

**COMMENTS OF**

**THE ENERGY FUTURE COALITION**

on

**THE ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED RULE:  
REGULATION OF FUEL AND FUEL ADDITIVES:  
RENEWABLE FUEL STANDARD PROGRAM**

**EPA-OAR-2005-0161**

**71 Fed. Reg. 55552 (September 22, 2006)**

**Submitted**

**November 12, 2006**

The Energy Future Coalition appreciates this opportunity to comment on the Environmental Protection Agency (EPA)'s proposed Renewable Fuel Standard (RFS).<sup>1</sup> The Energy Future Coalition is a bipartisan public policy initiative that brings together business, labor, political, and environmental leaders to develop a better energy future. The Coalition seeks to identify innovative policy options, particularly those involving alternative energy sources, that appeal to a diverse array of competing interests and attract broad political support. ([www.energyfuturecoalition.org](http://www.energyfuturecoalition.org)).

## I. Summary

In its proposed Mobile Source Air Toxics (“MSAT”) rule, the EPA stated that the cost of reducing benzene emissions by reducing the aromatic content of gasoline would be “much more costly” – perhaps five times more costly – than by direct benzene emissions control alone.<sup>2</sup> Yet the Coalition showed in its comments on the proposed MSAT rule that this is not the case, and the Coalition proposed a broad aromatics MSAT reductions rule that would produce 2.4 times the benzene reductions EPA sought at very low cost.<sup>3</sup> Now, EPA’s own proposed RFS greatly strengthens the Coalition’s case. The data and analysis used by EPA a few months later in its proposed RFS show that an Aromatics MSAT will achieve *greater* benzene emissions reductions than EPA’s proposed MSAT rule *at no cost* to refiners, when ethanol prices remain at or below

---

<sup>1</sup> 71 Fed. Reg. 55552 (September 22, 2006).

<sup>2</sup> See 71 Fed. Reg. 15864 (March 29, 2006) (“[I]t is much more costly for refiners to reduce benzene emissions through aromatics control than through benzene control.”). EPA’s economic analysis depended upon the 1993 Regulatory Impact Analysis for the Reformulated Gasoline Rule, which assumed that the cost of crude oil was \$17 per barrel.

<sup>3</sup> See Comments of the Energy Future Coalition on the Environmental Protection Agency’s Proposed Rule: Control of Hazardous Air Pollutants From Mobile Sources, EPA-HQ-OAR-2005-0036, 70 Fed. Reg. 15804 (March 29, 2006), submitted May 30, 2006 (“EFC MSAT Comment”) (attached hereto as Appendix B).

2006 levels and crude oil costs over \$50- 55 a barrel. In addition to much greater benzene reductions than EPA proposes (over 2.4 times as much), a cascade of additional air quality gains would accompany finalization of a strong aromatics MSAT rule: hundreds of billions of dollars of health benefits from reduced levels of PM<sub>2.5</sub>, ozone, CO, and CO<sub>2</sub>.<sup>4</sup>

The economic analysis contained in this Comment, combined with the EPA's updated observations about the role of secondary organic aerosols from gasoline combustion in causing the most severe fine particulate health effects,<sup>5</sup> demonstrates that the EPA should finalize a strong Aromatics MSAT Rule along the lines suggested by the Coalition.

## **II. The Relationship Between the Proposed RFS and the Proposed MSAT Rule**

Earlier this year, the Coalition asked EPA to adopt a Mobile Source Air Toxics (MSAT) rule (the "Aromatics MSAT Rule") under the Clean Air Act that would require substantial reductions in the toxic aromatic content of gasoline.<sup>6</sup> As the Coalition made clear in its comments on EPA's proposed MSAT rule, lowering the aromatic content of gasoline – a major source of fine particulates (PM<sub>2.5</sub>), ozone, and other damaging air pollutants – and replacing aromatics with domestic biofuels, primarily ethanol, would deliver tens of billions of dollars of health benefits, promote alternative fuels development, achieve a greater measure of energy independence, reduce trade deficits and agricultural price supports, and distribute more fairly the burden of industry compliance with the Clean Air Act.

---

<sup>4</sup> See EFC MSAT Comment at 18-47.

<sup>5</sup> See 71 Fed. Reg. at 55623-24; EPA Renewable Fuel Standard, Draft Regulatory Impact Analysis (RIA) (Sept. 2006) at 163-67.

<sup>6</sup> See generally EFC MSAT Comment.

The EPA's proposed RFS and the Coalition's proposed Aromatics MSAT Rule are mutually supportive and inextricably intertwined. In one respect, however, the Aromatics MSAT Rule would go further than the RFS: it would obligate refiners to use abundant, cost-effective ethanol, not merely to expand gasoline supplies, but to make basic changes in the content of gasoline – what EPA calls “the make up of gasoline” – so that it contains far fewer toxic aromatic compounds.

The EPA appears to leave open the possibility that refiners might choose to blend ethanol and lower aromatic content because of the operation of market forces alone. Yet EPA also states that the former MTBE feedstock, isobutylene, will now be used to make alkylate, “a moderate to high octane blendstock,” to obtain octane, although alkylate is a more expensive source of octane, with a lower octane number (92-93) than ethanol (115).

A “rational economic decision maker” in charge of a refinery would ordinarily prefer the least-cost solution in blending gasoline output. Ethanol or other renewables are cheap octane sources, in comparison to the aromatics and alkylates that also can be used to provide octane. But there is reason to believe refiners will choose to keep gasoline volumes up by leaving aromatics in gasoline while still blending ethanol and other renewables, ignoring the octane potential of the ethanol they add to gasoline. (The resulting “octane surfeit” would not harm vehicle engines.) Refiners may prefer to maintain control of the production of all gasoline constituents, passing the prices along to consumers, rather than subjecting themselves to the vagaries of dependence on suppliers of ethanol, who are out of their direct control.

Rather than trusting only to market forces to deliver the substantial health benefits of an aromatics MSAT rule, EPA should adopt an Aromatics MSAT rule in February as insurance that such benefits will be delivered. If it emerges that refiners would have elected to reduce the

aromatic content of gasoline even if an Aromatics MSAT Rule were not adopted, then no harm would have been done by adopting a rule that merely endorses what the market would have achieved without the rule. As shown below, crude oil prices will remain high for the indefinite future, and use of ethanol will impose no extra cost on refiners. Indeed, ethanol use is likely to reduce refiners' costs, which hopefully will benefit the driving public in the form of lower gasoline prices. Further, the rule would provide additional stability to renewables markets going forward into RFS implementation and beyond. The Coalition thus believes an Aromatics MSAT Rule is a necessary companion to the RFS and favorable market forces.

### **III. Higher Oil Prices and Increased Supplies of Ethanol**

Two significant changes in the overall gasoline supply picture have occurred since EPA completed its MSAT proposal. First, the price of crude oil has remained high and far exceeds the per-barrel cost assumptions that EPA regularly factored into fuels regulations and Regulatory Impact Assessments (RIAs) for over a decade, up to and including the proposed MSAT rule and its RIA. Second, actual and projected supplies of ethanol suitable for blending into gasoline have continued to rise, to the point that EPA felt compelled in the proposed RFS to analyze two ethanol supply scenarios (7.5 and 9.6 billion gallons) and two crude oil price scenarios (\$47 and \$70 a barrel). The crude oil price assumptions both greatly exceed price assumptions in the \$20 bbl range that underpinned earlier EPA analyses. In the future, crude oil is likely to stay above \$60 a barrel (see V below). Congress mandated a minimum 7.5 billion gallon RFS by 2012, but EPA believes that much more ethanol will in fact be purchased and reflects this belief by using a 9.6 billion gallon-a-year scenario for analysis, based on projections by the Energy Information Agency that this amount of ethanol will be reliably available by 2012. The Coalition believes projections of a 15-17 billion gallon ethanol fuel consumption level by the year 2012 are reasonable and likely, as explained in its comments on the proposed MSAT rule. These changes

in fuel economics and supply are remarkable, and they require careful, transparent, up-to-date analysis in EPA rule making under the fuels provisions of the Clean Air Act.

#### **IV. The Coalition's Aromatics MSAT Proposal**

In its MSAT comments, the Coalition noted that the specifics of a viable Aromatics MSAT Rule would need to be carefully developed by EPA. The Coalition did offer, however, one detailed scenario under which an Aromatics MSAT Rule could be adopted at low cost in a reasonable time frame.<sup>7</sup> The Coalition suggested a two-phase, seven-year implementation: Phase I would bring about roughly a 20 percent overall reduction in current aromatics levels by the year 2010. Phase I would reduce benzene emissions by 32,000 tons, which is twice the tailpipe emissions reductions EPA hopes to achieve with its 0.62 percent benzene content standard in the current proposed MSAT rule. In addition, Phase I would reduce other aromatic hazardous air pollutants (toluene, ethylbenzene, and xylene) by 154,421 tons (22.4 percent) and nonlisted aromatic emissions (C9, C10 aromatics) by 211,777 tons. Approximately 14 billion gallons of ethanol-equivalent renewable fuels would be necessary to maintain and expand the national's gasoline supply in Phase I.

A 20 percent aromatics reduction could reduce PM<sub>2.5</sub> by 22 percent in some urban areas, *i.e.*, as much as a 0.9µg/m<sup>3</sup> reduction in PM<sub>2.5</sub>. Based on EPA's quantification of PM<sub>2.5</sub> benefits, a 0.9 µg/m<sup>3</sup> PM<sub>2.5</sub> reduction would be valued at approximately \$90 billion in health benefits. Toxics reductions could yield an additional \$8 billion in benefits. VOC reductions resulting from reduced aromatic content would also reduce ozone, carbon monoxide, and carbon dioxide. Nonquantifiable health and welfare benefits would be similarly impressive. The nation's gasoline supply could not only be maintained, but expanded by one percent, under this approach.

---

<sup>7</sup> See EFC MSAT Comment at 5-12.

In Phase II, by 2014 aromatics would be reduced by approximately 33 percent from current aromatics gasoline content levels. Phase II would reduce benzene emissions by an additional 8,400 tons, for a total benzene emissions reduction of 39,189 tons by 2014 – far beyond the reductions currently proposed in the MSAT rule (16,000 tons). Other aromatic hazardous air pollutants (toluene, ethylbenzene, and xylene) would be reduced an additional 92,489 tons, for a total 35.8 percent reduction from current levels. Nonlisted aromatic emissions (C9, C10 aromatics) would be reduced by an additional 126,842 tons. Many billions of gallons of ethanol-equivalent renewable fuel would be required to meet the 2014 goal, but it would be misleading to suggest that corn ethanol would or even could supply all of the necessary fuel. By 2014 E85, E20, bioethers, and cellulosic ethanol would enter the supply picture. A 33 percent aromatic reduction by 2014 could reduce PM<sub>2.5</sub> by as much as 36 percent in some urban areas, and may represent as much as a 1.4 μg/m<sup>3</sup> reduction in PM<sub>2.5</sub>. A 1.4 μg/m<sup>3</sup> PM<sub>2.5</sub> reduction would be valued at approximately \$140 billion in health benefits. Toxics reductions would yield an additional \$12 billion in benefits. Phase II might include an averaging, banking, and trading (ABT) program for aromatics. An ABT program would allow refiners to choose among several options for complying with the aromatic content standard and would focus aromatic reductions where they are most needed.

## **V. Need for an Aromatics MSAT Rule**

The fundamental rationale for adopting an Aromatics MSAT Rule is to obtain environmental benefits – the PM<sub>2.5</sub>, ozone, CO, and CO<sub>2</sub> reductions that led the Coalition to support an Aromatics MSAT Rule in the first place. The Coalition understands that research on SOA (secondary organic aerosol) has progressed significantly over the past year. PM<sub>2.5</sub> causes severe health problems for the American public. A large share of organic fine particulates – the precursors of the most dangerous PM<sub>2.5</sub> and ozone – can be traced back to high levels of toluene

and xylene in gasoline. A year ago (November 2005), EPA stated that “aromatic compounds such as toluene, xylene, and trimethyl benzene are considered to be the most significant anthropogenic SOA precursors”<sup>8</sup> and that aromatic compounds “have been estimated to be responsible for 50 to 70 percent of SOA in some airsheds.”<sup>9</sup> Yet in the proposed MSAT rule, EPA stated that there was “limited data to suggest that aromatic compounds (toluene, xylene, and benzene) react photochemically in the atmosphere to form secondary particulate matter (in the form of secondary organic aerosol.”<sup>10</sup> However, in the RIA for the proposed RFS, EPA now acknowledges the significant contribution of aromatic compounds to the formation of SOA.<sup>11</sup>

One of EPA’s most recent unpublished studies finds that aromatic hydrocarbon emissions, especially toluene, may contribute to SOA at levels as low as 0.7 micrograms per cubic meter of urban air, but others think the number may be as high as 2 micrograms.<sup>12</sup> In

---

<sup>8</sup> See Proposed Rule To Implement the Fine Particle National Ambient Air Quality Standards, 70 Fed. Reg at 65,995, 65,996 (“Proposed PM<sub>2.5</sub> Implementation Rule”) (citing D. Grosjean & J.H. Seinfeld, *Parameterization of the Formation Potential of Secondary Organic Aerosols*, 23 Atmospheric Env’t 1733 (1989)).

<sup>9</sup> *Id.* at 65,996 (“The experimental work of Odum and others showed that the secondary organic aerosol formation potential of gasoline could be accounted for solely in terms of its aromatic fraction.”). EPA has raised questions about natural contributions to secondary organic aerosols (SOA), but this is likely to be relevant only in the south, where turpenes from pine trees may be a confounding factor.

<sup>10</sup> 71 Fed. Reg. at 15864.

<sup>11</sup> See e.g., EPA Renewable Fuel Standard, Draft Regulatory Impact Analysis (RIA) (Sept. 2006) at 164 (“The VOCs that have the greatest propensity to form SOA include aromatic hydrocarbons (such as toluene but even including benzene), higher molecular weight olefins and cyclic olefins, and higher molecular weight paraffins. Kleindienst et al suggest that a high fraction of SOA is due to aromatic hydrocarbon precursors. Furthermore, “aromatic products having a single alkyl group on the aromatic ring were found to represent a ‘high-yield’ family (e.g., toluene, ethylbenzene); compounds having multiple methyl groups (e.g., m-xylene, 1,2,4-trimethylbenzene) were found to represent a ‘low-yield’ family” (Kleindienst, 269). All of the above mentioned VOC precursors are important either because there are large amounts of these particular VOC emitted per day, or because a large fraction of the VOC reacts, or a combination of the two.”).

<sup>12</sup> See Draft RIA at 165 (“Researchers at EPA recently completed a field study in the Raleigh/Durham area of North Carolina that investigated the contribution of various sources to ambient

*(footnote continued on next page)*

terms of health and air quality, this means that if we accept as given current estimates of the health benefits to be obtained by reducing fine particulates, the benefit to America's health may be valued at over \$100 billion. Even if EPA benefits estimates are overstated, the benefits of an expanded MSAT rule *for fine particulates alone* may be tens of billions of dollars.<sup>13</sup> With potential benefits from controlling aromatics in gasoline, the topic of aromatic contribution to SOA justifies a higher priority for further research by EPA and other institutions.

The Coalition is promoting additional attention to the SOA-fuels nexus in meetings with air quality researchers, research organizations like the Health Effects Institute, and national, regional, and state air quality management organizations, in addition to its participation in federal policy making through comments such as these on EPA's implementation of the fuels provisions of the Clean Air Act and the Energy Policy Act of 2005.

## **VI. Analysis of RFS Cost to Refiners: the Zero-Cost "Tipping Point" Price of Crude Oil**

The EPA's proposed RFS contains data and projections that show that substituting renewable components (chiefly ethanol) to replace aromatic compounds required to be removed from gasoline under an Aromatics MSAT Rule would not only be cost-effective but would add zero cost to gasoline manufacture, whenever crude oil costs more than \$50-55 a barrel. Data and projections that continue to trend upward indicate that supplies of ethanol adequate to comply

---

*(footnote continued from previous page)*

PM 2.5 concentrations. In the study they identified toluene as an SOA precursor. They estimate that mobile sources contribute nearly 90% of the total toluene emissions in that region based on a chemical mass balance approach. At the same time, however, SOA attributable to non-fuel-related VOC (i.e., biogenic emissions) was found to be an even larger contributor to SOA (i.e., toluene was not likely the dominant source of SOA in this area). This study is currently undergoing peer review and will be published shortly. Qualitatively, however, this information is still quite useful since the study identifies a contributing source of SOA that is attributable almost entirely to mobile sources.”)

<sup>13</sup> See EFC MSAT Comment, IV. A. 1 (b)(ii).

with an Aromatics MSAT Rule will be available by the time the rule comes into full effect, i.e., 15 billion barrels by 2014.

In its comment on the proposed MSAT rule, the Coalition observed that the costs to refiners of reducing the aromatic content by blending ethanol are “not significant.”<sup>14</sup> Refiners can divert the crude oil fraction now used for aromatics to make more gasoline and save both money and energy. Gasoline supplies to the driving public can be kept up, and gas prices down, by adding biofuels to gasoline (as is required in any event under the RFS).

Using new data and projections provided by EPA itself in the Preamble and RIA of its proposed RFS, we have extended the economic analysis we performed in our MSAT Comment<sup>15</sup> (1) to correct what we believe is a slight overstatement of the cost of introducing renewable fuels into the gasoline supply and (2) to identify the “tipping point” at which the substitution of ethanol for aromatics will impose a zero net cost on refiners.

In the Preamble (Section VII) of the RFS, EPA presents an analysis of the impact of the expanded use of renewable fuels on the average cost of gasoline in the US. See Table 1. EPA’s cost analysis includes a number of other fuel market impacts in addition to the costs of expanded use of renewable fuel that caused EPA to overstate the costs of expanding ethanol use in gasoline. Specifically, EPA’s analysis factors in the cost effects of Congress’s repeal of the oxygen standard, which triggered the discontinuance of MTBE blending by the refining industry in early 2006, thereby causing the marketplace abruptly to transfer large ethanol volumes from Mid-western markets to meet demand in RFG markets. By including the costs of MTBE removal in its analysis, EPA includes RVP cost reduction and new alkylate production, although

---

<sup>14</sup> EFC MSAT Comment at 3.

<sup>15</sup> *See id.* at 18-22.

these are not related to expanding the use of ethanol or renewable fuel in the nation's gasoline. Thus, including these additional RFG-related effects into the RFS analysis has resulted in EPA's overstating the costs of expanding renewable ethanol in the U.S.

We have attempted to correct the relevant cost projections. Using assumptions similar to those used by EPA for crude oil supply and cost, gasoline cost, distribution cost, and expanded ethanol volume costs, our analysis focuses only on the contribution of the costs of expanding ethanol use in US. gasoline. A comparison of this analysis with EPA results is summarized in Table 1. Although both analyses show some cost increase in gasoline in the range of 0.3 to 0.9 cents per gallon when crude oil is \$47 per barrel, the analysis for \$70 crude oil shows a substantial decrease in gasoline costs of 0.9 to 1.3 cents per gallon as compared to EPA's, which show relatively little change in gasoline cost for \$70 oil.

**Table 1**

| <b>Summary of Average US Gasoline Cost Analysis for RFS<br/>Minimum Ethanol in RFG &amp; Without Government Subsidy Included</b> |  |                 |  |                 |
|--|--|-----------------|--|-----------------|
| <b>2004 Reference</b>  | Ethanol Use:<br>MTBE Use:                            |                 | 3,900 Million Gal /Yr<br>2,090 Million Gal /Yr |                 |
| <b>2012 Renewable Fuel</b>   | 7,200 Million Gal / Yr<br>(+ 3,300 Million Gal / Yr) |                 | 9,600 Million Gal / Yr<br>(+5,700 Gal / Yr)    |                 |
| Gasoline Replaced  | 2,380 Million Gal / Yr                               |                 | 3,965 Million Gal / Yr                         |                 |
| <b>Crude Forecast</b>  | <b>\$47 Oil</b>                                      | <b>\$70 Oil</b> | <b>\$47 Oil</b>                                | <b>\$70 Oil</b> |
| EPA Analysis (2004 \$)   | +0.33 c/g  | - 0.16 c/g      | +0.93 c/g                                      | - 0.07 c/g      |
| EFC Analysis (2004 \$)   | + 0.28 c/g   | - 0.90 c/g      | +0.70 c/g                                      | - 1.33 c/g      |

As is to be expected, the cost of replacing gasoline derived from crude oil with ethanol derived from biomass such as corn depends crucially on the market price of crude oil.

Extrapolation between the two crude price cases that EPA provides in the RFS preamble shows

that the zero cost point (indifference price) is approximately \$53-\$55 per barrel crude oil for the two ethanol volume expansion cases considered in the RFS. However, slight variation in the assumptions EPA has made regarding octane costs and refinery crack spreads (operating margins between crude oil and gasoline) can easily move these indifference points down by \$5 per barrel toward the \$47 per barrel reference case. All crude oil per-barrel prices above the indifference point, or “tipping point,” would make ethanol use economical, even before factoring in government subsidies. Including government subsidies in the analysis would in fact lower the crude oil indifference price point to less than \$40 per barrel, which is less than EPA’s low-end \$47 per barrel reference case.

Energy authorities such as the International Energy Agency (IEA) are now forecasting that crude oil prices will rise above \$60 per barrel in the near future. In addition, crude oil futures contracts for 2012 on the NYMEX are trading for over \$63 per barrel. Therefore, based on our analysis, the expanded use of ethanol in gasoline to reduce the nation’s dependency on crude oil is expected to be economically justified, even if government subsidies are not included in the analysis.

## **VII. Supply of Renewable Fuels Going Forward**

The EPA’s projections of future ethanol supply are conservative but for that reason are a reliable basis for the observations we make in this comment. As shown in Table VI.A.2-2 of the Preamble to the proposed RFS, once construction projects under way are complete by year’s end 2007, resulting US ethanol production capacity will be in excess of 7.3 billion gallons, which, with biodiesel production, will provide more than enough biofuel to satisfy the 2012 requirement of 7.5 billion gallons. But EPA points out that “ethanol production is not expected to stop here.” If all proposed plant capacity were to come to fruition, the combined domestic ethanol production could exceed 20 billion gallons, according to EPA. See Table VI.A.2-2.

