesel%20Report.pdf

PRELIMINARY ANALYSIS SUBJECT TO REVISON

Table 1. 2006 Cummins Engine (Dynamometer Testing)

Model: NOx = A + B · BioPct

(Note: Dataset does not yet include the data on B5.)

Bright yellow highlight indicates result is statistically significant at 95% confidence level or better.
Light yellow highlight indicates result is statistically significant at the 90% confidence level or better.

Biodiesel Type	Test Cycle	R^2	Intercept A	BioPct Slope B		Predicted NOx Increase for B5	Predicted NOx Increase for B10
			Value	Value	p value	% Change	Pct Change
Soy-based							
	UDDS	0.997	5.896	0.0100	0.001	0.8%	1.7%
	FTP	0.995	2.024	0.0052	0.003	1.3%	2.6%
	40 mph	1.000	2.030	0.0037	<0.0001	0.9%	1.8%
	50 mph	0.969	1.733	0.0028	0.016	0.8%	1.6%
Animal-based							
	UDDS	0.847	5.911	0.0021	0.080	0.2%	0.4%
	FTP	0.981	2.067	0.0031	0.001	0.7%	1.4%
	50 mph	0.887	1.768	0.0011	0.058	0.3%	0.6%

Turning to the importance of the magnitude of the NOx increases, the South Coast Air Quality Management District (SCAQMD) Final 2012 Air Quality Management Plan estimates 2014 NOx emissions from on-road and non-road diesel vehicles to be approximately 190 tons per day.[4] This means that the approximately 1% increase in NOx emissions due to B5 blends translates to an increase of about 2 tons per day in NOx emissions in the South Coast Air Basin alone, while an approximately 2% increase at B10 equals 4 tons per day within that basin. Continuing to B20 the impact would be 8 tons per day. That these are significant increases is clearly evidenced by the fact that both CARB and SCAQMD have adopted numerous emission control measures targeting NOx that have achieved reductions that are similar to or smaller than these values.

Instead of acknowledging emissions testing data CARB itself generated that show increases in NOx emissions associated with B5 and B10 blends, CARB staff instead claims that more research is necessary before it can consider mitigation of B5 impacts: [5]

> *Staff is currently contracting with the University of California at Riverside to develop data to determine whether there are significant adverse air-related impacts from the use of B5 blends sufficient to warrant mitigation in the future.*

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[4] See Figure 3-9 available at http://www.aqmd.gov/aqmp/2012aqmp/Final-February2013/MainDoc.pdf

[5] See page 4 of CARB's White Paper "Discussion of Conceptual Approach to Regulation of Alternative Diesel Fuels", February 15, 2013 which is available at http://www.arb.ca.gov/fuels/diesel/altdiesel/20130212ADFRegConcept.pdf

This represents an impermissible deferral of analysis and mitigation of significant impacts under CEQA. Moreover, as participants in the process that lead to the adoption of CARB's Low Carbon Fuel Standard (LCFS) regulation in 2009 where CARB adopted indirect land use change (ILUC) values based on preliminary and unsubstantiated modeling results claiming a need to rely on the best available science, Growth Energy finds CARB staff's current position that ignores actual data showing NOx increases from low level biodiesel blends to be unsupported.

2. The Proposed "Significance Threshold" for Biodiesel would Allow Significant Increases in NOx Emissions to Occur in the South Coast and San Joaquin Valley Air Basins Exacerbating Existing Air Quality Problems

In addition to CARB staff's failure to analyze low-level biodiesel blends, the "significance threshold" proposed by CARB staff for biodiesel use in California would allow significant increases in NOx emissions due to biodiesel use to occur in the South Coast and San Joaquin Valley air basins that experience the worst air quality problems in the state.

According to CARB staff's presentation for the September workshop,[6] staff is proposing to evaluate the significance of NOx increases due to biodiesel use on a statewide rather than a regional basis. Given the proposed use of a statewide average biodiesel level and the B10 significance threshold, the potential exists for significant quantities of B20 or even higher levels of biodiesel blends to be used without mitigation in areas of the state with significant air quality problems, such as the South Coast and/or San Joaquin Valley air basins. At this point, even CARB staff acknowledges that use of B20 blends results in significant NOx increases and as noted above based on CARB's own test data B20 use in the South Coast Air Basin could increase NOx emissions by as much as 8 tons per day in 2014.

Given the severe air quality problems that exist in the South Coast and San Joaquin Valley air basins, CARB must modify the proposed ADF regulation so that it guarantees that increased NOx emissions related to biodiesel use would not occur in these areas. The reduction of NOx emissions is important, particularly in light of CARB's "Vision for Clean Air,"[7] which demands the elimination of NOx emissions from diesel engines in both air basins as a perquisite for achieving the state's air quality goals.

3. The Proposed Transfer of Credit for Reductions in NOx Emissions Generated by Low NOx Diesel Producers to Offset Increases in NOx Emissions Generated by Biodiesel Producers is Not Equitable

[6] See slide 18 of the staff presentation for the September 5th workshop which is available at http://www.arb.ca.gov/fuels/diesel/altdiesel/20130905ADFWorkshopPresentation.pdf
[7] See http://www.arb.ca.gov/planning/vision/docs/vision_for_clean_air_public_review_draft.pdf

According to CARB staff's presentation at the September workshop,[8] staff is proposing to directly offset increases in NOx emissions resulting from the use of biodiesel with reductions in emissions due to the use of "low NOx" diesel fuels, which are defined by specific properties as shown in the staff presentation for the September 5th workshop.[9] To date, however, we are unaware of any information or explanation from CARB staff as to why producers of low NOx diesel fuels should be forced by CARB regulations to surrender credit for the NOx emission reductions their fuels achieve in order to benefit the producers of biodiesel fuels which increase NOx emissions.

Given that the production of low NOx diesel fuel is not currently mandated by any existing CARB regulation, the resulting emission benefits should be considered "surplus," and could presumably be used to generate Mobile Source Emission Reduction Credits under CARB regulations.[10] Further, the use of such fuels by fleets or distribution of such fuels by fuel providers could potentially be considered to be projects that qualify for incentive funding under the Carl Moyer Program.[11]

Instead of forcing producers of low NOx diesel fuels to transfer the credit for the NOx reductions attributable to their products without compensation to producers of biodiesel fuels that increase NOx emissions, CARB should establish a market mechanism to incentivize the production of low NOx fuels and to disincentivize the production of NOx-increasing biodiesel fuels. The most logical approach to accomplish this would seem to be providing NOx reduction credits to producers of low NOx fuels under the LCFS regulation while assigning NOx emission debits to producers of biodiesel and then requiring the latter to purchase and surrender credits sufficient to offset the increases in NOx emissions associated with their products.

4. The Proposed Treatment of Biodiesel and Biodiesel Blends Used in "New Technology Diesel Engines" (NTDEs) is Not Equitable With CARB's Treatment of Other Fuels

In addition to defects with the proposed ADF regulations described above, we are unaware of any published analysis or supporting data that the use of biodiesel at any concentration in NTDE's would not result in increased NOx emissions. The rationale for this treatment appears to be an assumption that the advanced emission control systems found on NTDEs eliminate any impact of fuel composition on emissions of NOx and potentially other pollutants.

