A Brief Summary of the Air Quality Impacts of Biofuels

By Brooke Coleman, Director, Renewable Energy Action Project

Air Quality & Biofuels: An Introduction

Biofuels are better known for their alleged air quality problems (primarily NOx) than for their multitude of benefits (virtually all other emissions, including carbon monoxide, toxics, and particulate matter). This is true because: (1) air quality agencies target NOx emissions as part of their regional air quality control plans for ozone (smog); and, (2) today's air quality regulatory framework encourages regulators to focus on individual pollutant categories. However, this regulatory dynamic does not mean that biofuel blending jeopardizes air quality attainment.

Air Quality & Biofuels: A Discussion of the Issues

Blending ethanol and biodiesel actually reduces emissions of most major pollutants. Figure 1 provides the directional emissions responses of common ethanol and biodiesel blends. Some organizations and state agencies have suggested that E10 and/or B20 should not be used because of the NOx and permeation concerns shown, based on the argument that an increase in any single pollutant jeopardizes state air quality attainment. Most often, they claim that an increase in NOx or permeation could increase smog formation (which in turn, jeopardizes state ozone attainment). The logical next step is to oppose ethanol and biodiesel blending in high ozone areas.

However, there are two major problems with this position.

First, this position leads to increases in emissions of other pollutants. Figure 2 demonstrates the air quality impacts of *not* blending ethanol and biodiesel; in other words, of removing ethanol or biodiesel from gasoline and diesel blends or exempting its use. As shown, the hypothetical decision not to use E10 or B20 leads to more carbon monoxide (CO), tailpipe VOC, toxics and particulate matter (PM) pollution. The scenario shown in Figure 2 is particularly noteworthy on the ethanol side, as E10 is quickly becoming the predominant fuel in many U.S. states (i.e. the baseline fuel), and some advocates want to allow certain regions *not* to use ethanol based on NOx or permeation concerns. This decision has a cost in the form of CO, PM and toxics.

Second, independent analysis strongly suggests that the decision *not* to use ethanol or biodiesel because of ozone concerns will not even create the desired effect of improving ozone. This issue can be illustrated in the context of the first problem: the only reasonable rebuttal to the problem of increasing other pollutants (by not using biofuels) is that the region in question is "in attainment" for these pollutants (particulate, CO, etc.), but not for ozone (smog). This attainment status theoretically justifies an "ozone-centric" fuels policy. This argument seems reasonable until the actual ozone impacts of common biofuels blends (E10 and B20) are investigated more closely. Figure 3 (see page 3) provides a summary of the latest independent analysis of the smog-forming potential (i.e. ozone impact) of common biofuel blends.

Figure 1

Common Pollutant Responses to Biofuels (compared to a 100% petroleum fuel baseline, by fuel type) **						
Fuel	CO	Tailpipe VOC	Evap VOC (Permeation)	NOx	Total Toxics	PM
Ethanol						
E10	Decrease	Decrease	Increase	(Increase)*	Decrease	Decrease
E85	Decrease	Decrease	Decrease	(Decrease)	Decrease	?
Biodiesel						
B5	Decrease	Decrease		No Impact	Decrease	Decrease
B20	Decrease	Decrease		?	Decrease	Decrease
B100	Decrease	Decrease		Increase	Decrease	Decrease

"( )" indicates a "likely" impact; "?" indicates incomplete data or scientific uncertainty.
** The reported slight NOx emissions increase from ethanol blends is not a consensus position, but is indicated here because the possibility of a NOx increase sparks the air quality debate about ethanol.*
*** Pollutant responses shown are generalizations based on the U.S. EPA Complex Model (which regulates federal RFG) and the California Predictive Model (which regulates California RFG only), and assume all other fuel parameters (e.g. sulfur, aromatics) are held constant. These impacts are often erased by fuel blend adjustments.*

Figure 2

Common Pollutant Responses to Biofuels (compared to a biofuel blend baseline, by fuel type) **						
Fuel	CO	Tailpipe VOC	Evap VOC	NOx	Total Toxics	PM
E10 Baseline[i]	-	-	-	-	-	-
Take Ethanol Out	Increase	Increase	Decrease	(Decrease) *	Increase	Increase
B20 Baseline	-	-	-	-	-	-
Take Biodiesel Out	Increase	Increase		(No Impact)	Increase	Increase

"( )" indicates a "likely" impact; "?" indicates incomplete data or scientific uncertainty.
** The reported slight NOx emissions increase from ethanol blends is not a consensus position, but is indicated here because the possibility of a NOx increase sparks the air quality debate about ethanol.*
*** Pollutant responses shown are generalizations based on the U.S. EPA Complex Model (which regulates federal RFG) and the California Predictive Model (which regulates California RFG only), and assume all other fuel parameters (e.g. sulfur, aromatics) are held constant. These impacts are often erased by fuel blend adjustments.*

