**Comments Submitted by the Energy Future Coalition and the Urban Air Initiative**

**Appendix I: Automakers who continue to use internal combustion engines must increase engine efficiency to meet LCFS standards and reduce GHGs.**

1. **Automaker studies confirm ethanol’s superior octane properties enable substantial reductions in most harmful urban pollutants**

This section contains links to auto industry studies on PM/PN, particulate filter technology, and E30 blend emissions and performance results.

* 2012 Ford/Maricq:  E30+ blends reduce PM and black carbon by 45%, NOx and HC by 20% in DI engines. <http://www.tandfonline.com/doi/pdf/10.1080/02786826.2011.648780>
* 2010 CARB/Zhang:  E30+ blends reduce PM/PN by 80+% in PFI engines. <http://www.calevc.org/carbzhang.pdf>
* 2013 Italian PAH emissions:  E30+ blends reduce highest potency (HMW) PAHs by 60+%, p. 9, Fig. 17. <http://www.sciencedirect.com/science/article/pii/S0306261912006836>
* 2010 Honda:  high boiler/high DBE aromatics most responsible for increased PN and PAH emissions, fuel quality changes necessary. <http://papers.sae.org/2010-01-2115/>
* 2013 Ford/Stein SAE:  ethanol blends’ impacts on SI engine emissions and performance.
<http://papers.sae.org/2013-01-1635/>
* 2013 Oak Ridge/Szybist, Splitter et al.:  E30 blends facilitate automaker compliance with fuel efficiency and carbon reduction targets. <http://pubs.acs.org/doi/abs/10.1021/ef401575e>
* 2009 Ford/Anderson:  Energy Security Act targets require orderly introduction of EXX blends. <http://papers.sae.org/2009-01-2770/>
* 2011 SWRI/Khalek:  SIDI engine PM/PN emissions, gasoline particulate filter technologies, and fuel composition discussion.  Smaller gasoline PN difficult to capture. <http://www.swri.org/3pubs/ttoday/Summer11/PDFs/ParticleEmissions.pdf>
1. **Vehicle technology advances must be optimized with gasoline quality improvements**

On June 3, 2014, in Washington, DC, the Energy Future Coalition held a workshop to bring together leading experts and policymakers to discuss fuel and filter technology options for avoiding or controlling particulate pollution from aromatic hydrocarbons in gasoline and the toxic substances that can accompany them, especially polycyclic aromatic hydrocarbons (PAHs). The event featured a panel of experts from the automobile, clean fuels, and filter technology sectors.

The four excellent presentations can be accessed at the following link:

<http://www.energyfuturecoalition.org/What-Were-Doing/Eliminating-Aromatics-Gasoline/Technical-and-Policy-Responses-Health-Risks-Ultrafine>

The experts agreed that improvements in gasoline quality were a critically important policy tool for optimizing vehicle technology advances required to meet stricter fuel efficiency and carbon reduction rules.

An important take away from Woebkenberg (Mercedes-Benz), Splitter (Oak Ridge National Labs), and Vander Griend (ICM, Inc.) was that the next generation of vehicles would benefit significantly from higher octane gasoline, preferably in the 94 AKI range. This would allow engine designers to optimize for higher efficiency and reduced emissions, primarily by downsizing and increasing compression ratios. However, the experts all agreed that using aromatic compounds to increase octane to this level would result in substantial increases in PM emissions, especially UFPs and their associated toxics. In contrast, Mercedes confirmed substantial reductions in PN emissions (e.g., 50% or more) with mid-level ethanol blends (AKA E30). In answer to a question about what would happen if E30 were widely available, Woebkenberg replied that the effect would be “magic” in terms of increased engine efficiency accompanied by significant reductions in carbon and particle-borne toxics emissions.

Dr. Derek Splitter of ORNL reported that ethanol’s superior octane properties are not fully understood, but involve a combination of octane sensitivity, heat of vaporization, flame speed, pressure sensitivity, and ethanol-specific kinetics. Referring to E30 as “Renewable Super Premium,” Splitter said that compared to regular gasoline, it enables much more aggressive downsizing and downspeeding, enabling higher fuel economy despite ethanol’s lower energy density. Oak Ridge research has confirmed that ethanol shows diminishing octane returns on blends above E50. He concluded that widespread use of E30 blends would offer a cost effective way to achieve a number of national policies simultaneously: RFS2, GHG – CAFE, and Tier 3.