Our primary concern with this proposal is that CARB staff has not provided any supporting data or analysis. In addition, if NTDEs are truly insensitive to fuel composition impacts, CARB should make changes similar to those proposed by biodiesel for other fuels. More specifically, if CARB staff's assumption that NTDE emissions are not sensitive to fuel composition is in fact correct, it follows that there is no longer any need to use CARB diesel fuel in NTDEs instead of less expensive federal diesel fuels which could be substituted without any adverse emission impacts.

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[8] See slide 19 of the staff presentation for the September 5th workshop which is available at http://www.arb.ca.gov/fuels/diesel/altdiesel/20130905ADFWorkshopPresentation.pdf
[9] See slide 24 of the staff presentation for the September 5th workshop which is available at http://www.arb.ca.gov/fuels/diesel/altdiesel/20130905ADFWorkshopPresentation.pdf
[10] See http://www.arb.ca.gov/msprog/mserc/mserc.htm
[11] See http://www.arb.ca.gov/msprog/moyer/moyer.htm

Clearly, CARB could develop a "significance threshold" for the sale of federal diesel fuel in California similar to that proposed for biodiesel which would achieve this objective while providing the benefit of reduced diesel costs without adverse air quality impacts. Growth Energy therefore encourages CARB staff to revise the ADF to avoid these impacts.

Sincerely,

David Bearden

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OTHER EXHIBITS

Public Review Draft
June 27, 2012

Vision for Clean Air: A Framework for Air Quality and Climate Planning

This document has been prepared by the staffs of the California Air Resources Board, the South Coast Air Quality Management District and the San Joaquin Valley Unified Air Pollution Control District. Publication does not signify that the contents reflect the views and policies of the Air Resources Board, the South Coast Air Quality Management District or the San Joaquin Valley Unified Air Pollution Control District. This document will be presented as an informational item at a noticed public meeting scheduled for June 28, 2012.

Table of Contents

Executive Summary

As California plans for the future, transformational technologies, cleaner energy, and greater efficiency are expected to provide the foundation for meeting air quality standards and climate goals. California's success in reducing smog has largely relied on technology and fuel advances, and as health-based air quality standards are tightened, the introduction of cleaner technologies must keep pace. More broadly, a transition to zero- and near-zero emission technologies is necessary to meet 2023 and 2032 air quality standards and 2050 climate goals. Many of the same technologies will address both air quality and climate needs. As such, strategies developed for air quality and climate change planning should be coordinated to make the most efficient use of limited resources and the time needed to develop cleaner technologies.

Vision for Clean Air: A Framework for Air Quality and Climate Planning takes a coordinated look at strategies to meet California's multiple air quality and climate goals well into the future. Its quantitative demonstration of the needed technology and energy transformation provides a foundation for future integrated air quality and climate program development. *Vision for Clean Air* focuses on mobile sources and associated energy production. Similar analyses will be necessary for industrial and other emission sources to develop a complete foundation for integrated planning.

Recognizing that the severity of California's air quality problems varies by region, *Vision for Clean Air* examines what is needed to attain air quality standards by the federal deadlines in the areas with the worst air quality -- the South Coast Air Basin and the San Joaquin Valley Air Basin. However, the technologies and strategies identified will pay clean air dividends for all air districts, helping them achieve or maintain federal air quality standards and reduce local air toxics exposure.

Ozone and Climate Planning Horizons

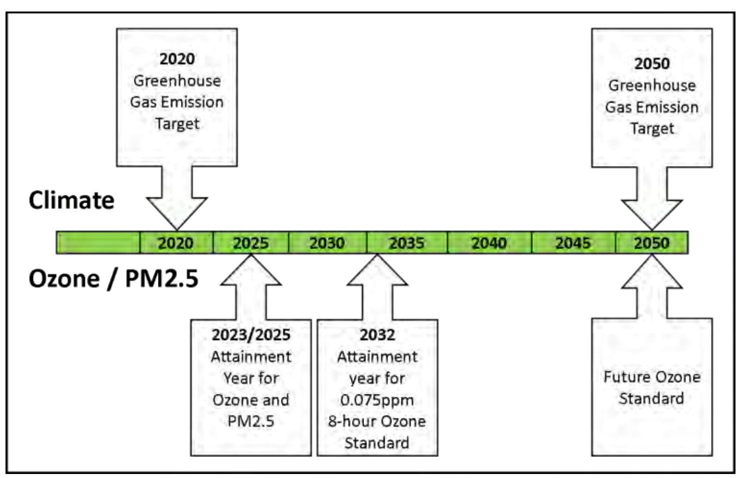


Figure 1

Achieving the 2020 greenhouse gas emission target established by the Global Warming Solutions Act of 2006 (AB 32) is a statewide goal. For the long term, California has set for itself the 2050 goal of greenhouse gas emissions of 80 percent less than 1990 levels overall, and specifically 80 percent less than 1990 levels for the transportation sector.[1] In 2013, the

[1] Governor Brown Executive Order B-16-2012

AB 32 Scoping Plan will be updated to address post-2020 greenhouse gas emissions.

In 2009, the Air Resources Board (ARB), the South Coast Air Quality Management District (SCAQMD) and the San Joaquin Valley Air Pollution Control District (SJVAPCD) developed a partnership with the U.S. Environmental Protection Agency (U.S. EPA) to promote technology advancements needed to meet air quality standards by federal deadlines. In *Vision for Clean Air,* ARB and the South Coast and San Joaquin Valley air districts examine how those technologies can meet both air quality and climate goals over time.

California's deadlines for meeting federal air quality standards extend past 2020, and U.S. EPA recently announced that the deadline for the updated ozone standard will be 2032.[2] Since scientific studies continue to document health impacts of air pollution at progressively lower levels, air quality standards are periodically revised, becoming more stringent over time. Broad deployment of zero- and near-zero emission technologies in the South Coast and San Joaquin Valley air basins will be needed in the 2023 to 2032 timeframe to attain current national health-based air quality standards as required by federal law.

For greenhouse gases, California's 2050 climate goal provides an ambitious long-term target. Many strategies developed to meet the shorter-term air quality standards — notably use of cleaner energy sources — will have benefits toward the longer-term climate goal. Pursuing cleaner energy sources is also the focus of the State's energy policies, providing the opportunity for economic, as well as environmental benefits. Coordinated planning with identified milestones will support the transition to zero-and near-zero emission technologies needed to meet these goals.

To explore the scope of technology advancements needed to meet air quality and climate goals, several key questions are posed:

- What technologies, fuels, and other strategies are needed to meet local air quality and greenhouse gas goals? Are they the same?
- What are the implications of federal air quality deadlines coming 20 to 30 years before the 2050 greenhouse gas goal?
- How can the strategies to meet local air quality targets and greenhouse gas goals best complement each other?
- What are the energy infrastructure demands of coordinated air quality and greenhouse gas strategies?