Figure 3

Summary of Recent Airshed Model Runs for Ethanol and Biodiesel					
Report	Fuel Tested	Region Modeled	Model Used	Results	Comments
EPA RIA (2007)	E0 E10	National	CAMx	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 = no impact)
MI DEQ	E0 E10	Southeast Michigan	CAMx	E10 penetration from 25% to 100% produced no discernable result on 8-hour ozone levels	Very basic inputs; not published. Permeation increase did not increase ozone (suggesting CO decrease offset permeation)
Environ (2005)	E0 E10	Denver Metropolitan	CAMx	100% E10 market penetration: no effect on ozone concentrations	Run did not account for permeation increase, but also did not account for CO decrease from ethanol in new cars
NREL (2003)	B0 B20	Northeast Lake Michigan Southern CA	CAMx	B20: no measurable adverse impact on 1-hour or 8-hour ozone in S. CA or 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	UAM	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.
Photochemical airshed models are generally accepted as the most accurate way to measure the actual ozone impacts of different fuel blends and emissions scenarios.					

In essence, Figure 3 shows that neither E10 nor B20 are real-world threats to ozone attainment. In many cases, NOx emissions are assumed to increase under both scenarios (notwithstanding the uncertainty of any NOx increase from biofuels), yet ozone increases are still not projected for either ethanol or biodiesel. For example, U.S. EPA conducted airshed model runs for dozens of U.S. counties (see EPA RIA, 2007)) and found that the average impact of increased ethanol use in the *worst counties* was 0.3 parts per billion (ppb); this represents roughly three-tenths of one percent of the 8-hour ozone standard, which is most likely well-within the margin of error for the analysis.

AIR QUALITY & BIOFUELS: THE NET PUBLIC HEALTH EFFECT?

Given the multitude of pollutant impacts associated with the use of ethanol and biodiesel, it makes sense to try to quantify the overall public health impact. As discussed, most organizations raising air quality concerns about ethanol and biodiesel are almost always focused on one piece of the air quality puzzle: ground-level ozone (smog). Broadening this perspective, this paper shows that the impact of common biofuel blends on ozone formation is likely negligible, whereas the impact on pollutants that are regulated separately from ozone (PM, Toxics, CO) is generally positive.

The next challenge is quantifying the net public health impact of these various impacts. On the positive side for biofuels, it is highly likely that the net public health impact of using biofuels is beneficial. This is likely true even if the alleged negative impacts of ethanol and biodiesel blending (NOx, permeation) are assumed to be true. This theory is supported by the fact that: (1) ethanol and biodiesel blending significantly reduces 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 permeation emissions, if assumed to be true, is negligible or extremely small (as shown in Figure 3).

While providing a technical analysis of this argument would exceed the scope of this report, 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").[1] It is also generally accepted that mobile sources account for a vast majority of human exposure to HAPs,[2] and a significant portion of human exposure to PM. It is therefore reasonable to conclude that the net impact of ethanol and biodiesel on PM and HAP emissions results in a significant public health benefit.

On the other side of the equation, this paper mentions legitimate technical/regulatory questions about the impact of ethanol and biodiesel blending on NOx, and in the case of ethanol, permeation as well. However, NOx and evaporative VOCs (permeation) are regulated to control ozone formation, and recent airshed model runs suggest that the use of ethanol (E10) and biodiesel (up to B20) do not measurably increase actual ozone levels (Figure 3). With regard to permeation emissions, it is useful to remember that permeation (an evaporative VOC) is a very small percentage of any state's overall gasoline hydrocarbon emissions inventory (e.g. ~ 4% in California), and that ethanol generally reduces tailpipe (i.e. non-evaporative) hydrocarbon emissions as (at least a partial) offset. Also, because ambient temperature is a primary catalyst for fuel permeation, states with colder climates than California will have much lower permeation rates.

As such, it is reasonable to suggest that the public health benefits of reduced particulate and HAP exposure from biofuels outweigh the negligible smog impact of any relative small NOx and permeation emissions increases from biofuels blends.[3] This likelyhood only raises further questions about any decision not to use ethanol or biodiesel based on air quality or public health concerns.

ANCILLARY BENEFITS OF BIOFUEL BLENDING

Often lost in the debate about the impact of biofuels on ozone-formation is the fact that renewable fuel production and use offers tremendous environmental and economic benefits. These benefits include: (1) greenhouse gas emissions reductions; (2) increased state tax revenue; (3) state job creation; (4) and reduced petroleum dependence. With regard to issue of petroleum dependence, fossil fuel combustion exacts substantial economic and environmental harms on U.S. states and regions, including massive job and state capital exportation to oil producing and refining regions and major air quality problems. With regard to air quality, fossil fuel combustion remains the overwhelming source of air pollution that leads to Clean Air Act ozone non-attainment status, as well as human exposure to toxins and particulate. The longer-term benefits of reducing state-level dependence on (and combustion of) petroleum fuels should not be lost on state regulators, especially from an air quality perspective.

---

[1] 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.
[2] Up to 88 percent, according to Hwww.scorecard.orgH; see Hhttp://www.scorecard.org/env-releases/hap/us.tclH. Up to 90 percent, according to the South Coast Air Quality Management District; see www.aqmd.gov/matesiidf/matestoc.htm.
[3] Again, the NOx issue remains controversial, while the permeation impact is widely accepted.