

COMMENTS OF
THE ENERGY FUTURE COALITION
AND URBAN AIR INITIATIVE

On the U.S. Environmental Protection Agency's Proposed Rule:

CONTROL OF AIR POLLUTION FROM MOTOR VEHICLES:
TIER 3 MOTOR VEHICLE EMISSION AND FUEL STANDARDS

Docket ID No. EPA-HQ-OAR-2011-0135

78 Fed. Reg. 29816 (May 21, 2013)

Submitted July 1, 2013

Contents

I.	Summary	3
II.	EPA Leadership Is Needed on Fuel Content for Certification and Consumer Use.	7
III.	EPA Must Reduce Mobile Source Air Toxics in Motor Vehicle Fuel.	10
	A. EPA Has Not Met its Obligation to Regulate MSATs.	11
	B. MSATs Have a Significant Impact on Human and Environmental Health, Especially in Urban Areas.	13
	1. Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)	14
	2. Fine Particle Pollution (PM _{2.5})	15
	3. Ultra-Fine Particles (“UFPs”)	19
	4. Polycyclic Aromatic Hydrocarbons (PAHs)	21
	5. High-Distillate Aromatics	23
	6. Climate Effects	25
	a. Black Carbon	26
	b. Other Gasoline-Produced Climate Forcing Agents	29
	C. A Splash-Blended Mid-level Ethanol Fuel Would Greatly Reduce Air Toxics and Related Pollutants in Motor Vehicle Exhaust, Protecting Air Quality and Slowing the Pace of Climate Change.	30
IV.	EPA Should Take Steps to Ensure a Market Transition to a Clean, High-Octane Fuel.	33
	A. EPA Should Approve a Splash-Blended Mid-level Ethanol Blend Certification Fuel.	34
	B. EPA Should Remove Regulatory Disincentives that Currently Impede the Production of Vehicles that Run on a Mid-Level Ethanol Blend.	37
	1. EPA Should Enable a Market for Optimized, Dedicated, and Flex-Fuel Vehicle Production through Recognition of Ethanol’s Life-Cycle GHG Benefits.	38
	2. EPA Should Correct the Fuel Economy Calculation to Remove Unnecessary Disincentives to Certification on a Mid-Level Ethanol Blend.	41
	3. EPA Should Grant the New Mid-Level Ethanol Blend the Same One-Pound RVP Waiver Congress Granted to E10.	44
	C. EPA Should Use its MSAT Authority to Phase Down Aromatics in Motor Vehicle Fuel.	46
V.	Conclusion	47
	APPENDIX I: R Factor and Federal Test Procedures for Fuel Economy Calculations	48
	I. Fuel Economy Calculations on Standard 1975 Test Fuel	48
	II. Fuel Economy Calculations for MY 1988 and Later	49
	APPENDIX II: The Factual Basis for EPA’s Decision Not to Regulate Aromatics in 2007 Is No Longer Applicable.	52

The Energy Future Coalition and Urban Air Initiative appreciate the opportunity to comment on the Environmental Protection Agency's Proposed Rule: Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards.

The Energy Future Coalition is a bipartisan public policy initiative that brings together business, labor, and environmental leaders to address the challenges and opportunities of the transition to cleaner energy technologies. The Coalition seeks to identify and advance innovative policy options that appeal to a diverse array of competing interests and attract broad political support. Urban Air Initiative is a group of concerned citizens, non-profit groups, agriculture organizations, businesses of all types, and other stakeholders determined to reduce the threat to public health posed by our use of petroleum-based fuels, especially in urban areas where citizens are exposed to mobile source emissions at dangerous levels.

Together, we file these comments in response to EPA's questions in the Proposed Rule about whether to approve "an alternative certification fuel such as a high-octane 30 percent ethanol by volume (E30) blend"¹ to enable more efficient engine design. Our comments will show not only the advisability of approving a mid-level ethanol blend certification fuel, but also the need to facilitate its use in order to comply with EPA's obligation to regulate mobile source air toxics (MSATs or "hazardous air pollutants"). We hope EPA will take advantage of this opportunity to usher in a new era of cleaner, higher-efficiency fuel, improving the lives of millions of American citizens and protecting both public health and the environment.

¹ Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards, 78 Fed. Reg. 29825 (May 21, 2013) [hereinafter "Proposed Tier 3 Rule"], *available at* <http://www.gpo.gov/fdsys/pkg/FR-2013-05-21/pdf/2013-08500.pdf>.

I. Summary

The Proposed Rule will deliver substantial economic, health, and environmental benefits to the nation; however, it inadequately considers the opportunity to enlarge those benefits and save tens of billions of dollars annually by facilitating a gradual shift in the content of motor vehicle fuel for light-duty vehicles. A mid-level ethanol blend fuel, created by splash-blending ethanol with a gasoline blendstock that meets current standards, would maximize benefits to air quality and public health, automotive performance, and consumer costs:

- Air quality and public health: Aromatic hydrocarbons—which are air toxics in their own right—make up approximately 20%-30% of standard motor vehicle fuel in the United States. On combustion, these compounds produce emissions of benzene, toluene, ethylbenzene, xylene, 1,3-butadiene, polycyclic aromatic hydrocarbons (PAHs), and a host of other hazardous air pollutants, including dangerous levels of fine and ultra-fine particulate matter (PM_{2.5} and UFPs). Ethanol is a substitute for octane-enhancing aromatics; the average aromatics content in gasoline has dropped 16 percent over the past decade due to ethanol blending.²

A recent study led by the Harvard Center for Risk Analysis, with participation by EPA, estimated the public health impacts from exposure to only one of these hazards—PM_{2.5} originating from aromatic hydrocarbons in gasoline—at approximately 3800 premature mortalities nationwide and total social costs of \$28.2

² Proposed Tier 3 Rule, 78 Fed. Reg. at 29909.

billion.³ A straight-line extrapolation of aromatics reduction from ethanol replacement suggests that a 30% ethanol blend would save on the order of \$9 billion annually for just this one of many public health benefits—more than the low end of the total monetized health benefits of the Proposed Rule.⁴ Of particular concern, emission reduction technology in newer vehicles may worsen PM_{2.5} pollution if aromatics are not reduced in fuel.⁵ Reduction of mobile source air toxics, required by the Clean Air Act Amendments of 1990, has been too long neglected by EPA.

Achieving reductions in PM_{2.5} from mobile sources would also reduce regulatory pressure on stationary sources to find ever more costly ways to meet the National Ambient Air Quality Standard for concentrations of PM_{2.5} in the air. Electric utilities already face annual costs of \$9.6 billion to reduce such hazardous air pollutants.⁶

As another example, the Proposed Rule notes, “as the ethanol level increases, the volatility increase caused by blending ethanol with gasoline begins to decline, such that at E30 there is only about a 0.5-psi RVP increase.”⁷ Indeed, a recent study by a team from Ford Motor Company and AVL Powertrain Engineering, Inc. concluded

³ Katherine von Stackelberg, et al., *Public Health Impacts of Secondary Particulate Formation from Aromatic Hydrocarbons in Gasoline*, *Environmental Health* 2013 12:19, Feb. 20, 2013, <http://www.ehjournal.net/content/pdf/1476-069X-12-19.pdf>.

⁴ Proposed Tier 3 Rule, 78 Fed. Reg. at 29827.

⁵ See *infra* Part III.B.3 & note 71.

⁶ National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units, 77 Fed. Reg. 9306 (Feb. 16, 2012), <http://www.gpo.gov/fdsys/pkg/FR-2012-02-16/pdf/2012-806.pdf>.

⁷ Proposed Tier 3 Rule, 78 Fed. Reg. at 29938.

that RVPs match that of base gasoline at ethanol concentrations of 30%.⁸ This has positive implications for the cost and ease of compliance with the Proposed Rule.

- Automotive performance: As the Proposed Rule notes, the use of a 30% ethanol blend “could help manufacturers that wish to raise compression ratios to improve vehicle efficiency, as a step toward complying with the 2017 and later light-duty greenhouse gas and CAFE standards.”⁹ The Ford/AVL team reviewed 10 properties of ethanol blends and concluded that “a mid-level ethanol blend (greater than E20 and less than E40) appears to be attractive as a long-term future fuel for the US, especially if used in vehicles optimized for such a fuel.”¹⁰ Despite the lower energy content of ethanol, in an optimized vehicle with an E30 blend, vehicle fuel economy and range can be maintained. An E30 blend in an engine designed to use that fuel would have “ridiculous power and good fuel economy,” one senior automotive engineer said.¹¹
- Consumer costs: Numerous economic analyses suggest that the replacement of gasoline with ethanol reduces the cost of gasoline. A recent study at Louisiana State University, for example, found that each additional billion gallons of ethanol reduces gasoline prices as much as \$0.06 per gallon.¹² Considering U.S. ethanol production in 2010 was more than 13 billion gallons, this would suggest savings of up to \$0.78

⁸ Robert A. Stein, et al., *An Overview of the Effects of Ethanol-Gasoline Blends on SI Engine Performance, Fuel Efficiency, and Emissions*, 6 SAE Int’l J. Engines 1 (2013).

⁹ Proposed Tier 3 Rule, 78 Fed. Reg. at 29825.