Steve Vander Griend of ICM provided data to underline the importance of “splash-blending” additional ethanol to E10 to make E30, as opposed to “match-blending”, where other components—especially aromatic compounds—are artificially added to shape the blend’s distillation curve. Woebkenberg and Splitter agreed that given ethanol’s superior octane properties, it makes no sense to add more aromatics when producing an E30, RSP blend.

1. **Substantial climate and health co-benefits would be achieved by using ethanol’s clean octane to improve gasoline quality**

Replacing carbon intensive aromatic compounds with less carbon-intensive ethanol to increase gasoline octane levels has been shown by Oak Ridge and other experts to have the potential of substantially reducing the carbon footprint of the U.S. LDV fleet. E30 “clean octane” would also help reduce the transportation sector’s carbon footprint in other ways.

In recent years, misinformed sources have contended that the increase in corn ethanol production has contributed to undesirable land use changes, and exacerbated carbon releases to the atmosphere.  The empirical evidence shows that this is not true, as farmers have largely shifted some soybean acres to corn, with substantial benefits to soil fertility, carbon sequestration, and feed/food supplies, as explained below.

Shifting soybean acres to corn acres has not reduced the feed ration supplies, but it has increased soil fertility and carbon sequestration and soil organic matter buildup.  After processing in an ethanol plant, an acre of corn yields as much protein as an acre of soybeans.  Because it is a photo-synthetically superior C4 plant, corn has an extraordinary ability to sequester carbon, and help to move fertilizer nutrients back to the surface for plant growth rather than polluting ground water.  Corn’s extensive deep root system makes it one of the few plants with this important capability that makes crop production sustainable.

**A multi-year USDA research project recently confirmed that no-till corn equaled switch grass in SOC (soil organic carbon) formation, and that over half the increase in SOC was below one foot depth.  The researchers estimated that deep soil SOC sequestration benefits of corn have been understated by 60 – 100% in modeling done to date.**[[1]](#footnote-1)

**Even Michael Pollan, a frequent critic of the current agricultural system, has singled out corn’s efficiency compared to other crops.  In his book, “Omnivore’s Dilemma”, Pollan noted:  “Few plants can manufacture quite as much organic matter (and calories) from the same quantities of sunlight and water and basic elements as corn.”  Pollan goes on to praise corn’s ability to extract carbon from the air.  “The C-4 trick represents an important economy for a plant, giving it an advantage…By recruiting extra atoms of carbon during each instance of photosynthesis, the corn plant is able to limit its loss of water and “fix”—that is take from the atmosphere and link in a useful molecule—significantly more carbon than other plants.”**

98% of U.S. corn is not directly consumed by people (less than one bushel per person per year, out of a 14 billion bushel crop), but instead used as livestock feed and for other purposes.  Importantly, when the starch portion of an acre of corn is converted to ethanol, what remains is as much protein and other equivalent high -value feed products as found in an acre of soybeans.

Since corn yields are nearly four times greater than soybean yields, and corn rebuilds SOC much more efficiently than soybeans, the economically and environmentally smart thing to do is to first process the corn to ethanol, and replace the starch with other low-value substitutes.  Doing so results in the same amount of protein and feed co-product equivalents offered by an acre of soybeans, increases soil fertility and captured carbon, and offers the added bonus of the corn ethanol industry’s job creation, health cost savings, oil import reduction, and environmental (aromatic substitution) benefits.

In the future, as corn yields increase with genetic engineering advances and other improved technologies, corn’s ability to simultaneously supply high octane fuel components, feed/food, and carbon sequestration benefits will also increase.  As grain output increases, so too does the output of the valuable corn stover residue which has value as a rebuilder of SOC, a feed ration component that can be mixed with ethanol’s high protein co-products to replace starch, and a feedstock for cellulosic ethanol production.  In summary, more corn, not less, is good for the environment (health and carbon co-benefits), the soil, the food supply, and the economy.

