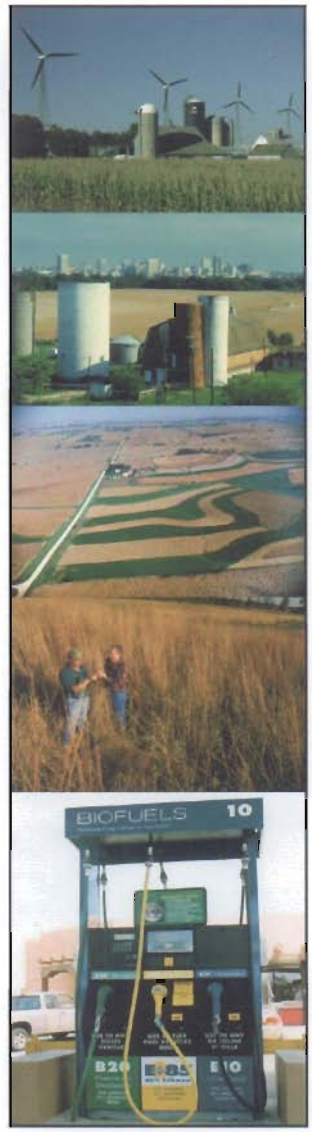
March 2006

Clearing the Air with Ethanol



a review of the real world impact from fuels blended with ethanol

Better Environmental Solutions

REAP
Renewable Energy Action Project

Clearing the Air with Ethanol

A review of the real world impact from fuels blended with ethanol

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Summary

The thesis of this report is that concerns about ethanol increasing ozone are based on the selective use of computer models, and not actual experience or the full weight of evidence. This analysis shows a consistent association between ethanol-blending and reduced ozone pollution from recent air quality monitoring conducted in Wisconsin, California, New York and other states. This report also challenges the model-based position that ethanol blends could increase ozone pollution.

Broadening the scope of the analysis produces a sharply different ozone profile for ethanol blends. Ozone concentrations depend on very complex photochemistry. The rate of ozone formation is determined from several factors, including the nonlinear function of the mixture of NOx and VOC in the atmosphere and local weather conditions. Local air management agencies establish ozone attainment strategies and profiles through the combined use of computer modeling and air quality monitoring. It is therefore important to consider the full weight of evidence – including air monitoring and airshed analysis – when such data is available.

In addition, ethanol reduces carbon monoxide (CO) and soot particulate matter (PM) emissions by at least one-third. Ethanol blending is a cost effective strategy to reduce PM levels in order to meet current and proposed EPA standards for PM and urban air toxics.

The data and studies supporting this conclusion are summarized below with links to the original data where possible.

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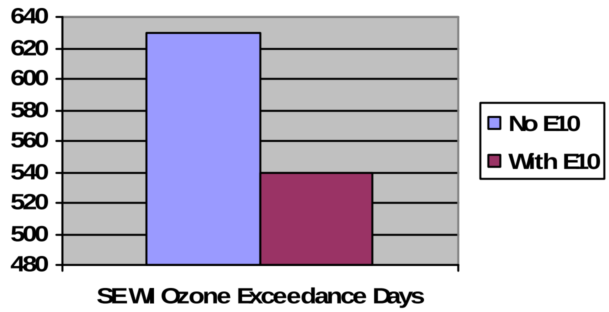
Cover photos courtesy USDA

Pollution Days Dropped since E10 Went into Use in Eastern Wisconsin

Wisconsin Department of Natural Resources (WDNR) data shows that ozone exceedance days decreased 16% since it adopted 10% ethanol (E10) in southeastern Wisconsin in 1994 as part of the reformulated gasoline (RFG) requirements.[1] Before 1994 the average was 630 ozone exceedance days in Milwaukee, Racine and Waukesha County monitoring stations. After 1994, when E10 became a part of reformulated gas, exceedances dropped to an average of 539 in the last two reporting years in those stations, a 16% reduction.