¹⁰ See Stein, et al., *supra* note 8.

¹¹ William H. Woebkenberg, Mercedes-Benz senior engineer for fuels policy in the United States, *quoted in* Matthew L. Wald, *Squeezing More From Ethanol*, N.Y. Times, May 3, 2013, at AU4, *available at* http://www.nytimes.com/2013/05/05/automobiles/squeezing-more-from-ethanol.html?_r=0.

¹² Hassan Marzoughi, *The Impact of Ethanol Production on the U.S. Gasoline Market* 16 (presented Feb. 4-7, 2012), *available at*: http://www.ethanol.org/pdf/contentmgmt/The_Impact_of_Ethanol_Production_on_the_US_Gasoline_Market.pdf.

per gallon of gasoline. Since Americans consume more than 130 billion gallons of gasoline annually,¹³ this amounts to more than \$100 billion a year in savings. Increased ethanol use would further reduce gasoline consumption, increase those savings, and lessen the nation's vulnerability to economic disruption due to fluctuations in oil prices.

For all these reasons, we commend EPA for requesting comment on whether it should approve “an alternative certification fuel such as a high-octane 30 percent ethanol by volume (E30) blend for vehicles [automobile manufacturers] might design or optimize for use on such a fuel.”¹⁴ Our answer to this is an emphatic ‘yes.’ But in order to achieve this environmentally sound and technologically progressive result, EPA must remove certain hurdles erected by the current regulatory regime, described below in Part II.

We also recommend that EPA take this opportunity to lead a nationwide transition to cleaner fuel in order to meet the requirements of the Clean Air Act Amendments of 1990 and ensure “the greatest degree of [air toxic] emissions reduction achievable” from motor vehicle exhaust.¹⁵ Shifting to a mid-level ethanol blend is achievable with currently available technology and a sensible plan of action; however, the regulatory regime currently governing certification fuel and fuel marketability has thus far prevented automobile manufacturers and fuel refiners from initiating such a change. As EPA recognized in the Proposed Rule, meaningful emissions reductions can only come about “as part of a systems approach in addressing the

¹³ U.S. Energy Information Administration, *How much gasoline does the United States consume?*, <http://www.eia.gov/tools/faqs/faq.cfm?id=23&t=10>.

¹⁴ Proposed Tier 3 Rule, 78 Fed. Reg. at 29825.

¹⁵ 42 U.S.C. § 7521(l)(2).

impacts of motor vehicles and fuels on air quality and public health.”¹⁶ EPA has both the power and legal authority to craft such an approach. With time—and the removal of regulatory disincentives for alternative fuels—the nation’s motor vehicles could all be running on cleaner, safer fuel and benefiting from the performance enhancement that a higher-octane blend would make possible.

Accordingly, we respectfully request that EPA take the following steps to facilitate a nationwide transition to a cleaner, safer mid-level ethanol blend vehicle fuel:

- Approve a splash-blended, mid-level ethanol blend as a certification fuel;
- Adjust the greenhouse gas emissions calculation for all vehicles certifying on this fuel to account for ethanol’s life-cycle carbon advantage over gasoline;
- Extend to this fuel the one-pound waiver for Reid vapor pressure (RVP) that currently applies to E10;
- Beginning with a future model year, require all new gasoline vehicles to be certified on this fuel; and
- Consistent with the pace of adoption of both fuel and vehicles, limit the aromatic content of all light-duty motor vehicle fuel to the greatest degree achievable.

II. EPA Leadership Is Needed on Fuel Content for Certification and Consumer Use.

In its Proposed Rule, EPA requests comment on whether the Agency should approve “an alternative certification fuel such as a high-octane 30 percent ethanol by volume (E30) blend for vehicles [automobile manufacturers] might design or optimize for use on such a fuel.”¹⁷ Our

¹⁶ Proposed Tier 3 Rule, 78 Fed. Reg. at 29995.

¹⁷ *Id.* at 29825.

answer to this is an emphatic ‘yes.’ But in order to achieve this environmentally sound and technologically progressive result, EPA must remove certain hurdles erected by the current regulatory regime. Under current EPA regulations, automobile manufacturers must show that a fuel is “commercially available” before the Agency will approve it for emissions and fuel economy certification.¹⁸ In its proposed Tier 3 Rule, EPA states that the fuel must “be readily available nationwide” to meet this standard and that the onus is on automobile manufacturers to make this showing.¹⁹ However, EPA also asks for comment on whether this standard is appropriate.²⁰ In the case of a new mid-level ethanol blend, we believe that this standard is not appropriate.

Automobile manufacturers are not in a position to ensure that a fuel is available to consumers nationwide. The market will not produce and distribute a fuel until there are vehicles that run on it, and automobile manufacturers will not mass-produce vehicles optimized to run on a new fuel without assurance that these vehicles can be certified on that fuel, and that the fuel will be available to consumers. Moreover, Congress has prohibited the introduction of commercial fuel that is not already “substantially similar” to an existing certification fuel,²¹ so even if automobile manufacturers were capable of creating a market for a new fuel by themselves, they would not be allowed to do so until that fuel, or one like it, had already been

¹⁸ 40 C.F.R. § 1065.701(c)(1)(ii) (setting forth this requirement for emissions certification); 40 C.F.R. § 600.113-12 (basing fuel economy certification on grams/mile values); *see* Joint Technical Support Document: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards 4-6 (Aug. 2012) (noting that the same “certification fuel” is used for “[t]wo-cycle testing for CAFE and CO₂ compliance), *available* at <http://www.epa.gov/otaq/climate/documents/420r12901.pdf>.

¹⁹ Proposed Tier 3 Rule, 78 Fed. Reg. at 29911.

²⁰ *Id.* (“We seek comment on the appropriateness of the alternative test fuel provisions at § 1065.701(c) . . .”).

²¹ 42 U.S.C. § 7545(f)(1).

approved as a certification fuel. The current regulatory regime thus imposes a catch-22 on the industry: The fuel necessary for the next generation of motor vehicle engines cannot be introduced into the market until it is approved as a certification fuel, and it cannot be approved as a certification fuel until it is available in the market.²² EPA should take the initiative to solve this collective action problem by (1) approving for new motor vehicle certification a high-octane, mid-level ethanol blend, subject to the environmentally relevant parameters discussed below, (2) ensuring that such fuel can be made commercially available, and (3) removing the regulatory disincentives that currently inhibit the development of efficient vehicles optimized or dedicated to operate on this fuel.

A market shift from current light-duty motor vehicle fuel to a mid-level ethanol blend would result in numerous benefits to the environment, to American drivers, and to the public at large. Increasing the ethanol content of fuel would reduce the United States' dependence on foreign oil and achieve corresponding benefits to national security. A mid-level ethanol blend would provide desirable gains in clean octane,²³ enabling better engine performance and efficiency.²⁴ Finally, and of primary significance for the purpose of these comments, adding ethanol to fuel would allow EPA to satisfy its statutory obligation to regulate air toxics in motor vehicle fuel by reducing aromatic hydrocarbons that naturally occur in gasoline and are added to

²² This also creates an artificial ethanol “blendwall,” impeding progress with the congressionally mandated Renewable Fuel Standard (RFS). *See* Memorandum from Jeff Herzog to Docket # EPA-HQ-OAR-2011-0135, Possible Approach to Fuel Quality Standards for Fuel Used in Flexible-Fuel Automotive Spark-Ignition Vehicles (FFVs) 2 (Apr. 8, 2013) (“[F]urther expansion of ethanol blended fuels . . . is important to satisfying the requirements of the RFS program.”).

²³ We use the term “clean octane” to describe octane-boosting components (such as ethanol) that do not include toxic aromatic compounds derived from crude oil.

²⁴ Stein, et al., *supra* note 8 (concluding that “a mid-level ethanol-gasoline blend (greater than E20 and less than E40) appears to be attractive as a future fuel” based on its “substantial increase in knock resistance,” improved “full load performance,” and “aspects of fuel efficiency enabled by increased ethanol content . . . , including downsizing and downspeeding opportunities, increased compression ratio, fundamental effects associated with ethanol combustion, and reduced enrichment requirement at high speed/high load conditions”).

motor vehicle fuel as an octane enhancer. Reducing these harmful additives by adding octane-rich (and less expensive) ethanol would substantially reduce the environmental impact of fuel emissions with direct health benefits and lower pollution control costs to the public, especially in urban areas.

III. EPA Must Reduce Mobile Source Air Toxics in Motor Vehicle Fuel.

What goes into motor vehicle fuel directly affects the emissions that come out the tailpipe. By transitioning to a mid-level ethanol blend, EPA would fulfill its statutory duty to regulate air toxics from mobile sources. In the 1990 Clean Air Act Amendments, Congress gave EPA the duty to “promulgate (and from time to time revise)” regulations governing emissions of “hazardous air pollutants from motor vehicles and motor vehicle fuels.”²⁵ Furthermore, Congress required that these regulations “reflect the greatest degree of emission reduction achievable through the application of technology which will be available”²⁶; in other words, the mandate is strict and technology-forcing. “Hazardous air pollutants,” as that term is used in section 202(l) of the Act, are synonymous with “mobile source air toxics” (MSATs) and include the aromatic compounds which currently make up approximately 20%-30% of light-duty motor vehicle fuel in the United States. On combustion, these aromatic hydrocarbons—which are air toxics in their own right—produce benzene, toluene, ethylbenzene, xylene, 1,3-butadiene, polycyclic aromatic hydrocarbons (PAHs), and a host of other hazardous air pollutants.²⁷ In

²⁵ Clean Air Act § 202(l), 42 U.S.C. § 7521(l).

