CFDC CLEAN FUELS DEVELOPMENT COALITION

# Issue Brief:
# Improving Air Quality through Transportation Fuels

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It is not an urban legend or Old Wives' tale that Henry Ford designed the first Model T to run on alcohol. It is a known and well documented fact that he envisioned a renewable, domestic fuel that among other things, he believed burned cleaner. That vision gave way to the realities of cheap and plentiful petroleum and 100 years and more than 100 million automobiles later, little has changed. That reliance on petroleum may quite possibly pose a significant health risk that we are just now beginning to fully grasp, but one that we have the ability to address.

The combustion of any chemical or product is never fully benign. The very act of exploding something, whether it is in the open or within the confines of an engine, has consequences. The composition of the fuels we use, that is to say what they are made of, will determine their impact on the air, water, and soil they come in contact with. The environmental impacts of latent products are often significantly less than those same products when heated or combusted. Evaporative emissions that waft from a running engine and the exhaust emissions that are the direct result of combustion create a potpourri of pollution that very few can say we fully understand. One thing we do know is that the old saying applies of "quality in, quality out," or perhaps more appropriate to this subject is "garbage in, garbage out."

## Background & History

Gasoline is produced by refining crude oil. By the time the refining process is concluded the resultant brew is made up of hundreds of chemicals and components which then are fed into internal combustion engines that transfer the valuable energy they carry in the form of BTUs (British Thermal Units), allowing us to move down the road.

The fact that gasoline has a high energy content is only part of the story. The real need, particularly with today's engine technology, is octane. The correct matching of octane rating and engine design is the crucial factor in achieving performance. Insufficient octane in the fuel causes engine knock and performance problems. Octane is not a natural element of gasoline but is essentially manufactured from the crude oil. It is buried deepest in the barrel and thus costs the most to produce. At any level, however, octane is the piece of the puzzle that makes it all happen. And herein lies the problem.

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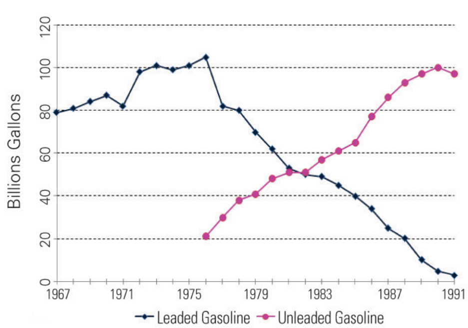
Producing the necessary level of octane can also be achieved with additives outside the oil barrel and is sometimes the cheaper route to pursue. The petroleum industry found an attractive source of anti-knock octane in tetraethyl lead. Unfortunately, lead is a known poison and despite numerous warnings and incidents in the 1920s such as fatalities resulting from lead poisoning, it became such a staple of gasoline that by the 1960s almost all gasoline contained lead. Early research in the late 1960s began to reveal that exhaust from automobiles carried that lead to the air we breathe.

Arguably one of the most memorable achievements ever by the post World War II federal government is the Clean Air Act (CAA) of 1970. This landmark legislation tackled a range of serious problems and issues, none more so than this issue of lead in gasoline and mobile source air pollution. The CAA created the Environmental Protection Agency and opened the door to a new era of regulatory actions that have saved countless lives and improved the health of our citizens. The removal of lead as well as reducing costs associated with chronic health issues was among the early victories of the new environmental movement, although it was a contentious process that resulted in a gradual phaseout rather than an immediate elimination.

**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*

## A Barrel of Problems—BTX

Unfortunately, eliminating one problem set the stage for the emergence of another. Eliminating lead created a dramatic demand for an octane substitute and refiners had few choices. Ethanol has the highest blending octane of the available additives but at that time did not exist in any commercial quantities. Furthermore, ethanol was produced outside the refinery gates and was a product the petroleum industry did not control. The easy answer for refiners was to turn inward and increase the reforming severity of their refining process to get more octane out of the crude oil they had.

Petroleum refiners synthesize toxic substances called "aromatics" from crude oil in order to increase gasoline octane levels and profits. These aromatics—primarily toluene—and their combustion by-products, are also commonly found in (secondhand) environmental tobacco smoke. Aromatics have been classified as Hazardous Air Pollutants by the EPA, and linked to a myriad of cancers, heart disease, and other debilitating, chronic, and costly medical conditions. The "family" of aromatics is often referred to as the BTX Group—benzene, toluene, and xylene. In addition to being the major source of mobile source air toxic emissions, toluene is now regarded as the primary man-made precursor to secondary organic aerosols (SOAs). These SOAs in turn are the primary sources of harmful fine particle pollution (PM2.5), especially in urban airsheds.

