# Killing Them Softly:
## *Oil Companies and the Public Health Threat of Gasoline Emissions in Urban Areas*

ETHANOL ACROSS AMERICA

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On April 1, 2014, with the assistance of the National Institute of Environmental Health Sciences, American Lung Association, Environmental Protection Agency, and the Urban Air Initiative, the Energy Future Coalition (EFC) assembled a group of highly regarded experts to explore the health effects of fine particles from vehicle emissions. Experts from such prestigious institutions as Carnegie-Mellon, Columbia University, UCLA, Tufts, Oregon State University, and Duke University explained how Americans within a mile or more of roadways are exposed on a daily basis to tens of billions of invisible, highly toxic particles emitted from cars and trucks on a per mile basis.

The workshop's transcript contains some sobering revelations, and to many of us who have studied this issue it confirms our worst fears—the fuels combusted on our nation's roadways are a predominant source of the most dangerous particle-borne toxic emissions, which are potent carcinogens and mutagens responsible for thousands of premature deaths each year.

Unlike black smoke from diesel, you can't see it, smell it or otherwise identify these emissions which are the smallest nano-sized particles emitted from gasoline but they can be the most lethal. Gasoline exhaust is a much greater contributor to these harmful particles than diesel or stationary sources in most urban areas. What is troubling is that these nano, or ultra-fine particles (UFPs) are so small they lodge deeply into the lungs and from there enter the bloodstream where they are passed to vulnerable organs presenting a higher risk of cancers and neurological damage. Children in the developmental stage are particularly at risk. These UFPs can be transported long distances and persist for long periods of time. The particles also carry black and "brown" carbon, recently identified as a powerful global warming agent. Add all this up and the particle-borne pollutants are responsible for tens of billions of dollars each year in avoidable health costs.

Substantial reductions in these emissions could prevent tens of thousands of premature mortalities and adverse health effects, including asthma, heart and respiratory diseases, learning disorders, and lower IQs. The research confirms that some of the most potent air toxics, Polycyclic Aromatic Hydrocarbons, or PAHs, have adverse effects similar to those caused by low level lead exposure.

## What Went Wrong

For starters, the Environmental Protection Agency vastly understates the magnitude of this problem due to seriously flawed models that rely on predictions and assumptions rather than real-time measurements. But we need to go back further and learn from the transition of the principal octane agent of the day, which was lead, to what could be an even greater problem which is the steady increase in aromatics and toxic compounds. As Henry Ford warned a century ago, when he and his scientists advocated using 30 percent ethanol to boost gasoline octane levels rather than lead or carcinogenic compounds, the petroleum industry went from marketing a product with a known poison to marketing products with known carcinogens. To boost gasoline octane levels, refiners replaced lead with tightly bound oil-based compounds that defy efficient combustion, no matter how hard automakers try. While emission technologies have clearly improved, the quality of U.S. gasoline has not kept pace. 25–30% of U.S. gasoline—approximately 40 billion gallons of carcinogenic compounds per year—is the worst of the worst: aromatics. One expert has likened these heavy, high boiling, carbon laden compounds to a breeding ground for lethal pollutants. Powerful oil interests—with the collaboration of EPA technocrats—have rigged the regulatory deck in terms of fuel certification and engine testing so that the true emissions effects of everyday consumer-grade gasoline are not reported. Coupled with EPA's flawed models, this sleight of hand results in substantial under-reporting of gasoline exhaust pollution. Fortunately, EPA has the authority it needs to put an end to the charade.

In the 1990 Clean Air Act Amendments—which banned the use of lead in gasoline—Congress also directed EPA to reduce the gasoline compounds most responsible for these air toxics "to the greatest degree achievable". Best available science and new technologies developed by auto manufacturers demonstrate

*Continued*

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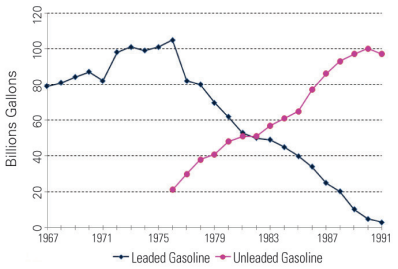
David Hallberg has more than 35 years of experience in the ethanol industry. He has served as legislative director in both the U.S. Senate and House of Representatives and was actively involved in drafting and enactment of much of the ethanol industry's formative legislation from 1977 to 1981. Dave founded and served as President/CEO of the Renewable Fuels Association from 1981 to 1985. He was a member of the U.S. delegation to the G8 Forum on Climate Change in Shonan Village, Japan, in 2001. Dave is the inventor of three U.S. patents for integrated processes to produce renewable fuels and reduce carbon emissions. Also, he served as director of the Nebraska Ethanol Board from 1998 to 2010, first appointed by Governor E. Benjamin Nelson. Dave is a recipient of the American Coalition of Ethanol Grassroots and Merle Anderson awards. He currently works with a number of clients in the biofuels arena.

that—as a complement to cleaner vehicles—improving gasoline quality by replacing gasoline aromatics with "clean octane" compounds can reduce these harmful particles and their toxic constituents by 45% – 85%.