Table VI.A.2-2  
Potential U.S. Ethanol Production Projects

|              | 2006 Baseline + UC* |            | Planned      |           | Proposed      |            | Total ETOH Potential |            |
|--------------|---------------------|------------|--------------|-----------|---------------|------------|----------------------|------------|
|              | MMGal/yr            | Plants     | MMGal/yr     | Plants    | MMGal/yr      | Plants     | MMGal/yr             | Plants     |
| PADD 1       | 0.4                 | 1          | 250          | 3         | 1,005         | 21         | 1,255                | 25         |
| PADD 2       | 7,010               | 128        | 1,940        | 15        | 7,506         | 90         | 16,458               | 233        |
| PADD 3       | 60                  | 2          | 108          | 1         | 599           | 9          | 767                  | 12         |
| PADD 4       | 155                 | 5          | 0            | 0         | 815           | 14         | 970                  | 19         |
| PADD 5       | 124                 | 5          | 128          | 2         | 676           | 18         | 928                  | 25         |
| <b>Total</b> | <b>7,349</b>        | <b>141</b> | <b>2,426</b> | <b>21</b> | <b>10,603</b> | <b>152</b> | <b>20,378</b>        | <b>314</b> |

\*Under Construction

In this table, the distinction between “planned” versus “proposed” ethanol plants means that as of June 2006, planned projects had completed permitting and financing and had definitive construction timelines, whereas proposed projects did not. Once all projects under construction and “planned” are complete (2012 or sooner), resulting ethanol production capacity would be 9.8 billion gallons. “This forecasted growth would double today’s production capacity and greatly exceed the 2012 renewable fuel requirement (7.5 billion gallons).” As stated in its comment on the proposed MSAT rule, the Coalition believes that ethanol production will exceed 14 billion gallons of ethanol-equivalent biofuels by 2010.

### VIII. Conclusion

In sum, the effect of adopting an MSAT Aromatics Rule would be to:

- lessen the economic impact on the driving public of the RFS;
- expand the gasoline supply by allowing aromatic compounds to be diverted from supplying octane to making more gasoline;
- achieve more benzene reductions than EPA has proposed in the MSAT rule, and at less cost;
- discourage refiners from using higher-cost, lower-octane-content sources such as aromatics and alkylates as octane sources; and
- ensure that the American public receives the tens of billions of dollars of health benefits that the RFS and Aromatics MSAT Rule together would confer.

## APPENDIX A

### Supporting Analysis

The cost analysis conducted by the EPA for the RFS includes a number of fuel market effects that are not related to expanding the use of renewable fuels in the nation's gasoline and therefore should be excluded from estimates of costs of expanding the use of ethanol. In particular, the removal of the oxygenate standard from the Reformulated Gasoline (RFG) program caused the use of MTBE to be abruptly discontinued by the refiners (prior to the removal of the oxygenate standard) because of increased liability risk for MTBE contamination. Instead of a multiyear transition to phase down MTBE use, the relatively quick switch required the transfer of existing volumes of ethanol from other gasoline markets to replace the 2 billion gallons per year of MTBE in RFG that had been lost. This shift required the refining industry to expand its production of RBOB (reformulated gasoline blendstock for oxygenate blending - a sub-RVP gasoline in the summer for ethanol blending). Thus EPA adds to the cost of the RFS: (1) the cost of removing MTBE, (2) the cost of construction of new alkylate capacity, and (3) the cost of reducing RVP necessary for blending ethanol into RFG.

The analysis conducted in this study excludes these additional costs related to removal of the oxygenate standard from RFG. It considers the effect of expanding ethanol blending by 3.3 and 5.7 billions gallons per year, based on ethanol's value in adding octane and displacing gasoline derived from crude oil. The analysis assumes that the required displacement of 2 billion gallons per year of MTBE in RFG is satisfied with ethanol transfers from the 3.9 billion gallons a year of ethanol available in existing markets.

### **Ethanol's Net Cost in Gasoline**

The analysis uses EPA's cost of production for ethanol from corn, which raises it from \$1.20 per gallon in the 7.3 BGY (billion gallons per year) case to \$1.26 per gallon in the 9.6 BGY case to reflect a higher corn price and lower DDGS co-product credits. To simplify the calculations, the analysis assumes that the expanding volume of ethanol is distributed into conventional gasoline in PADDs II, III and IV (47 percent of the nation's gasoline), since much of the existing ethanol is already used in the RFG markets located in PADDs I and V. The +3.3 BGY and +5.7 BGY ethanol expansions would require about 22 percent and 38 percent of the nation's gasoline pool. Since RFG represents about 33 percent of the nation's gasoline and is blended with existing ethanol, most of the remaining 77 percent of conventional gasoline market would be available for expanded E10 blending in this RFS analysis. Therefore, this analysis uses the gasoline cost and ethanol distribution cost typical for PADDs II, III and IV as well as the octane values (credits) expected for these regions.

### **RVP Cost Debits for Ethanol**

EPA reviews a number of RVP penalty scenarios under the assumption that expanding ethanol use will require sub-RVP base fuels, because state regulations may require adherence to all ASTM gasoline specifications for ethanol blends including RVP. However, the available evidence does not appear to support this belief. As part of an analysis conducted for DOE on ethanol distribution [Oak Ridge National Laboratory Ethanol Project, Downstream Alternatives, May 15, 2000], only seven states (CA, DE, HI, LA, RI, UT, & WY) did not allow ethanol RVP waivers. Although these states represent about 16 percent of the gasoline, most of it (13 percent) is already RVP-controlled with RFG programs (CA, DE, RI). The summer RVP of ethanol blending in RFG is also indirectly controlled through VOC performance targets, but sub-RVP is not utilized during the wintertime except in the states mentioned previously. Since RFG

represents about 33 percent of the nation's gasoline, the RVP-controlled summer share represents about 15 percent of the national year-round gasoline supply. Adding gasoline from other RVP controlled states along with the winter RFG for CA, DE, and RI will raise the total share to about 21 percent of total U.S. gasoline. Again, most of this RVP-controlled gasoline with ethanol is located in PADDs I and V, which means about 79 percent of the year-round gasoline supply does not regulate the RVP increase with E10 blends. Also, much of the gasoline sold in this country is distributed by common carrier systems, such as pipelines and also is distributed in common terminal systems which do not provide flexibility to distribute sub-RVP gasoline specifically for ethanol blending in conventional gasoline areas. Therefore, other than in the areas mentioned, there does not appear to be a regulatory requirement to use sub-RVP blends E10 blends in most of the country. An RVP debit or cost adjustment does not appear to be justified for the volume of ethanol being considered in the RFS analysis.

### **Octane Credit for Ethanol Blends**

To value the octane added from ethanol blending in the \$47 oil case, EPA uses octane cost estimates that vary for each PADD. However, in raising the cost estimate from \$47 to \$70 per barrel for oil, EPA makes the assumption that octane costs are not related to crude price and therefore stay constant. This is an incorrect assumption, because the cost for much of the crude-oil-derived octane, i.e., octane from aromatics, is tied directly to the cost of gasoline and therefore to the cost of crude oil. Much of the octane in gasoline is made by converting naphtha into high-octane aromatic compounds. However, in the process of making aromatics, some of the valuable gasoline liquid is downgraded to low-value fuel. Therefore, the cost of the aromatic octane is determined by the value lost divided by the octane gained. The higher the value of the gasoline liquid that is downgraded to fuel gas, the higher the cost of the octane from aromatics. As a result, the higher the price of crude oil, the higher the cost of octane from aromatics. This is

consistent with market observations, since the octane cost of premium gasoline, as well as other octane enhancers, has been climbing over the past years as crude oil prices have climbed. Therefore, this analysis uses a 0.9 ¢ / octane-gallon for valuing ethanol's octane in the \$47 per barrel case. It is proportionately raised to 1.35 ¢ in the \$70 oil case.

### **Sensitivity to Crude Oil Price**

The economic benefit of using ethanol to displace gasoline from crude oil is strongly related to crude oil price, because crude oil price determines both the cost of gasoline and the value of octane from ethanol. The cost analysis for expanding ethanol use in gasoline is summarized in the table below. The net cost of the ethanol delivered to the gasoline terminals includes the octane credits. The marginal value of the ethanol used in gasoline is then determined by crediting the net ethanol cost with the value for the gasoline displaced by the blended ethanol by using 77,500 Btu's per gallon of commercial grade ethanol versus 115,000 Btu's for gasoline.

Using EPA's cost assumptions, the marginal cost of blending a gallon of ethanol is 13 ¢ / gallon for the \$47 oil case, but the marginal cost contribution falls to a negative 41 ¢ per gallon blended in a \$70 oil case, as illustrated in the table. Therefore, cost impacts on average gasoline for the 7.2 BGY of ethanol goes from +0.3 ¢ / gallon to a negative 0.9 ¢ / gallon. The results for the 9.6 BGY case is similar in that the cost impact falls from a +0.7 ¢ / gallon to a negative 1.3 ¢ / gallon.

The sensitivity of the ethanol cost contributions are illustrated in Chart 1A for the 7.2 BGY case and in Chart 1B for the 9.6 BGY case. The margin contribution for a gallon of ethanol relative to crude prices are illustrated in Chart 2, while the average cost impact on the nation's gasoline is illustrated for the two ethanol expansion cases in Chart 3. Based on these assumptions and analyses, the zero cost point (indifference point) for expanding ethanol use

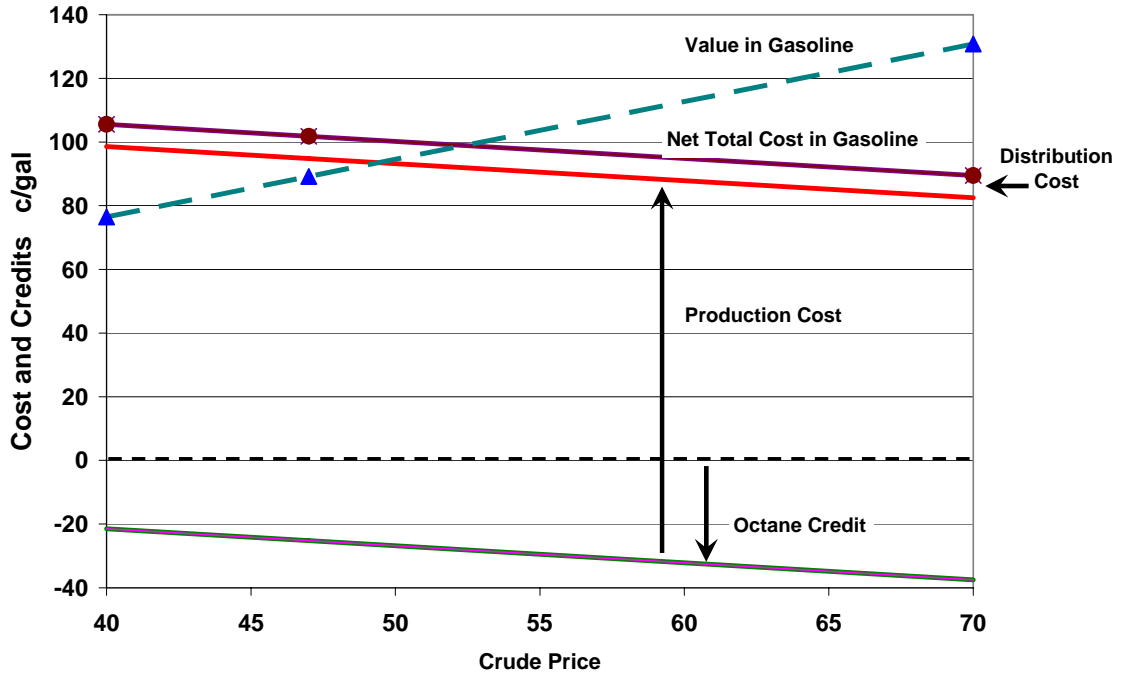
without subsidies is approximately \$55 oil for the 7.2 BGY case and \$53 oil for the 9.6 BGY case. Therefore, expanding ethanol use for octane purposes makes economic sense when crude prices are above these indifference points, and the market prices are expected to remain above these “tipping points” based on the recent short term outlook by EIA and the latest World Energy Outlook by IEA (International Energy Agency, November 8, 2006) as well as the Crude Oil futures contracts trading on the NYMEX.

| <b><u>2012 Cost of Gasoline (\$2004)</u></b> |         |                     |                       |
|--|---------|---------------------|-----------------------|
| Crude Oil Price                              | \$/B    | <b>47</b>           | <b>70</b>             |
| Refining Crack                               | \$/B    | <u>6.00</u>         | <u>8.94</u>           |
| Gasoline Cost                                | \$/B    | 53.00               | 78.94                 |
| Crude Oil Price                              | ¢ / gal | 111.9               | 166.7                 |
| Refining Crack                               | ¢ / gal | <u>14.3</u>         | <u>21.3</u>           |
| Gasoline Cost                                | ¢ / gal | 126.2               | 187.9                 |
| Distribution to Terminals                    | ¢ / gal | <u>6.0</u>          | <u>6.0</u>            |
| <b>Delivered Cost to Terminals</b>           | ¢ / gal | <b>132.2</b>        | <b>193.9</b>          |
| <b>7.2 Billion Gallons per year</b>          |         |                     |                       |
| <b><u>Ethanol Net Cost in Gasoline</u></b>   |         |                     |                       |
| Production                                   | ¢ / gal | 120.0               | 120.0                 |
| Octane Credit                                | ¢ / gal | (25.2)              | (37.5)                |
| RVP Debit                                    | ¢ / gal | 0.0                 | 0.0                   |
| Distribution Cost                            | ¢ / gal | <u>7.0</u>          | <u>7.0</u>            |
| <b>Net Cost Dlvr to Terminals</b>            | ¢ / gal | <b>101.8</b>        | <b>89.5</b>           |
| Gasoline Displacement Credit                 | ¢ / gal | <u>(89.1)</u>       | <u>(130.8)</u>        |
| <b>Net Cost Margin of Ethanol</b>            | ¢ / gal | <b>12.66</b>        | <b>(41.32)</b>        |
| <b>Avg US Gasoline Cost Change</b>           | ¢ / gal | <b>0.28</b>         | <b>(0.90)</b>         |
| <b>9.6 Billion Gallons per year</b>          |         |                     |                       |
| <b><u>Ethanol Net Cost in Gasoline</u></b>   |         |                     |                       |
| Production                                   | ¢ / gal | 126.0               | 126.0                 |
| Octane Credit                                | ¢ / gal | (25.2)              | (37.5)                |
| RVP Debit                                    | ¢ / gal | 0.0                 | 0.0                   |
| Distribution Cost                            | ¢ / gal | <u>7.0</u>          | <u>7.0</u>            |
| <b>Net Cost Dlvr to Terminals</b>            | ¢ / gal | <b>107.8</b>        | <b>95.5</b>           |
| Gasoline Displacement Credit                 | ¢ / gal | (89.1)              | (130.8)               |
| <b>Net Cost Margin of Ethanol</b>            | ¢ / gal | <b><u>18.66</u></b> | <b><u>(35.32)</u></b> |
| <b>Avg US Gasoline Cost Change</b>           | ¢ / gal | <b>0.70</b>         | <b>(1.33)</b>         |

## Chart 1 A

### Ethanol's Net Cost & Value in Gasoline

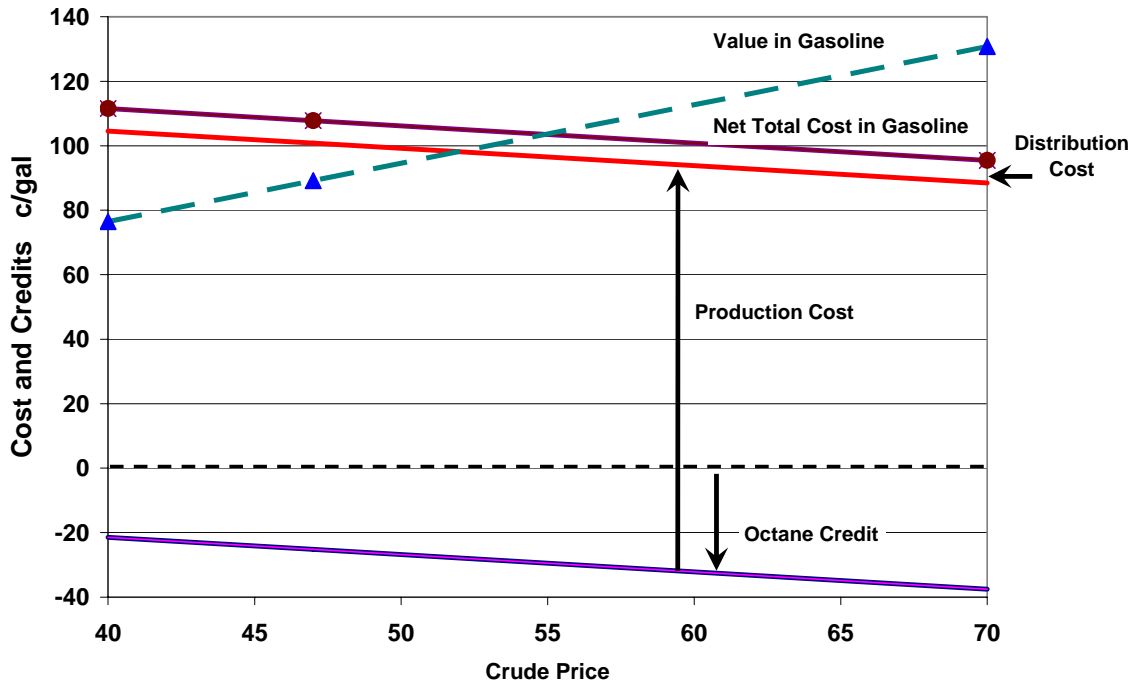
Case: 7.3 Billion Gallons per year 2012



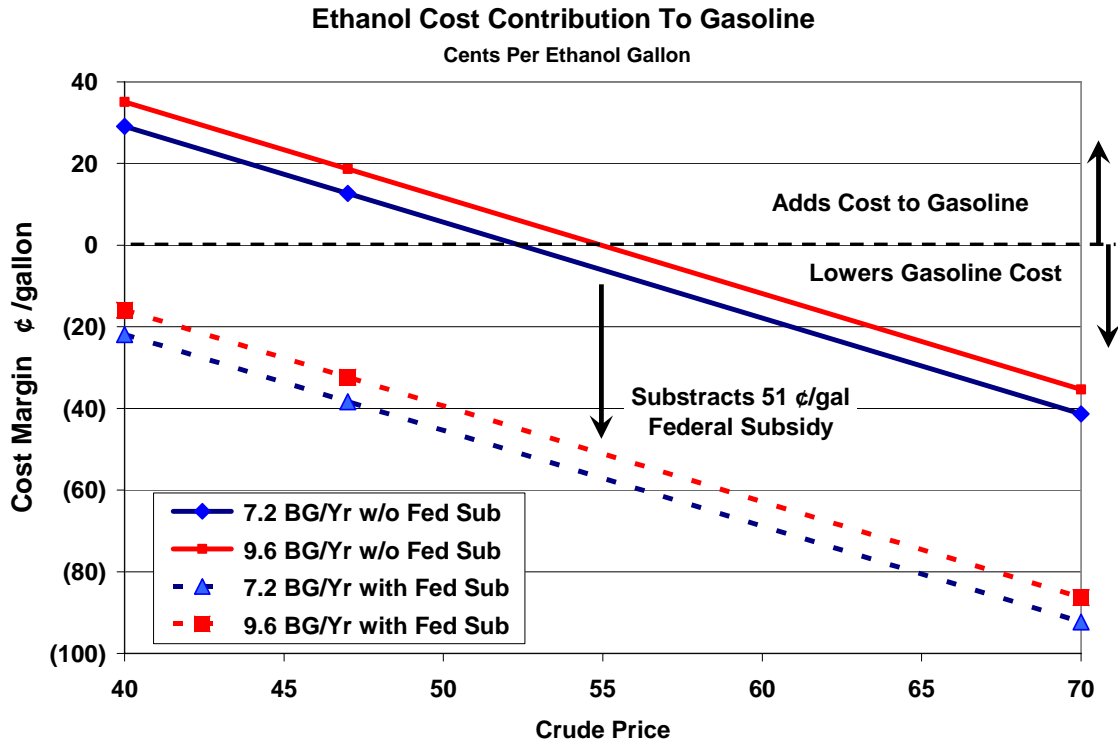
## Chart 1 B

### Ethanol's Net Cost & Value in Gasoline

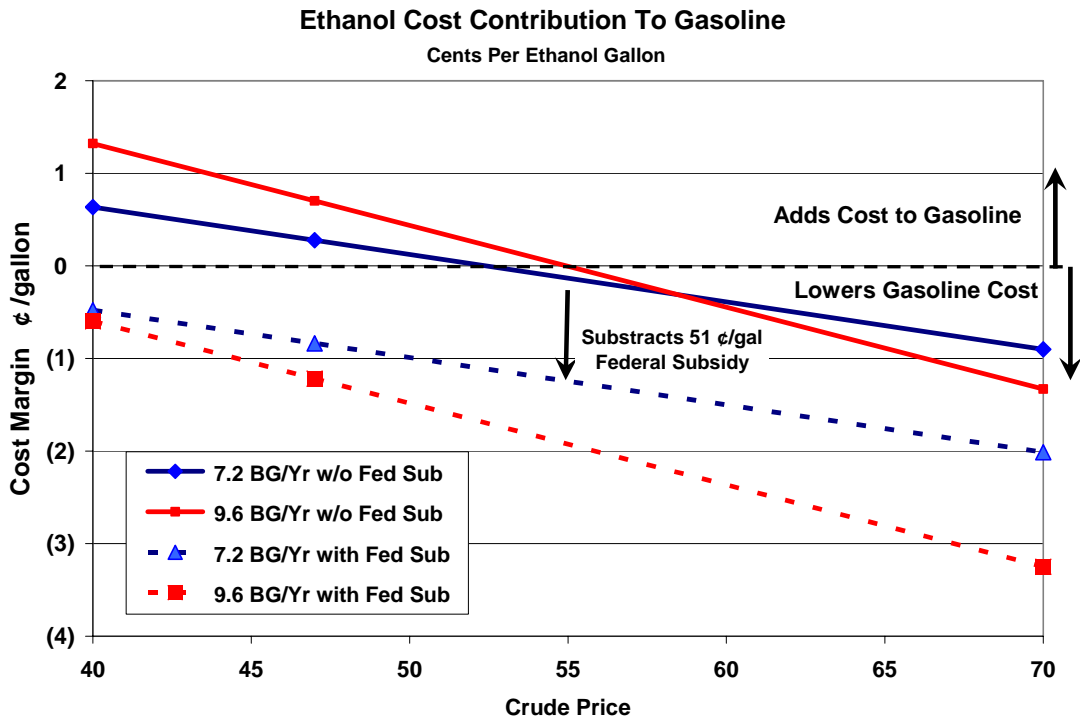
Case: 9.6 Billion Gallons per year 2012



**Chart 2**



**Chart 3**



**APPENDIX B**

**COMMENTS OF**

**THE ENERGY FUTURE COALITION**

on

**THE ENVIRONMENTAL PROTECTION AGENCY'S PROPOSED RULE:  
CONTROL OF HAZARDOUS AIR POLLUTANTS FROM MOBILE SOURCES**

**EPA-HQ-OAR-2005-0036**

**70 Fed. Reg. 15804 (March 29, 2006)**

**Submitted**

**May 30, 2006**

The Energy Future Coalition appreciates the opportunity to comment on the Environmental Protection Agency's Proposed Rule: Control of Hazardous Pollutants from Mobile Sources (the "MSAT rule").<sup>1</sup> The Energy Future Coalition is a bipartisan public policy initiative that brings together business, labor, and environmental leaders around the vision of a better energy future. The Coalition seeks to identify and advance innovative policy options that appeal to a diverse array of competing interests and attract broad political support.