Motor vehicle emissions are the major source of polycyclic aromatic hydrocarbons (PAHs) in outdoor air, while tobacco smoke is a major indoor source. PAHs are formed by the incomplete combustion of both gasoline and cigarettes, and the resultant soot and particulate particles are frequently found in combination with each other and other harmful chemicals. In addition, recent research indicates that molecules known as "persistent free radicals (PFRs)" are generated by both cigarette smoking and vehicle exhaust. Studies suggest that inhalation of these PFRs—which attach themselves onto fine

> *"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)
> Congressional Record, 101st Congress, Clean Air Act Amendment: Amendment No. 1423 to Amendment No. 1293

airborne particles, and can be transported long distances and exist indefinitely—can subject the average person to exposure of up to 300 times more harmful pollutants daily than smoking a cigarette.

According to *The Oil & Gas Journal* (April 1991, Volume 89, Issue 17), the aromatic levels in gasoline rose from about 22% of all gasoline sold in the early 1970's to 33% by 1990, *with some premium grades containing as high as 50% aromatics by volume!* In the minds of environmental leaders in Congress and the federal government, we were faced with a clear and present danger.

## Reformulated Gasoline and the Clean Air Act Amendments of 1990

Even in 1990, not knowing what we know now, it was clear this was a major issue and a looming health threat. The Clean Air Act had not been amended in 20 years and among the pressing needs was ensuring the overall quality of gasoline, and specifically the aromatic content. For the first time the focus shifted largely to the fuel rather than just the vehicles.

Nearly 21 years ago, Congress passed historic legislation by amending the Clean Air Act. As Senator Tom Harkin noted at the time, aromatic compounds in gasoline were identified as a major problem. Congress addressed this issue head on with the so-called "clean octane" provisions to the 1990 Clean Air Act Amendments (CAAA), which passed overwhelmingly on the Senate floor by a 69–30 vote. While it resulted in a measurable improvement to the quality of gasoline, the opportunity to do significantly more exists, without new legislation or taxpayer cost.

By virtue of even having this debate, the level of public awareness increased dramatically and the U.S. Congress immersed itself in this issue. Among the aromatic family of benzene, toluene, and xylene, benzene was identified as the primary culprit as a known human carcinogen and was specifically singled out in the reformulated gasoline (RFG) recipe designed by Congress.

Then Senate Environment Committee Ranking Member James Durenberger noted in 1990 that "Risks from benzene exposure reached 1 in 1,000 people in urban corridors, 50% of the mobile sources benzene emissions come from benzene in the fuel, and 50% come from the transformation of other aromatics when they are burned".

In the final RFG amendments crafted by Senators Tom Daschle, Harkin, and others, benzene was limited to 1% by volume. Combined with the requirements of lower vapor pressure and the addition of oxygenates, the quality of gasoline increased dramatically with the stroke of a pen when President George H. W. Bush signed the CAA into law. Combining the fuel and stationary provisions, the benefits have been astounding and continue to accrue.

## Straying from the Course

Passing legislation and implementing regulations can sometimes be described as a balloon flattening exercise—you can get a section to lie flat and conform but it will pop up somewhere else. In this case it was the limit of benzene that sent the petroleum industry scurrying back into their laboratories to come up with another solution in the quest for octane. Unfortunately, that solution was to increase the volume of other aromatics that not only are in themselves harmful but *when combusted can create benzene, a known human carcinogen and specifically had been capped at 1% in the CAA!*

Gasoline currently contains an average of 25% volume aromatics, the predominant element being toluene (methyl benzene). As noted earlier, toluene is recognized as a precursor to secondary organic aerosols (SOAs) which are in turn precursors and components of fine particulate matter—commonly known as PM2.5.

The health risks associated with these high levels of toxic aromatics cannot be overstated. PM levels at 2.5, 10, or any level are manifested as a congestive irritant and cause numerous lung and respiratory problems.

