Question 4. Environmental Impact of Increased Biofuels Consumption
Name/Affiliation: Mr. Brooke Coleman, Director, *Renewable Energy Action Project (REAP)*

What are the key environmental impacts of increased biofuels consumption? If some of the environmental impacts are adverse, what policy responses would be appropriate?

1. Increased Biofuels Consumption Will Reduce Emissions of Most Individual Pollutants

The air quality debate about biofuels tends to center around policy discussions about specific blends (e.g. B20, E10, E85). It is therefore instructive to break down the debate by popular fuel type. The estimated emissions response to ethanol or biodiesel depends on several factors, including the base gasoline used (federal or California, low RVP or high RVP, etc.) and the model chosen to do the analysis. Therefore, only general trends are indicated below.[1]

Common Pollutant Responses to Biofuels
(100% petroleum fuel baseline, by fuel type)

Fuel	CO	Tailpipe VOC	Evap VOC	NOx	Total Toxics	PM
Ethanol						
E10	Decrease	Decrease	(Increase)	? *	Decrease	(Decrease)
E85	Decrease	Decrease	Decrease	?	Decrease	?
Biodiesel						
B5	Decrease	Decrease		No Impact	Decrease	Decrease
B20	Decrease	Decrease		(No Impact)	Decrease	Decrease
B100	Decrease	Decrease		Increase	Decrease	Decrease

(1) Pollutant responses shown assume all other fuel parameters (e.g. sulfur, aromatics) are held constant (i.e. this table does <u>not</u> *reflect absolute emissions impacts because refiners can, and are often required to, adjust other fuel parameters to "zero out" any pollutant increase).*
(2) "( )" indicates a "likely" impact; "?" indicates incomplete data or scientific uncertainty.
** California believes there is a slight NOx increase from E10, and requires gasoline refiners to eliminate it with blend adjustments before market; U.S. enforces no such "NOx penalty" for the federal program at the current time.*

2. The alleged adverse impacts of increased biofuel use (NOx, evaporative VOC/permeation) are uncertain, but in either case will not result in worsened air quality.

Most organizations and individuals raising "air quality concerns" about ethanol and biodiesel are actually not focusing on air quality as a whole, but rather just one piece of the air quality puzzle: ground-level ozone (smog).[2] Put another way, the impact of biofuels on pollutants that are regulated separately from ozone (PM, Toxics, CO)[3] is generally positive, while the impact of biofuels on ozone precursors (NOx and VOC) is less certain and often debated.

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[1] The impacts shown occur when ethanol or biodiesel is simply added to gasoline or diesel in today's vehicles without adjusting other fuel properties. In the real world, other fuel properties (e.g. sulfur, RVP) are often adjusted to account for the unique characteristics of ethanol or biodiesel. For example, the RFG program does not allow an RFG-certified fuel to increase NOx emissions, whether blended with ethanol or not.
[2] The net impact of biofuels on "air quality" or "public health" has not been fully quantified, in part because the term "air quality" is used loosely and the relative impacts of ozone, particulate, toxics and other pollutants have not been integrated into a single "air quality" factor.
[3] Carbon monoxide is also an ozone precursor, but it is regulated in a separate category.

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Whether you believe that biofuels slightly increase NOx emissions, or the impact of biofuels on NOx is negligible, the body of scientific evidence suggests that these impacts are not going to worsen air quality. Federal and state governments control NOx and VOC emissions because of their impact as ozone (smog) precursors.[4] But photochemical airshed models, generally accepted as the most accurate method of demonstrating the actual ozone (smog) impacts of different fuel blends, show that common ethanol and biodiesel blends do not measurably increase ozone levels, even in the worst-case scenarios (i.e. assuming a slight NOx and evaporative VOC increase). The table below summarizes the most recent airshed-modeling runs.