## **I. Summary**

In the proposed MSAT rule, EPA fails in its statutory duty to set standards that control hazardous air pollutants from motor vehicles to the maximum extent that is reasonably achievable. It ignores an available option that is cost-effective and in use today – the replacement of aromatic compounds in gasoline with liquid biofuels.

The only improvement in gasoline quality that EPA has proposed is a slight reduction in the benzene content of a gallon of gasoline, from 0.97 to 0.62 percent. While this is a good step, the MSAT rule will only reduce benzene emissions from gasoline combustion by about 16,000 tons by 2015. This limited measure does not satisfy the requirements of the Clean Air Act, which "at a minimum" requires reductions in emissions of benzene and formaldehyde plus additional reductions in other air toxics that reflect the "greatest degree of emissions reductions

---

<sup>1</sup> EPA, Proposed Rule, Control of Hazardous Air Pollutants From Mobile Sources, 71 Fed. Reg. 15,804 (published in Federal Register on Mar. 29, 2006) [hereinafter "Proposed MSAT Rule"], available at <http://www.epa.gov/otaq/regs/toxics/msat-nprm-fr.pdf> and <http://www.epa.gov/otaq/toxics.htm#regs>.

achievable through the application of technology which will be available,” taking cost, noise, energy, safety, and lead times into account.<sup>2</sup>

What EPA should – and must – do is to impose controls on other gasoline aromatics in addition to benzene in order to achieve the greatest return in public health gains for the least cost. The two aromatic compounds of principal additional concern are also toxic hydrocarbons – toluene and xylene – which are added to gasoline to increase octane. Toluene and xylene account for more than half of all MSAT emissions and more than five times the emissions of benzene alone. All three chemicals are toxic in their own right: thus each is designated as a hazardous air pollutant under the Clean Air Act. Benzene is a known human carcinogen; toluene and xylene form benzene during the combustion process. But benzene and the other aromatics are also carbon-based precursors of fine particulate matter, which, according to EPA, is the single most important air pollution problem in the U.S. today. In addition, aromatics adversely affect national ozone levels, particularly in urban areas, as well as carbon monoxide and CO<sub>2</sub> levels. Consequently, any reductions in the aromatic content of gasoline would lead directly to significant improvements in air quality that have been valued by EPA in the tens of billions of dollars.

The costs to refiners of reducing the aromatic content of gasoline are not significant. Refiners can divert the crude oil fraction now used for aromatics to make more gasoline and save both money and energy. Supplies of gasoline to the driving public can be kept up, and gas prices down, by adding biofuels to gasoline – as is required in any event under the renewable fuels

---

<sup>2</sup> 42 U.S.C. § 7521, Emission standards for new motor vehicles or new motor vehicle engines, subsection (1)(2): Mobile source-related air toxics - Standards.

standard (RFS) mandated by the Energy Policy Act of 2005 (P.L. 109- 58, Sec. 1501, amending 42 U.S.C. § 7545).

Aromatics in gasoline account for an average of 27.6 percent of gasoline by volume in the summer and 23.6 percent by volume in the winter, for an overall average of 25.7 percent.<sup>3</sup> Stakeholders may disagree about the percentage rollbacks in aromatics that are appropriate, and on what schedule. But the Clean Air Act mandates the greatest cuts in gasoline aromatics that are technologically and economically achievable.

We think a strong case can be made for a long-term goal of eventually reducing the aromatic contribution to PM<sub>2.5</sub> by 80 percent, to approximate the percentage rollbacks that stationary sources and autos have been required to meet over the years to reduce their comparable emissions. The costs to refiners of meeting the 80 percent goal would be significant – but those costs would not be inconsistent with the time and resources spent by state and local governments in implementing ozone and PM<sub>2.5</sub> State Implementation Plans, or with the costs that stationary sources and auto manufacturers have had to incur to reduce PM<sub>2.5</sub> and ozone.

EPA is under a statutory and a court-ordered deadline to finalize the MSAT rule by February of 2007. Time is short for EPA to withdraw the current MSAT proposal entirely and repropose a rule that focuses on aromatic reductions. However, the environmental plaintiffs in

---

<sup>3</sup> See Petroleum Product Surveys by Northrop Grumman, Motor Gasolines (Summer 2005), NGMS-243 PPS 2006/1 and Motor Gasolines (Winter 2004-05), NGMS-240 PPS 2005/3, available at <http://pps.ms.northropgrumman.com>. There are a number of fuel surveys that report different aromatic content percentages, but all roughly estimate that aromatics account on average for 26 percent of gasoline. For example, EPA has compiled reports filed by refiners that indicate that non-benzene aromatics account for an average 25 percent of gasoline by volume and benzene accounts for one percent of gasoline content by volume excluding California. Taken together, aromatics therefore account for approximately 26 percent of the volume of motor fuel, i.e., roughly one-quarter of gasoline today consists of aromatic compounds. See <http://www.epa.gov/otaq/regs/fuels/rfg/properf/cg-params.htm> and <http://www.epa.gov/otaq/regs/fuels/rfg/properf/rfg-params.htm>. However, in the proposed MSAT Rule, EPA asserts without explanation that the aromatic content of gasoline is 30 percent.

the suit forcing EPA to act may be willing to allow the time needed to develop a more aggressive rule if it would achieve twice the benzene tailpipe emissions reductions EPA is seeking while at the same time obtaining significant additional benefits by phasing down other aromatics in gasoline. Alternatively, EPA could propose a supplemental rule that complements the current proposal. Either version of a new Aromatics MSAT Rule could and should require aromatics reductions that can reasonably be achieved in the next few years.

The exact time frame for this rule making needs to be carefully considered, as well as the particular requirements of such a new MSAT rule. Stakeholders and EPA will need to refine the specifics of an acceptable, cost beneficial, and protective Aromatics MSAT Rule. What follows is intended to show that there is at least one viable path to achieving these reductions:

- **Phase I: Over the next four years (2010), reduce aromatics to approximately 22 percent of gasoline content for summertime gasoline and to approximately 19 percent of gasoline content for wintertime gasoline – roughly a 20 percent reduction in current aromatics levels.**

Phase I represents a 20 percent reduction in the level of aromatics in gasoline. It would reduce benzene emissions by 32,000 tons, which is twice the tailpipe emissions reductions EPA hopes to achieve with its 0.62 percent benzene content standard. In addition, it would reduce other aromatic hazardous air pollutants (toluene, ethylbenzene, and xylene) by 154,421 tons (22.4 percent) and nonlisted aromatic emissions (C9, C10 aromatics) by 211,777 tons.

The potential benefits of these emissions reductions are substantial. Because aromatics contribute significantly to the formation of secondary organic aerosols (SOA), a 20 percent aromatics reduction could reduce PM<sub>2.5</sub> by 22 percent in some urban areas, *i.e.*, as much as a

0.9 $\mu\text{g}/\text{m}^3$  reduction in  $\text{PM}_{2.5}$ .<sup>4</sup> Based on EPA's quantification of  $\text{PM}_{2.5}$  benefits in past rules, as well as in the current proposed MSAT rule, a 0.9  $\mu\text{g}/\text{m}^3$   $\text{PM}_{2.5}$  reduction would be valued at approximately \$90 billion.<sup>5</sup> Toxics reductions could yield an additional \$8 billion in benefits.<sup>6</sup> While not as significant, VOC reductions resulting from an aromatic content standard would also reduce ozone, carbon monoxide, and carbon dioxide. Nonquantifiable health and welfare benefits may be similarly impressive. These may include reducing health effects not quantified in EPA's models, reducing environmental (ecosystem) impacts, improving visibility, and reducing impacts on agriculture, forests, and vegetation.

The nation's gasoline supply could not only be maintained, but expanded, under this approach. Refiners will divert feedstocks used in making aromatics to making nonaromatic gasoline constituents, resulting in a one percent gain in gasoline volume. Moreover, refiners are likely to make up octane losses by blending relatively cheap biofuel additives such as ethanol. The addition of ethanol to make up octane losses would increase the overall supply of gasoline

---

<sup>4</sup> For a comprehensive discussion of the toxics and  $\text{PM}_{2.5}$  benefits of reducing aromatics in gasoline, see C. Boyden Gray & Andrew R. Varcoe, Octane, Clean Air, And Renewable Fuels: A Modest Step Toward Energy Independence, 10 *Texas Review of Law & Politics* 9 (Fall 2005). The Energy Future Coalition is grateful to Ambassador Gray for calling the aromatics issues to its attention.

<sup>5</sup> EPA has estimated  $\text{PM}_{2.5}$  reduction benefits in several rulemakings. Taken together, the monetized value of a 1.0  $\mu\text{g}/\text{m}^3$   $\text{PM}_{2.5}$  reduction is roughly \$100 billion. See also Alan J. Krupnick, Focus on Particulates More Than Than Smog, in *New Approaches on Energy and the Environment* 69 (Richard D. Morgenstern & Paul R. Portney eds., 2004), available at [http://www.rff.org/rff/RFF\\_Press/CustomBookPages/NewApproachesonEnergyandtheEnvironment/load\\_e.cfm?url=/commonspot/security/getfile.cfm&PageID=15679](http://www.rff.org/rff/RFF_Press/CustomBookPages/NewApproachesonEnergyandtheEnvironment/load_e.cfm?url=/commonspot/security/getfile.cfm&PageID=15679) ("EPA studies of the costs and benefits of reducing particulates . . . show a cost-benefit ratio in the range of ten or twenty to one, roughly \$100 billion of benefits for every one microgram-per-cubic-meter reduction in fine-particulate concentrations.")

<sup>6</sup> Based on a rough estimate of \$48,000 per ton HAP reduction derived from previous HAP estimates of HAP reduction benefits for stationary sources and adjusting them for mobile source exposure. See Note 26 for a full discussion of this estimate.

by 10 percent – an additional 14 billion gallons.<sup>7</sup> Current projections for ethanol production reveal that there may be over 14 billion gallons per year of ethanol available by 2010. In addition to this potentially large domestic capacity, the Caribbean Basin Initiative would allow another 900 million gallons per year to enter the US. Therefore, it is likely that there will be adequate supplies of ethanol to supply the 14 billion gallons needed by 2010.<sup>8</sup>

As developed in detail below, EPA must identify the full benefits and costs of an Aromatics MSAT Rule before proposing it. In EPA’s analysis, the very large potential benefits of such a rule would have to be weighed against such costs as the higher Reid Vapor Pressure (RVP) of low-percentage ethanol gasoline blends such as E10 in ordinary gasoline blendstocks,<sup>9</sup>

---

<sup>7</sup> On a gallon-for-gallon volumetric basis, it would require approximately 7.2 billion gallons of ethanol to replace the 20 percent aromatic volume lost in Phase I (*i.e.*, aromatics comprise approximately 36 billion gallons of the total 140 billion gallon gasoline supply; 20 percent of 36 billion is 7.2 billion). However, a larger volume of ethanol is needed to replace the octane that is lost when aromatics are converted to nonaromatics during the reforming process. On an octane balancing basis, we estimate that almost two gallons of ethanol are needed to replace one gallon of aromatics. This is consistent with EPA’s estimate that for every 0.40 octane number loss, two percent by volume ethanol must be added to gasoline. *See* EPA, Draft Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources, EPA 420-D-06-004 (Feb. 2006) at 6-59, *available at* <http://www.epa.gov/otaq/reg/toxics/chapter6.pdf>.

<sup>8</sup> Jim Jordan & Associates, Fuels Blendstock Report (May 19, 2006).

<sup>9</sup> RVP issues arise for a small area of the country in the summer only when ozone is a concern. The US summer gasoline pool breaks down approximately as follows:

|                            |            |
|----------------------------|------------|
| RFG Markets (7 RVP)        | 33 percent |
| Conventional Markets       |            |
| States' Low RVP (Boutique) | 17 percent |
| Non-control (8.7 RVP)      | 50 percent |

Approximately 50 percent of the summer gasoline does not need RVP controls for ozone, since this gasoline is consumed in ozone attainment areas. The RFG program does not allow the RVP waiver for ethanol blending; VOC emissions reductions are achieved through controls that are imposed on the RBOB blends. Thus, the market breakdown suggests that only about 17 percent of the summer gasoline market is a concern if a one pound waiver for ethanol applies. This in turn is only about 9 percent of the gasoline pool on an annual basis. Using a simple (but very unlikely) assumption that ethanol cannot be used in that 9 percent of the annual market, the remaining 91 percent of gasoline volume could accept 12.5 billion gallons a year of ethanol without RVP issues arising. Congress anticipated this increased VOC concern in the Energy Policy Act of 2005 and gave those states with air quality issues (17 percent of

*(footnote continued on next page)*

the toxic potential of higher acetaldehyde emissions associated with ethanol blends,<sup>10</sup> and the land use, foodstuff, and transportation issues associated with greater use of biofuels such as ethanol. That said, we believe careful analysis will show that the benefits of an Aromatics MSAT Rule will far exceed its costs.

- **Phase II: By 2014, reduce aromatics to approximately 18.5 percent of gasoline content for summertime gasoline and to approximately 16.5 percent of gasoline content for wintertime gasoline.**

Phase II would bring about an overall reduction of 33 percent from current aromatics levels. Moreover, it would reduce benzene emissions by an additional 8,400 tons, for a total benzene emissions reduction of 39,189 tons by 2014. Other aromatic hazardous air pollutants (toluene, ethylbenzene, and xylene) would be reduced an additional 92,489 tons, for a total 35.8 percent reduction from current levels. Nonlisted aromatic emissions (C9, C10 aromatics) would be reduced by an additional 126,842 tons. Importantly, a 33 percent aromatic reduction in 2014 could reduce PM<sub>2.5</sub> by as much as 36 percent in some urban areas, and may represent as much as a 1.4µg/m<sup>3</sup> reduction in PM<sub>2.5</sub>. A 1.4 µg/m<sup>3</sup> PM<sub>2.5</sub> reduction would be valued at approximately

---

*(footnote continued from previous page)*

the summer market) the ability to petition the EPA for the removal of ethanol's one pound RVP waiver during the summertime. States concerned about ethanol's permeation VOCs have the option to use bioethers which do not cause permeation. Also, lowering aromatics content in gasoline through an aromatic MSAT rule or cap is another way to reduce mobile source VOCs by about 3 to 4 percent.

<sup>10</sup> In a review of the air quality impacts of ethanol, the California Environmental Policy Committee (CEPC) concluded that the use of ethanol results in slightly increased levels of acetaldehyde and peroxyacetyl nitrate (PAN), but that “these compounds are more than offset by reductions in formaldehyde,” which is more harmful than acetaldehyde. Furthermore, the CEPC concluded that other gasoline components are primarily responsible for acetaldehyde and PAN emissions in any event. “Other components of gasoline, such as aromatic compounds and olefins, are primarily responsible for the formation of formaldehyde, acetaldehyde, and PAN due to both their greater abundance in gasoline and their shorter atmospheric lifetimes.” See Renewable Fuels Association, “Ethanol Facts,” available at <http://www.ethanolrfa.org/resource/facts/environment>. Thus, high aromatic content once again accounts for harmful emissions from gasoline.

\$140 billion in health benefits. Toxics reductions would yield an additional \$12 billion in benefits.

Replacing gasoline volumes lost by the removal of additional aromatics could be achieved in several ways. Because of the variation in the aromatic content of gasoline throughout the U.S., and because the air quality problems caused by aromatics are most severe in urban areas, Phase II might include an averaging, banking, and trading (ABT) program for aromatics, somewhat similar to what EPA has proposed for benzene in the MSAT rule. An ABT program would allow refiners to choose among several options for complying with the aromatic content standard and would focus aromatic reductions where they are most needed. While the details of such an ABT program would have to be developed, the options in addition to E10 could include:

**A. E85**

E85 is a blend of 85 percent ethanol and 15 percent gasoline.<sup>11</sup> E85 is designed for use in flexible fuel vehicles (FFVs). FFVs are able to detect the ethanol/gasoline ratio and make adjustments to the engine's ignition timing and air/fuel mixture ratios to account for the ethanol and optimize performance and maintain emissions control. On May 18, 2006, leaders of Ford Motor Company, General Motors Corp., and DaimlerChrysler AG's Chrysler Group reported that they had produced 5 million flexible fuel vehicles to date and that they planned to bring an

---

<sup>11</sup> E85, like gasoline and diesel fuels, is seasonally adjusted to ensure proper starting and performance in different geographic locations. For example, E85 sold during colder months often contains 70 percent ethanol and 30 percent petroleum to produce the necessary vapor pressure for starting in cold temperatures. An E85 fueling site operator typically cannot carry over summer-blend E85, but rather must "blend down" any remaining summer fuel to make an E70 mixture. This may be done with relative ease by adding additional gasoline to the storage tank. There is no concern with carrying over winter-blend E70 into warmer months as flexible fuel vehicles operate on any blend of E85 and gasoline during warmer times. For retail service stations, seasonal fuel adjustments are handled automatically at the wholesale fuel terminal.

additional one million to the market in the coming year. This is equivalent to about 3 percent of the total fleet of cars, light trucks, SUVs, and vans on the road today. General Motors Corp. announced that it would introduce 19 new or redesigned engines and transmissions in 2007 model year vehicles and 14 new models that can run on E85.

Thus, there is already a market for E85 fuel, and it is expected to grow by 2014. Estimates are that as much as 6 billion gallons of corn-based ethanol, above that needed to satisfy Phase I discussed above, could be available for E85 fuel. Were demand to go beyond 6 billion gallons, it would have to be satisfied with cellulosic ethanol. Shell Oil has predicted that the global market for biofuels such as cellulosic ethanol will grow to exceed \$10 billion by 2012.

Refiners supplying E85 fuel to urban areas in nonattainment status under PM<sub>2.5</sub> and ozone standards could generate aromatic credits beginning in 2010. All credits generated could be used internally towards refiner compliance with the 18 percent aromatic content standard (“averaged”), “banked” for future use, and/or transferred (“traded”) to another refiner.

## **B. E20**

The state of Minnesota has mandated the use of 20 percent ethanol in its gasoline distribution network, subject to the fuel being certified and waived into commerce by EPA. Research is underway to evaluate E20 compatibility and drivability to support a waiver request.<sup>12</sup> Transitioning to a 20 percent ethanol blend of gasoline is not without precedent; Brazil, in its conversion to an ethanol-fueled economy, determined that operation with up to 22 percent ethanol in gasoline was safe for the cars and trucks then on the road in Brazil at the time. The

---

<sup>12</sup> See Jewitt and Associates, Minnesota E 20 Fuel Research Program (Jan. 2006), *available at* [http://www.nmma.org/lib/docs/nmma/gr/environmental/Minnesota\\_E\\_20\\_Fuel\\_Research\\_Program.doc](http://www.nmma.org/lib/docs/nmma/gr/environmental/Minnesota_E_20_Fuel_Research_Program.doc).

conversion to a 20 percent blend was accomplished with only minor issues arising for older vehicles. Recently, conversion to a 24 percent blend was accomplished in Brazil.

The ABT program would apply to E20 in the same way it would for E85, although fewer credits would be generated through the use of E20.

### **C. ETBE**

The amount of ethanol that can be added to gasoline is currently limited by law to 10 percent. However, ethanol can be combined with isobutylene (derived from natural gas or petroleum) to create ethyl tertiary butyl ether, or ETBE. Because ETBE can be added to gasoline in amounts up to 17 percent (and could be increased by EPA to 22 volume percent or 3.5 weight percent oxygen), it would offer refiners an alternative replacement for aromatics that would further expand the supply of blended fuel to the consumer.

Gasoline blended with ETBE is less volatile than ethanol blends and thus results in a lower RVP and lower ozone pollution. Unlike ethanol, ETBE can be added to gasoline at the refinery, reducing transportation risks and costs. It also has a higher octane rating than ethanol and burns more cleanly. Groundwater contamination risk would arise if underground gasoline storage tanks were to leak; however, ETBE has only about one-quarter the solubility of MTBE and therefore should present less of a groundwater risk than MTBE presented in the past. Moreover, EPA's tank integrity program has made significant strides; MTBE leak detections reached a high in the early 1990s, then declined precipitously, according to EPA and USGS data. Before Phase II becomes effective, underground tank integrity will have further improved. Nevertheless, among the factors EPA must weigh are ETBE storage and handling issues.

An important benefit of a supplemental aromatics rule is that even a Phase I aromatics rollback of 20 percent would reduce benzene emissions much more than is contemplated by the proposed MSAT rule. Benzene reductions would be twice the level achieved by the proposed

rule. If EPA were to do a complete benefit-cost analysis of reducing total aromatics by at least 20 percent, it would find this approach to be superior to the one proposed in the MSAT rule making. We recommend replacing the currently proposed rule with an Aromatics MSAT Rule. EPA's proposed benzene reduction goal is too modest: it merely would extend the benzene reduction level already required in reformulated gasoline to the rest of the nation's gasoline supply and thereby reduce benzene emissions by a mere 16,000 tons in 2015. It is even more telling that in the fifteen years the MSAT provision has been in the Clean Air Act, in its proposed MSAT rule, EPA is only attempting to reduce total aromatics emissions by less than one percent. A rule that reduces total air toxics one percent does not begin to meet the statutory standard. Even with respect to benzene alone, the reductions that EPA seeks are only about 10 percent.