**Summary of Leaded Gasoline Production vs. Unleaded with Higher Aromatics (1967-1991)**

The production of leaded gasoline decreased from 77.5 billion gallons in 1967 to 3.1 billion gallons in 1991, or to 3% of all gasoline produced. During that same period, unleaded gasoline with higher aromatic levels significantly increased.




*Source: U.S. EPA Report on Use of Alkyl-lead in Automotive Gasoline*

The ball is in EPA's court, and to their credit they recently announced they may take a good long look at UFPs. But that may be shutting the barn door after the horse has bolted. EPA looked at the relationship between toxics and octane (under what is called the Mobile Source Air Toxics (MSAT) review) in 2007 and the potential for ethanol to replace aromatics but failed to act. In the 7 years since then a great deal has changed. Between the exhaustive research conducted by groups like the Energy Future Coalition and the Urban Air Initiative, and what is becoming increasingly apparent to the health and auto industries, it is perplexing that EPA has not acted when you look at the following facts:

- Gasoline exhaust is the predominant source of the most dangerous pollutants in urban areas, as confirmed by real-time measurement of urban pollution plumes.
- Aromatic compounds which refiners add to gasoline to increase octane levels are the primary precursors to the most dangerous pollutants in urban areas, especially particle-borne toxics.
- While overlooked by EPA's flawed models, secondary organic aerosols (SOAs) constitute the major fraction of urban fine and ultrafine particulate matter (PM), which health experts say poses the greatest threat to human health.
- New research confirms that SOAs insulate and preserve carcinogenic, mutagenic polycyclic aromatic hydrocarbons (PAHs)—the predominant source of which is also gasoline aromatics—and enables their long-range transport (LRT). These SOA-borne PAHs persist for days and weeks, travel for miles, and penetrate into homes, cars, and schools.
- Splash-blending additional ethanol on top of widely available E10 gasoline produces a high-performance E30 blend with far less aromatic precursors. E30 blends reduce the most dangerous urban pollutants—PM/PN, SOAs, PAHs, and black carbon—by 45–85%.
- EPA models substantially under-predict gasoline exhaust contributions to urban black and "brown" carbon (BC). Thus, E30 blends' emissions reductions would provide *significant health and climate-related co-benefits*.
- Compared to aromatics, ethanol is higher octane, lower carbon, less expensive, and does not produce SOAs or PAHs.
- Unless regulators improve gasoline quality by reducing aromatic precursors, advanced engine technologies such as direct injection and lean-burn combustion, etc. are likely to increase emissions of particle-borne toxics, especially those carried by the more lethal nano-particles.
- A recent study by DOE's Oak Ridge National Laboratory concluded that E30 blends' higher octane could help automakers comply with new fuel efficiency and carbon reduction rules. A nationwide E30 program would make it easier for EPA to comply with several statutory requirements simultaneously and cost effectively: GHG – CAFE; RFS2; and MSAT.

## Through the Looking Glass

How one sees things depends on how one looks for it. In recent years, instrumentation technology advances have enabled real-time measurement of urban pollution plumes, the findings of which contradict conventional models that assume urban PM is primarily a product of diesel exhaust or biogenic sources (e.g., trees). For example, EPA models typically attribute only 5% of urban PM2.5 (based upon primary mass only) to gasoline exhaust. In fact, real-world results show that EPA's models are seriously flawed, and that they significantly under-predict gasoline's contribution to urban emissions. In a 2011 report to Congress, EPA itself admitted that its CMAQ model substantially under-reported SOA emissions from motor vehicles, yet still it has not taken corrective action.