Ozone Exceedance Days in Southeastern Wisconsin Stations from 1989-2002

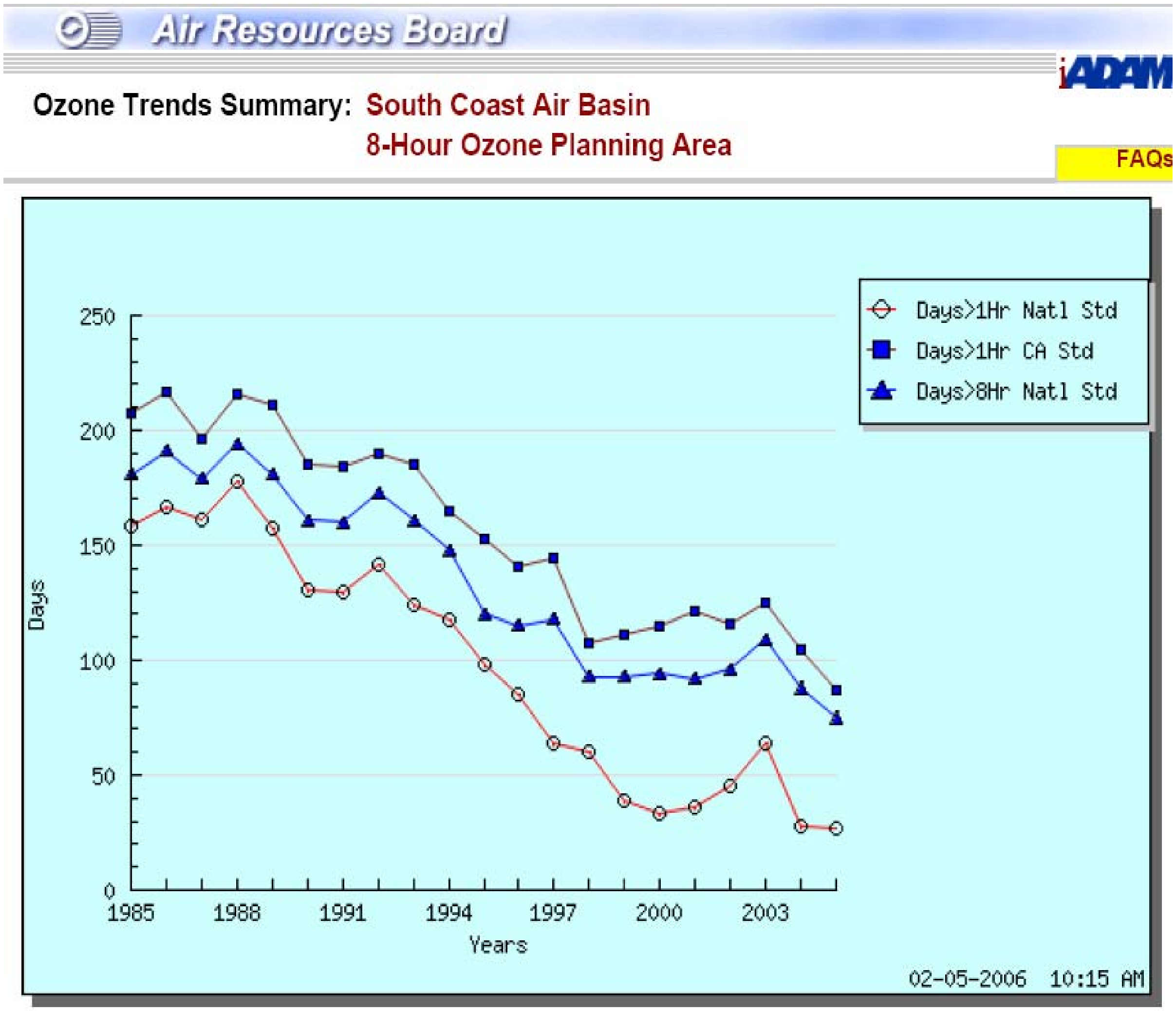
3 Year Period Ending In	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ozone Exceedance Days	756	676	638	592	579	544	589	604	617	580	600	575	506	506

Fewer Smog Days in California since Switching to E6

California Air Resource Board (CARB) data shows that ozone levels dropped significantly after E6 was put in use statewide in January 2004. For instance, exceedance days for the state one-hour ozone standard dropped from 125 in 2003 to 105 in 2004 to 97 in 2005, a 22% reduction in the South Coast Air Management District, one of the most polluted areas in the country.[2]

For more information on southern California ozone reductions, see the chart below. Between 2000 and 2003, some state agencies argued that ethanol would create increased ozone exceedance days in the South Coast if used to replace MTBE. As discussed, this report does not take the position that the air is cleaner solely because of ethanol, but instead offers irrefutable evidence that the air is cleaner with ethanol in California gasoline.

[1] 8-Hour Ozone Design Values, 3 Year Average, 1987-02, WI DNR.
[2] California Air Resources Board, Annual Ozone Summaries for Selected Regions, 1985-2006, http://www.arb.ca.gov/aqmis2/annual_ozone_pf.php.