[2] *Vision for Clean Air* uses 2035 as the target date for the updated ozone standard. After the analytical effort for *Vision for Clean Air* began, U.S. EPA formally set the attainment deadline at 2032.

- How do California's air quality and climate policies need to adapt as emissions move from the vehicle itself to predominantly upstream sources such as electricity and hydrogen or equivalent generation facilities?

Quantitative scenarios were developed for key transportation-related sectors to gain insight into the key questions above. The sectors that are the focus of this report are by far the largest contributors to greenhouse gas emissions and regional air pollution in California. Greenhouse gas emission reduction goals are statewide and the scenarios use a lifecycle emissions analysis approach. The analysis of smog-forming pollutants is regional, reflecting the need to meet air quality standards on that basis. The localized impacts of toxic diesel particulate matter are recognized, and play an important role when evaluating the passenger and freight transport systems. Reducing emissions in these mobile source sectors is key to attaining air quality and climate goals, but does not represent all of the emission reductions needed for individual regions to demonstrate attainment of federal air quality standards. Comprehensive attainment strategies containing both mobile and stationary source measures will be developed as individual regions develop new air quality plans.

The scenarios illustrate the nature of the technology transformation needed to meet the multiple program milestones through 2050. The scenarios highlight the interplay between reducing smog-forming pollutants and greenhouse gases. The scenario results demonstrate the importance of considering the multi-pollutant impacts of policy choices. Planning efforts, public investment, and rulemaking decisions by State, federal, and local agencies will play an important role in the outcome. In making these decisions, agencies will need to consider factors including technical feasibility and cost, downstream and upstream emission reduction potential, energy production capacity and infrastructure, and the necessary pace of transformation needed to meet air quality and climate goals.

In designing the scenarios, it was necessary to make general assumptions about future growth, the pace of introduction of various technologies, and other factors. It is recognized that the scenarios contained herein are not the only pathways to meet air quality and climate goals. Thus, the scenarios are not refined analyses that would be directly used for program development, but will provide input into future planning efforts by air quality agencies. Similarly, economic and environmental analyses are steps that need to be done in future plans.

An update to the AB 32 Scoping Plan is due in 2013. State Implementation Plans (SIPs) to meet the federal particulate matter air quality standards in the South Coast and the San Joaquin Valley are due later this year and major ozone SIPs for the recently updated federal ozone standard will be due in 2015. More detailed analyses will begin to emerge as part of these efforts.

Achieving California's Air Quality and Climate Goals

The federal Clean Air Act requires states to identify the reductions of smog-forming emissions necessary to meet each federal air quality standard. Also under the federal planning process, states must identify the actions needed to bring emissions down to the attainment levels by the required deadlines. These two parts of a state's SIP comprise the attainment demonstration. Federal rules set out detailed procedures, technical requirements, and public processes for the development of attainment demonstrations. As mentioned earlier, the scenarios in *Vision for Clean Air* are not intended to be attainment demonstrations within the meaning of the Clean Air Act, but they do serve to illustrate the scale of technology change needed to meet the federal standards in 2023 and beyond. The federal Clean Air Act specifically recognizes the need for advanced technologies in attainment demonstrations for extreme ozone nonattainment areas. The South Coast and San Joaquin Valley air basins are the only two extreme ozone areas in the nation.

> ***Meeting Federal Ozone Standards***
>
> **For the South Coast Air Basin, it is estimated that oxides of nitrogen, one of the key ingredients in ozone and fine particulate formation, must be reduced by around 80 percent from 2010 levels by 2023, and almost 90 percent by 2032. Similar levels of emissions reductions are likely needed in the San Joaquin Valley by 2032.**

The federally approved SIPs for these two regions rely on a mix of currently available technologies and the development of advanced technologies in order to attain the ozone air quality standard by 2023. Reaching the longer-term 2032 ozone air quality standard and the 2050 climate goal requires even greater transformation. This includes, for example, nearly complete transformation of passenger vehicles to zero-emission technologies, approximately 80 percent of the truck fleet to zero-or near-zero technology, and nearly all locomotives operating in the South Coast air basin to be using some form of zero-emission technology.

> ***Meeting Climate Change Goals***
>
> **To meet the goal of reducing California's greenhouse gas emissions to 1990 levels by 2050, emissions must be reduced by 85 percent from today's levels.**

The Global Warming Solutions Act of 2006 set the 2020 greenhouse gas emissions reduction goal into law. It directed ARB to develop early actions to reduce greenhouse gases while also preparing a Scoping Plan to identify how best to reach the 2020 limit. The State's goal to further reduce greenhouse gases by 2050 was first established when Governor Schwarzenegger signed Executive Order S-3-05 in 2005. In March 2012, Governor Brown issued Executive Order B-16-2012 setting a California target for reductions of greenhouse gas emissions from the transportation sector of 80 percent less than 1990 levels by 2050 and calling for the establishment of benchmarks for the penetration of zero-emission vehicles and infrastructure for 2015, 2020, and 2025.

Coordinated Air Quality and Climate Planning

The *Vision for Clean Air* scenarios illustrate seven key concepts that together provide a foundation for coordinated solutions to California's air quality and climate goals.

- **Technology Transformation:** Transformation to advanced, zero-and near-zero emission technologies, renewable clean fuels, and greater efficiency that can achieve both federal air quality standards and climate goals.
- **Early Action:** Acceleration of the pace of transformation to meet federal air quality standard deadlines, with early actions to develop and deploy zero- and near-zero technologies also needed to meet climate goals.
- **Cleaner Combustion:** Advanced technology NOx emissions standards for on- and off-road heavy-duty engines beyond the cleanest available today to meet federal air quality standards in a timely manner.
- **Multiple Strategies:** A combination of strategies — technology, energy, and efficiency — applied to each sector.
- **Federal Action:** Federal actions, in addition to actions by state and local agencies and governments, to help clean-up sources that travel nationally and internationally such as trucks, ships, locomotives and aircraft.
- **Efficiency Gains:** Greater system and operational efficiencies to mitigate the impacts of growth, especially in high-growth freight transport sectors and vehicle efficiency gains to reduce fuel usage and mitigate the cost of new technologies.
- **Energy Transformation:** Transformation of the upstream energy sector and its greenhouse gas and smog forming emissions concurrent with the transformation to advanced technologies downstream.

Development of coordinated solutions to California's air quality and climate goals will require the efforts of multiple agencies at all levels of government. The solutions span all sectors, rely on the development of multiple technologies, and require the coordinated deployment of technologies and energy infrastructure. ARB has the role of setting technology-forcing standards for mobile sources that have been the distinguishing feature of the State's air quality progress and climate leadership. Action by the federal government, for trucks, locomotives, aircraft, and ships, is also critical. Finally, transformation of the energy sector will require multiple agencies, including the California Energy Commission, the Public Utilities Commission, ARB, and local air districts, to share a common vision.