²⁶ *Id.*

²⁷ Elsewhere, the Clean Air Act provides that regulation of emissions of “toxic air pollutants” includes regulation of the “aromatic hydrocarbon content” of that fuel. 42 U.S.C. § 7545(k)(1)(A), (3)(A)(ii) (pertaining to reformulated gasoline); *see also* 42 U.S.C. § 7547(k)(10)(c) (defining “toxic air pollutants” to include benzene, 1,3-butadiene, and polycyclic organic matter (POM) [a term which includes PAHs such as naphthalene]). Another section of the Act explicitly includes the aromatics benzene “including benzene from gasoline,” toluene, and xylenes

addition, the combustion of aromatics in motor vehicle engines produces dangerous levels of fine and ultra-fine particulate matter (PM_{2.5} and UFPs), causing a range of environmental and human health effects, including thousands of deaths every year.²⁸ Finally, the combustion of aromatics in motor vehicle engines produces emissions of black carbon, one of the most powerful agents of climate change. Perhaps counterintuitively, in gasoline direct injection (GDI) engines (which are likely to become standard equipment in response to stricter fuel economy and greenhouse gas standards in the recent CAFE rule), emissions of black carbon and ultra-fine particles (UFPs) will increase if the level of aromatics in gasoline is not reduced.²⁹

A. EPA Has Not Met its Obligation to Regulate MSATs.

EPA has acknowledged that the “hazardous air pollutants” that must be regulated under section 202(l) of the Clean Air Act include aromatics, yet, apart from requiring a small decrease in benzene content in 2007,³⁰ the Agency has not yet substantially reduced aromatics in motor vehicle fuel. In a study required by section 202(l)(1), EPA discussed aromatics, including “benzene, formaldehyde, and 1,3-butadiene,” as well as the “gasoline particulate” that they produce.³¹ In its 2001 MSAT Rule, the Agency included in its list of MSATs the aromatics benzene, toluene, xylene, 1,3-butadiene, naphthalene, and polycyclic organic matter (POM), a

in a list of “hazardous air pollutants” subject to regulation. Clean Air Act § 112, 49 U.S.C. § 7412 (pertaining to emissions from stationary sources).

²⁸ See von Stackelberg, et al., *supra* note 3, at 1 (estimating a “baseline” of up to 4,700 deaths per year due to secondary organic aerosol (SOA) from gasoline, or over 6,300 deaths per year assuming 100% of aromatic-produced SOA in urban areas is from motor vehicles. These estimates did not take into account deaths from direct PM, the enhanced pathogenic qualities of UFPs, or PAH-related deaths); see *infra* Part III.B.6.a, III.B.3, III.B.4.

²⁹ See *infra* notes 71, 107.

³⁰ Control of Hazardous Air Pollutants from Mobile Sources, 72 Fed. Reg. 8428, 8477 (Feb. 26, 2007) [hereinafter “2007 MSAT Rule”].

³¹ Control of Emissions of Hazardous Air Pollutants from Mobile Sources, 66 Fed. Reg. 17230, 17234 (Mar. 29, 2001) [hereinafter “2001 MSAT Rule”].

subclass of air toxics that includes all PAHs.³² Nevertheless, EPA did not require any reductions in emissions beyond those already required by other existing or proposed mobile source regulations.³³ In its 2007 MSAT rule, EPA required a slight reduction in benzene content in vehicle fuel, but—based on several factual predicates that have since changed,³⁴ the Agency declined to regulate aromatics further.³⁵

Today, EPA has an opportunity to correct this deficiency and reduce the dangers of motor vehicle exhaust to public health. As noted in the Proposed Rule, more than 158 million Americans are currently experiencing unhealthy levels of air pollution, which are linked with respiratory and cardiovascular problems and other adverse health impacts that lead to increased medication use, hospital admissions, emergency department visits, and premature mortality. Motor vehicles are a particularly important source of exposure to air pollution, especially in urban areas.³⁶

Because current motor vehicle fuel is a major contributor to air toxics and particulate matter in the atmosphere,³⁷ and because benzene, toluene, ethylbenzene, and xylene (BTEX) (the class of aromatics added in the highest quantities to motor vehicle fuel) all produce benzene on combustion, EPA has the authority, and indeed the obligation, to reduce the aromatic content of

³² *Id.* at 17235.

³³ *Id.*

³⁴ *See* Appendix II.

³⁵ 2007 MSAT Rule, 72 Fed. Reg. at 8478-79; *see* Appendix II for a complete discussion of the changes in factual predicate since 2007.

³⁶ Proposed Tier 3 Rule, 78 Fed. Reg. at 29819.

³⁷ *See* California Office of Health Hazard Assessment, Summary of Scientific Meeting Held June, 2000 on Approaches to Assessing Health Impacts of Gasoline-Related Exposures in California, 5 [hereinafter “2000 Assessment of Gasoline-Related Health Impacts”], *available at* http://www.oehha.ca.gov/public_info/pdf/GasOEHHA.pdf.

motor vehicle fuel under sections 202(*l*) and 211 of the Clean Air Act. EPA must promulgate regulations that “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.”³⁸ While declining to regulate aromatics in 2007 because of cost and other factual predicates that are no longer applicable, the Agency acknowledged that “[t]here may be compelling reasons to consider aromatics control in the future, especially regarding reduction in secondary PM_{2.5} emissions, to the extent that evidence supports a role for aromatics in secondary PM_{2.5} formation.”³⁹ The Agency now acknowledges the important role of aromatics in PM_{2.5} formation,⁴⁰ and the time for cleaner gasoline has come; indeed, it is long overdue. EPA leadership to initiate a nationwide switch to a cleaner, less aromatics-intensive, mid-level ethanol blend would constitute a great stride toward a cleaner energy future and produce widespread environmental and health benefits.

B. MSATs Have a Significant Impact on Human and Environmental Health, Especially in Urban Areas.

Regulation of gasoline aromatics under Clean Air Act sections 211 and 202(*l*) is urgently needed because aromatics cause thousands of deaths each year, along with a host of other serious health and environmental problems. All of these problems would be greatly ameliorated through the use of a cleaner, mid-level ethanol blend.

³⁸ 42 U.S.C. § 7521(*l*)(2).

³⁹ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

⁴⁰ Clean Air Fine Particle Implementation Rule, 72 Fed. Reg. 20,586, 20,593 (Apr. 25, 2007) [hereinafter “PM Implementation Rule”].

1. Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)

Benzene, toluene, ethylbenzene, and xylene, known collectively as “BTEX,” are all aromatic compounds included in gasoline to increase its octane rating. These air toxics, which belong to a class known as volatile organic compounds (VOCs), are emitted in tailpipe exhaust. Recent studies show that the majority of BTEX (83%-100%) on and near roadways is the result of gasoline tailpipe emissions.⁴¹ As a result, BTEX from gasoline exhaust has significant health and developmental implications, especially for urban populations⁴²—pertinent to EPA’s environmental justice criterion in the Proposed Rule.⁴³

On their own, VOCs cause many harmful effects on the human nervous system and can contaminate soil and groundwater with lasting effects.⁴⁴ Benzene, for example, is a known human carcinogen and causes a range of health effects, including blood disorders and immunotoxicity.⁴⁵ Furthermore, once in the ambient air, VOCs combine through complex

⁴¹ See, e.g., Eric M. Fujita, et al., Concentrations of Air Toxics in Motor Vehicle-Dominated Environments, Health Effects Institute Research. Rep. No. 156, at 2 (2011); see also 2000 Assessment of Gasoline-Related Health Impacts, *supra* note 37, at 5 (“[I]t appears that light-duty gasoline vehicle particulate matter emissions are significantly underestimated in current inventories. Light-duty gasoline vehicles are the major source of 1,3-butadiene and BTEX.”).

⁴² K.P. Wyche, et al., *Gas Phase Precursors to Anthropogenic Secondary Organic Aerosol: Detailed Observations of 1,3,5-Trimethylbenzene Photooxidation*, 9 Atmos. Chem. Phys. 635 (2009) (“[Aromatic VOCs] make up as much as 40% of the total mass of anthropogenic hydrocarbon emissions in the city environment.”), available at <http://www.atmos-chem-phys.net/9/635/2009/acp-9-635-2009.pdf>; see also Frederica P. Perera, *Prenatal Polycyclic Aromatic Hydrocarbon (PAH) Exposure and Child Behavior at Age 6-7 Years*, 120 Environ. Health Perspectives 921, 921 (2012) (“Urban, minority populations in the United States often have disproportionate exposure to air pollution and are at greater risk for adverse health and developmental outcomes.”).

⁴³ Proposed Tier 3 Rule, 78 Fed. Reg. at 29849.