Summary of Recent Airshed Model Runs for Ethanol and Biodiesel

Report	Fuel Tested	Region Modeled	Results	Comments
EPA DRIA (2006)	E0 E10	National	E10: **no measurable impact** (< .5 ppb) on 8-hour design value ozone concentrations	Modeled several penetration scenarios only in regions where ethanol use would change (areas with no change in ethanol use would not have an impact).
MI DEQ	E0 E10	Southeast Michigan	Increasing E10 penetration from 25% to 100% produced **no discernable result** on 8-hour design value ozone concentrations	Run conducted with very basic inputs; not published. Permeation increase did not increase ozone (suggesting that CO decrease offsets permeation increase in this type of airshed).
Environ (2005)	E0 E10	Denver Metro	100% E10 market penetration: **no measurable effect** on ozone concentrations	Run did not account for permeation increase. Run also did not account for CO decrease in new cars.
NREL (2003)	B0 B20	Northeast Lake Michigan Southern CA	B20: **no measurable adverse impact** on 1-hour or 8-hour ozone attainment in Southern CA or the Eastern U.S.	Assumed a 2% NOx increase for B20, which NREL now believes does not exist (based on current data).
CARB (1999)	MTBE E0, E6 E10	Southern CA	E6/E10: **no measurable effect** on peak 1-hour ozone concentrations	Run did not account for (1) permeation increase; (2) CO decrease in new cars.

<u>3. Real World Air Quality Monitoring Demonstrates that Air Quality Has Continued to Improve, Sometimes at Greater Rates, With Ethanol in Gasoline</u>

There is a body of evidence rarely considered when analyzing the environmental impacts of ethanol. Unlike biodiesel, ethanol has been used in robust volumes in U.S. gasoline for many years. In March 2006, REAP completed a brief analysis of air quality monitoring data in the several states that substituted ethanol for MTBE in 2003 (report entitled “Clearing the Air with Ethanol,” available at www.ReapCoalition.org). In general, ozone exceedence days trended

[4] The Clean Air Act (CAA), last amended in 1990, requires U.S. EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. U.S. EPA enforces NAAQS for six (6) pollutants, called criteria pollutants: Carbon Monoxide (CO), Lead, Nitrogen Dioxide (NO2), Particulate Matter (PM), Ozone (O3 or Smog), and sulfur oxides (SO2). NOx and VOC are not regulated individually, but are considered ozone/smog precursors.

downward (at a greater rate than during MTBE years) after the introduction of E10 into states such as New York and Connecticut, and the introduction of E6 into California.[5]

These regions are notable in part because they are some of the most polluted areas in the country (Los Angeles, New York City, and Connecticut). This data exists in stark contrast to some of the air quality predictions made about ethanol during the MTBE phaseout debate of several years ago. While the downward trend in ozone exceedence days should not be solely attributed to ethanol blending, the data underscores the point that air quality modeling (and air quality science in general) is inherently uncertain, and should be cross-referenced against air monitoring data where available.

4. Increased Biofuels Consumption Will Reduce the Adverse Public Health Impact of Transportation Fuel Combustion

There is a high probability that the overall public health impact of using biofuels is positive. This is likely true even if the alleged negative impacts of ethanol and biodiesel blending (NOx, evaporative VOC) are assumed to be true. This conclusion is supported by the fact that: (1) ethanol and biodiesel significantly reduce emissions of pollutants that are generally believed to pose the greatest public health threat (PM and Toxics); and, (2) the actual ozone impact of the alleged increases in NOx and evaporative VOC (permeation) emissions, if assumed to be true, is negligible or extremely small (already shown above).

While providing a technical analysis of this argument would exceed the scope of this exercise, the argument can be supported in general terms. First, it is generally accepted that both ethanol and biodiesel reduce emissions of particulate matter (PM) and air toxics (i.e. Hazardous Air Pollutants or "HAPs"),[6] two of the most dangerous mobile source pollutant categories. It is also generally accepted that mobile sources account for a vast majority of human exposure to HAPs,[7] and a significant portion of human exposure to PM. It is therefore reasonable to conclude that the net impact of ethanol and biodiesel on reducing PM and HAP emissions results in a significant public health benefit without offsetting impacts on actual smog levels.