In sum, the potential benefits of aromatics controls include:

- reductions in toxic mobile emissions, PM<sub>2.5</sub>, and ozone in the nation's most polluted urban areas;
- fairer sharing of the burden of air quality improvement;
- support for the Energy Policy Act renewable fuels mandate and the President's emphasis on alternative fuels;
- a greater measure of energy independence; and
- reduction of trade deficits and agricultural price supports.

## **II. EPA's Regulatory Authority and Request for Comment**

The requirement for EPA to carry out rule making to reduce toxic emissions from mobile sources goes back to the Clean Air Act Amendments of 1990 (§202(l)). Congress required regulations to contain "reasonable requirements to control hazardous air pollutants from motor vehicle fuels" through "standards for such fuels or vehicles, or both, which the Administrator determines reflect *the greatest degree of emissions reduction achievable through the application*

*of technology which will be available*, taking into consideration the availability and costs of the technology, and noise, energy, and safety factors, and lead time.” (emphasis added) This requirement does not mandate the least costly degree of emission reduction; rather, it mandates the greatest degree of reduction possible, taking costs and other factors into account. Note also that the provision is “technology-forcing” because it requires, not just the best current technology can do today, but the best that it can do in the future.

Aside from its general mandate to require the greatest degree of achievable MSAT reductions, the Clean Air Act also specifically mandates that EPA’s regulations must, “at a minimum, apply to emissions of benzene” as well as formaldehyde. CAA § 202(l). Because the engine combustion of toluene and xylene in motor vehicles also produces benzene emissions, EPA’s failure to reduce the toluene and xylene content in gasoline is not consistent with this specific mandate, which applies to benzene emissions, not to benzene content.

It is quite clear that by electing to seek a reduction in benzene content alone, EPA has not satisfied its statutory mandate to impose the maximum degree of achievable MSAT emissions reductions. The history of EPA’s tardy implementation of the MSAT requirement is detailed in Appendix A. Taken together, toluene and xylene account for more than half of all MSAT emissions and more than five times the emissions of benzene alone. Achieving the maximum degree of MSAT emissions reductions cannot occur if toluene and xylene emissions are not regulated.

The Preamble of EPA’s proposed revised Mobile Source Air Toxics (MSAT) Rule contains a highly significant request for “comment on the potential benefits, costs, and other implications of aromatics controls for consideration in the future.” While EPA reaches the right conclusion, *i.e.*, that public comment is warranted, it still focuses almost exclusively on

additional reductions in the benzene content of gasoline and identifies several hurdles that it believes would need to be surmounted before stronger controls on gasoline aromatics could be finalized.

In fact, EPA's discussion of aromatics controls makes it appear not only that the Clean Air Act's MSAT provision calls for benzene fuel content reductions alone, but also that the law requires EPA to limit its analysis to the costs and benefits of achieving benzene controls alone. This interpretation of the Clean Air Act is too narrow. The Act clearly states that while benzene must "at a minimum" be controlled, all toxics in gasoline are to be reduced "to the greatest degree . . . achievable" by existing and expected technology. (*See Appendix A*) Thus, EPA has ignored its statutory obligation to examine all the costs and benefits of reducing gasoline aromatics.

Because of EPA's narrow focus on benzene, the potential benefits of controlling other air toxics like xylene and toluene to combat fine particulates and ozone did not receive the attention they deserve in the proposed MSAT rule. Instead, the burden of solving the fine particulate and ozone problems will continue to fall on the states and businesses that are subject to State Implementation Plans under the Clean Air Act. In addition, new ambient PM<sub>2.5</sub> controls will throw even more counties into nonattainment status for PM<sub>2.5</sub>.

The EPA's MSAT proposal also states that reducing aromatics generally is not the most cost-effective way to "reduce benzene levels."<sup>13</sup> Direct benzene reductions may or may not be

---

<sup>13</sup> EPA says an aromatics-based approach to reducing benzene levels from .97 to .62 percent of gasoline (its current proposal) would be five times as expensive as imposing direct benzene cuts. But EPA's analysis appears to be based entirely on a 1993 Regulatory Impact Analysis (RIA) that was prepared when oil was \$17 a barrel. EPA should at a minimum redo its analysis, taking into account today's oil prices, and the greater availability of ethanol. But even based on the outdated EPA analysis, the wider benefits of toxics, PM<sub>2.5</sub>, ozone, CO, and CO<sub>2</sub> reductions would overwhelm even EPA's flawed choice of direct benzene reductions.

the most cost-effective strategy to reduce benzene emissions. EPA also needs to look carefully at the fact that reducing toluene and xylene will indirectly cause additional reductions in benzene, because their combustion forms quantities of benzene. The point we cannot stress too strongly is that EPA must consider the enormous benefits of overall toxics reductions, which would include greater benzene reductions, fine particulate reductions, ozone reductions, and even greenhouse gas reductions that an aromatics-oriented MSAT rule could achieve.

A benefit-cost analysis that took total health benefits into account would almost certainly show the overwhelming desirability of greater aromatics reductions, as we develop more fully below. Fine particulate reductions alone would offer tens of billions of dollars of benefits, assuming EPA's PM<sub>2.5</sub> health risk estimates are correct. Several months ago, EPA stated that aromatics are considered to be the most significant gaseous precursors of carbon-based PM<sub>2.5</sub>. Gasoline aromatics are carbon-based, and carbon-based PM<sub>2.5</sub> appears to be more dangerous to public health than the sulfur and nitrogen aerosols associated with stationary source and automobile emissions. Even if EPA's PM<sub>2.5</sub> health effects predictions are overstated, the benefits from reducing fuel aromatics will still be very substantial. EPA's Regulatory Impact Analysis (RIA) on the currently proposed MSAT rule completely neglected to assess the overall benefits and costs of alternative levels of aromatics regulation. We have endeavored in this comment to point the way toward the analysis that should now be done.

A proper analysis of costs, benefits, and health risks would also have to reflect the fact that octane will be available at no additional cost through cleaner-burning components from renewable sources required by the renewable fuels standard (RFS) in the new Energy Policy Act of 2005 – fuels that increase crop prices and reduce the cost to the government of agricultural commodity price supports, which are a sticking point in international trade negotiations.

Moreover, benzene, toluene, xylene, and other aromatics would be available for chemical industry markets at lower prices. Demand for benzene in the chemicals market is expected to increase, as it has for some years. Toluene and xylene, which together account for over half of all hazardous emissions from onroad and nonroad vehicles, were each selling recently for over \$3.50 a gallon, which is more than benzene commands in the marketplace. At the same time, ethanol is cheaper than both benzene and these other aromatics. EPA must take all of these factors into account.

EPA's discussion of regulating aromatics through the MSAT rule clearly shows the agency's need to consult broadly and to be more transparent in stating how it reaches its conclusions. Its assertions in the proposed MSAT rule are at times unsupported, self-contradictory, and wrong. For example, EPA argues that controlling aromatics is too expensive and inefficient a means of reducing benzene, because replacing the octane loss is too difficult and costly. Yet the only way this assertion could possibly be supported is by using fuel component prices that are egregiously out of date at a time when the price of crude oil has remained above \$50 a barrel for the past year.<sup>14</sup> In other words, the agency is wrong about the price of octane replacement. EPA does acknowledge that "given the mandate for ethanol use and the cost associated with it, refiners can reduce their refining costs by further reducing aromatics." Thus, EPA implicitly acknowledges that the RFS will supply abundant octane that the refiners can use to offset octane losses from aromatics reductions.

EPA warns that ethanol and ETBE would increase emissions of aldehydes. Yet to be consistent, EPA should examine the total picture if aromatics were strictly controlled. The

---

<sup>14</sup> See Energy Economics Newsletter, Crude Oil Spot Prices, May 2, 2005 through May 26, 2006, available at [http://www.wtrg.com/daily/oiland\\_gasspot.html](http://www.wtrg.com/daily/oiland_gasspot.html).

overall benefits of an aromatics component to the MSAT rule, which EPA said is a “synergistic match” with the RFS, would certainly overwhelm the costs. Aldehyde health risks are not as substantial as the risks posed by PM, ozone, and other toxics. Further, reductions in aldehyde emissions could be achieved through improvements in the catalytic converter that would substantially reduce emissions and therefore health costs.

To support its request for comment on aromatics controls, EPA discards its prior finding that a large share of organic fine particulates – the precursors of the most dangerous PM<sub>2.5</sub> and ozone – can be traced back to high levels of toluene and xylene in gasoline. EPA states that it is trying to understand better the full significance of the mobile source contribution to total secondary fine particulate aerosols (SOA). In November 2005, EPA stated that “aromatic compounds such as toluene, xylene, and trimethyl benzene are considered to be the most significant anthropogenic SOA (secondary organic aerosol) precursors.”<sup>15</sup> It said aromatic compounds “have been estimated to be responsible for 50 to 70 percent of SOA in some airsheds.”<sup>16</sup> EPA acknowledges it has not caught up with the significant implications of reducing organic aerosols: “our current modeling tools do not fully reflect this.” One of EPA’s most recent studies, not yet published, suggests that aromatic hydrocarbon emissions, especially toluene, contribute to SOA at levels as low as 0.7 micrograms per cubic meter of urban air.

(Others think the number may be as high as 2 micrograms.) In terms of health and air quality,

---

<sup>15</sup> See Proposed Rule To Implement the Fine Particle National Ambient Air Quality Standards, 70 Fed. Reg at 65,995, 65,996 (“Proposed PM<sub>2.5</sub> Implementation Rule”) (citing D. Grosjean & J.H. Seinfeld, *Parameterization of the Formation Potential of Secondary Organic Aerosols*, 23 Atmospheric Env’t 1733 (1989)).

<sup>16</sup> *Id.* at 65,996 (“The experimental work of Odum and others showed that the secondary organic aerosol formation potential of gasoline could be accounted for solely in terms of its aromatic fraction.”). EPA has raised questions about natural contributions to secondary organic aerosols (SOA), but this is likely to be relevant only in the south, where turpenes from pine trees may be a confounding factor.

this means that if we accept as given current estimates of the health benefits to be obtained by reducing fine particulates, the benefit to America's health may be valued at over \$100 billion. Even if EPA's PM<sub>2.5</sub> benefits estimate is flawed and overstated, the benefits of an expanded MSAT rule *for fine particulates alone* may be tens of billions of dollars (*See* IV. A. 1 (b)(ii) below). Given these potential benefits of controlling aromatics in gasoline, the aromatic contribution to SOA justifies both immediate action and further research by EPA. It is unconscionable to leave billions of dollars of health benefits unclaimed.

### **III. Reducing Aromatics in Gasoline is Technically Feasible and Cost-effective**

Aromatics are used principally to provide the octane needed in finished gasoline.<sup>17</sup> Aromatics, however, increase VOC, NO<sub>x</sub>, and CO (carbon monoxide) emissions, as well as benzene emissions.

The aromatic content of gasoline can be estimated from various fuel surveys. Chart 1 compares the results of three such surveys conducted from 2003 to 2005. As Chart 1 illustrates, aromatics in gasoline comprise about 26 percent of the total gasoline pool on an annual average. The aromatic content of winter gasoline grades is generally lower than in summer grades by three to four percent, because of the addition of about 8 to 10 percent butane in the higher RVP (Reid Vapor Pressure) gasolines.

---

<sup>17</sup> When lead was used as the major octane source, aromatic levels in gasoline averaged about 20 percent. Aromatic levels in gasoline increased as lead was phased out, with peak levels being about 32 percent in the late 1980s.

## CHART 1

|                                   | National Average Gasoline Surveys |               |               |                        |               |               |
|-----------------------------------|-----------------------------------|---------------|---------------|------------------------|---------------|---------------|
|                                   | <u>Percent Aromatics</u>          |               |               | <u>Percent Benzene</u> |               |               |
|                                   | <u>Summer</u>                     | <u>Winter</u> | <u>Yr Avg</u> | <u>Summer</u>          | <u>Winter</u> | <u>Yr Avg</u> |
| EPA RFG Fuel Survey 2003          | 26.0                              | 23.5          | 24.8          | 1.00                   | 0.98          | 0.99          |
| Automaker AAM Survey 2004         | 27.6                              | NA            | NA            | 1.0                    | NA            | NA            |
| Northrop Grumman Fuel Survey 2005 | 27.6                              | 23.7          | 25.7          | 1.05                   | 1.04          | 1.05          |

Aromatics in gasoline come from two sources. About 80 percent of aromatics (comprising 20 percent of the finished gasoline) occur naturally in crude oil (these may be called “naturally occurring aromatics”). However, refiners also manufacture aromatics during reformer operations in order to add octane to the fuel (these may be called “discretionary aromatics”). About 20 percent of the aromatics found in today’s gasoline pool (comprising 5 percent of the finished gasoline) are discretionary aromatics and are added strictly to boost octane levels.

Yet other sources of octane are readily available. Oxygenates have been used for more than 25 years to add octane to gasoline. In the reformulated gasoline (RFG) program, oxygenates have significantly lowered aromatic levels as well as toxic emissions.

### **A. Reducing Aromatics in Gasoline is Cost-effective**

EPA notes in the proposed MSAT Rule that replacing aromatics with oxygenates has only been cost-effective for refiners when federal or state regulations require the use of oxygenates. This may have been true when crude oil was \$20 a barrel and the price of ethanol was \$1.00 a gallon, but it is no longer the case. In its 2006 Annual Energy Outlook, the Energy Information Administration (EIA) raised the forecasted price of crude oil to \$50-60 a barrel. Today, the actual price is closer to \$70 per barrel. Corn prices, however, are projected to remain

stable at roughly \$2.00 a bushel. The cost of ethanol is expected to stabilize at about \$1.20 per gallon, equivalent in energy terms to gasoline at \$1.80 a gallon.<sup>18</sup>

The cost of producing aromatics in gasoline is now considerably higher than the cost of producing ethanol on a dollar per volume basis. To illustrate the changed relationship between oil and ethanol, the history and forecasted price of crude oil, gasoline, and ethanol are shown in Chart 2 below. The cost of aromatics is shown as a premium cost above the cost of gasoline.

As shown in Chart 2, in the 1990s the total cost of ethanol was considerably higher than the cost of both conventional gasoline and aromatics, which required the federal government to provide refiners with a federal tax credit to make ethanol competitive.<sup>19</sup> With crude oil prices now above \$60 per barrel, the cost of ethanol, as a blended fueling agent is at least \$0.40 per gallon less than the equivalent volume of aromatics. It is at least \$0.90 per gallon cheaper than aromatics for the refiners when the federal subsidy is applied (\$0.51 per gallon). Based on EIA's forecast of oil prices remaining above \$50 per barrel, the cost advantage shrinks, but does not disappear over the next 10 years.

With oil company profits at record highs, refiners have the cash reserves and the profit incentive to invest in the changes in refinery operations needed to use aromatic octane replacements such as lower-cost biofuels. Adding renewable oxygenates will also significantly

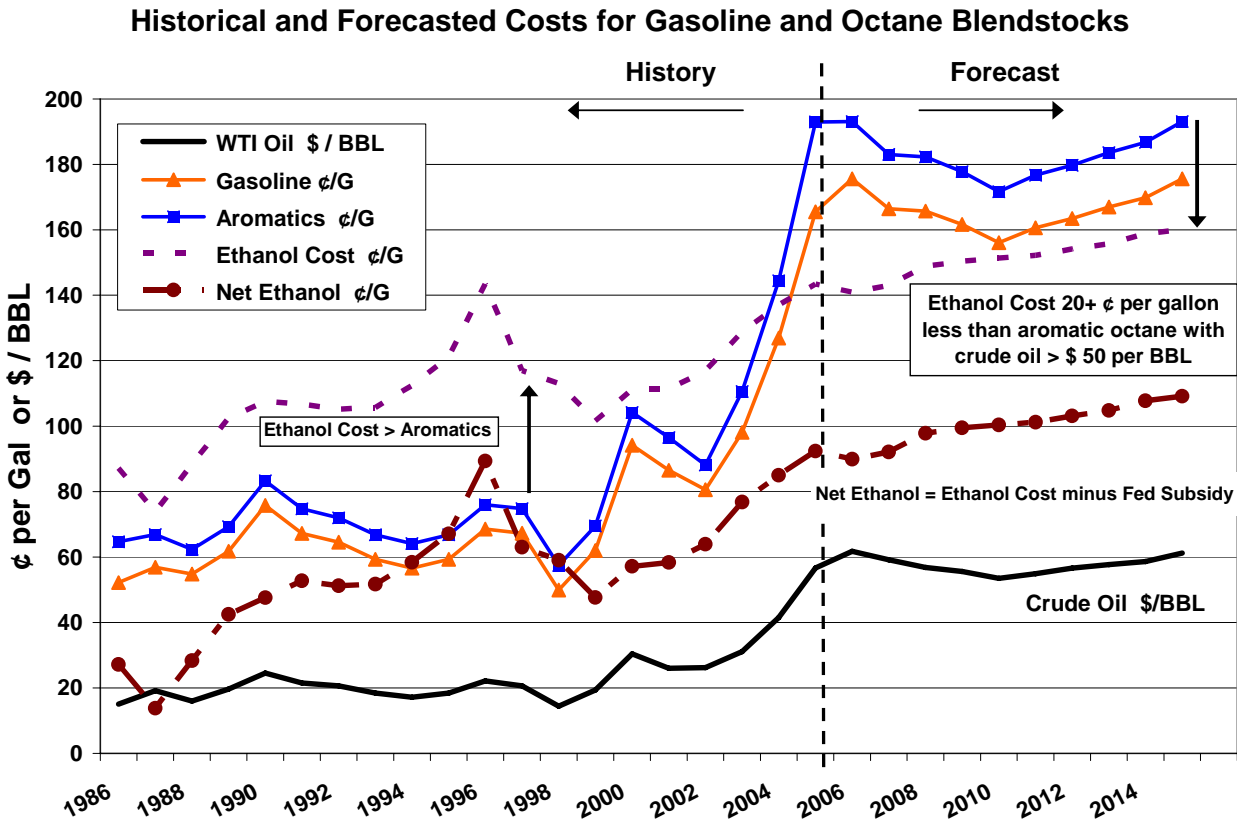
---

<sup>18</sup> Because recent demand has pressured supply, ethanol prices have fluctuated. With more production capacity coming on line, the price is expected to stabilize. The Energy Information Administration projects that the cost of corn-based ethanol in 2012 will be about \$1.20. See <http://www.eia.doe.gov/oiaf/aeo/conf/pdf/kydes.pdf>. This estimate is consistent with the USDA National Renewable Energy Laboratory (NREL) 2000 cost estimate of \$.88 gallon, when the cost is adjusted for increased natural gas prices. See <http://devafdc.nrel.gov/pdfs/4898.pdf>.

<sup>19</sup> Gasoline marketers and blenders that used a 10 percent ethanol blend were eligible for up to a 5.4 cent per gallon reduction from the federal excise tax on gasoline of 18.3 cents/gallon. The American Jobs Creation Act of 2004 replaced this system with a Volumetric Ethanol Excise Tax Credit of 51 cents per gallon on each gallon of ethanol blended with gasoline.

expand domestic gasoline supplies, which will partially ease the need to expand crude oil refining capacity.

**CHART 2**



**B. Adequate Supplies of Ethanol Will Be Available to Replace Octane Lost Through Reducing Aromatics in Gasoline**

Although the Energy Policy Act of 2005 contains a Renewable Fuels Standard (RFS) that will require refiners to blend renewable fuels equivalent to 7.5 billion gallons of ethanol per year by 2012, the ethanol industry is ramping up its production capacity to far greater levels. Current projections suggest that there may be as much as 14 billion gallons per year or more of ethanol available as early as 2010.<sup>20</sup> As Chart 3 illustrates, ethanol production capacity has grown over

<sup>20</sup> Jim Jordan & Associates, Fuels Blendstock Report (May 5, 2006).

40 percent in just the past six months. In addition to the potentially large domestic ethanol capacity, the Caribbean Basin Initiative would potentially allow another 900 million gallons per year of ethanol to enter the US without an import duty. This would make available a total of 15 billion gallons per year of ethanol in 2010, which is nearly equal to 10 percent of the expected gasoline demand in 2010.

**CHART 3**

| <b>US Ethanol Capacity Projections</b> |                            |                        |
|--|----------------------------|------------------------|
|  | <b>Billion Gals / Year</b> |                        |
|  | <b><u>Oct 2005</u></b>     | <b><u>May 2006</u></b> |
| Existing                               | 4,115                      | 4,724                  |
| Building                               | 1,152                      | 2,780                  |
| Probable                               | 2,558                      | 3,919                  |
| Less Certain                           | <u>2,138</u>               | <u>2,828</u>           |
| <b>Total</b>                           | <b>9,963</b>               | <b>14,251</b>          |
| <b>Percent Increase</b>                |                            | <b>43%</b>             |

**C. Reducing Aromatics in Gasoline is Technically Feasible**

As discussed above, an economic incentive now exists for replacing aromatics in gasoline with lower-cost renewable octane sources. It is also technically feasible to do so, particularly for the discretionary aromatics, i.e., those produced during the reforming process. While the remaining “natural” aromatics are not easily removed from gasoline, they can be diluted by using additional clean blend-stocks (such as renewable oxygenates and natural gasolines).