⁴⁴ See John S. Zogorski, et al., *The Quality of Our Nation’s Waters: Volatile Organic Compounds in the Nation’s Ground Water and Drinking-Water Supply Wells*, U.S. Department of the Interior, U.S. Geological Survey, Circular 1292, at 8, 9 (2006), available at <http://pubs.usgs.gov/circ/circ1292/pdf/circular1292.pdf>.

⁴⁵ 2007 MSAT Rule, 72 Fed. Reg. at 8435 (citing EPA, *Integrated Risk Information System File: Benzene* (2000), <http://www.epa.gov/iris/subst/0276.htm>); see generally EPA National Center for Environmental Assessment, Rep. No. EPA/635/R-02/001F, *Toxicological Review of Benzene (Noncancer Effects)* (2002), available at <http://www.epa.gov/iris/toxreviews/0276tr.pdf>.

chemical pathways to produce significant amounts of fine particle pollution, including particularly dangerous ultra-fine particles (UFPs), which can become coated by toxic polycyclic aromatic compounds (PAHs), allowing these harmful cytotoxic and mutagenic chemicals to penetrate deep inside the human body. Each of these dangerous forms of pollution caused by aromatics is discussed below.

2. Fine Particle Pollution (PM_{2.5})

Aromatics in gasoline are among the most efficient anthropogenic precursors of secondary organic aerosol (SOA),⁴⁶ a species of fine particulate matter (PM_{2.5})—*i.e.*, particles less than 2.5 micrometers in diameter. It is widely acknowledged that EPA’s current models do not adequately capture the SOA-forming potential of gasoline aromatics,⁴⁷ nor do motor vehicle

⁴⁶ E.Z. Nordin, et al., *Secondary Organic Aerosol Formation from Gasoline Passenger Vehicle Emissions Investigated in a Smog Chamber*, 12 *Atmos. Chem. & Phys. Discussions* 31,725, 31,749 (2012) (“As shown in this study gasoline exhaust readily forms secondary organic aerosol with a signature aerosol mass spectrum with similarities to the oxidized organic aerosol that commonly dominates the OA mass spectra in and downwind urban areas. This substantiates recent claims that gasoline SOA is a dominating source to SOA in and downwind large metropolitan areas.”), available at <http://www.atmos-chem-phys-discuss.net/12/31725/2012/acpd-12-31725-2012-print.pdf>; L. Hildebrandt, et al., *High Formation of Secondary Organic Aerosol from the Photo-oxidation of Toluene*, 9 *Atmos. Chem. Phys.* 2973, 2973 (2009), available at <http://www.atmos-chem-phys.net/9/2973/2009/acp-9-2973-2009.pdf> (“Toluene and other aromatics have long been viewed as the dominant anthropogenic secondary organic aerosol precursors.”); *id.* at 2984 (“The SOA yields from the photo-oxidation of toluene are higher than previously reported values.”); J.A. de Gouw, et al., *Sources of Particulate Matter in the Northeastern United States in Summer: 1. Direct Emissions and Secondary Formation of Organic Matter in Urban Plumes*, 113 *J. Geophys. Research* D08301, at 8 (2008) (“Particulate yields [of OM] . . . are . . . highest for aromatic compounds.” (citation omitted)); *see also id.* at 1 (“Approximately 37% of the secondary formation [of aerosol organic matter] can be accounted for by the removal of aromatic precursors.”).

⁴⁷ One recent study found that EPA’s CMAQ v5.0 model underestimates gasoline’s PM_{2.5} contribution by a factor of 3.8. Stackelberg, et al., *supra* note 3, at 5; *see also* Kenneth S. Docherty, et al., *Apportionment of Primary and Secondary Organic Aerosols in Southern California During the 2005 Study of Organic Aerosols in Riverside (SOAR-1)*, 42 *Environ. Sci. Tech.* 7655, 7660 (2008) (“With regard to SOA yields, it has been shown that model predictions based on simulation chamber yields dramatically underestimate SOA formation in the polluted atmosphere.” (citing R. Volkamer, et al., *Secondary Organic Aerosol Formation from Anthropogenic Air Pollution: Rapid and Higher than Expected*, 33 *Geophys. Research Letters* 17 (2006))); Draft Regulatory Impact Analysis: Tier 3 Motor Vehicle Emission and Fuel Standards, at 7-66 (March 2013) [hereinafter “Tier 3 DRIA”] (“Studies have indicated that ambient OC levels may be underestimated by current model parameterizations. While the treatment of new precursors has likely reduced the model/measurement bias, underestimates can persist.”); Q. Zhang, et al., *Ubiquity and Dominance of Oxygenated Species in Organic Aerosols in Anthropogenically-Influenced Northern Hemisphere Midlatitudes*, 34 *Geophys. Research Letters* L13801, at 1 (2007) (“[S]econdary organic aerosols (SOA),

emissions tests capture the formation of SOA.⁴⁸ However, aromatics' SOA formation potential is of deadly import, because SOA is a major contributor to the PM_{2.5} burden throughout the United States, particularly in urban areas.⁴⁹ In addition to SOA, gasoline aromatics produce direct PM in the form of black carbon and PAHs, both discussed below.⁵⁰ In fact, the entire PM_{2.5} formation potential of gasoline comes from aromatics.⁵¹ Ethanol, by contrast, does not produce PM_{2.5}, as EPA's own investigations have concluded.⁵² Thus, a reduction in the aromatic content of motor vehicle fuel would significantly reduce PM_{2.5} levels in urban areas and near roadways.⁵³

formed by chemical transformation and condensation of volatile and semivolatile species, are underestimated by an order of magnitude or more by current models when applied in and downwind of urban areas/polluted regions.”).

⁴⁸ See generally Nordin, et al., *supra* note 46, at 31726 (“[T]here is a lack of laboratory studies to systematically investigate SOA formation in real-world exhaust.”).

⁴⁹ See sources cited *supra* note 46; see also Nordin, et al., *supra* note 46, at 31726 (“Gasoline vehicles have elevated emissions of volatile organic compounds during cold starts and idling and have recently been pointed out as potentially the main source of anthropogenic secondary organic aerosol (SOA) in megacities.”); PM Implementation Rule, 72 Fed. Reg. at 20593 (“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.”); Wyche, et al., *supra* note 42, at 635; see also Elizabeth A. Stone, et al., *A Comparison of Summertime Secondary Organic Aerosol Source Contributions at Contrasting Urban Locations*, 43 Environ. Sci. Technol. 3448, 3454 (2009) (finding spatial differences in the primary and secondary sources of OC between cities and noting that they “demonstrate the need to treat geographically distinct source regions individually in the study of source contributions to SOA”).

⁵⁰ See *infra* Parts III.B.6.a, III.B.4.

⁵¹ See J.R. Odum, et al., *The Atmospheric Aerosol-Forming Potential of Whole Gasoline Vapor*, 276 Science 96, 96 (1997) (“[T]he atmospheric organic aerosol formation potential of whole gasoline vapor can be accounted for solely in terms of the aromatic fraction of the fuel.”), available at <http://www.unc.edu/courses/2007fall/envr/416/001/OdumScience97.pdf>.

⁵² See Tier 3 DRIA, *supra* note 47, at 7-64.

⁵³ See, e.g., R. Bahreini, et al., *Gasoline Emissions Dominate Over Diesel in Formation of Secondary Organic Aerosol Mass*, 39 Geophys. Research Letters L06805, at 1 (2012) (“[S]ubstantial reductions of SOA mass on local to global scales will be achieved by reducing gasoline vehicle emissions.”); Michael J. Kleeman, et al., *Source Apportionment of Secondary Organic Aerosol During a Severe Photochemical Smog Episode*, 41 Atmos. Environ. 576 (2007) (finding that gasoline engines represented the greatest anthropogenic contributor of SOA in Los Angeles during a smog event); 2000 Assessment of Gasoline-Related Health Impacts, *supra* note 37, at 18 (“For some of the high molecular weight PAH, gasoline appears to be the dominant source. Naphthalene levels are higher in gasoline than in diesel.”); *id.* at 26 (“Data from the Northern Front Range Study showed that even moderately clean vehicles emitted a lot more or comparable or higher emission rates of both gas phase and particle phase PAHs

PM_{2.5} is widely viewed as the most lethal air pollutant in the United States. It causes thousands of deaths every year, as well as a range of other health and environmental effects.⁵⁴ As EPA noted in its 2007 MSAT rule, “[h]ealth effects associated with short-term exposures (e.g., hours to days) in ambient PM_{2.5} include mortality, increased hospital admissions, heart and lung diseases, increased cough, adverse lower-respiratory symptoms, decrements in lung function and changes in heart rate rhythm and other cardiac effects.”⁵⁵ Studies also show associations between long-term exposure to PM_{2.5} and cardiorespiratory and lung-cancer mortality.⁵⁶ Because PM_{2.5} is particularly lethal, power plants and other stationary sources are strictly regulated to reduce emissions, and States must meet a National Ambient Air Quality Standard (NAAQS) that limits concentrations of PM_{2.5} in the air.