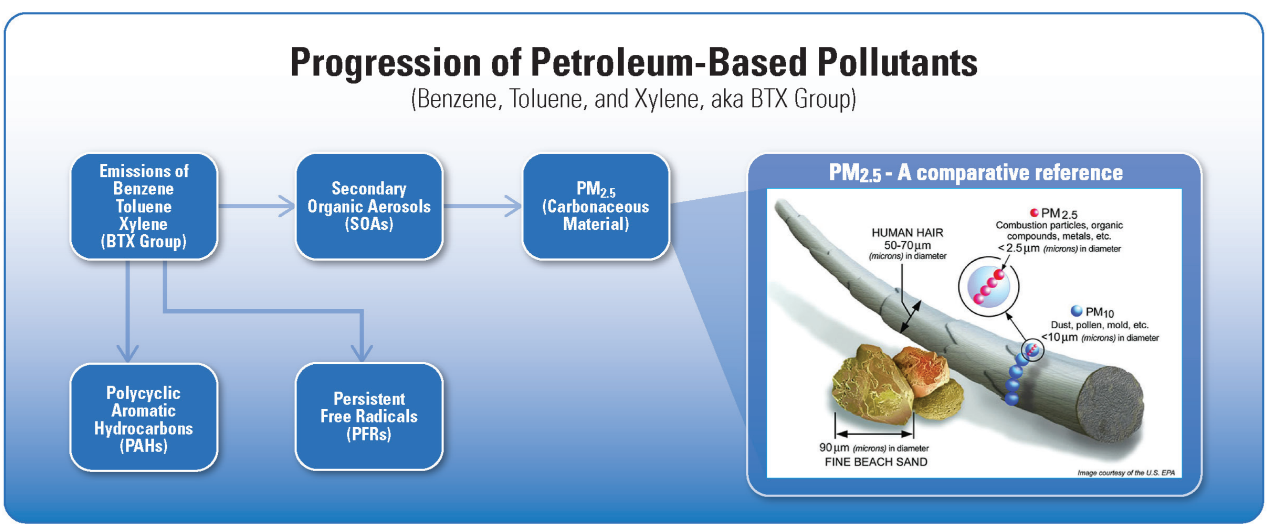
According to the Northeast States for Coordinated Air Use Management (NESCAUM), *"50% of cancer risk and 74% of non cancer risk related to breathing outdoor air results from mobile source air toxics emissions."*

In testimony given by EPA Administrator Lisa Jackson in August 2010, she said *"Particle Pollution is linked to a wide variety of serious Health effects… and premature death in people with heart and lung disease. Americans throughout the country are suffering from the effects of pollutants in our air, especially our children who are more vulnerable to these chemicals."*

The evidence list goes on, but the message is clear. Modifying transportation fuels to reduce air toxics and fine particulates can appreciably improve public health.

## So What Happened?

One of the great champions of this issue and a visionary in the development of alternative fuels in the United States is former Presidential Counsel, Ambassador, and educator C. Boyden Gray. Mr. Gray

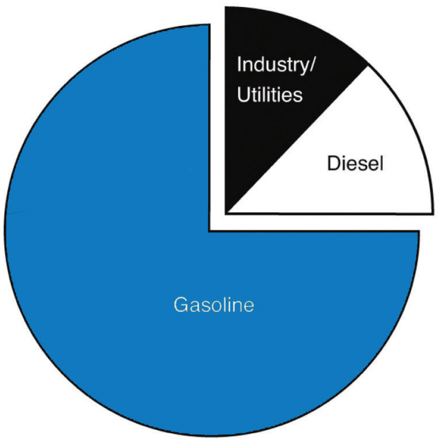



*Benzene, toluene, and xylene react and combine with other elements in the atmosphere to create harmful pollutants.*

argues that the Environmental Protection Agency has failed to seize the opportunity to follow the spirit, if not the letter of the law in the Clean Air Act.

It is undeniable that the Mobile Source provisions (Title II) of the CAAA and the specific RFG requirements were put in place to serve as a minimum threshold for aromatics reduction. In adopting the Senate RFG provisions, the House of Representatives went a step further and stated in the conference report that they intended for EPA to use "maximum achievable control technology to reduce levels of both benzene and non benzene aromatics in gasoline in order to protect the public health and environment." In their instructions to the EPA to promulgate regulations to carry out this program, the Senate and House Conference report directed EPA "to determine whether additional measures would increase emission reductions and are achievable." Ambassador Gray makes the case that such emission reductions are indeed within our grasp through the increased use of alternative fuels. Despite the fact that EPA has jurisdiction over two programs that require steep reductions in both PM2.5 and aromatics, they have effectively exempted gasoline from those provisions, despite EPA data confirming mobile sources are the primary source of pollution.