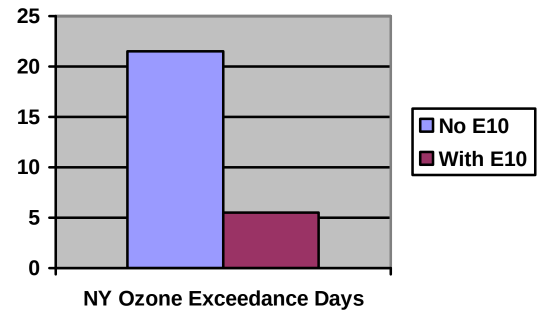


Fewer Smog Days since New York Switched to E10

The State of New York replaced MTBE blends with E10 on January 1, 2004. In the six years leading up to the use of E10, New York averaged 17 EPA 8-hour ozone exceedance days per year. In the two years leading up to the use of E10 (2002/2003), New York averaged 21.5 ozone exceedance days per year. In the two years since the switch to E10, New York has averaged 5.5 exceedance days per year, a 68% reduction.[4]

For more information on New York ozone reductions, see the chart below.

[4] EPA data at http://www.epa.gov/air/data/montrnd.html?st~NY~New%20York.

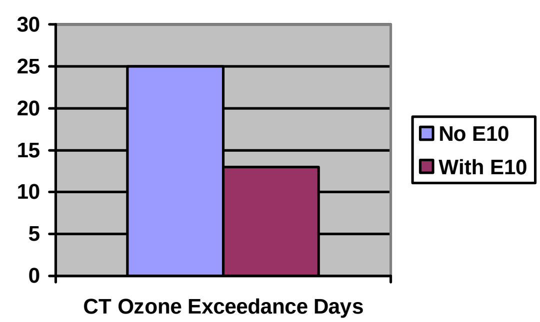


Annual Summary Information for Ozone (NY)

	1998	1999	2000	2001	2002	2003	2004	2005
8-hour Ozone Exceedance Days	14	20	7	17	28	15	1	10

Connecticut Pollution Drops with E10

The State of Connecticut replaced MTBE blends with E10 on January 1, 2004. In the six years leading up to the use of E10, Connecticut averaged 25 8-hour ozone exceedance days per year. In the two years leading up to the use of E10 (2002/2003), Connecticut also averaged 25 exceedance days per year. Since the introduction of E10, Connecticut has averaged 13 8-hour ozone exceedance days per year, a 48% reduction.[5]



Annual Summary Information for Ozone

	1998	1999	2000	2001	2002	2003	2004	2005
8-hour Ozone Exceedance Days	25	33	15	26	36	14	6	20
1-hour Ozone Exceedance Days	5	11	3	9	13	6	1	7

[5] Connecticut Department of Environmental Protection Ozone Summary, 1998-2005, *http://dep.state.ct.us/airmonitoring/ozone/ozonesummary.htm.*

Denver Study Shows Ozone Reduced with E10

A study for the Denver Regional Air Quality Council found that "[u]sing the June 2002 Denver Metropolitan Area (DMA) 8-hour ozone Early Action Compact (EAC) State Implementation Plan (SIP) photochemical modeling database and EPA's MOBILE6 and NONROAD mobile source emissions models, the use of a 100% penetration of a 10% ethanol blend (E10) in on-road and non-road mobile sources in Colorado was **estimated to produce no measurable effect on ozone concentrations in the DMA over the use of standard gasoline** (0% ethanol blend market penetration). The changes in 8-hour and 1-hour ozone concentrations due to the use of the ethanol blend were extremely small (<±0.5 ppb). **What small changes in ozone that were estimated suggested the use of the ethanol blend would produce small, but immeasurable, reductions in ozone concentrations in the DMA."**[6]

Michigan SEMCOG Study Shows E10 Benefits

The 2005 study for the Southeast Michigan Council of Governments (SEMCOG) funded by the American Petroleum Institute and others analyzed the emissions reduction potential of different gasoline and diesel fuel formulations for the eight counties in southeast Michigan. These counties are designated as marginal non-attainment area for the EPA 8-hour ozone standard. The emissions reduction potential for each option was evaluated and quantified. It evaluated California reformulated gasoline (CaRFG), regular RFG and other ethanol and non-ethanol fuels.