The purpose of the reformer unit is to convert long-chain hydrocarbons (C6 to C11) into aromatic high-octane components. As the reformer converts the feed hydrocarbons to aromatics, hydrogen and light gases are produced as byproducts. The liquid product, known as reformate, is

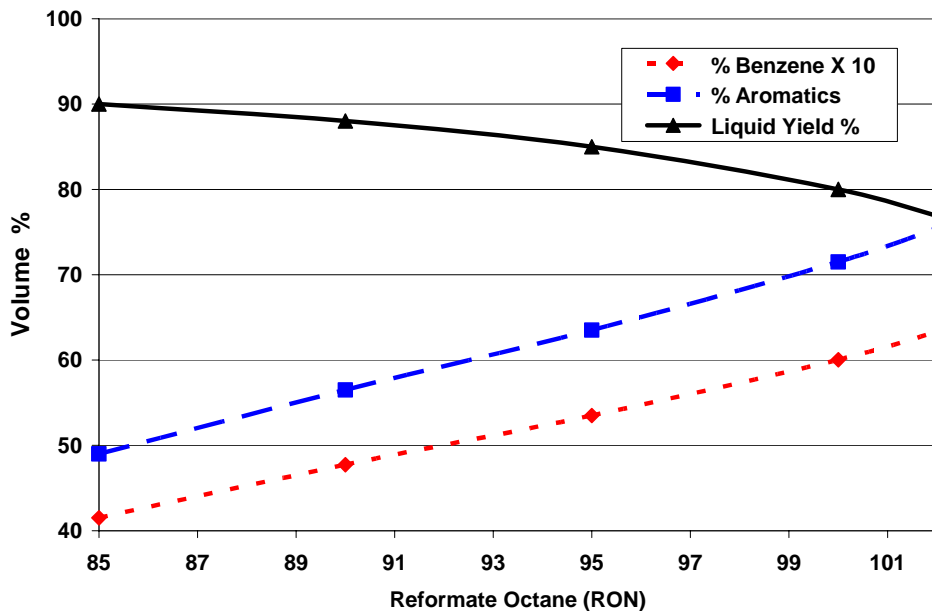
blended into gasoline or is sent to the aromatics extraction unit, where the aromatic compounds are separated from the rest of the hydrocarbons so that they can be sold in the chemical markets.

The discretionary aromatics are produced in the reformer as the refiner increases the reformat product RON (research octane number) from 85 to as high as 100, or even to 102.5 in some cases. The aromatics contained in reformat that is below 85 RON are mostly those made from the natural ring structures that are already in the naphtha feed to the reformer. Chart 4 illustrates a typical reformat aromatic content as a function of the reformat RON. Benzene is part of the aromatic production in the reformer operation and decreases as the reformat RON is reduced. (Note that the chart multiplies the reformat benzene content by a factor of 10 to make it easier to read on the scale.) Benzene production in the reformer represents a very substantial portion of the benzene in the gasoline pool; thus any decrease in the production of aromatics will cause a significant reduction of benzene in the gasoline pool. Chart 4 also illustrates the typical loss in liquid volume yield as more high-octane aromatics are created in the reformat product. The loss of liquid volume occurs when some of hydrocarbon molecules are cracked to smaller “light end” gases, and also from the hydrogen given off when making the benzene ring structure in the aromatics.

Eliminating the discretionary aromatics from gasoline is a simple function of maintaining the RON at 85.

CHART 4

Reformate Yields & Aromatic Content



**D. Aromatic Reductions With Renewable Oxygenates**

EPA’s Regulatory Impact Analysis for the proposed MSAT Rule examines the feasibility of recovering octane lost from benzene reductions. EPA notes that “[e]thanol’s very high octane number, which is 115 octane numbers, allows making up octane loss using a smaller volume than other blendstocks” and that “ethanol is an economical source of octane.”<sup>21</sup>

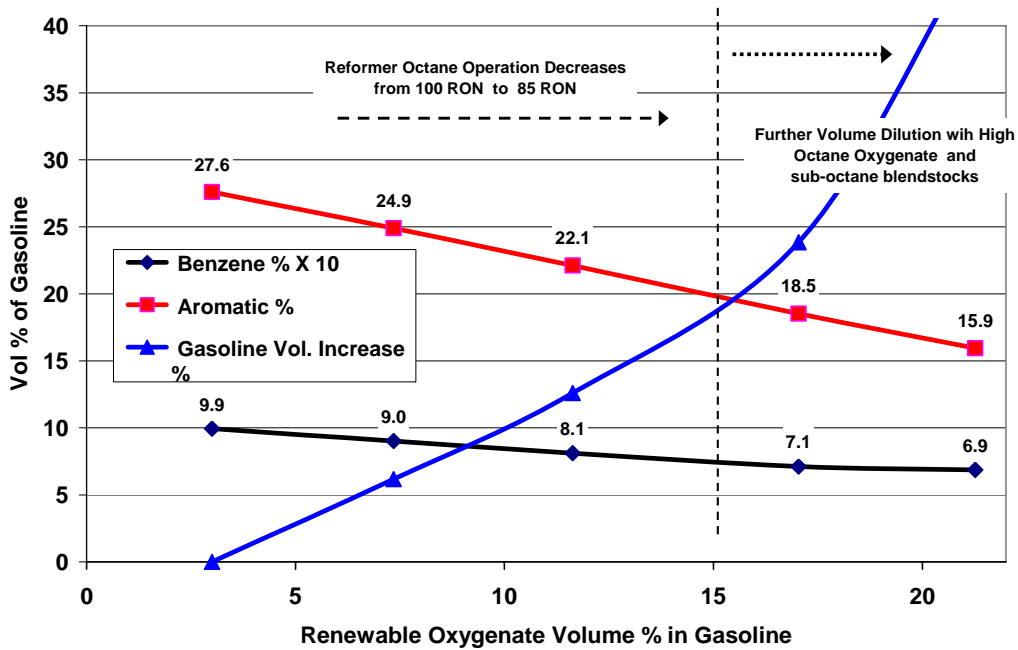
The US gasoline pool currently contains about three percent oxygenates by volume. Chart 5 illustrates the reduction in aromatics and benzene that can be potentially achieved by adding renewable fuels. The chart also demonstrates that the total gasoline supply is expanded

<sup>21</sup> EPA, Draft Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources, EPA 420-D-06-004 (Feb. 2006) at 6-58, available at <http://www.epa.gov/otaq/regs/toxics/chapter6.pdf>.

as the renewable fuel content of gasoline is increased. The chart is based on summertime averages, beginning with an average aromatic content of 27.6 percent by volume.

**CHART 5**

**Benzene & Aromatic Reduction with Renewable Oxygenates**



Note: benzene content has been multiplied by a factor of 10 to ease of reading the scale.

As Chart 5 demonstrates, raising the oxygenate level from the current 3 percent by volume of gasoline to about 12 percent can lower the summer aromatic content from 27.6 to about 22 percent. The benzene content of gasoline is similarly lowered from about 1 percent to about 0.8 percent. The total volume of gasoline is increased 7 percent.

Because gasoline is limited to 3.5 weight percent oxygen, about 10 percent ethanol can be blended into gasoline. To add more than 10 percent renewable oxygenate to gasoline under current law, some of the ethanol would have to be converted to a bio-ether, which is also a high octane, low-vapor-pressure, renewable oxygenate. Bio-ethers are created by combining butane, derived from natural gas liquids (NGLs), with ethanol. Bio-ethers could reduce the aromatic

content of gasoline to 18.5 percent and expand gasoline supplies as much as 13 percent compared to today, or about 10 percent on a gasoline energy-equivalent basis, since renewable oxygenates have a lower energy content than gasoline or aromatics.

#### **IV. The Benefits and Costs of Reducing Aromatics in Gasoline**

##### **A. The Benefits**

##### **1. Air Quality Benefits**

##### **a. Air Toxics Reduction**

EPA estimates that by 2007, U.S. mobile sources will be emitting 1.34 million tons of air toxics, about 40 percent lower than the 2.25 million tons emitted in 1996.<sup>22</sup> Toluene and xylene account for 60 percent of the total projected emissions (over 800,000 tons). However, these estimates may be overly optimistic.

In its 1996 air toxics assessment that was just released in February 2006, EPA estimates that approximately 110 million people live in areas of the U.S. where the combined upper-bound

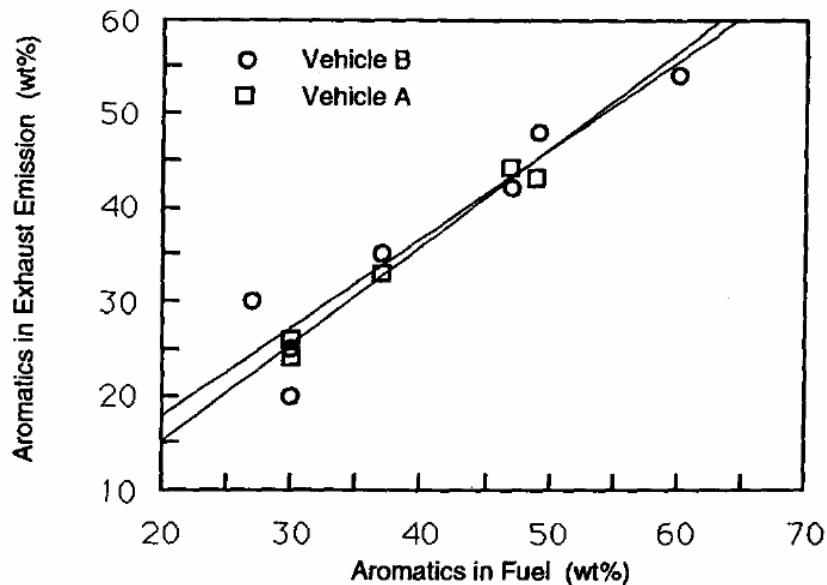
---

<sup>22</sup> See William Battye, U.S. EPA, Pub. No. EPA420-R-01-038, *The Projection of Mobile Source Air Toxics From 1996 To 2007: Emissions And Concentrations (Draft) 22* (Aug. 2001), available at, <http://www.epa.gov/otaq/regs/toxics/r01038.pdf>; EPA Technology Transfer Network National Air Toxics Assessment, Air Toxics Reduction, <http://www.epa.gov/ttn/atw/nata/natsatr.html> (citing Battye). Cf. EPA, Technology Transfer Network National Air Toxics Assessment, Summary of Results, <http://www.epa.gov/ttn/atw/nata/risksum.html>. The Battye projections take into account the effects of the RFG program, Tier 2, and other “regulatory programs which are projected to impact on HAP emissions in 2007,” but not regulations that will reduce diesel emissions beginning in 2007. The diesel regulations will not have a major effect on HAP emissions levels (except, of course, for emissions of diesel PM (which is classified as a HAP)). See, e.g., *id.* at 23 (in 1996, onroad benzene emissions from diesel vehicles were about two percent of total onroad benzene emissions; in 2007, diesel share is expected to be under four percent); *id.* at 26 (1996 nonroad diesel emissions were about ten percent of total; in 2007, diesel share is expected to be about eight percent); Control of Emissions of Hazardous Air Pollutants from Mobile Sources, 65 Fed. Reg. 48,058, 48,077 (Aug. 4, 2000) (to be codified at 40 C.F.R. pts. 80 & 86) (“Benzene is also emitted from diesel engines, but at levels approximately one-fortieth of that coming from gasoline vehicles.”).

lifetime cancer risk from all air toxics compounds exceeds 10 in a million.<sup>23</sup> This is 10 times greater than EPA's generally accepted cancer risk of one in one million.

Chart 6 demonstrates that there is a strong correlation between the aromatic content of gasoline and aromatic VOC exhaust emissions. Thus, reducing the aromatic content of gasoline would have a direct effect on reducing aromatic VOC emissions, which are both toxic air pollutants and precursors to the formation of fine particulate matter.

**CHART 6<sup>24</sup>**



**Fig. 9 Relationship between the Aromatics in Fuels and in Exhaust Emissions (Correlation Factor A=0.939, B=0.986)**

EPA estimates that its proposed 0.62 percent benzene cap will reduce benzene emissions by about 16,000 tons.<sup>25</sup> Yet using the RFG Complex Model to estimate emission changes, an

<sup>23</sup> See 1999 National-Scale Assessment, Summary of Results, available at <http://www.epa.gov/ttn/atw/nata1999/risksum.html>.

<sup>24</sup> Satoshi Yamazaki and Shuichi Kubo, Takehisa Yaegashi, Toshiaki, and Katsuji Otsubo (Toyota Motor), E. Robert Fanick (SwRI). Effects of the Gasoline Composition and Emission Control Systems on Exhaust HC Emissions, SAE Paper 92218

Aromatics MSAT rule that reduces the aromatic content of gasoline to 22 percent by 2010 will reduce annual benzene emissions far more than EPA's proposed rule. Chart 7 below shows the results of running the Complex Model (on behalf of the Energy Future Coalition) for two aromatic reduction scenarios for summertime gasoline compared to 2005 averages. Case 1 illustrates air quality gains that can be achieved if aromatics are reduced 20 percent, to a level of 22 percent in gasoline; Case 2 illustrates the benefits of reducing aromatics 33 percent, to a level of 18.5 percent in gasoline.

The model results show that benzene emissions decrease by about 25 percent for Case 1 and almost 30 percent for Case 2. Because of the improved distillation properties of the gasoline and the aromatic reduction, there is also a decrease in ozone precursors. Total VOCs decrease 3 percent for Case 1 and 4 percent for Case 2. NOx emissions similarly decrease by 1.7 percent and by 3 percent for each scenario respectively. CO emissions decrease by 10 percent for Case 1 and by 12 percent for Case 2. Aromatic VOCs (estimated from Chart 6 above) decrease by about 22 percent for Case 1 and by about 36 percent for Case 2.

---

*(footnote continued from previous page)*

<sup>25</sup> EPA, Draft Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources, EPA 420-D-06-004 (Feb. 2006) at 2-56, available at <http://www.epa.gov/otaq/regs/toxics/chapter2.pdf>.

### CHART 7

| Summer Fuel Properties & RFG Emissions Estimates |                          |                         |                            |                              | <u>Percent Reductions</u>  |                              |
|--|--------------------------|-------------------------|----------------------------|------------------------------|----------------------------|------------------------------|
| <u>Fuel Properties</u>                           | 1990<br>Baseline<br>Fuel | 2005<br>Fuel<br>Average | Case 1<br>22%<br>Aromatics | Case 2<br>18.5%<br>Aromatics | Case 1<br>22%<br>Aromatics | Case 2<br>18.5%<br>Aromatics |
| MTBE (wt% oxygen)                                | 0                        | 0.3                     |                            |                              |                            |                              |
| ETBE (wt% oxygen)                                | 0                        |                         | 0.42                       | 1.8                          |                            |                              |
| Ethanol (wt% oxygen)                             | 0                        | 0.5                     | 3.08                       | 1.7                          |                            |                              |
| SULFUR (ppm)                                     | 339                      | 30                      | 30                         | 30                           |                            |                              |
| RVP (psi)  | 8.7                      | 7.9                     | 7.9                        | 7.9                          |                            |                              |
| E200 (%)   | 41                       | 48.5                    | 52.7                       | 54.9                         |                            |                              |
| E300 (%)   | 83                       | 82.6                    | 84                         | 84.8                         |                            |                              |
| T50  | 218                      | 203                     | 194                        | 190                          |                            |                              |
| T90  | 329                      | 331                     | 325                        | 321                          |                            |                              |
| AROMATICS (vol%)                                 | 32                       | 27.6                    | 22.1                       | 18.5                         | 19.9%                      | 33.0%                        |
| OLEFINS (vol%)                                   | 9.2                      | 9.7                     | 8.9                        | 8.5                          |                            |                              |
| BENZENE (vol%)                                   | 1.53                     | 0.99                    | 0.81                       | 0.71                         | 18.2%                      | 28.3%                        |
| <b><u>Emissions</u></b>                          | <b><u>mg / mi</u></b>    | <b><u>mg / mi</u></b>   | <b><u>mg / mi</u></b>      | <b><u>mg / mi</u></b>        |                            |                              |
| Exhaust VOC                                      | 907.0                    | 787.8                   | 750.4                      | 736.4                        | 4.7%                       | 6.5%                         |
| Nonexhaust VOC                                   | <u>559.3</u>             | <u>419.7</u>            | <u>419.7</u>               | <u>419.7</u>                 |                            |                              |
| <b>Total VOC</b>                                 | 1466.3                   | 1207.5                  | 1170.1                     | 1156.0                       | 3.1%                       | 4.3%                         |
| Exhaust benzene                                  | 53.5                     | 35.9                    | 27.0                       | 24.8                         | 24.7%                      | 31.0%                        |
| Nonexhaust benzene                               | 6.2                      | 3.3                     | 2.7                        | 2.4                          | 17.2%                      | 27.4%                        |
| Acetaldehyde                                     | 4.4                      | 4.7                     | 10.4                       | 11.5                         | -122.6%                    | -146.8%                      |
| Formaldehyde                                     | 9.7                      | 10.1                    | 10.4                       | 10.6                         | -2.5%                      | -5.1%                        |
| Butadiene  | 9.4                      | 8.8                     | 7.6                        | 7.5                          | 13.2%                      | 15.4%                        |
| POM  | <u>3.0</u>               | <u>2.6</u>              | <u>2.5</u>                 | <u>2.5</u>                   | 4.7%                       | 6.5%                         |
| <b>Total exhaust toxics</b>                      | <u>80.1</u>              | <u>62.1</u>             | <u>57.9</u>                | <u>56.8</u>                  | 6.7%                       | 8.5%                         |
| <b>Total toxics</b>                              | 86.3                     | 65.4                    | 60.6                       | 59.2                         | 7.3%                       | 9.5%                         |
| <b>NOx</b>                                       | 1340.0                   | 1185.1                  | 1164.6                     | 1149.8                       | 1.7%                       | 3.0%                         |
| <b>CO</b>  | 11600.0                  | 9450.3                  | 8503.2                     | 8322.7                       | 10.0%                      | 11.9%                        |
| <b>Aromatic VOCs (est.)</b>                      | 422                      | 300                     | 233                        | 192                          | 22.4%                      | 35.8%                        |

Chart 8 below translates the percent emissions reductions achieved by reducing the aromatic content of gasoline into annual emissions tons. The inventory source emission estimates for 2010 are taken from the RIA for the proposed MSAT Rule. See RIA at 2-36 and 2-41.

### CHART 8

2010 Highway and Nonroad Air Toxic and Other Pollutants (Tons/year)

| <u>Toxics and Other Aromatics</u> | <u>Inventory Source</u> |                |                | <u>Reduction %</u> |               | <u>Reductions (Tons)</u> |                |
|-----------------------------------|-------------------------|----------------|----------------|--------------------|---------------|--------------------------|----------------|
|                                   | <u>Highway</u>          | <u>Nonroad</u> | <u>Total</u>   | <u>Case 1</u>      | <u>Case 2</u> | <u>Case 1</u>            | <u>Case 2</u>  |
| Formaldehyde (C1)                 | 32,240                  | 41,214         | 73,454         |                    |               |                          |                |
| Acetaldehyde (C2)                 | 13,909                  | 17,390         | 31,299         |                    |               |                          |                |
| Benzene (C6)                      | 79,550                  | 46,951         | 126,501        | 24.7%              | 31.0%         | 31,247                   | 39,189         |
| 1,3 Butadiene                     | 8,807                   | 6,799          |                |                    |               |                          |                |
| POM                               | 228                     | 302            |                |                    |               |                          |                |
| <b>Air Toxics - RFG Controls</b>  | <b>134,734</b>          | <b>112,656</b> | <b>231,254</b> | <b>7.3%</b>        | <b>9.5%</b>   | <b>16,882</b>            | <b>21,969</b>  |
| Toluene (C7)                      | 196,528                 | 173,428        | 369,956        |                    |               |                          |                |
| Ethylbenzene (C8)                 | 30,838                  | 32,395         | 63,233         |                    |               |                          |                |
| Xylenes (C8)                      | 115,004                 | 140,968        | 255,972        |                    |               |                          |                |
| <b>Air Toxics Other Aromatics</b> | <b>342,370</b>          | <b>346,791</b> | <b>689,161</b> | <b>22.4%</b>       | <b>35.8%</b>  | <b>154,421</b>           | <b>246,910</b> |
| C9 aromatics                      | 57,502                  | 70,484         | 127,986        |                    |               |                          |                |
| C10 aromatics                     | 57,502                  | 70,484         | 127,986        |                    |               |                          |                |
| <b>Total C7+ aromatics</b>        | <b>457,374</b>          | <b>487,759</b> | <b>945,133</b> | <b>22.4%</b>       | <b>35.8%</b>  | <b>211,777</b>           | <b>338,619</b> |
| <b>SOA Estimates (PM OC)</b>      |                         |                | <b>68,916</b>  | <b>22.4%</b>       | <b>35.8%</b>  | <b>15,442</b>            | <b>24,691</b>  |

As Chart 8 shows, reducing the aromatic content of gasoline to 22 percent by 2010 will reduce benzene emissions by about 32,000 tons. This is two times the benzene emissions reductions EPA hopes to achieve in its proposed MSAT rule. Further reducing aromatics in gasoline to 18.5 percent by 2014 will reduce total annual benzene emissions by 39,189 tons.

Reducing the aromatic content of gasoline also has the added benefit of reducing other aromatic HAPs by an estimated 154,421 to 246,910 tons per year. These include toluene, ethylbenzene, and xylene. The total combined annual reduction of HAPs and aromatics (C9 and C10 aromatics) is estimated to be 211,777 to 338,619 tons.

Significant health benefits can be achieved by reducing HAP emissions by lowering the aromatic content of gasoline. While EPA does not quantify the benefits of reducing benzene or other HAPs in the proposed rule on a per-ton basis, a rough estimate of \$48,000 per ton HAP reduction can be derived from previous EPA estimates of HAP reduction costs for stationary sources and adjusting them for mobile source exposure.<sup>26</sup> Using this estimate, reducing the aromatic content of gasoline to 22 percent would yield approximately \$8 billion in health benefits by 2010. Reducing aromatics to 18.5 percent in 2014 would yield approximately \$12 billion in health benefits.