According to a highly respected 2012 study, "**Gasoline emissions dominate over diesel in formation of secondary organic aerosol mass", Bahreini et al. (2012), Geophysical Research Letters, Vol. 39.**

- Air-borne and ground-based measurements of OA (organic aerosols) in Los Angeles Basin indicated that "the contribution from diesel emissions to SOA formation is zero within our certainties. Therefore, substantial reductions of SOA mass on local to global scales will be achieved by reducing gasoline vehicle emissions."
- "Consistent with previous studies, this indicates that gasoline vehicles are the dominant source of CO and light, single-ring aromatic VOCs including benzene and toluene."
- "Because diesel emissions contribute to POA, but not detectably to SOA, as photochemical processing and SOA formation proceeds, the contribution of diesel emissions to total OA decreases."
- "…for more accurate modeling of SOA formation in urban areas, future research should be directed at identifying specific species in the exhaust of gasoline engines that are responsible for SOA formation [see next study]."

- "Assuming that production of SOA relative to POA from gasoline exhaust follows the same trend as in LA… we estimate that within a day of processing, SOA from gasoline exhaust may reach 4 Tg/yr, which is 16% of recent global estimates of biogenic SOA. Our observations suggest that a decrease in the emission of organic species from gasoline engines may significantly reduce SOA concentrations on local and global scales."

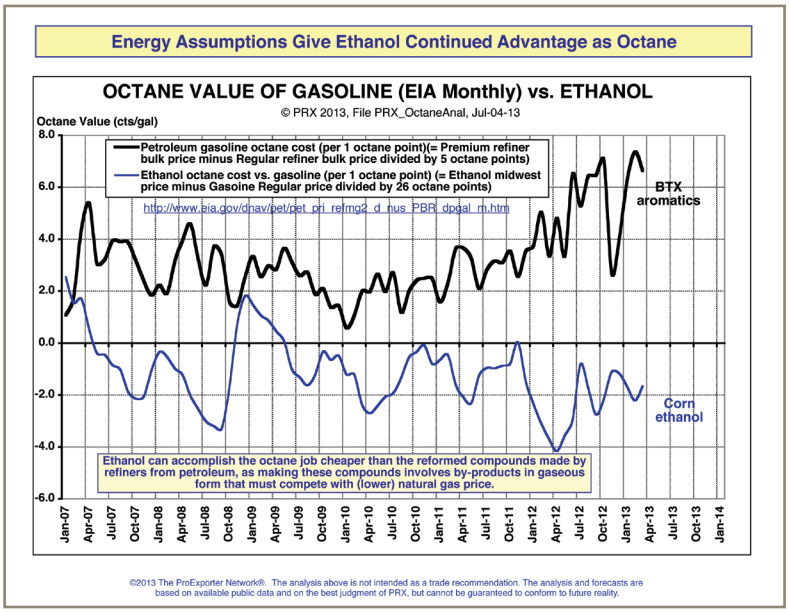
This is not an isolated study or outlier; many other real-time measurement studies have validated the results. One 2013 peer-reviewed study specifically compared Bahreini's work with another that questioned some of their findings, **"Secondary organic aerosol formation from idling gasoline passenger vehicle emissions investigated in a smog chamber", Nordin et al., (2013), Atmos. Chem. Phys., 13, 1601-6116.** Nordin et al. found that:

- "Gasoline vehicles have recently been pointed out as potentially the main source of anthropogenic secondary organic aerosol (SOA) in megacities."
- "Gasoline exhaust readily forms oxidized organic aerosols that commonly dominates the organic aerosol mass spectra downwind of urban areas…Classical C6 – C9 light aromatic precursors were responsible for up to 60% of the formed SOA, which is significantly higher than for diesel exhaust. Important candidates for additional precursors are higher-order aromatic compounds such as C10 and C11 light aromatics, naphthalene and methyl-napththalenes. We conclude that approaches using only light aromatic precursors given an incomplete picture of the magnitude of SOA formation and the SOA composition from gasoline exhaust."
- "The benzene (a known carcinogen) concentration is strongly elevated in these idling experiments compared to the fuel content (benzene is regulated to less than 1% by volume in gasoline in Europe), most likely due to formation of benzene from other light aromatic compounds in the catalyst…The enrichment of benzene in the exhaust is also found in road tunnel emission measurements."
- Since gasoline exhaust SOA is a more complex mixture than SOA from pure precursors, it can be expected that gasoline SOA resembles atmospheric observations better than SOA from pure precursors."
- "This implies that relatively low concentrations of PAHs can give a significant contribution to SOA formation."
- As shown in this study, gasoline exhaust readily forms secondary organic aerosol. This substantiates recent claims that gasoline is a dominating source to SOA in and downwind of large metropolitan areas."