**Gasoline is the largest source of man-made carcinogens.**




*Source: U.S. Environmental Protection Agency*

## Fast Facts About Motor Fuels and Air Pollution

- U.S. motorists consume approximately 130 billion gallons of gasoline annually, roughly three times more gasoline than diesel fuel. A majority of diesel use occurs in OTR (over-the-road) vehicles http://www.eia.doe.gov/oiaf/ieo/transportation.html; Source: Weekday and Weekend Air Pollutant Levels in Ozone Problem Areas in the United States, Dr. Douglas R. Lawson, et al, NREL, August 23, 2005, DEER 2005.
- Aromatic hydrocarbons (benzene, toluene, xylene) are synthesized from crude oil (most of which is imported) by refiners in an energy intensive process called catalytic reforming, which causes gasoline yield losses ranging from 20 – 30% http://www.nrel.gov/analysis/pdfs/44517.pdf, p. 17.
- Refiners produce aromatics to increase gasoline octane levels & value.
- Many aromatic hydrocarbons such as benzene, toluene and 1,3 butadiene are regulated Mobile Source Air Toxics (MSATs).
- Mobile Source Air Toxics (MSATs), such as toluene and benzene are produced during combustion of gasoline.
- Toluene is the dominant anthropogenic secondary organic aerosol (SOA) precursor of fine particulates, PM2.5 http://www.atmos-chem-phys.net/9/2973/2009/acp-9-2973-2009.pdf; http://www.trolp.org/main_pgs/issues/v10n1/Gray.pdf, pp. 42–45.
- Polycyclic aromatic hydrocarbons (PAHs) are also produced during combustion http://cebp.aacrjournals.org/content/14/3/709.full
- Aromatics may also be involved in formation of Persistent Free Radicals (PFRs). http://www.ev.com/knowledge-center/car-exhaust-could-be-creating-chemicals-as-harmful-as-cigarette-smoke.html
- Gasoline exhaust especially threatens the most vulnerable members of our society, including the unborn, young children, and the elderly. http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.11173#Conclusion
- Gasoline aromatics, BTX (benzene, toluene, xylene) are the primary source of carcinogenic benzene in urban airsheds.
- Oxides of nitrogen (NOx), can form when combustion engines emit nitric oxide (NO), which then converts to nitrogen dioxide (NO2) later in the presence of oxygen.
- NOx mixes with volatile organic compounds (VOCs) in the presence of sunlight to produce ground-level ozone (O3), known as urban smog, a criteria.

*Continued on page 6*

## Fast Facts About Motor Fuels and Air Pollution *continued*

- NOx reductions in urban areas can in certain cases increase ambient ozone levels [Source: Weekday and Weekend Air Pollutant Levels in Ozone Problem Areas in the United States, Dr. Douglas R. Lawson, et al, NREL, August 23, 2005, DEER 2005; http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2005/session2/2005_deer_lawson.pdf]
- The combustion and photo-oxidation of aromatic by-products also are the primary cause of harmful PAHs (polycyclic aromatic hydrocarbons) & PFRs (persistent free radicals), which in combination with the fine particulates they generate, lodge in humans' lungs and organs to cause a wide range of cancers, heart disease, asthma, and other chronic and deadly conditions.
- According to the National Renewable Energy Laboratory of the U.S. Department of Energy, producing aromatics is a very energy intensive process.
- Processing low-octane naphtha into aromatics in a catalytic (high severity) reformer results in a 20–30% loss in gasoline yield.
- Alternatives to aromatic compounds are readily available like ethanol (113 octane) which has superior octane enhancing qualities compared to aromatics, the most common of which is toluene (93 octane).
- Ethanol and other alternative fuels help to reduce VOC emissions by replacing aromatics and reducing CO, fine particulates, and benzene emissions; thus, helping to control ozone formation.
- Ethanol has 40–90% less carbon than the aromatics it replaces (aromatics have 20% more carbon intensity than gasoline, & EPA has concluded that ethanol is at least 20% less carbon intensive than gasoline), thus helping to reduce emissions of the greenhouse gases linked to climate change.
- NREL found that in just a two-year period (2005–2007), the use of high octane ethanol reduced reformer severity enough to reduce imports of finished gasoline by 280 million barrels, saving Americans $22 billion http://www.nrel.gov/analysis/pdfs/44517.pdf
- As crude oil prices increase, reducing and ultimately eliminating aromatics in gasoline will save U.S. motorists billions of dollars per year in reduced imports of crude oil & gasoline http://www.eia.doe.gov/emeu/steo/pub/steo_text.pdf
- Since ethanol is already a refined, zero sulfur, high octane product, it represents a major boost to U.S. gasoline supplies, & thus saves motorists billions of dollars in reduced gasoline prices. http://www.nrel.gov/analysis/pdfs/44517.pdf