### **b. Fine Particulate Matter Reduction**

Fine particulate matter (PM<sub>2.5</sub>) is mostly made up of ammonium salt aerosols (nitrates, and sulfates) and carbonaceous compounds (primary tailpipe carbon and secondary organic aerosols). Of these two groups, the carbonaceous PM compounds are considered to be much more toxic to the respiratory system than the inorganic salts (e.g., highly water-soluble fertilizers). Indeed, there is strong (and accumulating) evidence that high fine-particle

---

<sup>26</sup> This estimate presumes a 3:1 ratio between the potency of mobile-source emissions and that of stationary-source emissions in causing toxics exposures. The 3:1 ratio is derived from the Office of Management and Budget's decision to value mobile-source emissions of nitrogen oxide precursors to PM<sub>2.5</sub> at two to three times the value of stationary-source emissions. *See* Office of Mgmt. & Budget, *Validating Regulatory Analysis: 2005 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities* 99 app. B (Dec. 2005), available at [http://www.whitehouse.gov/omb/inforeg/2005\\_cb/final\\_2005\\_cb\\_report.pdf](http://www.whitehouse.gov/omb/inforeg/2005_cb/final_2005_cb_report.pdf) (valuing stationary-source reductions at \$370 to \$3,800 per ton and mobile-source reductions at \$1,100 to \$11,600 per ton); *id.* at 100 (explaining differences in estimates for mobile-source and stationary-source emissions). The report suggests caution in using this ratio for other purposes, arguably for purposes involving other NO<sub>x</sub> estimates; or perhaps estimates for PM precursors other than NO<sub>x</sub>. *See Id.* at 100 ("NO<sub>x</sub> benefit estimates are difficult to transfer to other applications, however. The location of reductions, reductions in other PM precursors, air chemistry, meteorology, emission release heights, baseline conditions, etc. can have dramatic effects on the relationship between NO<sub>x</sub> emission reductions and ambient PM concentrations. Further, the understanding of the atmospheric chemistry characterizing PM formation and photochemical air quality modeling are rapidly evolving.").

concentrations lead to chronic respiratory disease, hospitalizations, and premature deaths.<sup>27</sup> EPA estimates that roughly ninety million people – about thirty percent of the U.S. population – reside in “nonattainment” counties that have fine-PM levels above national maximum limits.<sup>28</sup>

Recent EPA monitoring data suggest that over 40 percent of fine particulate matter is carbon-based. Typically the percentage is higher (about 43 percent) in urban areas and lower (about 38 percent) in rural areas.<sup>29</sup> The component of urban fine particulate mass that comes from urban rather than regional sources – the “urban increment” – is predominantly carbon.<sup>30</sup>

---

<sup>27</sup> See American Lung Ass’n, *State of The Air 2005, Protect The Air You Breathe* 59, 55, available at [http://www.lungusa2.org/embargo/sota05/SOTA05\\_final.pdf](http://www.lungusa2.org/embargo/sota05/SOTA05_final.pdf) (“Studies showing the dangers of particle pollution are pouring in by the thousands.”); Jocelyn Kaiser, *Mounting Evidence Indicts Fine-Particle Pollution*, 307 *Sci.* 1858, 1859 (Mar. 25, 2005) (“[T]he list of health effects linked to fine particles keeps growing.”); U.S. EPA, FY 2004 Annual Report, Section II: Performance Results, available at [http://www.epa.gov/ocfopage/finstatement/2004ar/aro4\\_section2.pdf](http://www.epa.gov/ocfopage/finstatement/2004ar/aro4_section2.pdf) at Goal 1-4 (EPA’s 2005 research findings support the association between exposure to particulate matter (PM), illness, and even death); Particulate Matter Science For Policy Makers: A NARSTO Assessment 17–18 (Peter H. McMurry et al., eds., 2004); *Fine Particulate Air Pollution and Mortality in Nine California Counties: Results from Calfine*, *Envtl. Health Persp.* 4, available at <http://ehp.niehs.nih.gov/members/2005/8335/8335.pdf>.

<sup>28</sup> See Proposed PM<sub>2.5</sub> Implementation Rule at 65,990.

<sup>29</sup> Recent EPA monitoring data indicate that carbonaceous matter is between 35 percent and 59 percent of fine-particle mass at urban sites and between 26 percent and 57 percent in rural sites. See Proposed PM<sub>2.5</sub> Implementation Rule at 65,993. The sulfate contribution to fine PM is comparable to that of carbon, but smaller (except in some rural areas). Nitrates and ammonium make still smaller contributions. *Id.*

“[T]he relative importance of sulfates and nitrates from power generation [as PM<sub>2.5</sub> precursors] is declining as the result of recent reductions in precursor emissions from these sources as part of regulations like the acid rain program.” See EPA, Interim Regulatory Impact Analysis for the PM<sub>2.5</sub> National Ambient Air Quality Standards 2-23 (Jan. 17, 2006) (“Interim PM<sub>2.5</sub> NAAQS RIA”), available under “Technical Support Documents” at <http://www.epa.gov/air/particles/actions.html>. Moreover, it now appears that some past EPA estimates of the sulfate contribution to PM<sub>2.5</sub> had been inflated by inadvertent inclusion of the contribution of secondary organic aerosols (SOAs) from vehicles and other sources. See *Id.* at 2-23, 2-24.

<sup>30</sup> See EPA, Proposed PM<sub>2.5</sub> Implementation Rule at 65,994 (“Carbonaceous mass is the largest contributor to urban increments in all regions of the country. In east coast and midwestern urban areas, carbon can account for as much as 70–90 percent of the total urban increment.”). “The urban increment for sulfate, on the other hand, appears to be fairly low in most locations.” *Id.* at 65,995.

Nonroad diesel, onroad diesel, gasoline highway vehicles, and fire-related activities are regarded to be important major contributors to this urban excess of carbon.

In the Preamble to the proposed rule to implement the PM<sub>2.5</sub> National Ambient Air Quality Standards issued in late 2005, EPA stated that toluene, xylene, and other aromatics “are considered to be the most significant” manmade precursors to carbon fine particulates.<sup>31</sup> EPA went on to note that the organic aerosol formation potential of gasoline can be accounted for *solely* in terms of its aromatic fraction<sup>32</sup> and that aromatic compounds have been estimated to be responsible for 50 to 70 percent of all such aerosols in some areas.<sup>33</sup> According to the EPA 1999 National Emissions Inventory, about two thirds of emissions of benzene, toluene, and xylene,

---

<sup>31</sup> *See Id.* at 65,996 (“Aromatic compounds such as toluene, xylene, and trimethyl benzene 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.”). *See also* Particulate Matter Science for Policy Makers: A NARSTO [North America Research Study on Tropospheric Ozone] Assessment 25 (Peter H. McMurry et al., eds., 2004) (“The most significant anthropogenic precursors [of organic carbon PM<sub>2.5</sub>] are aromatics emitted by transportation and industrial sources (e.g., toluene, xylenes, trimethylbenzenes).”).

Nonanthropogenic sources are also a source of carbon PM<sub>2.5</sub> precursors, though not of aromatics. The extent of their contribution is unknown. “Despite significant progress that has been made in understanding the origins and properties of SOA, it remains the least understood component of PM<sub>2.5</sub>.” EPA, Proposed Implementation Rule at 65,997.

<sup>32</sup> *See* EPA, Proposed Implementation Rule at 65,996.

<sup>33</sup> *Id.* at 65,995.

considered singly or together, come from mobile pollution sources.<sup>34</sup> Toluene and xylene alone account for over half of all mobile source air toxics emissions.<sup>35</sup>

EPA clearly recognizes that there are immense benefits in reducing fine particulate matter. In its final rule to control emissions from nonroad diesel engines and fuel, EPA estimates that by 2020 annual emissions of particulate matter will be reduced by 86,000 tons, and that by 2030 particulate matter will be reduced by 129,000 tons.<sup>36</sup> By 2020, the regulations will result in net health and welfare benefits valued at \$41 billion or \$42 billion per year in 2000 dollars, depending on which discount rate is applied.<sup>37</sup> By 2030, the net annual benefits are estimated at \$78 or \$81 billion in 2000 dollars, again depending on the choice of discount rate. Consistent

---

<sup>34</sup> See EPA, AirData, County Emissions Report – Hazardous Air Pollutants, available at <http://oaspub.epa.gov/airdata/adnti.summary?geotype=us&geocode=USA&geoinfo=%3Fus%7EUSA%7EUnited+States&pol=H017+H166+H183&year=&emis=a&fld=urb&fld=major&fld=area&fld=onroad&fld=nonroad&rpp=25>. For more on the NEI database, see EPA, AirData, About the National Emission Inventory Database, available at <http://www.epa.gov/air/data/neidb.html>; EPA, AirData, Generating Reports and Maps, available at <http://www.epa.gov/air/data/reports.html>; and EPA, AirData, Select Geographic Area, available at <http://www.epa.gov/air/data/geosel.html>.

<sup>35</sup> Toluene and xylene amount to over half the sum of emissions of all MSATs (not merely of all aromatic MSATs), including acetaldehyde, 1,3-butadiene, and formaldehyde. See William Battye, The Projection of Mobile Source Air Toxics From 1996 to 2007: Emissions and Concentrations (Draft) 22 (Aug. 2001), available at <http://www.epa.gov/otaq/regs/toxics/r01038.pdf> (in 1996, total mobile-source HAP emissions were 2,248,000 tons, including 775,000 tons of toluene, 543,000 tons of xylene, and 259,000 tons of benzene; total projected 2007 emissions are 1,341,000 tons, including 466,000 tons of toluene, 341,000 tons of xylene, and 147,000 tons of benzene); see also EPA, Technology Transfer Network, National Air Toxics Assessment, Air Toxics Reduction, <http://www.epa.gov/ttn/atw/nata/natsatr.html> (using Battye projections and citing Battye).

Benzene itself, though it is subject to reduction for other reasons (among other things, it is a known carcinogen), is not thought to form SOAs, see EPA, Proposed Implementation Rule at 65 (chart); but it is worth noting that taken together, benzene, toluene, and xylene amount to about two-thirds of all MSAT emissions. See Battye, MSAT Projections at 22.

<sup>36</sup> Control of Emissions of Air Pollution From Nonroad Diesel Engines and Fuel, 69 Fed. Reg. 38,958 (June 29, 2004).

<sup>37</sup> *Id.* at 39,135 (for 2020, \$42 billion quantified net benefits assuming a three percent discount rate and \$41 billion assuming a seven percent discount rate; for 2030, \$78 billion assuming the lower rate and \$81 billion assuming the higher rate).

with the nonroad diesel rule, EPA's MSAT proposal estimates that the cold-temperature vehicle standards will reduce PM<sub>2.5</sub> by 20,000 tons by 2030, which equates to health and welfare benefits valued at \$5.9 or \$6.5 billion depending on which discount rate is assumed.<sup>38</sup> These estimates imply that every microgram-per-cubic-meter( $\mu\text{g}/\text{m}^3$ ) reduction in population-weighted levels of fine particulate matter nationwide yields roughly \$100 billion in annual health benefits.<sup>39</sup>

In March 2005, EPA finalized its Clean Air Interstate Rule (CAIR), which will sharply reduce fine particulates attributable to power plants in the eastern US by capping emissions of nitrogen oxides (NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>).<sup>40</sup> EPA estimates that the required NO<sub>x</sub> and SO<sub>2</sub> emissions reductions would, by themselves, bring into attainment 52 of the 79 counties that are otherwise projected to be in nonattainment for PM<sub>2.5</sub> in 2010, and 57 of the 74 counties that are otherwise projected to be in nonattainment for PM<sub>2.5</sub> in 2015. In its Regulatory Impact Analysis for the rule, EPA predicted that in the eastern US, population-weighted fine-PM annual averages will have “declined by 8.1 percent (or 0.96  $\mu\text{g}/\text{m}^3$ ) in 2010 and 9.8 percent (or 1.15  $\mu\text{g}/\text{m}^3$ ) in

---

<sup>38</sup> EPA, Draft Regulatory Impact Analysis: Control of Hazardous Air Pollutants from Mobile Sources, EPA 420-D-06-004 (Feb. 2006) at 12-21, available at <http://www.epa.gov/otaq/regs/toxics/chapter12.pdf>.

<sup>39</sup> For the nonroad diesel rule, EPA reported that “[o]n a population-weighted basis, the average modeled change in future-year PM<sub>2.5</sub> annual averages is projected to decrease by 0.42  $\mu\text{g}/\text{m}^3$  (3.3%) in 2020, and 0.59  $\mu\text{g}/\text{m}^3$  (0.6%) in 2030.” Control of Emissions of Air Pollution From Nonroad Diesel Engines and Fuel, 69 Fed. Reg. at 38,967. \$42 billion divided by 0.42  $\mu\text{g}/\text{m}^3$ , of course, is exactly \$100 billion per  $\mu\text{g}/\text{m}^3$ . \$81 billion divided by 0.59  $\mu\text{g}/\text{m}^3$  is \$137.3 billion per  $\mu\text{g}/\text{m}^3$ . If one uses the \$41 billion and \$78 billion estimates instead, the results are \$97.6 billion per  $\mu\text{g}/\text{m}^3$  and \$132.2 billion per  $\mu\text{g}/\text{m}^3$ , respectively.

For the proposed MSAT rule, EPA projected that on a population weighted basis the average modeled change in future-year PM<sub>2.5</sub> annual averages associated with is projected to decrease by 0.077  $\mu\text{g}/\text{m}^3$  in 2020, and 0.091  $\mu\text{g}/\text{m}^3$  in 2030. \$5.9 billion divided by 0.077  $\mu\text{g}/\text{m}^3$  is \$76 billion per  $\mu\text{g}/\text{m}^3$ ; \$6.5 billion divided by 0.091 is \$71 billion per  $\mu\text{g}/\text{m}^3$ .

<sup>40</sup> 70 Fed. Reg. 25161 (March 12, 2005).

2015.”<sup>41</sup> The net annual monetized benefits (almost all of them from particulate matter reductions) are estimated at \$60.4 billion or \$71.4 billion in 2010, and \$83.2 billion or \$98.5 billion in 2015, in 1999 dollars, depending on the discount rate. The benefit per population-weighted  $\mu\text{g}/\text{m}^3$  reduction equals \$62.9 billion or \$74.4 billion for 2010 and to \$72.3 billion or \$85.7 billion for 2020.

Despite the  $\text{PM}_{2.5}$  reductions that will be achieved by the CAIR rule, fine particulate levels will remain significantly higher in densely populated areas than in rural areas. The population-weighted  $\text{PM}_{2.5}$  average in the East will still be  $10.0 \mu\text{g}/\text{m}^3$  in 2010 and  $9.5 \mu\text{g}/\text{m}^3$  in 2015. Reducing aromatics is perhaps the only remaining cost-effective means by which EPA can further reduce ambient  $\text{PM}_{2.5}$ .

(i) Reducing Aromatics Will Further Reduce  $\text{PM}_{2.5}$

EPA’s 2010 projected emissions for toluene, ethylbenzene, xylene, and the C9 and C10 aromatics total 945,133 tons (“total aromatic VOCs”). *See* Chart 8. Methods for determining precisely how much of these total aromatic VOCs react photochemically in the atmosphere to form secondary particulate matter in the form of secondary organic aerosols (SOA) have not been conclusively established. Nevertheless, there is accumulating evidence that strongly suggests that mobile source aromatic VOCs are the most significant source of SOA.

Charts 9 and 10 below illustrate two potential SOA yields from published studies for mobile source aromatic VOCs. In general, these studies estimate that SOA yields are about 5 to 10 percent of total aromatic VOCs. Chart 10 suggests that the SOA yields are about 5 percent for mono-alkyl aromatics and about 10 percent for multi-alkyl aromatics. Using these yield

---

<sup>41</sup> *See* U.S. EPA, Pub. No. EPA-452/R-05-002, Regulatory Impact Analysis For The Final Clean Air Interstate Rule, at 2-1 to -2 (Mar. 2005), *available at* <http://www.epa.gov/airprog/oar/interstateairquality/pdfs/finaltech08.pdf>.

estimates, SOA would constitute 64,232 tons of the 904,232 tons of aromatic VOC emissions projected in 2010. As discussed further below, however, based on recent work conducted by EPA and others, this SOA yield is significantly underestimated, perhaps by factors of 5 to 15.

CHART 9<sup>42</sup>

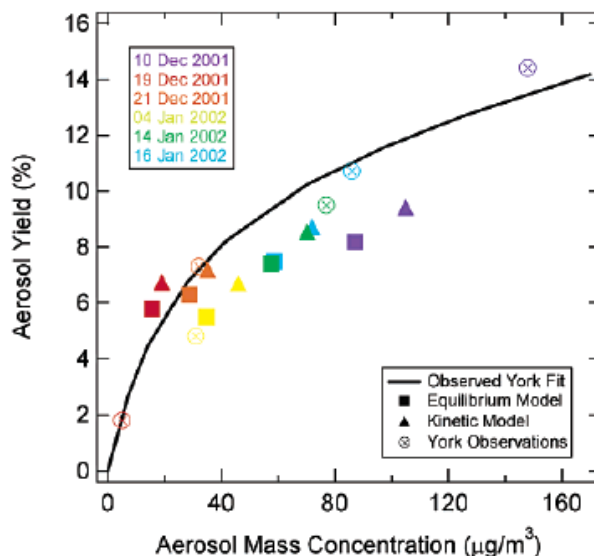
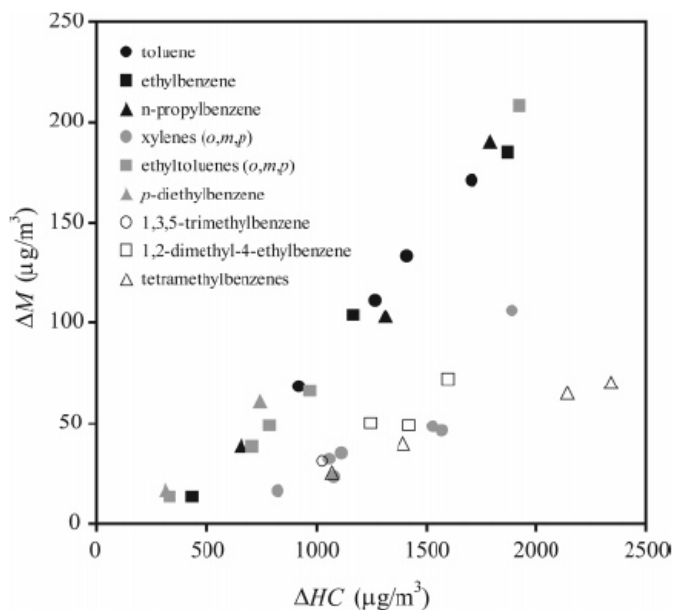


FIGURE 2. Comparison between the measured and modeled aerosol yield dependence on aerosol mass concentration. The line represents a two-product fit to observed data (not corrected for wall losses) using (E4) with the following coefficients:  $a_1 = 12.4$ ;  $K_1 = 0.0182$ ;  $a_2 = 17.9$ ;  $K_2 = 0.00236$ . This is appropriate for comparison with the models. For comparison with other experimental results, when the York observations are corrected for particle wall loss, the fitted parameters are as follows:  $a_1 = 0.0406$ ;  $K_1 = 385$ ;  $a_2 = 0.652$ ;  $K_2 = 7.31$ . A particle density of  $1.4 \text{ g cm}^{-3}$  was used to convert volume to mass.

<sup>42</sup> Stroud, C, et al., Simulating Organic Aerosol Formation During the Photooxidation of Toluene/NO<sub>x</sub> Mixtures: Comparing the Equilibrium and Kinetic Assumption, *Environ. Sci. Technol.*, 38, 1471-79.

CHART 10<sup>43</sup>



**FIGURE 3.  $\Delta M$  vs  $\Delta HC$  for the photooxidation of a number of aromatic compounds, as measured by Odum et al. (19). Symbol color indicates level of alkyl substitution: monosubstituted (black), disubstituted (gray), or tri- and tetrasubstituted (open). In some cases, isomers are lumped together (as in the case of *o*-, *m*-, and *p*-xylenes), which accounts for much of the observed scatter for a single aromatic.**

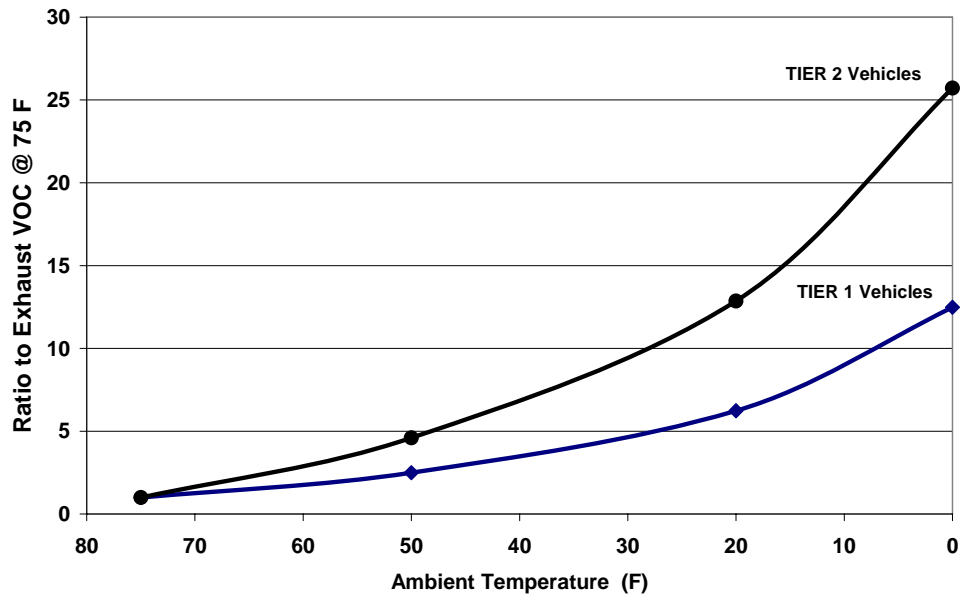
In the proposed MSAT Rule, EPA analyzed the effects of cold temperatures on vehicle emissions. That analysis shows that cold-start exhaust VOCs increase significantly with colder ambient temperatures because of the poor vaporization of fuels under cold engine operations. The results of EPA's analysis are expressed in Chart 11 as the ratio of vehicle cold-start emissions as a function of ambient temperature for both older Tier 1 vehicles and more current Tier 2 vehicles. For example, an early summer morning temperature of 50° F may increase VOC emissions 2.5 to 5 times that of VOC emissions on a 75° F day. In the winter, an early morning cold ambient temperature of 20° F might increase the cold start emissions by a factor of 7 to 14. This analysis suggests that the SOA yield of 68,916 tons estimated in Chart 8 may be higher by

<sup>43</sup> Kroll, J. and J. Seinfeld, Representation of Secondary Organic Laboratory Chamber Data and the Interpretation of Mechanisms of Particle Growth, *Environ. Sci. Technol.* 39, 4159-4165.

factors of 2 to 5 in the summer in many areas of the country, and may be even higher in the winter.

**CHART 11**

**Cold Start Exhaust VOCs vs Ambient Temperature**



The work illustrated in Chart 12 suggests that the SOA yields from aromatics might increase by a factor of three when the ambient air temperature decreases from 95° F to 60° F because of a shift in condensation equilibriums. The yield would be expected to increase further if the temperature decreased further.