"**The Complex Model indicates that exhaust VOC benefits are more with ethanol than without ethanol…. NOx benefits are again highest with CaRFG and RFG, with slightly less benefit when ethanol is not included.** Finally, toxic benefits appear to be greatest with RFG, due to low benzene assumed for this case. **100% E10 market appears to have toxic benefits**, due to the fact that ethanol gasoline in Michigan appears to have a lower benzene content (1.2%) than without ethanol (1.5%)."[7]

The SEMCOG report does raise questions about NOx and permeation (evaporative VOC) emissions from E10. The report estimates that E10 could slightly increase NOx and permeation emissions if California data is the basis for the analysis. However, U.S. EPA and others have expressed concerns about California's NOx analysis (see section entitled "California Predictive Model Findings Uncertain" below). And California's permeation numbers are preliminary, and will remain under review until late 2006.[8] Further, a recent

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[6] Ralph E. Morris, Gerard Mansell, Edward Tai, Cuong Tran, "Photochemical Modeling of the Effects of the Use of Ethanol Blends in Gasoline Engines on Ozone Concentrations in the Denver Region," Environ International Corporation, August 8, 2005.

[7] Emission Reductions from changes to Gasoline and Diesel Specifications and Diesel Engine Retrofits in the Southeast Michigan Area, Air Improvement Resources, February 2005, Page 54, www.semcog.org/Products/pdfs/AIR%20Final%20Fuels%20Report.pdf.

[8] The State of California and the Coordinating Research Council (CRC) released the results of a 2-year, 10-vehicle permeation-testing program in September 2004. Several different entities have attempted to extrapolate the data to create a fleet-wide (or statewide) profile. There is significant variation (differing by a factor of three)

Michigan analysis suggests that even worst-case permeation emissions scenarios may have little or no effect on ground level ozone.

Michigan Analysis Shows Ozone Benefits of E10 with Permeation Included

A recent airshed (CAMx) model run conducted by the Michigan Department of Environmental Quality (MDEQ) using the air quality predictions published in the SEMCOG report predicted that 100% E10 would reduce ozone (smog) levels slightly in the regions tested, even with preliminary permeation data taken into account.[9]

The CAMx run showed the air quality effects of E10 in Southeastern Michigan under two scenarios: (1) with the CO and permeation (VOC) impacts estimated by the SEMCOG report, and (2) with just the CO impacts shown by the SEMCOG report (to isolate the alleged VOC impacts of permeation). The runs revealed slight ozone benefits for E10 in both scenarios, and no overall ozone impact from the permeation increases estimated by the SEMCOG report. The photochemical profile, temperature, and fleet mix in Southeastern Michigan are similar to eastern Wisconsin.

As a rule, airshed models better reflect local responses to changes in fuel properties than fuels regulations (often called models) such as the California Predictive Model or the U.S. EPA Complex Model, because airshed models account for the unique fleet and atmospheric conditions of the particular regions where they are run.

California Predictive Model Findings Uncertain

The primary air quality concern of E10 opponents is that NOx emissions might increase from passenger cars, based on projections contained in the California Predictive Model. However, the NOx analysis contained in the California Predictive Model and the actual "real world" impact of ethanol on NOx emissions remains uncertain.

The U.S. EPA acknowledged this uncertainty in 2001 while considering the State of California's claim that ethanol blending would increase NOx emissions. U.S. EPA stated that it was "concerned that considerable disparity existed among the models in the estimated direction and magnitude of the NOx response to change in [ethanol content], all else being constant."[10] U.S. EPA continued, "[i]t should be noted that the magnitude of the NOx response to [ethanol], even as predicted by the [California Model], is not large when compared to NOx emission differences between vehicles, or test-to-test variability in emissions . . . [t]he small size of the [ethanol] effect on NOx emissions indicated in all of these models **makes it difficult to detect statistically and to quantify precisely**."[11] As

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with regard to how the data is extrapolated to reflect statewide fleet-wide impacts. California is conducting more tests, and a review of its preliminary analysis in 2006. See section entitled "Recent and Ongoing Studies".

[9] Jim Haywood, MI DEQ, conducted the CAMx model run in 2005. This run was conducted with "basic" input speciations, but remains an important piece of evidence in support of the beneficial impacts of E10 in SE Michigan type airsheds because, unlike other analyses, CAMx takes into account the unique atmospheric conditions of the region tested.

[10] See EPA-420-S-01-008, June 2001, p. 5 at www.epa.gov/otaq/rfg_regs.htm#waiver. EPA's reference to "oxygen" is ethanol for the purposes of California's waiver request.

[11] *Id.*

detailed above, ozone levels dropped to record-low levels in California with ethanol in the fuel. The uncertainty of the NOx response to ethanol was also noted in the most recent tailpipe emissions analysis conducted to date by the Coordinating Research Council (CRC). The Council conducted an analysis of all available data on the emissions response to ethanol, and concluded, "[t]he results in the literature show some tendency for NOx emissions to increase with greater ethanol levels, **but this trend is not consistent or statistically significant over a wide range of studies**."[12]

Second, EPA found that the California NOx analysis is "unique to California's regulatory structure and specific to California refineries' technical configurations."[13] **The model used to regulate fuels outside of California – the U.S. EPA Complex Model – does not predict a significant NOx increase from E10**. Yet, the California NOx analysis continues to be the primary source of concerns about E10 *outside* of California. The unique nature of California's NOx analysis is not well understood at the state level, and continues to complicate efforts to accurately quantify the impacts of E10 outside of California.