Nevertheless, States are currently unable to obtain routine State Implementation Plan credit toward meeting the NAAQS by reducing SOA from motor vehicles,⁵⁷ and EPA’s own

than diesel vehicles.”); Shang Liu, et al., *Secondary Organic Aerosol Formation from Fossil Fuel Sources Contribute Majority of Summertime Organic Mass at Bakersfield*, 117 J. Geophys. Research D00V26, at 1 (2012) (“In urban areas, the major source [of the organic fraction of atmospheric particles] is fossil fuel combustion from gasoline- and diesel-powered vehicles and other industrial activities (e.g., oil burning).”), available at <http://onlinelibrary.wiley.com/doi/10.1029/2012JD018170/pdf>.

⁵⁴ See C. Arden Pope III, *Epidemiology of Fine Particulate Air Pollution and Human Health: Biologic Mechanisms and Who’s at Risk?*, 108 Environ. Health Perspectives Supplements (2000); Pope, et al., *Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution*, 287 JAMA 1132 (2002), available at http://www.epw.senate.gov/107th/Levy_1.pdf.

⁵⁵ 2007 MSAT Rule, 72 Fed. Reg. at 8443; accord Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. 14670, 14808-09 (March 26, 2010) [hereinafter “RFS2”] (“Health effects associated with short-term exposures (hours to days) to ambient PM include premature mortality, aggravation of cardiovascular and lung disease (as indicated by increased hospital admissions and emergency department visits), increased respiratory symptoms including cough and difficulty breathing, decrements in lung function, altered heart rate rhythm, and other more subtle changes in blood markers related to cardiovascular health.”).

⁵⁶ See RFS2, 75 Fed. Reg. at 14808-09 (“Long-term exposure to PM_{2.5} and sulfates has also been associated with mortality from cardiopulmonary disease and lung cancer, and effects on the respiratory system such as reduced lung function growth or development of respiratory disease. A new analysis shows an association between long-term PM_{2.5} exposure and a subclinical measure of atherosclerosis.”).

⁵⁷ In order to obtain SIP credit for mobile source reductions, States would have to undertake costly studies to, in effect, prove to EPA that credit is warranted, and even then credit would not be ensured. See PM Implementation Rule, 72 Fed. Reg. at 20594.

PM_{2.5} regulations focus mainly on stationary sources such as power plants. As a result, costly reductions are required in remote areas, while relatively little is done to reduce PM_{2.5}—particularly SOA—from motor vehicles, even in densely populated areas, where the benefits of reducing mobile source PM would be significantly higher on a per-ton basis.⁵⁸ This anomaly is particularly perverse considering that, unlike stationary source reductions, which cost billions of dollars per year to implement,⁵⁹ reducing SOA from motor vehicle fuel could save consumers billions of dollars per year at the pump.⁶⁰ Focusing exclusively on stationary sources thus places an unnecessary burden on state regulators, who must require unnecessarily costly ways to reduce PM pollution in order to meet their NAAQS obligations. This regulatory disparity between mobile and stationary sources effectively grants refiners a “hidden subsidy,” since aromatics’ considerable health costs are both borne directly by affected citizens, taxpayers, and health

⁵⁸ EPA, Environmental Benefits Mapping and Analysis Program (BenMAP): RSM-based Benefit Per Ton Estimates, (estimating the national average benefit in per ton reduction of PM at \$630,000 for mobile sources and only \$520,000 for point sources such as EGUs), <http://www.epa.gov/airquality/benmap/bpt.html>; see also Neal Fann, et al., *The Influence of Location, Source, and Emission Type in Estimates of the Human Health Benefits of Reducing a Ton of Air Pollution*, 2 Air Qual. Atmos. Health 169, 170, 173-74 (2009) (finding that “the size of the population exposed to PM_{2.5} and the susceptibility of that population to adverse health outcomes” is an important factor in calculating the benefit of pollution reduction, and that “area source and mobile source [as opposed to ‘point source’/EGU] carbonaceous particle emissions, in particular, show the highest [benefit per ton]—suggesting that the emissions and population centers exposed are colocated”).

⁵⁹ See, e.g., National Emission Standards for Hazardous Air Pollutants from Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units, 77 Fed. Reg. 9304, 9305-06 & table 2 n.b (Feb. 16, 2012) [hereinafter “Utility MACT”], (estimating annual social costs of \$9.6 billion to implement, with over 90% of monetized benefits coming from reduction in premature fatalities due to PM), <http://www.gpo.gov/fdsys/pkg/FR-2012-02-16/pdf/2012-806.pdf>.

⁶⁰ A recent study at Louisiana State University found that “each additional billion gallons of ethanol reduces gasoline prices as much as \$0.06 per gallon. Considering U.S. ethanol production in 2010, which was more than 13 billion gallons, ethanol production could result in having lower gasoline prices of up to \$0.78 per gallon.” Hassan Marzoughi, *The Impact of Ethanol Production on the U.S. Gasoline Market* 16 (presented Feb. 4-7, 2012), http://www.ethanol.org/pdf/contentmgmt/The_Impact_of_Ethanol_Production_on_the_US_Gasoline_Market.pdf. Likewise, a study at Iowa State University suggests “that increases in ethanol production over the last decade have reduced overall blended fuel prices.” Notice of Decision Regarding Requests for a Waiver of the Renewable Fuel Standard, 77 Fed. Reg. 70752, 70766 (Nov. 27, 2012) [hereinafter RFS Waiver Denial] (citing Xiaodong Du & Dermot J. Hayes, *The Impact of Ethanol Production on U.S. and Regional Gasoline Markets: An Update to 2012* (May 2012), available at <http://www.card.iastate.edu/publications/synopsis.aspx?id=1166>)).

providers and transferred indirectly to other businesses by state environmental authorities—even though aromatics could be significantly reduced by ethanol at far lower cost than other means of control.

3. Ultra-Fine Particles (“UFPs”)

When it comes to fine particulate pollution, size and type matter. Because of their small size, ultra-fine particles (UFPs)—that is, particles less than 100 nanometers in diameter—are an especially dangerous byproduct of high-distillate aromatics,⁶¹ including naphthalene, in gasoline. Unlike larger particles, which can sometimes deposit in the mouth and throat after inhalation, UFPs are likely to travel deep into the alveolar region of the lungs,⁶² which allows them to function as vehicles on which dangerous toxic compounds such as PAHs⁶³ (also present in large quantities in gasoline exhaust as a result of aromatics combustion) can enter bodily tissues and wreak havoc on a cellular level.⁶⁴ Once in the alveolar tissue, UFP-borne PAHs (and the particulate matter itself) can be absorbed into the bloodstream and enter other bodily organs, such as the liver.⁶⁵ UFPs in gasoline exhaust exhibit a relatively high number of these so-called “redox-active” compounds. Paired with greater bioavailability and lung retention than other

⁶¹ See *infra* Part III.B.5.

⁶² See, e.g., Morton Lippmann & Roy E. Albert, *The Effect of Particle Size on the Regional Deposition of Inhaled Aerosols in the Human Respiratory Tract*, 30 *Am. Indus. Hyg. Ass’n J.* 257 (1969), available at <http://legacy.library.ucsf.edu/documentStore/b/p/e/bpe89c00/Sbpe89c00.pdf>.

⁶³ See *infra* Part III.B.4.

⁶⁴ Gwami Shrestha, et al., *Black Carbon’s Properties and Role in the Environment: A Comprehensive Review*, 2 *Sustainability* 294, 307 (2010), available at <http://www.mdpi.com/2071-1050/2/1/294/pdf>; 2000 Assessment of Gasoline-Related Health Impacts, *supra* note 37, at 4 (Because of their small size, UFPs “can serve as an important vehicle for carrying other toxicants into the lung.”).

⁶⁵ Shrestha, et al., *supra* note 64, at 307-08; 2000 Assessment of Gasoline-Related Health Impacts, *supra* note 37, at 4.

forms of particulate, this makes UFPs highly pathogenic.⁶⁶ Studies have linked UFPs to myriad adverse health effects, including asthma and other respiratory conditions; cardiovascular disease; preterm births; a wide range of cancers; DNA damage; even autism and brain disorders.⁶⁷ Furthermore, the small size of UFPs means that—beyond the added danger posed by particle type—each ton of UFPs is more dangerous than a ton of PM_{2.5} because UFP pollution contains many more particles per unit mass (this property is known as “particle number,” or “PN”).⁶⁸ However, because EPA currently regulates only mass, but not particle number or type, of particulate pollution,⁶⁹ the Agency has yet to separately measure or regulate these highly pathogenic UFPs. Of particular concern, emission reduction technology in newer vehicles tends to produce more high-particle-number emissions, even as it reduces particulate emissions by mass.⁷⁰ Thus, the health impact of UFP pollution will only grow as the next generation of direct

⁶⁶ Jesus A. Araujo & Andre E. Nel, *Particulate Matter and Atherosclerosis: Role of Particle Size, Composition and Oxidative Stress*, 6 *Particle & Fibre Toxicology* (2009), available at <http://www.particleandfibretoxicology.com/content/6/1/24/ref> (also noting that “[i]t will be important to determine whether all these factors confer greater toxicity to UFP in human subjects since they may imply the need for adjusting the metrics of exposure to take account of particle number, surface area, and oxidant potential”).