The SCAQMD, SJVAPCD, and other local air districts play a key role through actions to accelerate the use of new, cleaner mobile technologies at the regional level to improve air quality and meet federal air quality standards. While *Vision for Clean Air* focuses on the mobile sectors and the energy system to power them, attainment of the federal air quality standards will also require similar transformation of traditional stationary sources covered through SIP planning. Air districts will need to continue their actions to reduce emissions from these sources in order to meet federal requirements. Metropolitan planning organizations, port authorities, and local governments will also play important roles in the overall pollution control strategies.

Private sector activities will be key to developing the technology, building the engines, and implementing the necessary transformation. Engine and vehicle manufacturers will need to continue the development and marketing of advanced technologies. Energy industries will need to supply the renewable fuels and energy, including the necessary infrastructure. In the freight transport industries, increased efficiencies that support growth while mitigating environmental impacts will be essential. Both public and private investment will be needed to enable the technology transformation necessary to achieve California's air quality and climate goals.

Vision for Clean Air lays the foundation for an integrated approach to develop and deploy the cleanest emissions control technologies. For many of the sectors discussed, zero- and near-zero emission technologies have been developed or anticipated to be developed over the next few years. *Vision for Clean Air* provides a timeline for coordinated development and accelerated deployment of the types of technologies expected to be needed in each of the sectors.

Vision for Clean Air is being released as a draft document for discussion at a public meeting in June 2012 and at public workshops in August. The document sets the stage for subsequent planning efforts through scenarios designed to illustrate the scope of change needed to meet federal air quality standards and California's climate goals. The scenarios presented are not intended to identify a specific course of action to meet each air quality and climate goal. Nor are the scenarios a prediction of the actual mix of vehicle technologies, fuels, and clean energy sources expected to emerge in the long term. Public and private investment, regulatory decisions, and consumer preferences will all affect the success of specific strategies and options to meet these ambitious goals.

An Approach for Integrating Air Quality and Climate Planning

The federally approved 2007 State Implementation Plans for the South Coast Air Basin and the San Joaquin Valley Air Basin call for broad use of advanced technologies, clean energy, and greater efficiencies to provide the foundation for meeting federal air quality standards. The 2008 Scoping Plan, required by California's Global Warming Solutions Act of 2006, similarly called for a statewide transition to clean energy and advanced technologies and outlined actions toward that end. To understand the interplay among strategies to meet air quality and climate goals, and to develop common and effective solutions to both, basic questions need to be answered. These include:

Crosscutting Issues

Figure 2

- What technologies, fuels, and other strategies are needed to meet local air quality and greenhouse gas goals? Are they the same?

- What are the implications of federal air quality deadlines coming 20 to 30 years before the 2050 greenhouse gas goal?

- Is the pace of needed transformation the same? How can the strategies to meet air quality targets and greenhouse gas goals best complement each other?

- What are the energy infrastructure demands of coordinated air quality and greenhouse gas strategies?

- How do California's air quality and climate policies need to adapt as emissions move from the vehicle itself to predominantly upstream sources such as electricity and hydrogen generation facilities?

To begin to answer these questions and lay a foundation for future coordinated planning for criteria pollutants regulated through air quality standards (i.e., criteria pollutants), toxic pollutants such as diesel particulate matter, and greenhouse gases, *Vision for Clean Air* uses quantitative scenarios. These scenarios examine the nature of the technology and fuel transformation needed to meet the multiple air quality and greenhouse gas milestones between now and 2050.

Vision Scenarios

Under the Clean Air Act, traditional air quality planning typically focuses on the emissions reductions expected in a single future year from regulations adopted in the immediate three to five years. *Vision for Clean Air* takes a broader approach and uses scenarios to illustrate the change needed in multiple milestone years to meet future emissions targets. This effort is not a plan, but rather, it provides valuable insight for future planning efforts that will include a stakeholder input process. This long-term approach is more common in greenhouse gas analyses. The advantage of long-term planning is that it reveals the scope of advanced technologies needed, how quickly the technologies need to come on line, and the key decision points for technology development and deployment along the way.

A scenario is a combination of technology, energy, and efficiency assumptions that change over time. Scenarios represent a projection of what could be possible — a ―what if" story that provides context for decision-making. Scenarios are intended to inform decision-making but are not predictions of what the future will be. So rather than being a list of State Implementation Plan or SIP-ready control measures, the scenarios provide a view of a mix of technologies that could be successful in helping California meet its multi-pollutant goals. Further, the scenarios do not represent a policy choice that favors certain technologies and fuels over others. This scenario planning effort does not identify winners or losers on a specific path to meet air quality and climate goals. Rather, it demonstrates a combination of technologies and fuels that yield the scale of needed transformation. Any other mix of technologies and fuels achieving equivalent or better regional criteria pollutant and life cycle greenhouse gas reductions can be considered part of the scenario.

A Scenario is a "What If" Set of Assumptions about Technologies, Fuels and Efficiencies

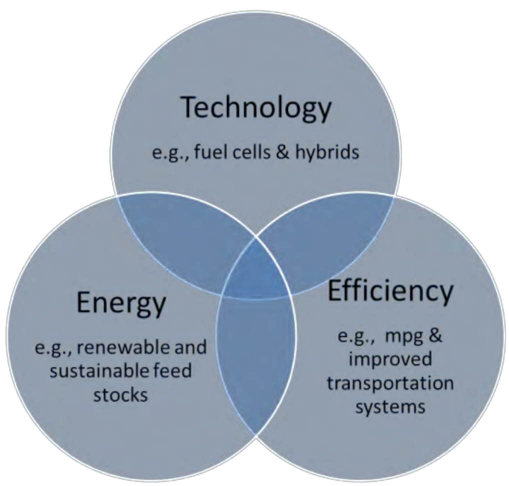


Figure 3

Scenarios were developed through an iterative process of assuming varying levels of technology sales penetration, fuel supply, and efficiency changes. These are ambitious assumptions going beyond the existing programs, and could be expected to require further actions, such as innovation, investment, incentives, and regulations to achieve. However, the scenarios do not include actions such as further incentive funding to accelerate penetration of advanced technologies and clean fuels to meet federal

Scenarios for Mobile Sectors

Scenarios have been developed for passenger cars; freight transport, including trucks, ships, locomotives, cargo handling equipment, and harbor craft; planes, and off-road equipment. The scenarios also include the refineries and power plants needed to produce the fuels and electricity to power the engines in these devices. Together, this covers approximately 45 percent of the State's greenhouse gas emissions and approximately 85 percent of its NOx emissions. The remainder of the greenhouse gas emissions are from non-transportation related sources such as industrial, power generation, commercial, residential and agricultural uses.