Third, the NOx emissions increases predicted by the California Predictive Model may be off by as much as 50 percent. Because state-sponsored tailpipe tests had not been completed in time for the latest version of the Predictive Model (2000), the California Air Resources Board (CARB) was forced to assume that E10 blends increased NOx emissions in Model Year 1996+ (Tech 5) vehicles. Half of the NOx "hit" attributed to E10 in the California Predictive Model comes from this assumption. **California Air Resources Board-sponsored Tech 5 tailpipe tests completed about a year later revealed that ethanol blends did not increase NOx emissions in comparison to 100% petroleum blends in about a dozen Tech 5 vehicles**.[14] This discrepancy is under review by CARB and stakeholders in 2006.

The 2005 Michigan SEMCOG report that many states have used for their own E10 analysis flags the California NOx issue. The SEMCOG report states, "readers are cautioned that when the NOx effects [of using ethanol] are evaluated using the [California] Predictive Model, **the results in this study could overestimate the NOx effect, especially in the outlying projection years when 1996 and later vehicles predominate."[15]** Yet, most states have not corrected for this overestimation in their analysis.

In general, any air quality analysis based on the California Predictive Model should note the large uncertainties in quantifying the E10 NOx profile, and policy-making decisions should not be based on any single model.

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[12] See http://www.crcao.com/reports/recentstudies2006/E-67%20Final%20Report.pdf, p. 48. For a discussion of the report, see "Recent and Ongoing Studies" below.

[13] See EPA-420-S-01-008, June 2001, p. 9.

[14] See http://www.arb.ca.gov/fuels/gasoline/meeting/2001/allianceprestn.pdf, pp. 15-17. California is in the process of incorporating these test results; to be completed in 2006. But as of today, the California Predictive Model is still based on the old assumptions.

[15] Emission Reductions from changes to Gasoline and Diesel Specifications and Diesel Engine Retrofits in the Southeast Michigan Area, Air Improvement Resources, February 2005, p. 23, www.semcog.org/Products/pdfs/AIR%20Final%20Fuels%20Report.pdf.

Ethanol Reduces Carbon Monoxide, an Ozone Precursor

Carbon monoxide (CO) is a significant ozone precursor. U.S. EPA recently found that "[c]arbon monoxide is linked closely… to the cycle of tropospheric ozone and participates in the formation of 20 to 40% of the ozone found in non-urban areas. Carbon monoxide plays an important role in atmospheric photochemistry in regional and urban environments… In numerical simulations of at least one urban air shed, **CO was found to participate in the formation of 10 to 20% of the ozone found there**… On- and non-road mobile sources account for approximately 80% of the 1997 nationwide emissions inventory for CO."[17]
A Colorado DPHE study showed that E10 reduces carbon monoxide pollution by 11% from passenger vehicles.[18] 2001 California tailpipe tests showed that ethanol reduces CO emissions in even the newest vehicles, where it was previously thought that the CO emissions benefits of ethanol did not exist.[19]

This is important because many states continue to under estimate the impact of ethanol on CO in their ozone analyses. For example, in 2005 the Wisconsin DNR adopted for its final conclusions the results of the MOBILE6.2 model, which shows a net increase in on-road CO emissions for E10 (100.7 tons per day). This use of MOBILE6.2 data is highly questionable given that the weight of evidence (and both the Complex Model and the Predictive Model) demonstrates significant reductions in on-road CO emissions with ethanol. It is well recognized in the air quality community that ethanol blends reduce CO emissions from on-road passenger vehicles. This is confirmed by the recent SEMCOG report, which concludes, "100% E10 fuel scenarios would significantly reduce both on-road and off-road CO emissions."[20] In another example of undercounting CO, the California Predictive Model does not give E10 credit for reducing CO emissions in the newest vehicles, even though tailpipe exhaust emissions data now confirms that ethanol does in fact reduce CO emissions in today's vehicles.[21]

Failure to accurately quantify the CO emissions impacts of ethanol greatly affects the overall air quality profile of E10 with regard to ozone. This is because the net ozone impact of any prospective fuel is compiled from the cumulative impact of all ozone precursors, including VOC, CO and NOx. As such, benefits in one area (e.g. CO) can offset a problem in another area (e.g. NOx) to produce a net ozone benefit. Undercounting CO can alter the air quality profile of E10 directionally. Some experts believe that CO is the reason why ethanol blends have been associated with lower ozone levels on the ground.