CHART 12<sup>44</sup>

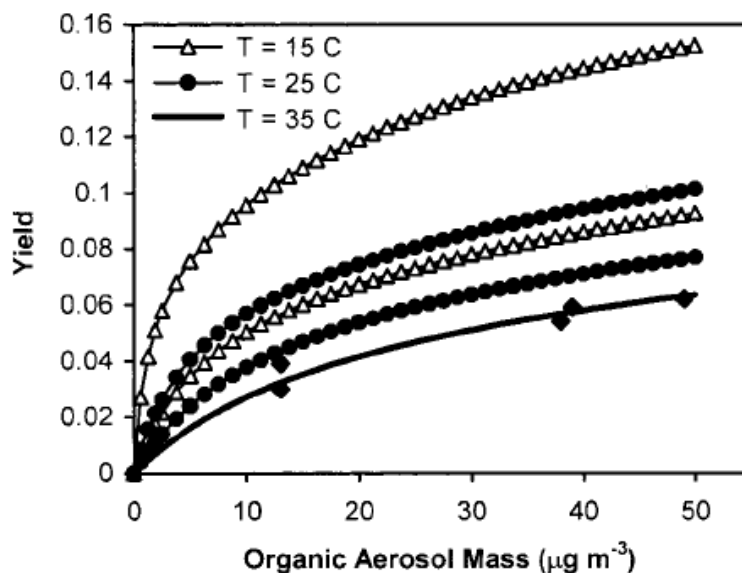


FIGURE 1. Estimated range of high yield aromatic SOA yields as a function of organic aerosol mass at 15, 25, and 35 °C. Upper and lower values correspond to  $H_1 = H_2 = 25$  and 10 kcal mol<sup>-1</sup>, respectively. Parameter values used are  $\alpha_1 = 0.071$ ,  $\alpha_2 = 0.138$ ,  $K_1^* = 0.053$ ,  $K_2^* = 0.0019$ ,  $T^* = 35$  °C.

The above studies suggest that there is an inverse relationship between PM<sub>2.5</sub> organic carbon (OC) and peak ozone levels related to vehicle emissions. While hotter summer temperatures will raise ozone levels, cooler summer days appear to increase VOCs from cold starts, as well as increase SOA yields from the aromatic portion of the vehicle VOCs. Therefore, cool summer days might contribute to an increase in PM<sub>2.5</sub> OC. The results from these same studies also imply that mobile source VOCs may play a much larger role during the winter time with much higher aromatic VOC emissions and higher SOA yields.

Only a few studies have attempted to apportion PM<sub>2.5</sub> organic carbon sources. EPA compiled these studies in 2003.<sup>45</sup> The organic carbon fraction of total PM<sub>2.5</sub> mass ( $\mu\text{g}/\text{m}^3$ )

<sup>44</sup> Sheehan, P. and F. Bowman, Estimated Effects of Temperature on Secondary Organic Aerosol Concentrations, *Environ. Sci. Technol.*, 35, 2129.

attributable to gasoline-driven mobile sources ranged from 4 to 33 percent ( $.04 \mu\text{g}/\text{m}^3$  to  $4.2 \mu\text{g}/\text{m}^3$ ). One study that was published in 2004, analyzed 10 years of organic carbon data for Washington, DC, and found that gasoline represented about  $3 \mu\text{g}/\text{m}^3$  of the  $\text{PM}_{2.5}$  organic carbon during the summer, increasing to about  $4.75 \mu\text{g}/\text{m}^3$  in the winter season. The researchers concluded that SOAs are the largest  $\text{PM}_{2.5}$  source in Washington, DC, accounting for 60 percent of the  $\text{PM}_{2.5}$  mass concentrations.<sup>46</sup>

The following PM speciation charts (Charts 13 a, b and c) for three cities were developed using 2004 and 2005 data downloaded from EPA's AIREXPLORER system. The monthly averages are plotted for Total  $\text{PM}_{2.5}$ , Total Carbonaceous  $\text{PM}_{2.5}$ ,  $\text{PM}_{2.5}$  OC and  $\text{PM}_{2.5}$  EC (elemental carbon). The three cities (Washington, DC, New York, and Detroit) usually have cold winters when most other large VOC sources, such as biogenic VOCs and architectural coating VOCs, are minimal. Chart 14 shows only the  $\text{PM}_{2.5}$  OC from the three cities on a monthly basis, as well as the monthly average and annual average of all three. The seasonal comparisons in these charts suggest that:

- $\text{PM}_{2.5}$  OC levels are high in winter months even though most VOC sources (other than gasoline vehicle VOCs) are greatly diminished;
- winter  $\text{PM}_{2.5}$  OC can be higher than the annual average even though total PM will generally be lowest in the winter months; and
- the higher winter VOC and aromatic emissions from gasoline vehicles in these northern cities is directly linked to  $\text{PM}_{2.5}$  OC.

---

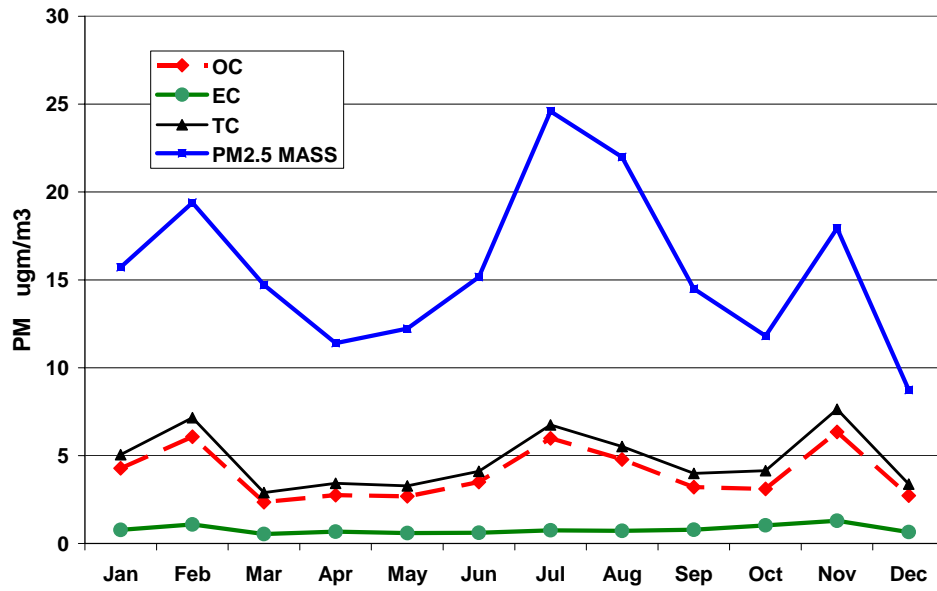
*(footnote continued from previous page)*

<sup>45</sup> EPA, Second Draft Technical Report, Compilation Of Existing Studies On Source Apportionment For  $\text{PM}_{2.5}$  (Aug. 2003), available at <http://www.epa.gov/oar/oaqps/pm25/docs/compsareports.pdf>.

<sup>46</sup> Kim, E. and P. Hopke, Source Apportionment of Fine Particles in Washington, DC, Utilizing Temperature-Resolved Carbon Fractions, *Air & Waste Management Assoc.*, 54:773-785 (July 2004).

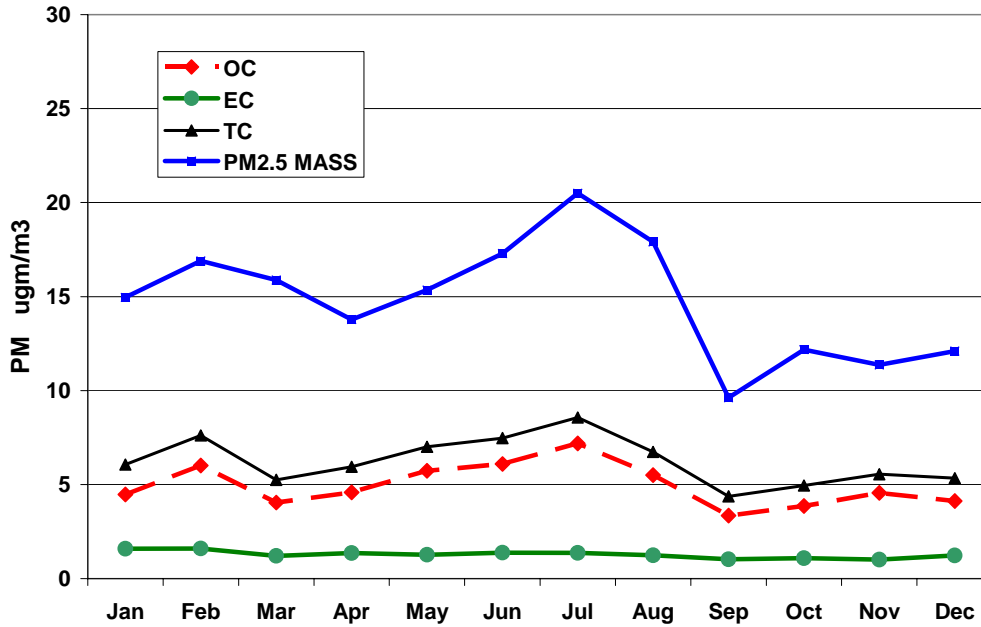
### CHART 13 a

Wash DC PM Monthly Speciation



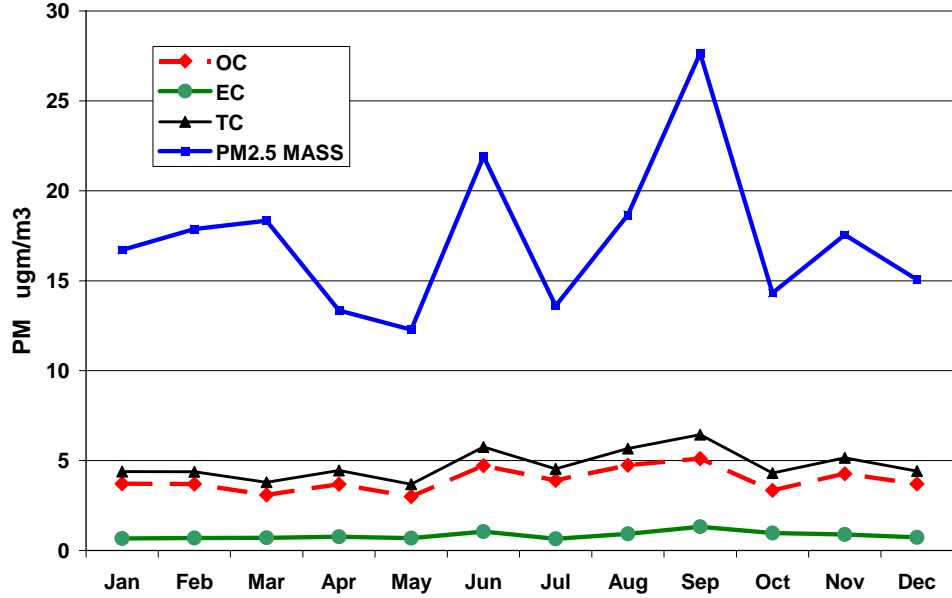
### CHART 13 b

NYC PM Monthly Speciation



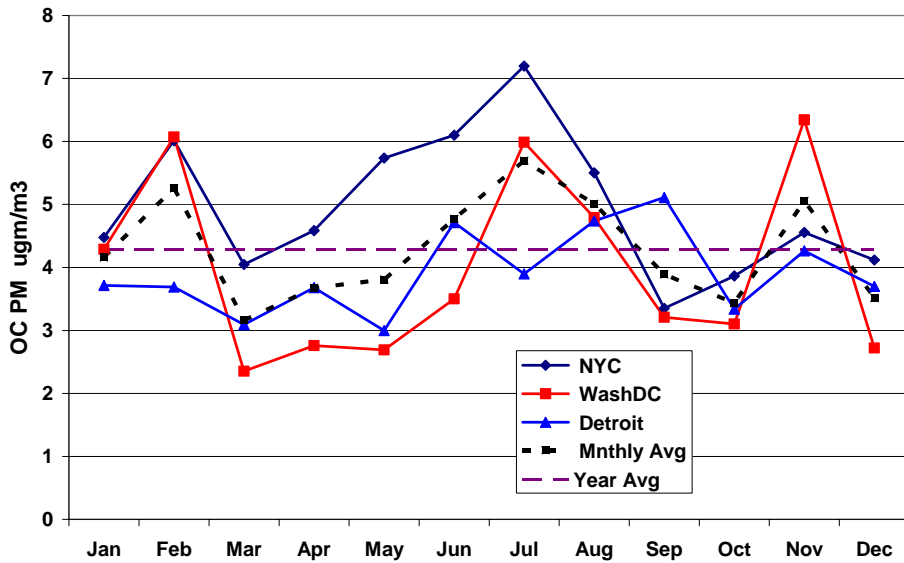
### CHART 13 c

Detroit PM Monthly Speciation



### CHART 14

3 Cities Monthly OC PM



(ii) Reducing Aromatics in Gasoline Achieves Significant Health Benefits

The above analysis suggests that aromatics contribute on average about 4  $\mu\text{g}/\text{m}^3$  to total  $\text{PM}_{2.5}$  mass. This analysis is consistent with EPA's preliminary analysis of secondary organic carbon aerosol speciation data in Research Triangle Park, North Carolina. It is our understanding that EPA found that the SOA fraction of total  $\text{PM}_{2.5}$  mass (estimated to be 15-16  $\mu\text{g}/\text{m}^3$ ) is 2-5.5  $\mu\text{g}/\text{m}^3$ , and that toluene alone contributed about 1.5  $\mu\text{g}/\text{m}^3$  to the total mass.

Chart 8 (on page 30) illustrates that reducing the aromatic content of gasoline to 22 percent in 2010 and to 18.5 percent in 2014 would reduce SOA 22.4 percent and 35.8 percent respectively. A 22.4 percent reduction in SOA would equal a 0.9  $\mu\text{g}/\text{m}^3$  reduction in  $\text{PM}_{2.5}$ ; a 35.8 percent SOA reduction would equal a 1.4  $\mu\text{g}/\text{m}^3$   $\text{PM}_{2.5}$  reduction. Based on EPA's quantification of  $\text{PM}_{2.5}$  benefits in past rules, as well as in this proposed rule, a 1.0  $\mu\text{g}/\text{m}^3$   $\text{PM}_{2.5}$  reduction is roughly equivalent to \$100 billion. Thus, a 0.9  $\mu\text{g}/\text{m}^3$   $\text{PM}_{2.5}$  reduction would yield \$90 billion in health benefits, and a 1.4  $\mu\text{g}/\text{m}^3$   $\text{PM}_{2.5}$  reduction would yield \$140 billion in benefits.

**c. Ozone**

While not as great as the  $\text{PM}_{2.5}$  benefits, ozone reduction benefits are still quite large. EPA recognizes that the oxidation of aromatic hydrocarbons constitutes an important component of the chemistry of ozone formation in urban atmospheres.<sup>47</sup> Replacing aromatics with cleaner renewable octane components will help achieve national ambient air quality standards for particulate matter and for ozone.

---

<sup>47</sup> US EPA, Air Quality Criteria for Ozone and Related Photochemical Oxidants (Feb. 2006) at 2-5.

Model calculations indicate that aromatic compounds may contribute more than 30 percent of the photooxidant formation in urban areas.<sup>48</sup> As shown by EPA's RFG Complex Model, aromatics in gasoline contribute to ozone precursors by directly increasing NO<sub>x</sub>, VOC, and CO emissions. In addition, the relatively high boiling point of aromatics raises the gasoline's 50 percent point temperature, which contributes to even more NO<sub>x</sub> and VOC emissions. Aromatic VOCs are also some of the most potent atmospherically reactive VOCs that form ozone during hot summer days, as compared to other gasoline VOCs. The aromatic contribution to ozone formation becomes even more important when one considers that nearly half the gasoline-related VOCs in the inventory now come from off-road engines that do not have the sophisticated emission control systems (catalytic converters) that other motor vehicle engines have. Unfortunately, the full contribution of gasoline aromatics to ozone is somewhat masked, because some of the factors mentioned here have not been adequately captured or broken out in the existing EPA mobile and area source models. Significantly, EPA does not disagree. EPA acknowledged this defect in the Preamble to the proposed MSAT rule and is attempting to correct it.

Because aromatics are the highest boiling-temperature blendstocks used in gasoline, they are the most difficult to vaporize in the cold engine during the first few minutes after start-up, before the catalytic converters are warmed up and become effective. Because the aromatics do not fully vaporize during this initial cold-start mode, the partially liquid aromatics cannot mix with air to fully combust in the engine. Therefore, these pyrolyzed (partially burned) aromatics produce both more unburned aromatic VOCs and higher PM carbon in the vehicle exhaust. In

---

<sup>48</sup> Le Bras, G., *Chemical Processes in Atmospheric Oxidation*, Springer (1997).

fact, these cold-start engine operations represent nearly 80 percent of the VOC emissions from the vehicle's daily operating cycle.

Thus, reducing the aromatic content of gasoline will directly reduce aromatic VOC emissions. As shown in Chart 7 (on page 29), a 20 percent reduction in aromatics (Phase I) would reduce total VOC emissions 3.1 percent and NO<sub>x</sub> emissions 1.7 percent. A 33 percent reduction in aromatics (Phase 2) would reduce total VOCs emissions 4.3 percent and NO<sub>x</sub> emissions 3.0 percent.

**d. Carbon monoxide reductions**

Carbon monoxide (CO) is a component of motor vehicle exhaust that results from incomplete combustion of fuel. It is a major ozone precursor. EPA estimates that nationwide, two-thirds of carbon monoxide emissions come from transportation sources, with the largest contribution coming from highway motor vehicles. In urban areas, EPA estimates that motor vehicles can contribute more than 90 percent to CO pollution. Studies have shown that CO can be equivalent to 25 to 50 percent of the mobile-related contribution from volatile organic compounds (VOC).

Chart 7 shows that reducing the aromatic content of gasoline 20 percent reduces CO emissions 10 percent. A 33 percent reduction in aromatics reduces CO 11.9 percent.

**e. CO<sub>2</sub> reductions**

The United States produces an estimated 21 percent of the world's greenhouse gas emissions (GHG). Transportation sources were responsible for about 27 percent of total U.S. GHG emissions in 2003 (1,866.7 Tg CO<sub>2</sub> Eq.).<sup>49</sup> In 2003, about 81 percent of transportation

---

<sup>49</sup> US EPA, Greenhouse Gas Emissions from the U.S. Transportation Sector: 1990–2003, EPA Rep. No. 420 R 06 003 (March 2006) available at <http://www.epa.gov/otaq/climate/420r06003.pdf>.

GHG emissions in the United States came from “onroad” vehicles, including passenger cars, sport-utility vehicles (SUVs), vans, motorcycles, and medium- and heavy-duty trucks and buses. Thus, replacing aromatics in gasoline with less carbon-intensive alternatives would reduce carbon dioxide emissions and any associated greenhouse effects.

The point of the analysis in this section is that the direct air quality health benefits of reducing air toxics, PM<sub>2.5</sub>, ozone, CO, and CO<sub>2</sub> via the MSAT rule may amount to considerably more than \$140 billion, assuming EPA’s health benefits calculations to be accurate. Even if EPA’s benefits calculations are high by a substantial margin, the benefits relative to costs of an MSAT-based approach to PM<sub>2.5</sub> and ozone (as compared to NAAQS/NSR/CAIR approaches) are still substantial.

## **2. Providing states with more flexibility in designing SIPs and control strategies for stationary sources**

The largest part of the U.S. air pollution control effort over the past thirty-six years has been focused on achieving the National Ambient Air Quality Standards (NAAQS) for particulate matter (particularly fine particulates) and ozone through an elaborate and burdensome “partnership” of state and local government and the federal government. State and local governments have labored to implement State Implementation Plans (SIPs) under federal EPA supervision, and, in many major urban areas, they have labored unsuccessfully. Vehicle inspection programs, high-occupancy vehicle traffic lanes, staggered commuter hours, facility siting and transportation control reviews, additional requirements for industrial stationary sources, and many other costly and difficult-to-implement requirements have created a substantial burden, even before adding the huge legal, administrative, and political investments state and particularly local governments must make in air quality planning. Time, money, discord, and failure weigh down the ozone and PM<sub>2.5</sub> SIP programs.

EPA should take these costs into account in proposing an Aromatics MSAT Rule. Such a rule would apply the cost-beneficial Clean Air Act strategy that its more successful programs in other parts of the statute require: uniform federal technology-based performance criteria. Gasoline content requirements for aromatics would be relatively easy to add to the current EPA gasoline certification program under the Complex Model. State and local governments would receive a powerful EPA-administered boost toward achieving their SIP goals. Many ozone and PM<sub>2.5</sub> SIPs would come into attainment by operation of the Aromatics MSAT alone.

**3. Accelerating acceptance of the renewable fuels standard (RFS) by encouraging the use of renewable octane components**

A stronger MSAT rule would accelerate acceptance and achievement of the RFS mandated by the Energy Policy Act of 2005 and quickly bring about “over-compliance” with the RFS. The Energy Policy Act requires refiners to increase their use of renewable fuels such as biomass-based ethanol and its ether derivative ETBE. This new program will in time add billions of gallons of domestically produced fuel to the nation’s automotive fuel supply. The Energy Policy Act also requires EPA to study ETBE and other ethers, analyzing impacts to air quality, water resources, and public health. ETBE could provide a high-octane, cleaner-burning substitute for the air toxics removed from gasoline as a result of the MSAT rule, while simultaneously expanding domestic gasoline supplies. The Energy Policy Act requires EPA to study ETBE and other ethers, analyzing impacts to air quality, water resources, and public health.

If EPA were to require the Phase I and Phase II reductions recommended here, refiners could keep gasoline volumes up by adding up to 15 billion gallons of ethanol or other biofuels to gasoline. This is twice the current 7.5 billion gallons required by 2012 under the RFS, but ethanol producers are on track already to exceed the 2012 goal. Thirty-four new ethanol plants

are under construction. Eight of the 95 existing plants are expanding production. Up to 150 more new plants or expansions are in the planning stages at present.<sup>50</sup>

If over a period of twenty or more years EPA were to require an 80 percent reduction of aromatics in gasoline, approximately 21 percent of the content of today's conventional gasoline could be replaced with cleaner-burning substitutes. The result would be a market for up to 30 billion gallons of renewable fuels per year. Ethanol from corn alone could not provide this volume. But cellulosic ethanol production could make up the difference by more than doubling ethanol production, given the necessary phase-in over time. Alternatively, gasoline volumes could be kept high, and ethanol requirements lowered, by manufacturing ETBE, which can be blended up to 17-22 percent of a gallon of gasoline, while providing abundant octane and higher levels of air quality.