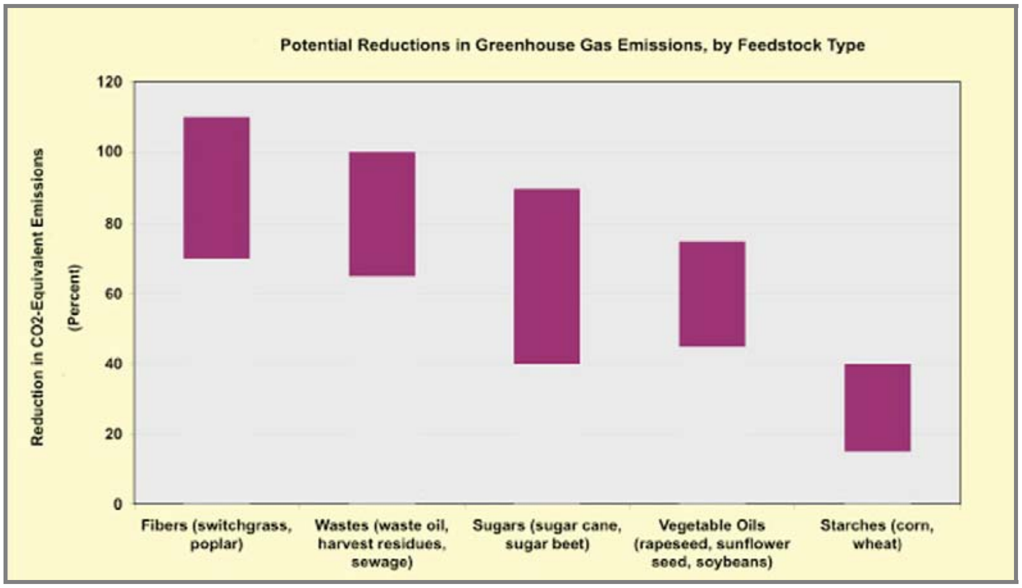
5. Increased Biofuels Consumption Will Reduce Greenhouse Gas (GHG) Emissions

The greenhouse gas (GHG) emissions impacts of biofuels, especially ethanol, are a point of debate. GHG modeling is highly uncertain, and "full life cycle" model inputs change over time and are based heavily on guided assumptions that can be contested. However, the body of evidence suggests that the CO2 benefits of ethanol range from a modest reduction (12 percent) to

[5] Air monitoring ozone data for New York, California and Connecticut is available at www.reapcoalition.org/pdfs/shortAQpres.pdf. In all three cases, ethanol was substituted for MTBE during 2003; therefore, 2004 and 2005 were ethanol-blending years (no MTBE).
[6] Gary Z. Whitten, *Air Quality and Ethanol in Gasoline*, Smog Reyes (2004); see also EPA420-D-06-008 (September 2006) at http://www.epa.gov/otaq/renewablefuels/420d06008.pdf.
[7] Up to 88 percent, according to www.scorecard.org; see http://www.scorecard.org/env-releases/hap/us.tcl. Up to 90 percent, according to the South Coast Air Quality Management District; see www.aqmd.gov/matesiidf/matestoc.htm.

a very significant reduction (86 percent), depending on the feedstock and production processes used, while the CO2 benefits of biodiesel are generally more consistent.[8]

With regard to the overall debate about GHG emissions and biofuels, REAP believes that it is increasingly unproductive to discuss biofuels in segregated, end-product terms. There is an increasingly fluid relationship between biofuel production and feedstock use. For example, the GHG impacts for corn ethanol alone range from marginal to a 60 percent reduction, depending on how the corn is grown, harvested and processed. Further, today's corn ethanol producers are underwriting a "second generation" corn ethanol made from corn kernels, stover and stalk fibers (with very good GHG reduction potential). Likewise, plants that utilize sugar cane to produce ethanol are not cellulosic ethanol producers, but their GHG profile is nonetheless very good (~ 75 percent reduction). The following chart estimates the GHG impact of biofuels by feedstock.



REAP believes that furthering the laboratory debate about what the "right number" is for GHG emissions from biofuels is less productive than furthering the public debate about policies that will provide a market framework for various biofuel alternatives to thrive. All forms of biofuels are better than petroleum for the purpose of GHG reductions and energy independence.