In what is referred to as the MSAT (mobile sources air toxics) Rulemaking of 2007, the EPA concluded that further control of these air toxic substances was not economically justified or warranted. In part that was based on economic models that included oil at a range of $17–$35 per barrel and grain prices at all time highs. This led to the conclusion that ethanol, a proven octane additive, was prohibitively expensive and the cost benefit was not demonstrated. While grain prices have come down, have gone up, and are likely to come down again, oil has remained at significantly higher levels than EPA's assumptions and as of this writing hovers near $100 per barrel. EPA further justified its decision by stating that ethanol was already diluting the aromatic content of gasoline as a result of the Renewable Fuels Standard and would not be able to supply the additional volumes necessary to fill the void created by reducing aromatics even further. Passage In December of 2007 of the expanded Renewable Fuel Standard addresses this issue by requiring significant new volumes of ethanol.

In a 2010 review of this subject, Ambassador Gray offered the following analysis of the EPA position on the MSAT ruling:

> *There is today little question about the evidentiary support for the major role aromatics play in secondary aromatic aerosol (SOA) PM2.5 emissions. Just two months after the MSAT ruling, EPA issued the final rule for PM implementation. There in the section on VOCs (volatile organic compounds), EPA said that "high molecular weight organic compounds are to be regulated as primary PM2.5 emissions for the purposes of the PM2.5 implementation rule." It also noted that "Aromatic compounds such as toluene...are considered to be the most significant anthropogenic SOA precursors and have been estimated to be responsible for 50 to 70 percent of total SOA in some airsheds."*
>
> *More precise evaluations of these relationships have become clear since the issuance of the MSAT rule. In the RIA (regulatory impact assessment) for the RFS II, EPA again acknowledges that toluene*

> *"The Benefits and Costs of the Clean Air Act from 1990 to 2020" shows that the benefits of avoiding early death, preventing heart attacks and asthma attacks, and reducing the number of sick days for employees far exceed costs of implementing clean air protections. These benefits lead to a more productive workforce, and enable consumers and businesses to spend less on health care—all of which help strengthen the economy."*
>
> —Lisa Jackson, Administrator, US EPA, March 2011

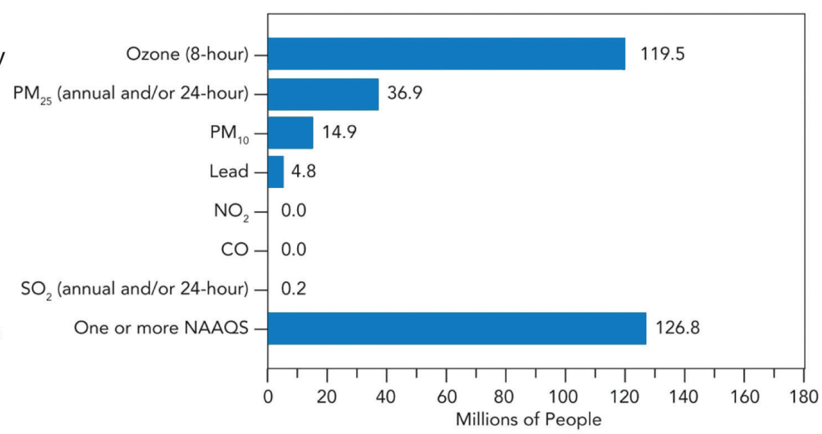
*is "an important contributor to anthropogenic SOA," and that its studies were indicating that mobile sources "accounted for 70% of the total nationwide ambient concentration of toluene." Moreoever, EPA again noted that "Due to the high octane quality of ethanol, it greatly reduces" the need for and level of high-octane components "such as aromatics including toluene (which is the major aromatic compound in gasoline)." Finally, EPA identified recent work that "suggests that we are finding ambient PM levels on an annual basis of about 0.15 mg/m3 associated with toluene" in five cities.*

## Dollars and Sense

Even though EPA identifies ethanol as a specific solution to aromatic compounds, Boyden Gray and many others point out that ethanol is but one of the alternatives currently available to displace petroleum. Natural gas, electric vehicles, and other fuels can play a significant role in reducing aromatics. Whatever alternative fuels are used, this should be first and foremost a health initiative. The fact that establishing a goal to improve public health can provide an impetus to the use of alternative fuels has obvious and additional benefits. But health benefits should trump concerns over refinery costs to the multibillion dollar petroleum industry. In fact, the presence of ethanol in the gasoline pool has been demonstrated to reduce the cost of gasoline by increasing supplies, and according to the International Energy Agency reduces not just gasoline, but the price of crude oil as well—a benefit that accrues worldwide.