All of this would be a significant boost for agricultural markets and would help reduce the cost of agricultural commodity price supports. Moreover, aromatics (e.g., benzene, toluene, xylene) would be available for chemical industry markets. Toluene and xylene, which together account for over half of all hazardous emissions from onroad and nonroad vehicles, were each selling recently for over \$3.50 a gallon. Demand for benzene in the chemicals market is expected to continue to increase, as it has for some years; however, at some point the large quantities of xylene and toluene feedstocks removed from gasoline would begin to oversupply demand in chemical and other economic sectors, and suitable alternative uses and markets would need to be developed.

---

<sup>50</sup> "Chrysler Expanding Its Ethanol Model Line: E85 Mixture Requires Less Gas in 'Flex-Fuel' Vehicles," *The Washington Post*, April 26, 2006 at D-1.

#### **4. Promoting energy independence and correcting trade imbalances by decreasing reliance on crude oil imports**

A shift away from aromatics in gasoline promotes energy independence by reducing reliance on crude oil. The U.S. imports 66 percent of its oil (13.3 mbd out of 20.3 mbd supplied), and more than 40 percent of these imports come from OPEC countries and the Persian Gulf region (5.5 mbd).<sup>51</sup> In January 2006, the cost of petroleum imports increased 46 percent from January 2005. In February 2006, the U.S. Department of Commerce reported that the trade deficit reached a record level of \$726 billion in 2005, an 18 percent increase over 2004.<sup>52</sup> The rapid increases in the price of oil and related products were responsible for 63 percent of the increase in the deficit. The average price of crude oil imports increased 39 percent over 2004, and the volume of petroleum product imports increased 4 percent in 2005.<sup>53</sup> Thus, reducing reliance on imported crude oil will help correct trade imbalances.

#### **5. Reducing the cost of agricultural commodity price support payments, benefiting the federal budget and US trade policy**

If carried out at large scale, the increased use of agricultural resources for energy will have the effect of raising the prices of most commodity crops and reducing the need for subsidies – with particular benefits for producers of those crops in developing countries. Indeed, an analysis by the University of Tennessee found that such a strategy would all but eliminate the need for price-based support payments for most crops in the U.S. In other words, an aggressive

---

<sup>51</sup> See Energy Information Administration, Monthly Energy Review (April 2006), available at <http://www.eia.doe.gov/emeu/mer/overview.html>.

<sup>52</sup> See U.S. Census Bureau Annual Trade Highlights, available at <http://www.census.gov/foreign-trade/statistics/highlights/annual.html>.

<sup>53</sup> Economic Policy Institute, “Trade Picture,” (Feb. 2006) (reporting on US Dep’t of Commerce 2005 trade figures), available at [http://www.epinet.org/content.cfm/webfeatures\\_econindicators\\_tradepict20060210](http://www.epinet.org/content.cfm/webfeatures_econindicators_tradepict20060210).

program of bioenergy development would reduce the cost of government support to farmers without diminishing their income.

Encouragement of a world biofuels market would also be important to developing countries. Once biofuels begin to compete with petroleum at large scale – that is, as a substitute and not as an additive – the demand for agricultural feedstocks will increase farm income and drive economic development globally. The market, indeed, is so large that governments in the EU and U.S. could support domestic production and increase imports at the same time. In developing countries, the emergence of a domestic biofuels industry would provide a clean energy alternative to imported oil, a potential export market, increased income to the agricultural sector, and a capital flow to support rural economic development.

## **B. The Costs**

### **1. Economic Costs and Considerations**

#### **a. Refiners**

Regarding costs to refiners and society of an Aromatics MSAT Rule, the news is good. The costs to refiners of rolling back benzene to EPA's recently proposed .62 percent level would be about a penny a gallon of gasoline, according to EPA. EPA's estimates may be low and should be verified.<sup>54</sup> But an aromatics-based approach would be cheaper. The costs to refiners of the first phase of an aromatics-based rule would be zero or conceivably negative, i.e., the refiners would come out ahead and make money because of Phase I of this regulation.

Refiners incur little or no marginal costs in running crude oil cracking and reforming equipment so that more gasoline instead of aromatics is produced, at least up to the point

---

<sup>54</sup> Its penny-a-gallon estimate appears to be based on a 1993 RIA and outdated compliance cost data.

aromatics are reduced to approximately 22 percent of gasoline under Phase I. Equipment already in place can be switched to other production. As developed above, the components of crude oil formerly used to make aromatics can be diverted to making more gasoline or other petrochemical products that command good margins in sales into the chemical industry and other sectors. If ethanol and other cheaper replacement sources for the octane lost by phasing down aromatics were not available, refiners would have to make alkylate and isomers to replace aromatics. Then high costs would be incurred. This is the reason that in California today, "CARBOB," the baseline gasoline to which ethanol is added to make California RFG, is selling at 15 to 20 cents a gallon more than it is elsewhere in the nation. That is because California limits ethanol use to about 6 percent and has banned the use of MTBE. Thus, California refiners must use expensive alkylate and isomers in CARBOB. But alkylate and isomers do not have to be made if more ethanol and other renewable oxygenates are used.

Moreover, it is vital to understand that in making aromatics from crude oil, refiners lose 20 percent of the feedstocks (gasoline naphtha) used to make aromatics. An unavoidable side effect of producing aromatics is simultaneous production of a gaseous-state hydrocarbon that refiners cannot use to make gasoline. Those gases are then burned as fuel in refiners' production operations. Thus, by ceasing to produce aromatics, refiners will free up 20 percent more aromatics feedstocks from which to produce additional gasoline. Thus, the Aromatics MSAT Rule will have the effect of increasing the overall supply of gasoline.

The addition to the gasoline supply would not be insignificant. For example, if aromatics are reduced to 21 rather than the current 26 average percent of gasoline, the concomitant gasoline supply increase would be approximately one percent. If, the lost octane is replaced entirely by ethanol, the added ethanol volume will increase the volume of gasoline supply by another 5

percent over the gasoline volume that just using aromatics would have provided. Thus, the overall increase in gasoline supplies as a result of Phase I of the MSAT Rule is 7 to 8 percent. No gasoline supply penalty accompanies implementing the Aromatics MSAT Rule with ethanol; indeed, the opposite will occur and gasoline supplies will be increased.

The only cost increase to refiners under Phase I, may be the associated with expanding hydrogen production capacity to replace the reformer hydrogen production that is lost when aromatics are not manufactured in the reformer. These costs, however, are minor.

**b. Consumer Costs and the Aromatics MSAT Rule**

Would costs to the consumer increase? There is no reason in the proposed Aromatics MSAT Rule that they should. Daily or “spot” market prices for both ethanol and gasoline may vary significantly, but the focus should be on the manufacturers’ longer-term costs to produce ethanol and gasoline, which today is approximately \$1.40 a gallon for ethanol and \$1.60 or more a gallon for gasoline.<sup>55</sup>

Phase I would by itself reduce benzene emissions to a level greater than sought in the current proposed MSAT rule. Such a reduction in benzene emissions, using the Aromatics MSAT Rule approach, could be achieved without refiners’ investing additional capital in benzene removal technology. In other words, were the goal merely to achieve the benzene emissions reductions that EPA seeks in the current proposal, from the refiners’ point of view reducing aromatics is the cheapest way to do it. However, the Clean Air Act MSAT provision requires that benzene emissions be reduced to the maximum extent technologically feasible,

---

<sup>55</sup> In passing, one notes that ethanol is commanding about \$2.70 a gallon with gasoline prices currently above this level. Thus profits to both refiners and ethanol producers right now are approaching 100 percent. Ethanol prices are going to decline significantly as supplies increase; presumably, the same could occur for gasoline.

taking costs and other factors into account. Environmental and health advocates are likely to bring suit challenging any rule that fails to mandate additional in-refinery technology to reduce benzene content to the lowest levels economically feasible. But if both benzene and aromatics content reductions were mandated, very large air toxics reduction gains could result: less benzene would be available in gasoline itself, and less emissions would result from the combustion of aromatics to form additional benzene.<sup>56</sup> In other words, enormous strides in reducing public exposure to benzene, a known human carcinogen, would occur from the combination of lowering both the benzene content and the aromatics content of gasoline.

**c. The Key Role Of Higher-Priced Crude Oil**

The price of crude oil, now well above \$60 a barrel (May 2006), makes substitution of ethanol and other biofuels for aromatics economically attractive. Indeed, it makes such substitution the only economically rational choice for refiners to make, barring that anti-competitive strategies come into play. Even without an Aromatics MSAT Rule, economically rational refiners should curtail aromatics and benzene production and sell benzene and aromatics into high-demand markets in the chemical industry or other sectors at favorable margins. This would increase their ability to produce more gasoline, by not sacrificing 20 percent of aromatic feedstocks to the unavoidable gaseous phase compounds unsuitable for making gasoline that are formed when aromatics are produced. Then refiners would restore gasoline volumes lost from removing benzene and aromatics by substituting lower-priced ethanol or other high-octane biofuels into gasoline to keep up – and indeed expand – clean-burning gasoline supplies.

---

<sup>56</sup> Some benzene in the exhaust is produced from the incomplete combustion of other aromatics when only the alky branches on these aromatics are split off to leave the more stable benzene ring structure remaining.

In an era of \$17-20 a barrel crude oil, an era that appears to be gone forever, the costs of creating gasoline presented a different picture. For many years it was cheaper to make aromatics from crude oil in order to add octane to gasoline than for refiners to buy and blend chemical oxygenates such as MTBE or ethanol in order to add octane. But even these economics changed when MTBE was made inexpensively and competed favorably with aromatics as a source of octane for gasoline. During the first years of the federal RFG program mandated by the Clean Air Act, it became clear that refiners could and would reduce aromatics economically by substituting MTBE or ethanol, thus keeping octane and gas supplies up and air pollution and prices down. By not making aromatics, refiners were able to produce 2 percent more gasoline from the crude oil fractions that were not diverted into gaseous phase hydrocarbon production as a necessary concomitant of aromatics creation. MTBE also helped create larger gasoline volumes (up to 17 percent of MTBE could be blended under law). The result was 4-5 percent more gasoline on the market. Indeed, the downward pressure on consumer gasoline prices created by abundant supplies of MTBE-reformulated gasoline caused widespread concern in the oil industry and led to price-fixing allegations and embarrassment for at least one gasoline refiner when a company memo was found that called for action to eliminate the oxygen requirement from the federal RFG program. Refiners could not sell the larger supplies of gasoline at favorable margins. In the winter and spring of 2006, the reverse of this process is causing additional constriction in gasoline supplies (adjusting for hurricane- and foreign supply-induced shortfall), with resulting gasoline price rises and spikes and a potentially greater surge in gasoline prices during the 2006 summer driving season.

Although refiners will have access to more replacement octane from expanding ethanol use, the refiners may maintain that if forced to remove benzene and aromatics from gasoline,

they will have to use expensive alkylation and isomerization technology to make the alkylate and isomers needed to provide replacement octane for gasoline. But they can only argue that this is necessary by ignoring the ready supply of clean-burning, octane-rich, low-priced ethanol. With MTBE, the refiners had an excuse by claiming that it contaminates groundwater by leaking from underground storage tanks. What makes ethanol the rational economic choice over alkylate and isomers is \$50-70 a barrel crude oil and relatively cheap ethanol. The refiners' phase-down of MTBE, before they can fully replace it with ethanol, has in fact recently caused the aromatic content of gasoline to rise once again, as a recent Caldecott Tunnel study in the San Francisco Bay area has shown.<sup>57</sup>

## **2. Environmental Costs and Considerations**

### **a. The RVP of Ethanol**

Gasoline's propensity to evaporate is measured by Reid vapor pressure (RVP). Because RVP measures the tendency of a material to evaporate, in the case of gasoline, it also measures the tendency of gasoline to produce volatile organic compounds (VOCs).

In order to control VOC emissions, the Clean Air Act Amendments of 1990 require that all gasoline be limited to an RVP maximum of 9.0 psi during the summer high ozone season, which the EPA has defined as June 1 - September 15. The Act also authorized EPA to set more stringent standards for nonattainment areas. As a result, EPA limits areas designated as "high volatility non-attainment" to a maximum RVP of 7.8 psi during the high ozone season. Some states elected to require even more stringent restrictions to achieve local clean air goals, and require 7.2- and 7.0-psi gasolines.

---

<sup>57</sup> See Robert Harley, Aromatic Hydrocarbon Trends in Gasoline, On-Road Vehicle Emissions & Ambient Air, Presentation at the Coordinating Research Council 16<sup>th</sup> Road Emissions Workshop (March 29, 2006).

When 10 percent ethanol is added to 9.0-psi conventional gasoline, the RVP of the mixture will rise to about 10 psi. Thus, the CAA allows conventional gasoline containing 10 percent ethanol to exceed the RVP maximums by 1 psi.<sup>58</sup>

RVP issues arise for a small area of the country in the summer only when ozone is a concern. The US summer gasoline pool breaks down approximately as follows:

|                            |            |
|----------------------------|------------|
| RFG Markets (7 RVP)        | 33 percent |
| Conventional Markets       |            |
| States' Low RVP (Boutique) | 17 percent |
| Non-control (8.7 RVP)      | 50 percent |

Approximately 50 percent of the summer gasoline does not need RVP controls for ozone, since this gasoline is consumed in ozone attainment areas. The RFG program does not allow the RVP waiver for ethanol blending; VOC emissions reductions are achieved through controls that are imposed on the RBOB blends. Thus, the market breakdown suggests that only about 17 percent of the summer gasoline market is a concern if a one-pound waiver for ethanol applies. This in turn is only about 9 percent of the gasoline pool on an annual basis. Using a simple (but very unlikely) assumption that ethanol cannot be used in that 9 percent of the annual market, the remaining 91 percent of gasoline volume could accept 12.5 billion gallons a year of ethanol without RVP issues arising. Congress anticipated this increased VOC concern in the Energy Policy Act of 2005 and gave those states with air quality issues (17 percent of the summer market) the ability to petition the EPA for the removal of ethanol's one-pound RVP waiver during the summertime. States concerned about ethanol's permeation VOCs have the option to use bioethers, which do not cause permeation. Also, lowering aromatics content in gasoline

---

<sup>58</sup> CAA section 211(h)(4).

through an aromatic MSAT rule or cap is another way to reduce mobile source VOCs by about 3 to 4 percent.

**b. Acetaldehyde emissions**

In a review of the air quality impacts of ethanol, the California Environmental Policy Committee (CEPC) concluded that the use of ethanol results in slightly increased levels of acetaldehyde and peroxyacetyl nitrate (PAN), but that “these compounds are more than offset by reductions in formaldehyde,” which is more harmful than acetaldehyde. Furthermore, the CEPC concluded that other gasoline components are primarily responsible for acetaldehyde and PAN emissions in any event. “Other components of gasoline, such as aromatic compounds and olefins, are primarily responsible for the formation of formaldehyde, acetaldehyde, and PAN due to both their greater abundance in gasoline and their shorter atmospheric lifetimes.” [Supply citation] Thus high aromatic content once again accounts for harmful emissions from gasoline.

**c. Groundwater contamination**

Releases of ethanol fuels to groundwater could occur from underground storage tank systems (USTs) and tanker truck or railcar accidents. In addition, small releases may occur from motor vehicle accidents where the fuel tank is damaged. UST releases can be either single events (large or small releases) or chronic small releases over time. Because of the substantial improvements to release prevention, detection, and corrective action technologies for USTs, the frequency of occurrence of releases is expected to be far less than it was 5 or 10 years ago. The size of releases is also expected to be smaller, and the time to detection much shorter, so the potential for such releases to migrate off-site is much less likely than in the past. If releases do occur, they could be detected quickly and appropriate corrective actions taken.

Ethanol is soluble in water and rapidly biodegrades in groundwater under most conditions. Most small releases of ethanol (e.g., 10s – 100s of gallons) should not persist for

more than a few weeks or months and would in most cases not travel far from the spill location. If large amounts of ethanol are released to subsurface (e.g., 1000s of gallons), or possibly for the case of chronic, infrequent small releases, it is possible that even with rapid biodegradation, ethanol may persist for much longer periods of time in groundwater and migrate offsite. EPA should evaluate these relatively small risks relative to the large potential air quality benefits that can be achieved.

**APPENDIX A**

## **EPA'S LEGAL AUTHORITY FOR REGULATING MSATS**

Congress added a requirement in the Clean Air Act in 1990 that required EPA to carry out rule making to reduce toxic air emissions from mobile sources (§202(l)). This provision directed EPA to complete a study of the need for, and feasibility of, mobile source air toxic regulations by May 15, 1992, and to promulgate regulations based on that study by May 15, 1995. 42 U.S.C. § 7521(l)(2). Congress required regulations to contain “reasonable requirements to control hazardous air pollutants from motor vehicle fuels” through “standards for such fuels or vehicles, or both, which the Administrator determines reflect *the greatest degree of emissions reduction achievable through the application of technology which will be available*, taking into consideration the standards established under subsection (a), the availability and costs of the technology, and noise, energy, and safety factors, and lead time.” *Id.* (emphasis added). This requirement does not mandate the least costly degree of emission reduction; rather, it mandates the greatest degree of reduction possible, taking costs (and other factors) into account. Note also that the provision is “technology-forcing” in that it requires, not just the best current technology can do today, but the best that it can do in the future.

The EPA did not meet the statutory deadlines, and environmental groups brought suit against the EPA to compel it to complete the rule making. *See Sierra Club v. Browner*, No. 95-1747 (D.D.C. Sept. 13, 1995). Shortly after this lawsuit was initiated, EPA entered into a consent decree setting a schedule for agency action. Consistent with the consent decree, EPA issued a proposed rule in August 2000 and a final rule in March 2001. *See* proposed rule at 65 Fed. Reg. 48,058 (Aug. 4, 2000) and final rule at 66 Fed. Reg. 17,230 (March 29, 2001) (the “MSAT rule”).

The EPA complied with the court-ordered deadlines, but it did not require any reductions in emissions beyond those already required by other existing or proposed mobile source regulations. Instead, EPA promulgated a rule merely intended to ensure that existing levels of air quality were maintained, not improved. Under this “anti-backsliding” rule, annual average toxics emissions from gasoline must be at least as good as the average annual performance of the gasoline produced or imported during the period 1998-2000 (the “baseline period”). Baseline performance is determined separately for each refinery and importer. EPA explained that it was adopting these near-term anti-backsliding controls on mobile source air toxics, but that it intended to continue to study mobile source air toxics issues and revise those controls as appropriate.

EPA also established a schedule for future rulemaking to address additional controls (codified at 40 C.F.R. § 80.1045). Section 80.1045 provided that EPA must issue a proposed rule by July 1, 2003, and a final rule by July 1, 2004. 40 C.F.R. § 80.1045.

Environmental groups unsuccessfully challenged the 2001 MSAT rule before the Court of Appeals for the District of Columbia. *See Sierra Club v. E.P.A.*, 325 F.3d 374, 377 (D.C. Cir. 2003). The court concluded that it was not illegal for EPA to defer rulemaking on controls of hazardous air pollutants from motor vehicles and motor vehicle fuel until a later time. *Id.* at 380. It bears noting that the court’s rejection of the legal arguments brought in the petition was not an endorsement of the EPA’s decision as a policy matter.

EPA did not propose additional controls by July 1, 2003, as promised in 40 C.F.R. § 80.1045. Therefore, in January 2004 environmental groups again brought suit to compel agency action. EPA filed a motion to dismiss. In the course of denying EPA’s motion, the court held

that § 80.1045 imposed a nondiscretionary duty on EPA to meet the deadlines set forth in 40 C.F.R. § 80.1045.

Accordingly, in July 2005, EPA proposed to settle the matter, agreeing to a consent decree with the environmental groups. The consent decree provided that by or before February 28, 2006, EPA would propose a rule “containing requirements to control hazardous air pollutants from motor vehicles and motor vehicle fuels as the Administrator determines are appropriate pursuant to section 202(1)(2) of the Clean Air Act, or, in the alternative, propose that no such requirements are necessary.” EPA must promulgate a final rule no later than February 9, 2007. Consent Decree ¶ 2.

Just one month after EPA entered into the consent decree, the President signed the Energy Policy Act of 2005. Section 1504 of the Act specifically addresses EPA’s MSAT rule, providing that “[n]ot later than July 1, 2007, the Administrator shall promulgate final regulations to control hazardous air pollutants from motor vehicles and motor vehicle fuels, as provided for in section 80.1045 of title 40, Code of Federal Regulations (as in effect on the date of enactment of this subparagraph), and as authorized under section 202(1) of the Clean Air Act.” This provision does not, however, nullify the settlement agreement. If EPA fails to meet the deadlines specified in the consent decree, the environmental groups can immediately return to court and ask the court to order EPA to do so.

On August 9, 2005, EPA published a notice in the Federal Register seeking public comment on the consent decree. 70 Fed. Reg. 46168. The American Petroleum Institute (API) filed the only comment. API argued that EPA had flexibility to extend the rulemaking deadline because the Energy Policy Act requires EPA to promulgate additional mobile air toxics regulations by July 1, 2007. API also asked EPA to consider the other obligations the Energy

Policy Act imposed upon it, including the promulgation of a workable renewable fuels standard program starting in 2006 and changes to regulations to conform with the repeal of the oxygenate mandate. After the public comment period closed, the Justice Department filed a motion requesting that the court enter the decree. The court entered a final order on January 20, 2006.

By electing to seek a reduction in benzene content alone, EPA has not satisfied its statutory mandate to impose the maximum degree of achievable MSAT emissions reductions. Taken together, toluene and xylene account for more than half of all MSAT emissions and more than five times the emissions of benzene alone. Achieving the maximum degree of MSAT emissions reductions cannot occur if toluene and xylene emissions are not regulated.

Aside from its general mandate to require the greatest degree of achievable MSAT reductions, the Clean Air Act also specifically mandates that EPA's regulations must, "at a minimum, apply to emissions of benzene" as well as formaldehyde. CAA § 202(l). Because the engine combustion of toluene and xylene in motor vehicles also produces benzene emissions, EPA's failure to reduce the toluene and xylene content in gasoline is not consistent with this specific mandate, which applies to benzene emissions, not to benzene content. In other words, reductions in both benzene and other aromatics in gasoline are necessary even if the goal is to achieve maximum reductions in benzene emissions alone.