1. **Substantial reductions are possible in urban black carbon emissions with clean octane gasoline**

Scientists and regulators have identified soot (also known as black carbon, or BC) as a major contributor to climate change and harmful global warming, accountable for as much as 30-40 percent of the rise in global temperatures. Nations are proposing aggressive remediation measures such as installing filters on diesel engines. <http://www.nytimes.com/2012/02/18/opinion/a-second-front-in-the-climate-war.html?_r=2&nl=todaysheadlines&emc=tha211>

In addition to its global warming effects, press reports have identified BC as “perhaps the most deadly widespread air pollutant”. <http://www.washingtonpost.com/national/health-science/epa-to-tighten-national-soot-standards/2012/06/14/gJQABYsPdV_story.html>

New real-time measurements suggest that black carbon emissions from light-duty gasoline vehicles are significantly underestimated, as found by Liggio et al:[[2]](#footnote-2)

“Unlike the results for gasoline vehicles, the measured BC emission factor for heavy-duty diesel vehicles was in reasonable agreement with previous measurements. This suggests, the team concluded, that greater attention needs to be paid to black carbon from gasoline engines to obtain a full understanding of the impact of black carbon on air quality and climate and to devise appropriate mitigation strategies.

“The present results also have implications for BC measurements, modeling, and emission regulations. ... The gap between BC mass emissions of HDDV and LDGV is likely to shrink further as regulations for HDDV continue to take effect and alternate technologies for fuel delivery in gasoline vehicles (i.e., gasoline direct injection; GDI) become more popular. BC emissions from GDI engines have been observed to be significantly higher than those from conventional engines. The present results suggest that further dynamometer and on-road measurements of BC from gasoline vehicles are required in order to corroborate our findings and to improve emissions inventories in support of modeling, national and international policies, and estimates of impacts on health, the environment, and climate.”

A recent Ford Motor study (2012 Ford/Maricq, cited above) found that gasoline direct injection (GDI) vehicle exhaust PM is dominated by EC/BC, rather than organic carbon (OC), contrary to what EPA concluded in its 2008 Kansas City study, which found that OC accounted for 80% of PM emissions. Ford said this discrepancy stems from the differences between port fuel injection (PFI) and GDI engine technologies. Ford found that GDI vehicles fueled by E0 (gasoline with no ethanol) emit an approximate range of from 8 – 15 x 1012 per mile (vs. cubic meter). E30+ blends reduce BC emissions by 45%. Consequently, a nationwide clean octane program could achieve a significant, if not predominant, share of the EPA’s targeted emissions of urban BC in a cost-effective, technologically proven, and consumer-friendly manner.

Numerous experts have concluded that spark ignition gasoline-powered engines are a larger source of urban BC emissions than diesel engines (96% of the U.S. vehicle fleet is gasoline powered). In one recent study based upon CalTrans vehicle data, SI gasoline emissions were a factor of 8 to 10 greater than heavy duty diesel emissions. <http://aaqr.org/VOL10_No1_February2010/6_AAQR-09-05-IR-0036_43-58.pdf>, Table 1, p. 46

In a December 2011 PM study for its LEV III rule, CARB stated that “recent studies show that gasoline engines also play a key role” in PM emissions, and that EC/BC “dominates PM”. <http://www.arb.ca.gov/regact/2012/leviiighg2012/levappp.pdf>, p. 88, p. 11, Fig. 4

“Contrary to the perception diesel vehicles are the main vehicular source of PAHs, light-duty gasoline vehicles have been found to be the most important source of PAH emissions in some urban areas.” BC has high porosity and a large surface area, and thus easily adsorbs the carcinogenic and mutagenic PAHs, and transports them to the lungs and organs. <http://earthjustice.org/sites/default/files/black-carbon/jiang-et-al-2005-mexico-city.pdf>, p. 3378

Honda researchers (2010 Honda study, cited above) noted that gasoline engines are responsible for a significant share of urban particulate emissions. Honda warned that in order to reduce both harmful global warming emissions, as well as health-threatening PN/PAH emissions, gasoline fuel quality must be improved to complement advances in vehicle hardware.

1. U.S. Department of Agriculture, Agricultural Research Service, “A Surprising Supply of Deep Soil Carbon,” February 2014. <http://www.ars.usda.gov/is/AR/archive/feb14/soil0214.htm> [↑](#footnote-ref-1)
2. J. Liggio et al., “Are Emissions of Black Carbon from Gasoline Vehicles Underestimated? Insights from Near and On-Road Measurements.” *Environmental Science & Technology*, 2012. doi: [10.1021/es2033845](http://dx.doi.org/10.1021/es2033845) [↑](#footnote-ref-2)