Ethanol is among several cost effective alternatives that exist that can directly replace toluene and other aromatics in gasoline. The EPA clearly has the statutory authority to reduce aromatics levels under the Clean Air Act. Doing so would save the U.S. tens of billions of dollars each year in avoidable and unnecessary health care costs that can be prevented, and would dramatically reduce exposure by Americans to these deadly air toxics

Despite Clean Air Progress, approximately 127 million people lived in counties that exceeded any national ambient air quality standard (NAAQS) in 2008. Ground level ozone and particle pollution still present challenges in may areas of the country.




Source: US EPA, Feb. 2010, EPA-454/R 09-002 and fine particulates. This is particularly critical for the most vulnerable members of our society, such as the very young and elderly.

The White House Office of Management and Budget, perhaps the toughest sell in the U.S. when it comes to demonstrating savings, values mobile source air emissions of NOx precursors to PM2.5 as twice the value of stationary source air emissions. Ambassador Gray argues that calculating a per ton cost for reductions of air toxics, the avoided health care costs are estimated to be in the billions of dollars.

This notion is supported by a report released in March 2011 by the U.S. Environmental Protection Agency (EPA) which estimates that the benefits of reducing fine particle and ground level ozone pollution under the 1990 Clean Air Act amendments will reach approximately $2 trillion in 2020 while saving 230,000 people from early death in that year alone. The report studied the effects of the Clean Air Act updates on the economy, public health and the environment between 1990 and 2020. The EPA report received extensive review and input from the Council on Clean Air Compliance Analysis, an independent panel of distinguished economists, scientists and public health experts established by Congress in 1991.

According to the US EPA, in 2010 alone, the reductions in fine particle and ozone pollution from the 1990 Clean Air Act amendments prevented more than:

- 160,000 cases of premature mortality
- 130,000 heart attacks
- 13 million lost work days
- 1.7 million asthma attacks

In 2020, the study projects benefits will be even greater, preventing more than:

- 230,000 cases of premature mortality
- 200,000 heart attacks
- 17 million lost work days
- 2.4 million asthma attacks

In the previously referenced review of the EPA ruling on the MSAT, Ambassador Gray calculates the value of the pollution savings from the aromatic reductions…. *Since reducing one mg/m3 of (PM derived aromatics) produces $100 billion in health benefits, a .15% reduction is worth $15 billion in benefits. Finally, and perhaps most importantly, EPA has recently for the first time calculated and ranked the relative benefits of reducing individual PM2.5 precursors (i.e., VOCs, SO2 and NOx). In the just issued CAFE (corporate average fuel economy) rule, for example, EPA calculates the per ton value of direct PM2.5 emissions (principally carbonaceous mobile source emissions, including SOA) at $270,000/ton vs. just $4,700 for NOx and $28,000 for SOx from stationary sources.*

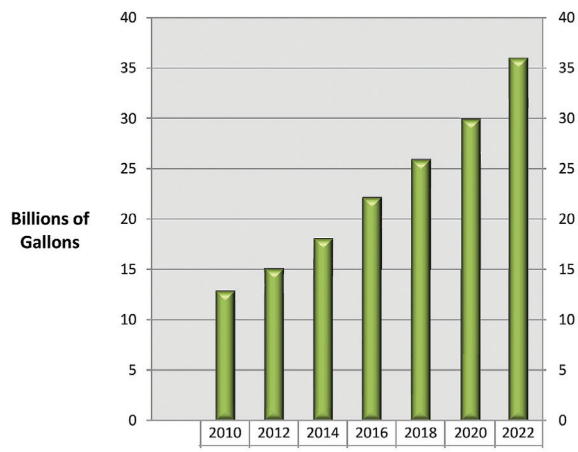
*The more complete explanation cited for EPA (Neal Fann, 2009) notes that "carbonaceous particles tend to be emitted in close proximity to population centers" and that mobile sources show the "highest $/ton" – many times higher than SOx, the next highest and NOx, the lowest (i.e., $550,000/ton vs. $62,000 and $15,000 respectively). At the same time, EPA has just revised its mobile modeling, and recently published its new MOVES2010 Mobile Source Emissions Model. In this new model, EPA's estimate of mobile source PM2.5 emissions "is significantly higher compared to" the previous model. This is based, according to the EPA, on data developed as part of EPA's Metro Kansas City study, "which showed much higher PM2.5 emissions at low ambient temperatures than previously known." This study attributes at least part of the results to a better understanding of the role of aromatics, and the changes made were the result of requests by local air quality officials seeking to be allowed to claim PM reductions from transport VOC limits (in apparent response to the final PM rule presumption, described above, against considering VOCs as a PM control measure....If one adds the billions in health benefits available from reducing aromatics (and related VOCs), the net benefits from increased ethanol use are huge and should compel EPA to require a reduction of all aromatics.*