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[17] Air Quality Criteria for Carbon Monoxide, EPA 600/P-99/001F, June 2000, pp E-1– E-6.
[18] Ragazzi, et al, "The Impact of 10% Ethanol Blended Fuel on Exhaust Emissions of Tier 0 and Tier 1 Light Duty Vehicles at 35 Degrees," CO DPHE 1999, www.cdphe.state.co.us/ap/down/oxyfuelstudy.PDF.
[19] See http://www.arb.ca.gov/fuels/gasoline/meeting/2001/allianceprestn.pdf
[20] SEMCOG, p. 13.
[21] See http://www.arb.ca.gov/fuels/gasoline/meeting/2001/allianceprestn.pdf, and http://www.crcao.com/reports/recentstudies2006/E-67%20Final%20Report.pdf.

Ethanol Reduces Soot Particulate Pollution

According to the American Lung Association, more than 2,000 studies link soot pollution to health problems like cancer, asthma and heart attacks.[22] EPA is proposing new soot particulate matter (PM) standards. Several states must submit soot PM State Implementation Plans in 2008 for the current standards and 2011 for the proposed standards.

A growing number of studies show that E10 reduces soot particulate pollution. A 1999 study by the Colorado Division of Public Health and the Environment showed that E10 reduced soot pollution by 36% from newer vehicles and more in older, more polluting vehicles. This study was in cold weather conditions.[23] A 1997 study published in *Environmental Science and Technology* showed that older vehicles burning 10% ethanol produced up to 22% less soot particulate pollution than those burning regular gasoline.[24]

Ethanol Reduces Dangerous Hydrocarbon Pollution

Ethanol also reduces other dangerous pollutants such as cancer-causing benzene. This is important because our air is more than 700 times too polluted with cancer-causing chemicals according to Environmental Defense's analysis at the Scorecard.org. More than three-quarters, or 88%, of the risk comes from cars, trucks and other "mobile" sources with pollutants like benzene.[25] Ethanol replaces octane-enhancing toxics in gasoline, reducing the cancer risks of driving and living near roadways. The Colorado DPHE study showed E10 reduced hydrocarbon pollution like benzene by 16.5%.

Recent and Ongoing Studies

Three recent studies shed additional light on the ethanol air quality debate. In two separate reports, the Coordinating Research Council (CRC) released vehicle test data for several categories of exhaust emissions ("CRC E-67 study") and evaporative VOC (permeation) emissions ("CRC E-65 study") from 10 cars with various fuel blends, including ethanol.[26] In January 2006 the California Air Resources Board released a draft report on the relative impact of CO and VOC emissions on ground level ozone formation ("ARB CO study"). While none of the studies should be considered definitive proof of any one theory about ethanol, some of the test results cast further doubt on key modeling assumptions that are at the center of concerns about the air quality impacts of ethanol.

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22 American Lung Association response to EPA's soot particulate proposed rule, www.lungusa.org/site/apps/nl/content3.asp?c=dvLUK9O0E&b=40404&ct=1740673.

23 Ragazzi, et al, "The Impact of 10% Ethanol Blended Fuel on Exhaust Emissions of Tier 0 and Tier 1 Light Duty Vehicles at 35 Degrees," CO DPHE 1999, www.cdphe.state.co.us/ap/down/oxyfuelstudy.PDF.

24 Malawa, et al, "Effect of Ambient Temperature and E-10 Fuel on Primary Exhaust Particulate Matter Emission from Lights Duty Vehicles," EST, 31(5) 1302-1307.

25 Environmental Defense, POLLUTION LOCATOR|Hazardous Air Pollutants | National Report, http://www.scorecard.org/env-releases/hap/us.tcl.

26 The CRC exhaust emissions report is a final report (E-67), while the CRC permeation analysis (E-65) is ongoing.

A brief discussion of each report is provided below:

- The CRC E-67 study tested exhaust emissions from 12 latest-technology passenger vehicles with 12 different fuel blends.[27] The test results confirm the inherent complexities of predicting the emissions impacts of different fuel blends. In many cases, the emissions impact of ethanol changed directionally with the alteration of other fuel properties. For example, ethanol slightly reduced NOx emissions in some scenarios (or 0% ethanol fuels *increased* NOx in some scenarios) and slightly increased NOx in others. Ethanol blends significantly reduced CO emissions in comparison to 0% ethanol fuels. This CO response is important because most models (including the California Predictive Model) attribute zero CO benefit to ethanol fuels in latest-technology vehicles. The California Predictive Model also assigns a steep "NOx penalty" to all ethanol blends, while the U.S. EPA Complex Model does not. While the CRC E-67 study should not be considered definitive, it nonetheless casts serious doubt on the position that ethanol blends increase NOx emissions across the board, and fail to reduce CO emissions in latest-technology vehicles.