⁶⁷ Lee Hotz, *The Hidden Toll of Traffic Jams*, *The Wall Street Journal*, Nov. 8, 2011, at D1, available at <http://online.wsj.com/article/SB10001424052970203733504577024000381790904.html>.

⁶⁸ See Araujo & Nel, *supra* note 66 (“[P]articles < 0.1-0.2 μm, which contribute very little to overall PM_{2.5} mass, represent > 85-90% of the total PM_{2.5} particle number. Therefore, it is conceivable that larger particle numbers in UFP atmospheres, despite a smaller mass, could result in larger biological effects. In our study, development of larger atherosclerotic lesions in the UFP exposures correlated with increased particle numbers rather than with PM mass.” (footnote call omitted)); Zhi Ning & Constantinos Sioutas, *Atmospheric Processes Influencing Aerosols Generated by Combustion and the Inference of Their Impact on Public Exposure: A Review*, 10 *Aerosol & Air Quality* 43, 54-55 (2010) (“The emission of these smaller particles in the atmosphere may pose a greater threat to public health, since they deposit deeper in the human respiratory systems and their chemical composition appears to be intrinsically more toxic than the non-labile PM. . . . Given the increased toxicity of these semi-volatile species [e.g., PAHs], efforts should be made to reduce their emissions from newer vehicles, including reductions in their gas-phase precursors formed during the combustion process.”), available at http://aaqr.org/VOL10_No1_February2010/6_AAQR-09-05-IR-0036_43-58.pdf.

⁶⁹ See 40 C.F.R. § 86.096-8(a)(1) (setting emissions standards in grams per mile).

⁷⁰ See Ning & Sioutas, *supra* note 68, at 54 (“Advanced vehicle emission control technologies are effective in reducing solid, non-labile PM emissions by means of filtration. However, recent investigations have shown substantial increases (by one order of magnitude and often more) of particle number emissions from retrofitted

injection vehicles replaces older port injection vehicles. Perhaps counterintuitively, newer vehicles tend to emit more UFPs than legacy vehicles by as much as fourfold.⁷¹

4. Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a chemical subset of polycyclic organic matter (POM) and are a particularly dangerous, yet largely unregulated, air toxic largely attributable to mobile sources generally,⁷² and gasoline-fueled vehicles in particular.⁷³ As with UFPs, PAHs are produced by aromatics in gasoline,⁷⁴ particularly high-distillate aromatics.⁷⁵ PAHs can exist in both gaseous and particle

vehicles due to the formation of nucleation mode particles from organic vapors in the exhaust.”); Walter Piock, et al., *Strategies Toward Meeting Future Particulate Matter Emission Requirements in Homogeneous Gasoline Direct Injection Engines*, SAE International (2011), available at <http://delphi.com/pdf/techpapers/2011-01-1212.pdf>.

⁷¹ See Health Effects Institute Special Committee on Emerging Technologies, *The Future of Vehicle Fuels and Technologies: Anticipating Health Benefits and Challenges* 3 (2011) (“Because of the less complete mixing of fuel vapor and air [in a direct-injection engine] . . . , the particulate emissions of the engine increase, including the number of ultrafine particles.”); Felix Leach, et al., *The Effect of Fuel Volatility and Aromatic Content on Particulate Emissions from GDI Engines* (presented at 16th Combustion Generated Nanoparticles, Zurich, 2012), available at http://www.lav.ethz.ch/nanoparticle_conf/Former/Posters_I-L.pdf; Constantinos Sioutas, et al., Final Technical Report: Physical and Chemical Characteristics of PM in the LAB (Source Receptor Study): Topic C: Studies of the Effects of Varying Spatial and Temporal Patterns of Ambient Particulate Matter (PM) and Co-pollutants and Resulting Health Effects with Emphasis on the Role of Atmospheric Chemistry (Mar. 30, 2005) (“Compared to previous studies at the Caldecott tunnel, less particle mass but more particle numbers (by factors of 2-4 fold) are emitted by vehicles than was the case 7 years ago. As the emissions of carbonaceous PM of newer engines decreases, the formation of nucleation mode particles is favored due to the reduction of the available surface for adsorption of the semi-volatile material. The resulting supersaturation of the mostly organic vapor increases the production of nano-particles by nucleation.”), available at <http://www.epa.gov/ncer/reports/r827352C014fr.pdf>; see also *infra* note 107 & accompanying text (discussing increased black carbon emission from direct injection engines).

⁷² See Control of Hazardous Air Pollutants from Mobile Sources, Regulatory Impact Analysis, at 3-112 (2007) [hereinafter “2007 MSAT RIA”] (“Major sources of PAHs include mobile sources.”); Ning & Sioutas, *supra* note 68, at 50 (“PAH concentrations were consistently higher when the nearby freeway was busy with traffic during morning rush hours.”).

⁷³ 2000 Assessment of Gasoline-Related Health Impacts, *supra* note 37, at 5 (“Light-duty gasoline vehicles emit particulate matter containing higher fractions of particulate PAHs [than heavy-duty diesel vehicles]. Light-duty gasoline vehicles are significant sources of gas phase PAHs. Cold starts, high accelerations, and high emitters account for most of the [LDV] particulate matter emissions. . . . [I]t appears that [LDV] particulate matter emissions are significantly underestimated in current inventories. Light-duty gasoline vehicles are the major source of 1,3-butadiene and BTEX.”).

⁷⁴ See generally *id.*; Memorandum from Robert Harley, Department of Civil and Environmental Engineering, U.C. Berkeley, to Steve Brisby, Stationary Source Division, California Air Resources Board (Apr. 26, 2007) (“[L]owering heavy aromatics in gasoline could help to reduce polycyclic aromatic hydrocarbons (PAH), another class of toxic compounds that are not included currently in the predictive model’s definition of toxic pollutant emissions.”).

form. They are oxidative derivatives of gasoline aromatics and result from incomplete combustion of fused aromatic rings. Many aromatics are themselves PAHs. Naphthalene, for instance, is a dangerous aromatic in motor vehicle fuel—and it is the simplest of the PAHs. However, the most harmful PAHs are the high-molecular-weight PAHs that coat UFPs.⁷⁶ Urban UFPs disproportionately carry PAHs.⁷⁷ As EPA noted in its 2007 MSAT rule, “[r]ecent studies have found that maternal exposures to PAHs in a population of pregnant women were associated with several adverse birth outcomes, including low birth weight and reduced length at birth, as well as impaired cognitive development at age three.”⁷⁸ Laboratory experiments show that fetal nervous systems may be particularly sensitive to PAHs,⁷⁹ which can cross the placenta and blood-brain barrier from mother to child.⁸⁰ PAHs have been linked to a range of adverse health outcomes in infants and children, including developmental delay, reduced IQ, anxiety/depression, and possible endocrine disruption.⁸¹ Motor vehicle emissions are a major

⁷⁵ See *infra* Part III.B.5.

⁷⁶ See Yuling Jia, et al., *Estimated Reduction in Cancer Risk due to PAH Exposures If Source Control Measures during the 2008 Beijing Olympics Were Sustained*, 119 *Environ. Health Perspect.* 815, 820 (2011) (noting the importance of including high-molecular-weight PAHs in pollution studies despite their low environmental concentrations because of the disproportionately high cancer risk associated with them), available at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3114816/>; see also *supra* Part III.B.3 (discussing UFPs).

⁷⁷ Araujo & Nel, *supra* note 66 (“Urban UFP contain a higher content per unit mass of polycyclic aromatic hydrocarbons (PAH).”).

⁷⁸ 72 Fed. Reg. at 8439.

⁷⁹ Perera, *supra* note 42, at 921 (citing L.A. Brown, et al., *Down-Regulation of Early Ionotropic Glutamate Receptor Subunit Developmental Expression as a Mechanism for Observed Plasticity Deficits Following Gestational Exposure to Benzo(a)pyrene*, 28 *Neurotoxicology* 965 (2007); M.M. McCallister, et al., *Prenatal Exposure to Benzo(a)pyrene Impairs Later-Life Cortical Neuronal Function*, 29 *Neurotoxicology* 946 (2008); D.D. Wormley, *Environmental Contaminant-Mixture Effects on CNS Development, Plasticity, and Behavior*, 197 *Toxicol. Appl. Pharmacol.* 49 (2004)).

⁸⁰ Perera, *supra* note 42, at 921 (citing Brown, *supra* note 79).

⁸¹ *Id.*

source of PAHs found to contaminate groundwater and aquatic organisms.⁸² As with other hazardous air toxics from gasoline, the worst effects of PAHs are found in urban areas.⁸³

Although PAHs and their associated health risks are better understood today than in the recent past, EPA restates verbatim its six-year-old statement of uncertainty about their prevalence.⁸⁴

5. High-Distillate Aromatics

The temperature at which a given percentage of fuel, by volume, will evaporate is an important characteristic from a pollution perspective. Gasoline contains a wide range of components, including aromatics of various molecular weights and chemical properties, which boil at different temperatures. High-distillate aromatics evaporate only at very high temperatures and often do not vaporize during gasoline combustion.⁸⁵ “T50,” “T90,” and “endpoint” numbers for a given fuel refer to the temperatures at which 50%, 90%, and 100% of the fuel will evaporate, respectively. Since compounds that do not evaporate during engine combustion are often emitted from the tailpipe in the form of dangerous pollution, the more high boilers present in a fuel blend (and thus the higher the T50, T90, and endpoint numbers of the fuel), the more

⁸² See EPA, Technical Factsheet on Polycyclic Aromatic Hydrocarbons (PAHs) (“If released to soil [benzo(a)pyrene] will be expected to adsorb very strongly and will not be expected to leach to the groundwater. However, its presence in some groundwater samples indicates that it can be transported there by some mechanism.”), available at <http://www.epa.gov/ogwdw/pdfs/factsheets/soc/tech/pahs.pdf>; 2007 MSAT Rule, 72 Fed. Reg. at 8444 (“[R]ecent studies have reported gasoline and diesel vehicles as major contributors in the atmospheric deposition of PAHs to [various watersheds].”).