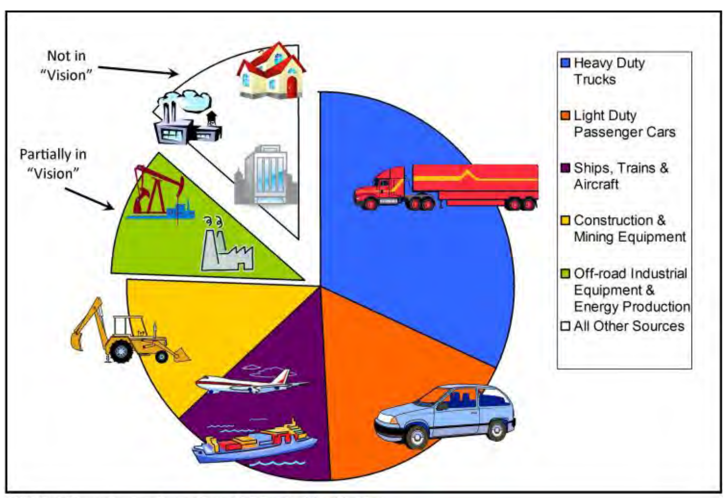
air quality deadlines. For example, expedited turnover of vehicles, as has been achieved with incentives programs implemented by State and local jurisdictions, is not assumed in the scenarios. All of the scenarios include as the starting point all technology and fuel regulations in place today, including passenger vehicle standards, truck and engine standards, the low carbon fuel standard, and the 33 percent renewable electricity requirement.

Most of the technologies and energy sources relied on in the scenarios exist in some form today; some technologies are already on the market, while others are still maturing through demonstration programs and limited test markets.[3] As a result, *Vision for Clean Air* focuses on the development and deployment of emerging technologies not the invention of undefined future technologies. The available technologies that provide fewer smog-forming and greenhouse gas emissions are fuel cells, electric hybrids with a large portion operating in an —all electric range”, and electric vehicles, a combination of which is assumed to be the future norm over time. Similarly, alternative fuels such as hydrogen and clean biofuels such as cellulosic ethanol and biomethane and other renewable energy sources are assumed to play an important role in the energy sectors. Additional operational efficiencies to reduce vehicle miles traveled and overall energy demand are also assumed to occur.

Vision Targets

Targets are characterized as the percent reduction needed from today's emission levels in order to meet the federal air quality standards for ozone and the State's long-term goal to reduce greenhouse gas emissions to 80 percent below 1990 levels by 2050. New federal air quality standards for particulate matter are also expected in the near future. Legally-binding emission targets to attain federal air quality standards are established through the air quality planning process set out in State and federal law. The attainment targets for the 0.080 ppm ozone standard, with a 2023 attainment date, are set in the State's federally approved ozone plans. Planning for the 0.075 ppm federal standard is just beginning, but the attainment target is 2032 for the

Relationship of Vision Inventory to SIP Inventory
2010 NOx SIP Sources as Portion of Total Inventory



CEPAM 2009 Almanac Inventory, Summer Average Emissions, South Coast Emissions

Figure 4

[3] The single exception is the carbon capture sequestration process that will be necessary if fossil fuels are to remain in the energy mix of the future. This process has been demonstrated in limited cases, but long-term data has yet to be developed.

extreme ozone areas of the South Coast Air Basin and San Joaquin Valley. The targets used here are estimates of what the attainment targets could be past 2023 based on current air quality information. *Vision for Clean Air* focuses on oxides of nitrogen (NOx) emissions as NOx is the most critical pollutant for reducing regional ozone and fine particulate matter.

The SIP air quality targets and the 2050 greenhouse gas goal apply to the total emissions from all sources. In developing future SIPs and climate plans, the full spectrum of emissions sources must be considered. *Vision for Clean Air* focuses on mobile sectors and assumes the same percent reduction must be achieved by each. Future planning efforts will need to look at the tradeoffs among strategies for specific source categories that achieve relatively more or fewer reductions in light of technological, economic, and other factors. The following are the air quality goals used in the scenario development process:

- Achieve the 0.08 ppm 8-hour federal ozone standard by 2023 by reducing NOx emissions by 80 percent from 2010 levels.

- Achieve the 0.075 ppm 8-hour federal ozone standard by 2032 by reducing NOx emissions by 90 percent from 2010 levels.

- Reduce greenhouse gas emissions by 80 percent below 1990 levels by 2050. This is equivalent to 85 percent from today's levels.

This document does not evaluate emission reductions needed to attain a potential new ozone standard (i.e., 0.06 - 0.07 ppm 8-hr standard). As scientific studies are documenting health impacts of air pollution at very low levels, it is expected that further NOx reductions will be needed in the long-term. U.S. EPA is expected to consider adopting an ozone standard lower than 0.075 ppm in 2013. Achieving a future ozone standard in the range EPA is expected to consider could require additional NOx emissions reductions, totaling 95 percent from 2010 levels.

Air Quality Challenges in the South Coast and San Joaquin Valley

California is home to two of the nation's most pressing air quality challenges. The South Coast and the San Joaquin Valley are the only two areas in the country designated as extreme nonattainment for the federal ozone standard. These same two areas also experience high levels of fine particulate matter. Because of the severity of the air quality changes in these two areas, they determine the transformational change needed to meet federal air quality standards throughout the State. Still, while they face a similar air quality challenge, they are different in terms of the nature of their emission sources.

South Coast Air Basin

The 2007 SIP for the federal ozone standard contains commitments for emission reductions from mobile sources that rely on advancement of technologies, as authorized under Section 182(e)(5) of the federal Clean Air Act. These measures, which have come to be known as the —Black Box,” account for a substantial portion of the NOx emission reductions needed to attain the federal ozone standards — over 200 tons/day. Attaining these standards will require reductions in emissions of nitrogen oxides (NOx) well beyond reductions resulting from current rules, programs, and commercially-available technologies.

Mobile sources emit over 80 percent of regional NOx and therefore must be the largest part of the solution. For the South Coast, the top NOx emission sources projected in 2023 are shown in Figure 5. On-road truck categories are projected to comprise the single largest contributor to regional NOx in 2023. Other equipment involved in goods movement, such as marine vessels, locomotives and aircraft, are also substantial NOx sources.

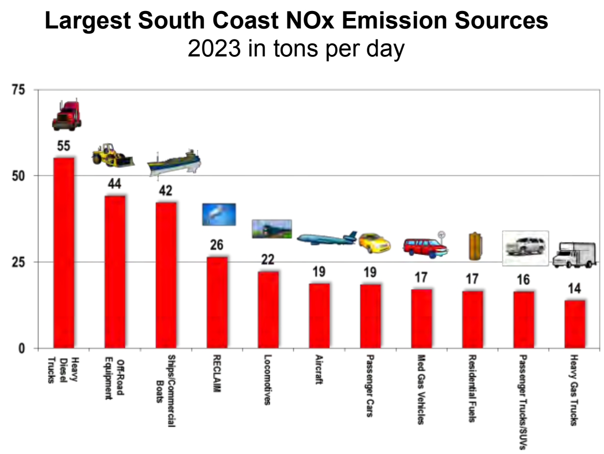


Figure 5

Preliminary projections indicate that the region must reduce regional NOx emissions by about two-thirds by 2023 beyond the benefits of adopted rules and programs, and three quarters by 2032, to attain the national ozone standards as required by federal law.