- The CRC E-65 permeation study is the first part of a two-part analysis of permeation (evaporative VOC) emissions in California.[28] In essence, the study confirms what air quality regulators have known for some time: that both ethanol and non-oxygenated blends increase fuel evaporation relative to an MTBE-fuel baseline.[29] The degree of the impact – on a mass emissions basis – has not yet been finalized.[30] While permeation may increase the regulatory burden of blending ethanol, it is not a prohibitive factor. Any given blend – containing ethanol or not – slightly increases emissions in some areas and decreases emissions in others.[31] Fuel regulations focus on a prospective fuel's cumulative impact on criteria pollutants. What this study confirms is that all fuel regulations (i.e. EPA Complex Model, CA Predictive Model) must have a "permeation factor" to ensure that permeation is properly accounted

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[27] The study focused on the effects of altering three different regulatory parameters – ethanol content, T50 and T90 – while keeping others constant.

[28] The program tested permeation emissions from 10 pre-2001 vehicles containing California-compliant gasoline with MTBE, 5.7% ethanol or no oxygenate. Using MTBE fuel as a baseline, both ethanol blends and non-oxygenated blends increased permeation emissions. Ethanol blends increased permeation by a greater degree than non-oxygenated blends.

[29] Using MTBE-blended fuel as a baseline, ethanol blends increase permeation emissions by a greater degree than non-oxygenated blends. Regulators have known this for several years. For example, the California Air Resources Board added a "permeation factor" to the California Predictive Model in 1999 – even before any tests had been conducted – that penalizes ethanol blends for roughly 13 tons per day (tpd) of VOC-equivalent permeation emissions. The updated model may include a more substantial permeation factor. See n. 31, 32.

[30] Test data from 10 vehicles must be extrapolated to provide an estimation of a fleet-wide (or statewide) VOC impact. Current estimations differ by a factor of three. This process is highly dependent on assumptions, and is ongoing in collaboration with phase 2 of the permeation study, due to be released in late 2006.

[31] The process of certifying a fuel under the Complex or Predictive Model is a "balancing game." For example, ethanol blends are generally believed to reduce *exhaust* VOC emissions while increasing *evaporative* VOC emissions. Permeation is a small fraction of the overall VOC inventory, which in turn is only one category of ozone precursors. Blenders can market a fuel that increases permeation as long as it does not unlawfully increase overall VOC emissions (i.e. permeation is mitigated elsewhere in the blend). See n. 32.

for.[32] The second part of the analysis (scheduled for completion in 2006) will test newer vehicles, and higher ethanol blends (E10, E20 and E85).

- The draft ARB CO study (January 2006) assesses the relative ozone impact of VOC and CO emissions for California vehicles using ethanol-blended gasoline during a peak ozone period (>125 ppb O3). This analysis is critical because some believe that the CO upside of ethanol outweighs its permeation-related VOC downside to produce a net ozone benefit. The argument depends upon how much weight is ascribed to CO versus VOC with regard to ozone formation (its relative ozone reactivity).[33] The draft report – based on an airshed model run set to a federal peak ozone period in California – finds that the 8-hour peak ozone VOC ozone impact is 39 times greater than CO in California (i.e. 39 tons of CO produce the same ozone effect as 1 ton of VOC). If adopted in California, a 39-to-1 VOC to CO ratio would greatly benefit the air quality profile of ethanol because it represents a 33% *increase* in the relative importance of CO with regard to ozone formation (the CA Predictive Model assumes a 59-to-1 ratio), and ethanol significantly reduces CO emissions. The California Predictive Model should be corrected to reflect the results of this analysis.

Summary and Recommendations

A growing body of experience and evidence shows that ethanol has air quality benefits for ground level ozone and soot PM reduction. To promote the benefits of ethanol as an alternative fuel, we urge state and local policymakers to consider the following:

- Utilize the "full weight of evidence" approach for determining the air quality impacts of ethanol (and other biofuels) and implementing policies that promote its use. Such analyses should consider new EPA, CARB and other state air quality monitoring data demonstrating that ozone exceedance days dropped after ethanol use increased in several states. Airshed models are far more accurate in projecting a region's response to changes in fuel properties than regulatory models. Critical policy decisions should not be made without them.