## Cleaner Cars Require Better Gasoline

In the 1990 Clean Air Amendments, Congress directed EPA to make sure that automakers did not have to bear the entire emissions compliance burden. Congress wanted EPA to make sure that gasoline quality kept pace with vehicle technology improvements. Cleaning up our gasoline and savings billions of dollars in health costs is not rocket science. The Brazilian experience has proven that cost effective changes can be made to the U.S. transportation system so that more efficient vehicle technology is optimized. We must put an end to the existing "garbage in and garbage out" fuels policy. In fact, it was the auto industry that rang the alarm bell that compliance with strict new fuel efficiency and carbon reduction rules would require higher octane gasoline. However, fuel providers must use the right kind of octane—"clean octane"—or toxic UFP emissions will increase as advanced technologies like direct injection come to dominate the fleet. In a revealing 2012 study **"The Impact of Ethanol Fuel Blends on PM Emissions from a Light-Duty GDI (Direct Injection) Vehicle", Maricq/Ford Motor Co., 2012**, a central finding is that "When the ethanol content increases to >30%, there is a statistically significant 30–45% reduction in PM mass and number emissions observed for both engine calibrations…Engine-out hydrocarbon and NOx emissions exhibit 10–20% decreases, consistent with oxygenated fuel additives."

- "Three areas related to motor vehicles and air quality are experiencing major changes. The first is fuel composition… increased reliance on renewable fuels…The second is the



*"Aromatic hydrocarbons in gasoline include benzene, toluene, and xylene. Benzene is a known carcinogen, one of the worst air toxics. 85% of all benzene in the air we breathe comes from motor vehicle exhaust. Xylene from automobile exhaust in the morning rush hour will form ozone [smog] in sunlight to choke our lungs by the afternoon trip home. Toluene, another aromatic, usually forms benzene during the combustion process and thus becomes carcinogenic along with benzene in the gasoline."*

—U.S. Senator Tom Harkin (D-IA), Current Chairman, US Senate Committee on Health, Education, Labor and Pensions

Congressional Record, 101st Congress, Clean Air Act Amendment: Amendment No. 1423 to Amendment No. 1293, March 29, 1990

growth of gasoline direct injection (GDI) engine technology… The third is regulatory: CARB and EPA are both contemplating next-generation emissions standards which would lower tailpipe PM emissions…". (p. 1)

- "Three PM emissions metrics are examined: (1) mass; (2) elemental/organic carbon (EC/OC); and (3) total particle number." (p. 2)
- "All three metrics indicate a statistically significant reduction in particulate emissions with E32 and E45 fuels compared to base gasoline…The decrease from E0 to these fuels is on average ~30% by particle number and ~45% by mass." (p. 4)
- "Overall, the effects of ethanol blends on GDI vehicle PM emissions described above agree with previous work." (p. 6)

## Let's Not Repeat the Same Mistakes

We have seen this movie before. Entrenched interests delayed regulatory action for decades as leaded gasoline poisoned our cities, and as tobacco smoke sickened and killed millions (many of the PAHs found in gasoline exhaust are the same PAHs found in tobacco smoke). Dozens if not hundreds of peer-reviewed studies by renowned experts—many of them paid for by EPA—confirm that gasoline aromatics are the predominant source of the nation's greatest health threats. 25 years ago, at the same time it was banning lead in gasoline, Congress explicitly instructed EPA to reduce air toxics caused by gasoline aromatics "to the greatest degree achievable". During debate on the successful 69 – 30 Senate vote on March 29, 1990 that created reformulated gasoline, Senator Tom Daschle said this about EPA and aromatics: *"Unfortunately, EPA has known about this problem for more than a decade and has repeatedly failed to address it. Despite the fact that mobile source toxics account for more than half the air pollution-related cancer deaths annually, EPA does not regulate mobile source toxics. I simply do not trust EPA to implement a program that has been stonewalled for more than a decade…The oil industry is one of the most powerful industries in the world. The EPA is not immune to pressure, both from well financed lobbying and from divergent interests within the Administration itself."* Clean octane substitutes are widely available, cost effective, and will improve not only Americans' health but vehicle performance. It is time for EPA to enforce the law, and give the country a win-win-win: substantial reductions in carbon and toxic emissions, lower cost gasoline, and better performing cars.

No more hall pass for the petroleum industry—we must no longer stand by while they are Killing Us Softly.

This ***"Killing Them Softly: Oil Companies and The Public Health Threat of Gasoline Emissions in Urban Areas"*** **White Paper** was produced and is distributed as part of a continuing series sponsored by the Ethanol Across America education campaign. Research and analytical data provided by the Urban Air Initiative. The ***Ethanol Across America*** White Paper series provides an opportunity for public officials, industry, academia and others to express their views on issues relating to the development of ethanol and other alternative fuels. Interested parties are encouraged to submit papers or ideas to **cfdcinc@aol.com**.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