Since most of the significant sources are already controlled by over 90 percent, attainment of the ozone standards in the South Coast Air Basin will require broad deployment of zero- and near-zero emission technologies in the 2023 to 2032 timeframe. On-land transportation sources such as trucks, locomotives, and cargo handling equipment have technological potential to achieve zero- and near-zero emission levels. Current and potential technologies include hybrid-electric, battery-electric, and hydrogen fuel cell on-road vehicle technologies. Other technologies and fuels may also serve regional

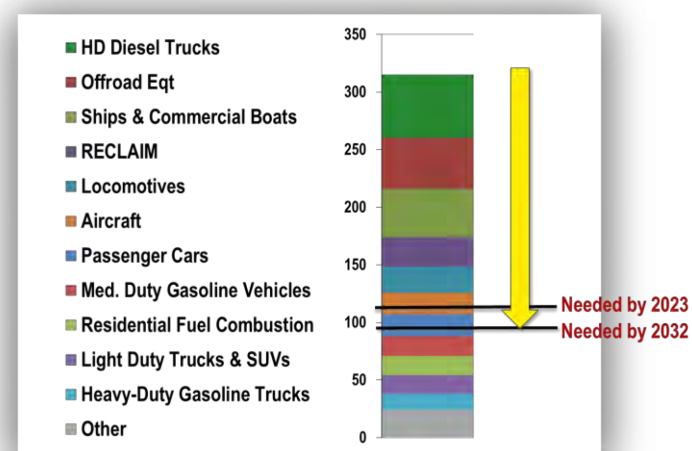


Figure 6

needs, e.g. natural gas-electric hybrids or alternative fuels coupled with advanced aftertreatment technologies. Air quality regulatory agencies have historically set policies and requirements that are performance based and allow any technologies that will achieve needed emission reductions on time.

While there has been much progress in developing and deploying transportation technologies with zero- and near-zero emissions (particularly for light-duty vehicles and passenger transit), additional technology development, demonstration, and commercialization will be required prior to broad deployment in freight and other applications.

San Joaquin Valley Air Basin

Diesel trucks are also the single largest source of NOx emissions in the San Joaquin Valley. However, truck traffic in the Valley is dominated by interstate trucks and other through traffic traveling on the major north-south corridors of Interstate 5 and State Route 99. In contrast, a significant amount of South Coast truck traffic is associated with freight transport from the ports and inland. As a result, the age and activity of the trucks in the two regions differ, suggesting that there may be different options and constraints in terms of technology transformation for trucks that operate in the Valley.

Passenger vehicles are the second largest source of NOx emissions in the San Joaquin Valley. The Valley may present different challenges in terms of infrastructure to support advanced technology passenger vehicles given the nature of urban development in the region.

With the most productive agricultural region in the nation, the San Joaquin Valley is also home to the unique emissions sources of the agricultural industry. While mobile agricultural equipment emissions are significant, a separate scenario was not developed for these sources. Efforts are underway now to clean up mobile agricultural equipment to the cleanest currently available conventional technology. Emission reductions from those efforts are important for reducing ozone levels and measures to achieve these reductions are part of the region's ozone SIP. Given the challenges posed by the operational requirements of this type of equipment and the importance of continuing the current cleanup efforts, consideration of potential future technologies is not included here.

The current NOx targets are set in the approved ozone SIP for the San Joaquin Valley. Like the South Coast, the San Joaquin Valley SIP includes longer-term (—Black Box") emission reductions due by 2023. Because emissions in the South Coast are so large compared to the Valley, the absolute magnitude of the reductions needed is less than in the South Coast. Nevertheless, the scale of needed transformation is similar. Air quality modeling for the San Joaquin Valley to determine what emission reductions are needed to attain the 0.075 ppm ozone standard in 2032 will be done for the SIP due in 2015. Given the stringent level of the standard, it is expected that on a percentage basis the San Joaquin Valley and South Coast will need a similar magnitude of new reductions.

Vision Tool

A spreadsheet-based tool developed from the Argonne National Laboratory Vision 2011 Model was used to evaluate the scenarios. The Argonne model was intended to be used to evaluate transportation energy policy questions in the context of greenhouse gas emissions. The *Vision for Clean Air* effort started with the Argonne model and was heavily modified and expanded, such that the tool used for *Vision for Clean Air* is fundamentally a different model.

The basic steps outlined in Figure 7 forecast penetration of vehicle technology and fuels into passenger car and truck fleets based on vehicle stock turnover rates, the rates at which new vehicles and technologies enter the fleet and old vehicles leave. The Argonne model is limited in that it only models greenhouse gases and only for passenger vehicles and trucks based on national fleet characteristics. The tool used for *Vision for Clean Air* adds forecasting capability for smog-forming pollutants (NOx and reactive organic gases) and diesel particles. It is also a California-specific model using new vehicle sales, vehicle miles traveled, vehicle survival rates, and emission rates from ARB's mobile source emissions model, EMFAC. Finally, non-road mobile sources, off-road equipment, locomotives, ships, harbor craft, and cargo handling equipment are included based on ARB's existing emissions inventory models for these sources.

Vision for Clean Air Modeling Structure

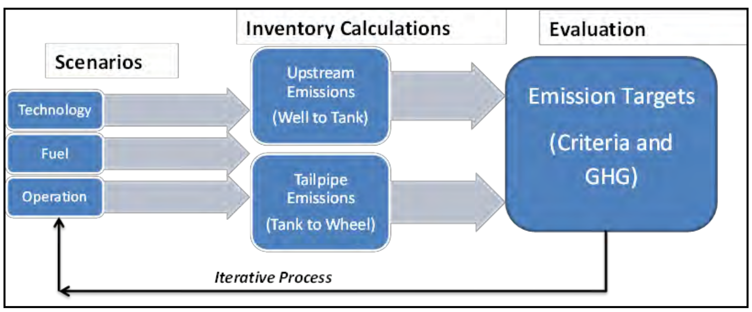


Figure 7

Fuel and electricity demand are estimated by type based on the fleet technology mix, vehicle miles traveled, and engine efficiencies. Emissions from energy production activities are then calculated using assumptions about fuel feedstock, carbon intensity, and NOx emission rates. Carbon emissions are calculated with a global lifecycle from energy production to end use. Smog-forming emissions use a modified life-cycle approach where upstream, fuel pathway emissions are included only if they are within the region studied in the scenario. For simplicity, it was assumed that one half of the NOx emissions from mobile source-related energy production occur within the region in which the energy is used.