- Expand the scope of analysis beyond ozone (without jeopardizing ozone achievements), to include the serious public health hazard of particulate (soot) emissions and the potential health and air quality impacts of unmitigated petroleum combustion. Ethanol blending reduces soot particulate matter (PM) pollution by up to 36%. Soot is a major public health threat, and many states will be in "non-attainment" under the new EPA PM standards.

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[32] As discussed, once the regulation accounts for a certain emissions response (e.g. permeation), blenders must mitigate for it. In crude terms, if the regulation attributes 13 tpd of increased VOC/permeation emissions to adding 10% ethanol, then E10 blenders must produce a base gasoline with 13 fewer tpd of VOC emissions to produce a certifiable E10 fuel (with zero net VOC impact).

[33] It is well established that VOCs are more "reactive" than CO with regard to forming ground level ozone (smog). The question is how much more reactive. VOC/CO reactivity factors vary from 15-to-1 (VOC only 15 times as reactive as CO) to 60-to-1 (VOC 60 times as reactive as CO). Weighting or un-weighting the impact of CO on ozone can have a very significant impact on the projected overall air quality impact of ethanol blends.

- Ensure that carbon monoxide (CO) is properly accounted for as an ozone precursor. New studies reveal that CO is undercounted as an ozone precursor in many of the most prominent fuel models, including the California Predictive Model. Both U.S. EPA and the National Research Council (NRC) have acknowledged the ozone-forming properties of CO. Ethanol blends significantly reduce CO pollution, even in latest-technology vehicles.

- Support state-level Renewable Fuels Standards (RFS). A state-level RFS allows transportation fuel marketers to use a combination of low and high blends (and a combination of different renewable fuels)[34] to meet percentage-based RFS targets. A state RFS also complements state and federal fuels regulations because specific blends are not prescribed by the program. Marketers will gravitate toward the fuels with the fewest regulatory burdens and production costs.

- Support state incentives to promote "high-blend" ethanol. E85 as a viable near-term strategy to promote ethanol use and fuel diversification. However, the widespread use of E85 depends upon infrastructural and vehicle changes. Volunteer efforts by the automobile and oil industry will not be enough to energize E85 programs to the point of substantial petroleum displacement. Incentive programs will be necessary to jumpstart the use of high-blends.

- Do not abandon low-blend (E6-E10) ethanol markets. The ethanol blending market is a proven catalyst for bio-industrial growth, fuels diversification, and CO2 emissions reductions in several states. Blending markets offer far greater petroleum displacement potential in the near and intermediate terms than high blend programs. Further, in most cases high-blend markets have emerged from state-level commitments to low blends. Blending programs are also a "hedge" against short-term blending component and fuel supply disruptions and pump price spikes that often result in variances from fuel regulations and increased pollution. Such programs need not mandate specific blend characteristics, and can complement state and federal air quality improvement efforts and fuels regulations. Legislative efforts can include explicit air quality protections.

- Support incentives for the use of cellulosic feedstocks for ethanol production. Some ethanol blending bills include commitments to utilize cellulosic feedstocks for a certain percentage of in-state production by a certain date. Ethanol blending initiatives should include incentives for the use of cellulosic ethanol.

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[34] A discussion of biodiesel, eDiesel, renewable diesel and other renewable fuels and additives is beyond the scope of this report.

Background on Authors

Brett Hulsey, MNS, is President and Founder of Better Environmental Solutions, an environmental health consulting firm promoting practical solutions today for a better tomorrow to save lives, jobs and money. He is author of "Highway Health Hazards," "Cancer, Chemicals, and You," "The Great Lakes States: America's New Cancer Alley," and more than 20 reports on health, clean air, energy, and the environment. He worked for the Sierra Club for more than 17 years where he started the Protect our Children from Cancer Project, worked to pass the Clean Air Act amendments in 1990, was environmental policy advisor to President Clinton and an Energy Conservation Advocate in the Carter Administration.

Brooke Coleman is the director and founder of the Renewable Energy Action Project (REAP), a national coalition of organizations promoting renewable energy use. He has been involved with transportation fuels at the regulatory and policy making level since 1998, first as the Clean Fuels and Climate Change Director for Bluewater Network (a division of Friends of the Earth) and later as the director of REAP. He led a national campaign to expose the dangers of and ban the gasoline additive MTBE, and currently promotes renewable fuels as a viable, near-term strategy to address petroleum dependence and global climate change. He is a graduate of the Northeastern University School of Law.

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