⁸³ Kanae Bekki, et al., *Evaluation of Toxic Activities of Polycyclic Aromatic Hydrocarbon Derivatives Using In Vitro Bioassay*, 55 J. Health Sci. 601, 606-07 (2009) (“PAH ketones and quinines originating from gasoline and diesel engine exhausts are present at comparatively high concentrations . . . in urban air.”), available at <http://dspace.lib.kanazawa-u.ac.jp/dspace/bitstream/2297/19415/1/PH-PR-BEKKI-K-601.pdf>.

⁸⁴ Tier 3 DRIA, *supra* note 47, at 6-25 (“Trends in PAH deposition levels are difficult to discern because of highly variable ambient air concentrations, lack of consistency in monitoring methods, and the significant influence of local sources on deposition levels.”); 2007 MSAT RIA, *supra* note 72, at 3-112 (same). Despite EPA’s recognition of the dangers of PAHs, the Agency excludes PAHs from the performance evaluation of its CMAQ model. See Tier 3 DRIA, *supra* note 47, at 7-58.

⁸⁵ See Tier 3 DRIA, *supra* note 47, at 3-11 (“[G]asoline containing a large fraction of heavier aromatics compounds with high [double bond equivalent] values result in greater vehicle PM emissions.”).

pollution the fuel will cause. If T50, T90, and endpoint numbers are reduced, on the other hand, pollution will decrease.

High-distillate aromatics raise the T50, T90, and endpoint numbers of a fuel blend because they evaporate only at very high temperatures. As discussed above, these “heavy” aromatics, including naphthalene, are the primary source for dangerous UFPs and the PAHs that bind to them.⁸⁶ It is no surprise, then, that fuel blends with higher levels of high-distillate aromatics produce more of nearly every type of pollution. In a 2010 SAE paper, Honda reports that predictive modeling

indicated that aromatics with a high boiling point and a high double bond equivalent (DBE) value tended to produce more PN emissions. . . . [A]ll of the additional PN is considered a PAH . . . with a high boiling point or soot. The higher the boiling point hydrocarbon added, the more the PN increases. This trend is particularly notable with aromatic substances.⁸⁷

EPA’s EPAAct model corroborates this observation. To produce the fuels used in the EPAAct study, modelers created new types of gasoline “blendstock” to mix with ethanol, so that the final blends would maintain the same T50 and T90 numbers as the non-ethanol fuels used in the study. Because ethanol has a relatively low boiling point, mixing ethanol with standard gasoline (*i.e.*, “splash blending”) results in final blends with significantly lower T50 and T90 numbers. Therefore, in order to maintain the original T50 and T90 numbers, modelers had to increase the high boiler components of the gasoline blendstock when adding ethanol—resulting in blends with a much larger proportion of high-distillate aromatics than would be permitted in market gasoline. (For a discussion of the significance of this methodology, see below at Part IV.A.).

⁸⁶ See *supra* Parts III.B.3 and III.B.4; see also generally 2000 Assessment of Gasoline-Related Health Impacts, *supra* note 37, at 5 (“Light-duty gasoline and heavy-duty diesel vehicles emit significant numbers of ultrafine particles.”).

⁸⁷ Koichiro Aikawa, et al., *Development of a Predictive Model for Gasoline Vehicle Particulate Matter Emissions*, 3 SAE Int’l J. Fuels & Lubricants, 610, 610-11 (Oct. 25, 2010).

Adding high-distillate aromatics caused nearly every type of tailpipe pollution to increase. For example, the EPAct study found hot-running NO_x emissions to be “dominated by the effect of . . . ethanol, followed closely by aromatics.”⁸⁸ This result can only be explained by the addition of high-distillate aromatics to compensate for ethanol’s favorable effect on the T50 and T90 numbers of blended fuel.⁸⁹ Not surprisingly, these harmful aromatics increased NO_x emissions. That effect cannot be attributed to ethanol. When ethanol is simply splash-blended into ordinary gasoline, it has the opposite effect—it lowers NO_x emissions.⁹⁰

6. Climate Effects

In addition to producing traditional air pollutants, aromatics in motor vehicle fuel contribute to global climate change.

⁸⁸ EPAct/V2/E-89: Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Final Report 221, Rep. No. EPA-420-R-13-002 (2013) [hereinafter “EPAct Results Report”], *available at* <http://www.epa.gov/otaq/models/moves/documents/420r13002.pdf>; *but see id.* at 221 (finding that aromatics—not ethanol—“is the single most important effect [on cold-start NO_x emissions] by a wide margin”); *id.* (finding RVP to be the most important term for hot-start NO_x emissions, but suggesting measurement error); EPAct/V2/E-89: Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Final Report on Program Design and Data Collection 76, Rep. No. EPA-420-R-13-004 (2013) [hereinafter “EPAct Design Report”], *available at* <http://www.epa.gov/otaq/models/moves/documents/420r13004.pdf> (noting as one “source of measurement error and variability” that “dilute gaseous emission measurements such as NO_x may have sample concentrations similar in magnitude to background for some portions of the test”).

⁸⁹ EPA has acknowledged that the increased NO_x emissions it has predicted for some ethanol blends “depend[] on how other fuel properties change.” Partial Grant of Clean Air Act Waiver Application Submitted by Growth Energy To Increase the Allowable Ethanol Content of Gasoline to 15 Percent, 76 Fed. Reg. 4662, 4672 (Jan. 26, 2011) [hereinafter “2011 E15 Waiver”].

⁹⁰ *See* M. Matti Maricq, et al., *The Impact of Ethanol Fuel Blends on PM Emissions from a Light-Duty GDI Vehicle*, 46 *Aerosol Sci. & Tech.* 580 (2011) (finding decreases in NO_x emissions of “about 20%” when the ethanol content of fuel is increased from 0% to 17% or higher).

a. Black Carbon

Black carbon (BC), commonly referred to as “soot,” is the “carbonaceous component of PM that absorbs all wavelengths of solar radiation.”⁹¹ The term “BC” is often used interchangeably with elemental carbon (EC), but the two terms refer to different measurement techniques that capture roughly the same substance.⁹² BC emissions result from incomplete engine combustion, which is worsened by the presence of high-distillate aromatics in motor vehicle fuel.⁹³ BC is considered either PM_{2.5} or UFP, depending on its size. Apart from being a form of direct PM with various health and environmental effects described above, BC has an established impact on climate change.⁹⁴

After CO₂, BC is considered the second largest contributor to global warming, and it causes net radiative forcing through a number of processes.⁹⁵ For instance, its “high capacity for light absorption and its role in key atmospheric processes link it to a range of climate impacts, including increased temperatures, accelerated ice and snow melt, and disruptions in precipitation

⁹¹ California Air Resources Board, LEV III PM Technical Support Document: Development of Particulate Matter Mass Standards for Future Light-Duty Vehicles, at P-104 (Dec. 7, 2011) [hereinafter “CARB LEV III PM”], available at <http://www.arb.ca.gov/regact/2012/leviiighg2012/levapp.pdf>.

⁹² Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter, at 6-39 (Dec. 2012) [hereinafter “PM RIA”] (“BC and elemental carbon (EC)(or particulate elemental carbon (PEC)) are used interchangeably in this report because the EPA traditionally estimates EC emissions rather than BC and for the purpose of this analysis these measures are essentially equivalent.”), available at <http://www.epa.gov/ttn/ecas/regdata/RIAs/finalria.pdf>; see also CARB LEV III PM, *supra* note 91, at P-103 to P-105.

⁹³ See *supra* Part III.B.5.

⁹⁴ CARB LEV III PM, *supra* note 91, at P-102 (citing S. Memon, et al., *A Study About Particle Filter Application on a State-of-the-Art Homogenous Turbocharged 2L DI Gasoline Engine*, 297 *Science* 2250 (2002); V. Ramanathan & G. Carmichael, *Global & Regional Climate Changes Due to Black Carbon*, 1 *Nature Geoscience* 221 (2008)); available at <http://www-ramanathan.ucsd.edu/files/pr160.pdf>.