In addition to reducing health care expenditures by tens of billions of dollars per year, a substantial reduction in the use of toxic aromatics in gasoline will save Americans tens of billions more in reduced expenditures on gasoline and imported oil. For example, when we look at substituting high-octane ethanol for toluene, the most commonly used aromatic (approximately 25% by volume in the U.S. gasoline pool) it would have a decided economic advantage. Substituting ethanol for toluene and other aromatics would enable refiners to increase their yield of gasoline and other high-value products such as diesel and jet fuel by reducing the need for energy intensive reforming of crude oil. In order to produce aromatics and related blending components, the typical refinery suffers gasoline yield losses of as much as 30% or more.

A November 2008 analysis conducted for the National Renewable Energy Laboratory of the U.S. Department of Energy revealed that ethanol's high octane qualities had already enabled refiners to keep "gasoline prices in RFG [reformulated gasoline] markets today about 51 cents per gallon lower than they would be with no ethanol". The NREL report also confirmed that the use of ethanol as an octane substitute for fossil-based enhancers "allowed the nation to eliminate 280 million barrels of high-cost, imported gasoline, reducing U.S. spending on foreign gasoline imports by $22 billion [over the period 2005 to 2007]." As crude oil prices continue to rise, the costs of toluene and the other aromatics will escalate even further, making the use of domestically produced, high octane substitutes even more cost effective.

Using domestically-produced high octane substitutes will help boost the U.S. economy and save consumers money by reducing the cost of gasoline, diesel, and jet fuels. In addition, toluene and the other aromatics can then be diverted to their highest value use in the petrochemical industry, and used as competitively priced feedstocks for everything from plastics to paints.

With a current gasoline pool of approximately 135 billion gallons, 25% aromatics by volume represent nearly 34 billion gallons of fuel that can be replaced with clean burning alternatives. Even a modest reduction of 50% in aromatic levels would create a market for 15 billion gallons of ethanol or other fuels, which happens to be nearly the exact amount of renewable fuels required under the Renewable Fuels Standard in addition to the amount currently being used in the United States.




**Renewable Fuel Requirements under RFS II**

## Putting the Pieces Together—Cars, Fuel, and Health

Critics might argue that current automobiles are limited as to the amount of ethanol they can use. That argument is only true if one ignores the nine million flexible fuel vehicles (FFVs) that are on the road today. One would also have to ignore the 12 million vehicles that are planned to be manufactured by the end of 2012, or ignore the vision that the majority, if not all of the new cars produced over the next decade can indeed be FFVs. These FFVs can burn any combination of gasoline and ethanol up to 85% ethanol. With the overall objective of reducing aromatic levels across the entire gasoline pool, these FFVs can shoulder the lion's share of the load and replace carcinogenic, debilitating components of gasoline with domestic, clean burning, job-creating fuels.

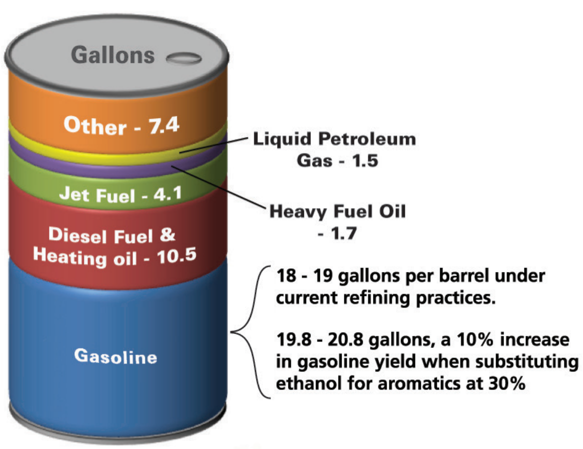
Again, keeping in mind the potential for a range of alternative fuels to contribute to the replacement of aromatics, one scenario studied for this Brief was the use of 30% ethanol in all gasoline (E30). As noted, there is enough ethanol that could be produced and imported under the RFS to meet this demand; because of the gasoline yield losses in producing these aromatics, ethanol at this level replaces gasoline at a 1:1, or possibly greater level. As the percentage of ethanol is blended into conventional blendstock gasoline, the share of naptha increases while the share of isomerate and reformate decreases. For the E30 scenario, the gasoline yield increased 10.05%, meaning 10% more gasoline produced from the same barrel.