This modified lifecycle approach for analyzing smog-forming emissions associated with mobile-source energy production differs from typical air quality planning. In SIPs, mobile and stationary source emissions (including refineries and power plants) are calculated and reported separately. The advantage to linking upstream and http://www.epa.gov/airquality/ozonepollution/designations/2008standards/final/region9f.htm

United States Environmental Protection Agency

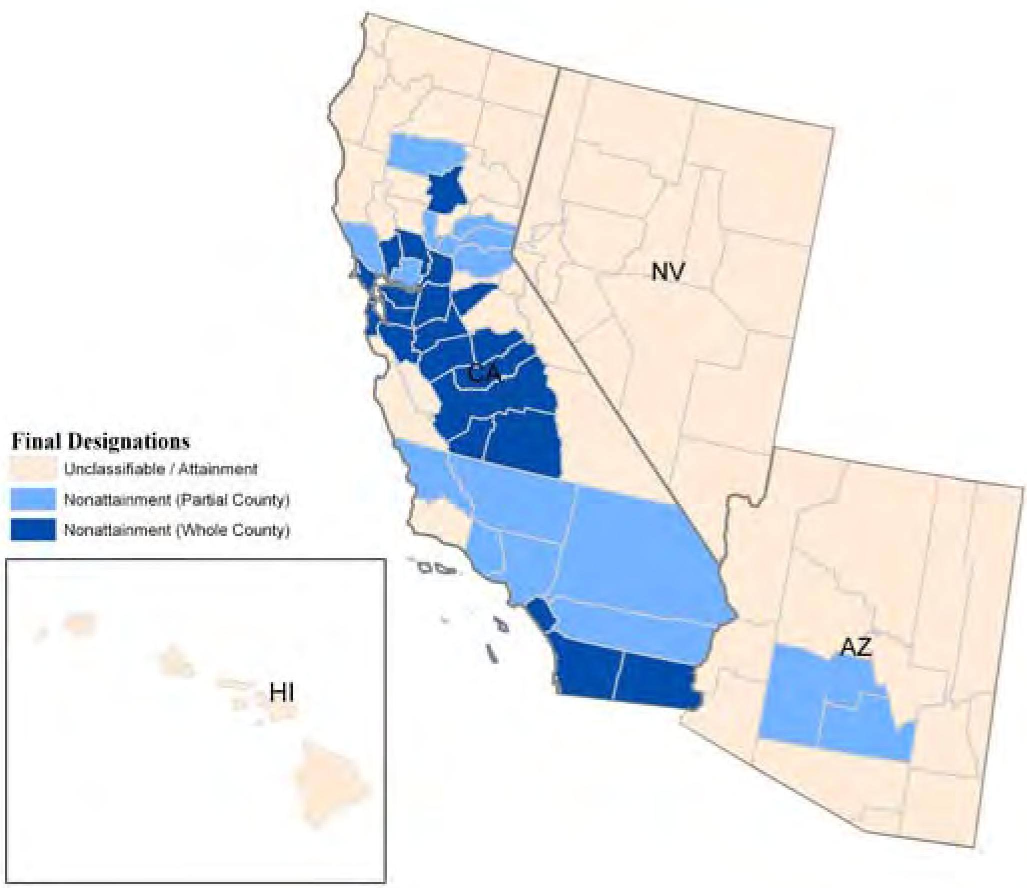
Area Designations for 2008 Ground-level Ozone Standards

2008 Ground-level Ozone Standards — Region 9 Final Designations, April 2012

EPA is implementing the 2008 ozone standards as required by the Clean Air Act. Meeting these standards will provide important public and environmental health benefits. EPA has worked closely with states and tribes to identify areas in the country that meet the standards and those that need to take steps to reduce ozone pollution.

EPAs final designations are based on air quality monitoring data, recommendations submitted by the states and tribes, and other technical information. EPA will work closely with states and tribes to implement the standards using a common sense approach that improves air quality, maximizes flexibilities and minimizes burden on state and local governments.

Map of Final Designations - EPA Region 9



This table identifies area designations for EPAs region 9 states. In some cases EPA designated partial counties. These are identified by a (P). If a county is not listed below, EPA has designated it as unclassifiable/attainment.

EPA Areas for Designations for the 2008 Ozone Standards

State	Area Name	Counties	Area Classification
American Samoa	Entire territory is unclassifiable/attainment		
Arizona	Phoenix-Mesa, AZ	Maricopa (p)	Marginal
		Pinal (p)	
	Rest of state is unclassifiable/attainment		
California	Calaveras County, CA	Calaveras	Marginal
	Chico (Butte County), CA	Butte	Marginal
	Imperial County, CA	Imperial	Marginal
	Kern County (Eastern Kern), CA	Kern (p)	Marginal
	Los Angeles-San Bernardino Counties (West Mojave Desert), CA	Los Angeles (p)	Severe
		San Bernardino (p)	
	Los Angeles-South Coast Air Basin, CA	Los Angeles (p)	Extreme
		Orange	
		Riverside (p)	
		San Bernardino (p)	
	Mariposa County, CA	Mariposa	Marginal
	Nevada County (Western part), CA	Nevada (p)	Marginal
	Riverside County (Coachella Valley), CA	Riverside (p)	Severe
	Sacramento Metro, CA	El Dorado (p)	Severe
		Placer (p)	
		Sacramento	
		Solano (p)	
		Sutter (p)	
		Yolo	
	San Diego County, CA	San Diego	Marginal
	San Francisco Bay Area, CA	Alameda	Marginal
		Contra Costa	
		Marin	
		Napa	
		San Francisco	
		San Mateo	

State	Area Name	Counties	Area Classification
		Santa Clara Solano (p) Sonoma (p)	
	San Joaquin Valley, CA	Fresno Kern (p) Kings Madera Merced San Joaquin Stanislaus Tulare	Extreme
	San Luis Obispo (Eastern San Luis Obispo), CA	San Luis Obispo (p)	Marginal
	Tuscan Buttes, CA	Tehama (p)	Marginal
	Ventura County, CA	Ventura (p)	Serious
	Morongo Areas of Indian Country (Morongo Band of Mission Indians)	Areas of Indian Country	Serious
	Pechanga Areas of Indian Country (Pechanga Band of Luiseno Mission Indians of the Pechanga Reservation)	Areas of Indian Country	Moderate
	Rest of state is unclassifiable/attainment		
Guam	Entire territory is unclassifiable/attainment		
Hawaii	Entire state is unclassifiable/attainment		
Nevada	Entire state is unclassifiable/attainment		
Northern Mariana Islands	Entire territory is unclassifiable/attainment		

< Back to US map

Tribal information is available on the Tribal Designations page.