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[8] REAP considers the work conducted by Michael Wang and others at the Argonne National Laboratory to be the "guidepost" for ethanol GHG impacts. Argonne has published several analyses of the GHG emissions impacts of ethanol over the last ten years. Argonne's most recent report (2005) in effect confirms the agency's previous conclusions: that corn-based ethanol reduces GHG emissions by 18-29 percent on a per-gallon basis, while cellulosic ethanol reduces GHG emissions by 85-86 percent. Two recent reports, which are useful for cross reference, offer slightly more conservative "point estimates" of the GHG impacts of corn ethanol, while confirming the very significant GHG benefits of cellulosic ethanol and biodiesel. See Hill, J., Nelson, E., Tilman, D., Polasky, S., & Tiffany, D., (2006) *Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels* (Univ. of Minn., St. Paul, MN), PNAS 11206-11210 & Farrell, A. E., Plevin, R. J., Turner, B. T., Jones, A. D., O'Hare, M. & Kammen, D. M. (2006) *Science* 311, 506–508. For biodiesel GHG impacts, see also Sheehan, J., Camobreco, V., Duffield, J., Graboski, M. & Shapouri, H. (1998) *Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus* (Natl. Renewable Energy Lab., Golden, CO), NREL Publ. No. SR-580-24089. NREL and the Argonne National Laboratory are working on an update as of 2007.

6. Most of the environmental issues associated with biofuels are regulatory; as a result, the solutions are largely regulatory.

If the net air quality impact of using biofuels is positive from a non-ozone perspective, and the NOx and VOC concerns cited above do not measurably increase actual ozone levels, one might conclude that the increased use of biofuels does not raise immediate air quality concerns. This is generally true. However, today's air quality control schema complicates the issue.

Air quality regulators are legally bound by the Clean Air Act (CAA) to achieve attainment with National Ambient Air Quality Standards (NAAQS). [9] Under the CAA, states with "nonattainment" areas (in violation of NAAQS) must submit State Implementation Plans (SIPs) to U.S. EPA, laying out how they plan to achieve compliance with the applicable limits. SIPs often make voluntary but legally binding commitments to reduce inventories of individual pollutants (e.g. NOx) to achieve attainment. This regulatory requirement can lead to a paradoxical situation in which a local air quality control agency opposes biofuel use based on the possibility of a "SIP hit"[10] – i.e. a possible emissions increase in a key SIP inventory like NOx – even if the net "ozone-forming potential" of the particular biofuel blend is negligible or positive.

The solution to this problem does *not* require reconsidering the CAA (a hallmark of environmental protection). Fortunately, there is flexibility in the SIP program. The CAA requires progress, but does not micromanage the process or the method of determining compliance.[11] A SIP emissions inventory includes well-defined commitments to develop measures for pollutant reductions and less defined long-term strategies across both stationary and mobile sources.[12] Unfortunately, air quality control agencies do not often use this flexibility for the purpose of fuels diversification. A reasonable first step for encouraging more forward-thinking SIP designs is to establish a **U.S. EPA working group** to analyze ways in which the current air quality control scheme (CAA/SIP) could be used to diversify the U.S. fuels market with biofuels.

The most obvious initial outcome would be to issue "SIP guidance" documentation to state and regional air quality control agencies, detailing how U.S. EPA recognizes the importance of fuels diversification for air quality protection, and providing guidance for how to achieve results. This documentation should encourage air quality regulators to prioritize the significant gains that can be achieved with fuels diversification, even if such gains can only be achieved in the longer term.[13] Because biofuels are cleaner in their pure form than petroleum fuels (lower sulfur, toxicity, carbon content, etc.), there is great potential to make further air quality gains with their increased use irrespective of the policy imperative of climate change and energy independence.

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[9] See footnote 4.
[10] A term used to describe a situation in which a SIP targets is jeopardized by an unplanned emissions increase.
[11] The SIP is a working document that can be revised when changes are needed. For SIP guidance, see http://www.epa.gov/air/ozonepollution/SIPToolkit/index.html.
[12] For a state-level perspective on federal and state SIP requirements, see https://www.aqmd.gov/aqmp/docs/2003AQMPChap6.pdf.
[13] This approach is also necessary because current strategies are reaching the point of diminishing return. Most major fuel controls – whether sulfur, RVP, olefins, aromatics, distillation temperature, or toxics – are near their threshold minimums or optimum levels for petroleum fuels. It is therefore likely that adding fundamentally cleaner liquid biofuels to the transportation fuels market will reap greater returns than continuing to press for incremental reductions or adjustments in fuel controls.