**Comparison of Primary Pollutants**
Conventional Gasoline vs. E30

| Primary Pollutants | Potential Reductions w/E30 |
|---|---|
| Benzene/toxics[1] | **75%** |
| Total toxic mass emissions (adjusted for California potency factors)[2] | **63%** |
| Secondary organic aerosols/ PM2.5 [3] | **90 – 100%** |
| CO/VOCs[4] | **18 - 90+%** |
| Carbon dioxide[5] | **40 – 100%** |

[1] *Texas Review of Law and Politics, supra, footnotes #173*
[2] *EPA Complex Model; CARB toxic potency factor*
[3] *Whitten, supra, p. 1*
[4] *OSTP (1997) study; Whitten, supra, p. 1*
[5] *EPA IDLUC final report; HEI, supra, p. 3*

## Products Made From a Barrel of Crude Oil




*SOURCE: U.S. Department of Energy, Energy Information Administration (2009), U.S. Department of Energy, National Renewable Energy Laboratory. (2008). The Impact of Ethanol Blending on U.S. Gasoline Prices. McKinsey and Company. NREL/SR-670-44517*

After calculating a mileage loss due to the lower BTU content of ethanol of approximately 10% *(based on a linear extension of EPA and DOE data)*, this scenario provides significant benefits. Other scenarios examined as part of this study included widespread application of natural gas in fleets as well as electric vehicles, both of which showed the potential for significant aromatic reductions.

It is worth remembering why this is a worthy pursuit. In 2010 the citizens of the United States sent $337 billion of their hard-earned money to foreign countries to purchase oil. With prices on the rise, the oil import bill for January 2011, typically one of the lowest months of motor fuel consumption, was approximately $33 billion according to U.S. Commerce Department data. At that rate, we would shatter the 2010 totals. Even without any consideration of the health impacts, purely from a pocketbook standpoint it should be a national priority to reverse this trend.

In its March 2011 Assessment of the Clean Air Act, EPA looked at key health effects outcomes associated with PM2.5 and ozone *with* and *without* the control programs. The following table shows the reduction in risks of various air pollution related health effects in terms of number of cases

| Health Effect Reductions (PM2.5 & Ozone Only) | Pollutant(s) | Year 2010 | Year 2020 |
|---|---|---|---|
| PM2.5 Adult Mortality | PM | 160,000 | 230,000 |
| PM2.5 Infant Mortality | PM | 230 | 280 |
| Ozone Mortality | Ozone | 4,300 | 7,100 |
| Chronic Bronchitis | PM | 54,000 | 75,000 |
| Acute Bronchitis | PM | 130,000 | 180,000 |
| Acute Myocardial Infarction | PM | 130,000 | 200,000 |
| Asthma Exacerbation | PM | 1,700,000 | 2,400,000 |
| Hospital Admissions | PM, Ozone | 86,000 | 135,000 |
| Emergency Room Visits | PM, Ozone | 86,000 | 120,000 |
| Restricted Activity Days | PM, Ozone | 84,000,000 | 110,000,000 |
| School Loss Days | Ozone | 3,200,000 | 5,400,000 |
| Lost Work Days | PM | 13,000,000 | 17,000,000 |

**Exhibit 8. Differences in key health effects outcomes associated with fine particles (PM2.5) and ozone between the *With-CAAA* and *Without-CAAA* scenarios for the 2010 and 2020 study target years. (In number of cases avoided, rounded to 2 significant digits). The table shows the reductions in risk of various air pollution-related health effects achieved by 1990 Clean Air Act Amendment programs, with each risk change expressed as the equivalent number of incidences avoided across the exposed population.**

avoided due to these Clean Air Act Amendment programs. The results are substantial. With mobile source emissions playing such a significant role in air pollution, the reduction in aromatics has had no small part in providing the benefits EPA has identified. As stated throughout this Brief, the EPA has the ability to use the regulatory authority it already has to further reduce toxic aromatics and particulate matter to protect the health of our citizens. In so doing they would assume a dramatic leadership role in furtherance of national energy, environmental, and health objectives.

Please look for Volume II of this Issue Brief which will be released in the coming months. In this follow-up document we will examine in depth the economic, environmental, and performance issues associated with reducing toxic aromatics.

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