Recommendations from Region 9 States and EPA Responses

Last updated on Friday, February 01, 2013

South Coast
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SCAQMD Air Quality Significance Thresholds

Mass Daily Thresholds [a]		
Pollutant	**Construction [b]**	**Operation [c]**
NOx	100 lbs/day	55 lbs/day
VOC	75 lbs/day	55 lbs/day
PM10	150 lbs/day	150 lbs/day
PM2.5	55 lbs/day	55 lbs/day
SOx	150 lbs/day	150 lbs/day
CO	550 lbs/day	550 lbs/day
Lead	3 lbs/day	3 lbs/day

Toxic Air Contaminants (TACs), Odor, and GHG Thresholds	
TACs (including carcinogens and non-carcinogens)	Maximum Incremental Cancer Risk ≥ 10 in 1 million Cancer Burden > 0.5 excess cancer cases (in areas ≥ 1 in 1 million) Chronic & Acute Hazard Index ≥ 1.0 (project increment)
Odor	Project creates an odor nuisance pursuant to SCAQMD Rule 402
GHG	10,000 MT/yr CO2eq for industrial facilities

Ambient Air Quality Standards for Criteria Pollutants [d]	
NO2 1-hour average annual arithmetic mean	SCAQMD is in attainment; project is significant if it causes or contributes to an exceedance of the following attainment standards: 0.18 ppm (state) 0.03 ppm (state) and 0.0534 ppm (federal)
PM10 24-hour average annual average	10.4 $\pi g/m^3$ (construction)[e] & 2.5 $\pi g/m^3$ (operation) 1.0 $\pi g/m^3$
PM2.5 24-hour average	10.4 $\pi g/m^3$ (construction)[e] & 2.5 $\pi g/m^3$ (operation)
SO2 1-hour average 24-hour average	0.25 ppm (state) & 0.075 ppm (federal – 99^{th} percentile) 0.04 ppm (state)
Sulfate 24-hour average	25 $\pi g/m^3$ (state)
CO 1-hour average 8-hour average	SCAQMD is in attainment; project is significant if it causes or contributes to an exceedance of the following attainment standards: 20 ppm (state) and 35 ppm (federal) 9.0 ppm (state/federal)
Lead 30-day Average Rolling 3-month average Quarterly average	1.5 $\pi g/m^3$ (state) 0.15 $\pi g/m^3$ (federal) 1.5 $\pi g/m^3$ (federal)

[a] Source: SCAQMD CEQA Handbook (SCAQMD, 1993)
[b] Construction thresholds apply to both the South Coast Air Basin and Coachella Valley (Salton Sea and Mojave Desert Air Basins).
[c] For Coachella Valley, the mass daily thresholds for operation are the same as the construction thresholds.
[d] Ambient air quality thresholds for criteria pollutants based on SCAQMD Rule 1303, Table A-2 unless otherwise stated.
[e] Ambient air quality threshold based on SCAQMD Rule 403.

KEY: lbs/day = pounds per day ppm = parts per million $\pi g/m^3$ = microgram per cubic meter ≥ = greater than or equal to
MT/yr CO2eq = metric tons per year of CO2 equivalents > = greater than

Revision: March 2011

GUIDE FOR ASSESSING AND MITIGATING AIR QUALITY IMPACTS

Prepared by
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This document is an advisory document, that provides Lead Agencies, consultants, and project applicants with uniform procedures for addressing air quality in environmental documents. Copies and updates are available from the SJVAPCD Planning Division at (559) 230-5800. Questions on content should be addressed to either the Mobile Source/ CEQA Section at (559) 230-5800 or the SJVAPCD CEQA representative at the regional office that covers the county in which the project is located.

ACKNOWLEDGEMENTS

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GUIDE FOR ASSESSING AND MITIGATING AIR QUALITY IMPACTS

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Demolition Asbestos Impacts. Project construction sometimes requires the demolition of existing buildings at the project site. Buildings often include materials containing asbestos. Airborne asbestos fibers pose a serious health threat if adequate control techniques are not carried out when the material is disturbed. The demolition, renovation, or removal of asbestos-containing materials is subject to the limitations of the National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulations as listed in the Code of Federal Regulations[34] requiring notification and inspection. Most demolitions and many renovations are subject to an asbestos inspection prior to start of activity. The SJVAPCD's Compliance Division in the appropriate region should be consulted prior to commencing any demolition or renovation of any building to determine inspection and compliance requirements. Strict compliance with existing asbestos regulations will normally prevent asbestos from being considered a significant adverse impact.

4.3.2 Thresholds of Significance for Impacts from Project Operations

The term "project operations" refers to the full range of activities that can or may generate pollutant emissions when the development is functioning in its intended use. For projects such as office parks, shopping centers, residential subdivisions, and other indirect sources, motor vehicles traveling to and from the projects represent the primary source of air pollutant emissions. For industrial projects and some commercial projects, equipment operation and manufacturing processes can be of greatest concern from an emissions standpoint. Significance thresholds discussed below address the impacts of these emission sources on local and regional air quality. Thresholds are also provided for other potential impacts related to project operations, such as odors and toxic air contaminants.

(Lead Agencies may refer to Section 5, for guidance on calculating emissions and determining whether significance thresholds for project operations may be exceeded, and thus whether more detailed air quality analysis may be needed.)

Ozone Precursor Emissions Threshold. Ozone precursor emissions from project operations should be compared to the thresholds provided in Table 4-1. Projects that emit ozone precursor air pollutants in excess of the levels in Table 4-1 will be considered to have a significant air quality impact.

Both direct and indirect emissions should be included when determining whether the project exceeds these thresholds. The following total emissions thresholds for air quality have been established by the SJVAPCD for project operations. Projects in the SJVAB with operation-related emissions that exceed these emission thresholds will be considered to have significant air quality impacts.

[34] 40CFR Part 61, Subpart M

Table 4-1
Ozone Precursor Emissions Thresholds
For Project Operations

Pollutant	Tons/yr.
ROG	10
NOx	10

Local Carbon Monoxide Concentrations Threshold. Estimated CO concentrations, as determined by an appropriate model, exceeding the California Ambient Air Quality Standard (CAAQS) of 9 parts per million (ppm) averaged over 8 hours and 20 ppm for 1 hour will be considered a significant impact.

Odor Impacts Threshold. While offensive odors rarely cause any physical harm, they can be very unpleasant, leading to considerable distress among the public and often generating citizen complaints to local governments and the SJVAPCD. Any project with the potential to frequently expose members of the public to objectionable odors will be deemed to have a significant impact. Odor impacts on residential areas and other sensitive receptors, such as hospitals, day-care centers, schools, etc., warrant the closest scrutiny, but consideration should also be given to other land uses where people may congregate, such as recreational facilities, worksites, and commercial areas. Analysis of potential odor impacts should be conducted for the following two situations:

- **Generators –** projects that would potentially generate odorous emissions proposed to locate near existing sensitive receptors or other land uses where people may congregate, *and*

- **Receivers –** residential or other sensitive receptor projects or other projects built for the intent of attracting people locating near existing odor sources.

The SJVAPCD has determined some common types of facilities that have been known to produce odors in the SJV. These are presented in Table 4-2 along with a reasonable distance from the source where the degree of odors could possibly be significant.

A Lead Agency should use Table 4-2 to determine whether the proposed project, either as a generator or a receiver, would result in sensitive receptors being within the distances indicated in Table 4-2. In addition, recognizing that this list of facilities is not meant to be all-inclusive, the Lead Agency should evaluate facilities not included in the table or projects separated by greater distances than indicated in Table 4-2 if warranted by local conditions or special circumstances. If the proposed project would result in sensitive receptors being located closer than the screening level distances indicated in Table 4-2, a more detailed analysis, as described in Section 5, should be conducted.