⁹⁵ See, e.g., V. Ramanathan, *Indian Ocean Experiment: An Integrated Analysis of the Climate Forcing and Effects of the Great Indo-Asian Haze*, 106 *J. Geophys. Res.* 28,371 (2001), available at http://saga.pmel.noaa.gov/publications/pdfs/2001/ramanathan_etal_2001.pdf; Chul E. Chung, et al., *Global Anthropogenic Aerosol Direct Forcing Derived from Satellite and Ground-Based Observations*, 110 *J. Geophys. Res.* D24207 (2005), available at <http://ramanathan.ucsd.edu/files/pr137.pdf>; *supra* note 93.

patterns.”⁹⁶ When deposited on snow and ice, BC darkens the surface, thereby decreasing reflectivity and increasing absorption; this raises surface temperatures and accelerates melting.⁹⁷ BC deposits have been linked to accelerated snow and ice melting in certain areas,⁹⁸ including Himalayan glaciers⁹⁹ and in the Western United States, where BC deposition on mountain glaciers causes early spring melting and impacts freshwater resources.¹⁰⁰ EPA, in the Regulatory Impact Assessment accompanying last year's proposed PM implementation rule, cites research showing that “[p]er unit of mass in the atmosphere, BC can absorb a million times more energy than CO₂.”¹⁰¹ Because BC is such a powerful agent of climate change, and yet is relatively

⁹⁶ EPA, Report to Congress on Black Carbon: Department of the Interior, Environment, and Related Agencies Appropriations Act, 2010, at 11 (2012) [hereinafter “Black Carbon Report”], *available at* <http://www.epa.gov/blackcarbon/2012report/fullreport.pdf>.

⁹⁷ *Id.* at 12.

⁹⁸ PM RIA, *supra* note 92, at 6-38; Mark G. Flanner, et al., *Present-Day Climate Forcing and Response from Black Carbon in Snow*, 112 J. Geophys. Research D11202 (2007), *available at* http://dust.ess.uci.edu/ppr/ppr_FZR07_csz.pdf; W. Wiscombe & S. Warren, *A Model for the Spectral Albedo of Snow: Snow Containing Atmospheric Aerosols*, 37 J. Atmos. Sci. 2734 (1980).

⁹⁹ Ramanathan & Carmichael, *supra* note 94.

¹⁰⁰ PM RIA, *supra* note 92, at 6-35 (citing O.L. Hadley, et al., *Measured Black Carbon Deposition on the Sierra Nevada Snow Pack and Implication for Snow Pack Retreat*, 10 Atmos. Chem. Phys. Discuss. 10463 (2010); Y. Qian, et al., *Effects of Soot-Induced Snow Albedo Change on Snowpack and Hydrological Cycle in Western United States based on Weather Research Forecasting Chemistry and Regional Climate Simulations*, 114 J. Geophys. Research DO2108 (2009)).

¹⁰¹ EPA, Regulatory Impact Analysis for the Proposed Revisions to the National Ambient Air Quality Standards for Particulate Matter 6-35 (2012), *available at* http://www.epa.gov/ttn/ecas/regdata/RIAs/PMRIACombinedFile_Bookmarked.pdf. EPA also stated in its recent Report to Congress on Black Carbon that an

important implication of BC’s strong absorptive capacity, coupled with its short atmospheric lifetime, is that when emissions of BC are reduced, atmospheric concentrations of BC will decrease immediately and the climate, in turn, will respond relatively quickly. The potential for near-term climate responses (within a decade) is one of the strongest drivers of the current scientific interest in BC. Mitigation efforts that reduce BC emissions can halt the effects of BC on temperature, snow and ice, and precipitation almost immediately.

EPA, Black Carbon Report, *supra* note 96, at 27 (emphasis omitted).

short-lived, controlling its emission from fossil fuel has been identified as one of the most effective and immediate ways of slowing global climate change.¹⁰²

Mobile sources are “the dominant contributor to total BC emissions in the United States.”¹⁰³ Indeed, EPA estimates that mobile sources are responsible for a majority—52.3%—of BC emissions in the USA.¹⁰⁴ Although heavy-duty diesel vehicles have been thought to be the main contributor of BC emissions, recent studies show that light-duty gasoline emissions form a very significant part of the overall BC burden and that past research seriously underestimated this contribution.¹⁰⁵ In fact, recent tests performed by the California Air Resources Board (CARB) estimate that—in stark contrast to prior understanding—EC accounts for approximately 70% of PM mass emissions from gasoline-powered light duty vehicles.¹⁰⁶ What is worse, newer, gasoline direct injection (GDI) engines emit significantly more black carbon than legacy port fuel injection (PFI) engines,¹⁰⁷ so the contribution of gasoline vehicles to ambient soot is likely to significantly worsen in future years as auto manufacturers gravitate to

¹⁰² Mark Z. Jacobson, Control of Fossil-Fuel Particulate Black Carbon and Organic Matter, Possibly the Most Effective Method of Slowing Global Warming, 107 *J. Geophys. Res.* 4410 (2002).

¹⁰³ EPA, Black Carbon Report, *supra* note 96, at 89.

¹⁰⁴ *Id.* at 88.

¹⁰⁵ John Liggio, et al., *Are Emissions of Black Carbon from Gasoline Vehicles Underestimated? Insights from Near and On-Road Measurements*, 46 *Environ. Sci. & Tech.* 4819, 4819 (2012) (finding that BC from gasoline vehicles is at least a factor of two higher than previous North American measurements and suggesting that greater attention must be paid to black carbon from gasoline engines).

¹⁰⁶ CARB LEV III PM, *supra* note 91, at P-123 (“This result is in stark contrast to lower EC/PM ratios reported by others.”).

¹⁰⁷ *Id.*; see also Liggio, et al., *supra* note 105, at 4826 (finding that increased popularity of GDI engines in the future could further shrink the gap between gasoline and diesel BC emissions); Maricq, et al., *supra* note 89, at 582 (finding that, while a prior EPA study reported that non-soot components account for about 80% of gasoline PM, direct injection produces a very different result); see also Shrestha, et al., *supra* note 64, at 295 (“Maximizing BC formation (as charcoal and char) during combustion processes can decrease CO₂ emission on one hand, whereas on the other hand, it can increase atmospheric pollution with excess soot BC yield.”).

GDI technology in order to meet more stringent fuel economy and CO₂ emissions standards in years 2017 and beyond.

In sum, soot formed by aromatics in motor vehicle fuel has a significant impact on climate change, putting it at direct odds with EPA's goal in the recent 2017 and Later Model Year Light Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards¹⁰⁸ and with the Administration's strong commitment to slowing and preventing global climate change. As noted above, black carbon, like all gasoline PM, is attributable solely to the aromatic content of the fuel.¹⁰⁹

b. Other Gasoline-Produced Climate Forcing Agents

Beyond black carbon, current motor vehicle fuel negatively impacts climate change in several additional ways. SOA, produced in significant quantities by gasoline aromatics, has a direct climate forcing effect.¹¹⁰ In addition, current motor vehicle fuel blends, and aromatics in particular, produce significant greenhouse gas pollution that would be mitigated in mid-level ethanol blends.¹¹¹

¹⁰⁸ 77 Fed. Reg. 62624 (Oct. 15, 2012).

¹⁰⁹ See Odum, et al., *supra* note 51, at 96.

¹¹⁰ See M. Kanakidou, et al., *Organic Aerosol and Global Climate Modelling: a Review*, 5 *Atmos. Chem. & Phys. Disc.* 1053, 1054 (2005), available at <http://atmos-chem-phys.net/5/1053/2005/acp-5-1053-2005.pdf>; Steven F. Maria, et al., *Organic Aerosol Growth Mechanisms and Their Climate Forcing Implications*, 306 *Science* 1921 (1997), available at <http://oya.ucsd.edu/papers/Maria2004science.pdf>.

¹¹¹ See *infra* Part III.

C. A Splash-Blended Mid-level Ethanol Fuel Would Greatly Reduce Air Toxics and Related Pollutants in Motor Vehicle Exhaust, Protecting Air Quality and Slowing the Pace of Climate Change.

Splash blending ethanol with gasoline blendstock, at a level between 20% and 45% on a volumetric basis, would produce a high-octane, clean fuel with significantly less aromatic content, thereby reducing numerous forms of tailpipe pollution, including BTEX,¹¹² UFPs,¹¹³ PAHs,¹¹⁴ SOA,¹¹⁵ and black carbon,¹¹⁶ in accordance with EPA's statutory MSAT obligation.¹¹⁷ In addition, because of ethanol's oxygenate quality, a mid-level ethanol blend would reduce pollution, particularly carbon monoxide (CO), beyond what could be achieved by simple reduction of toxic aromatics.¹¹⁸ Other significant co-benefits would include increased U.S.

¹¹² See 2000 Assessment of Gasoline-Related Health Impacts, *supra* note 37, at 5 ("Light-duty gasoline vehicles are the major source of . . . BTEX.").

¹¹³ See Dabrina D. Dutcher, et al., *Emissions from Ethanol-Gasoline Blends: A Single Particle Perspective*, 2 Atmosphere 195 (2011) (finding "sharp decreases in particle number concentrations in the accumulation mode with added fuel ethanol"), available at <http://www.mdpi.com/2073-4433/2/2/182/pdf>.

¹¹⁴ See M.A. Costagliola, et al., *Combustion Efficiency and Engine Out Emissions of a S.I. Engine Fueled with Alcohol/Gasoline Blends*, Applied Energy 1, 10 & fig. 17 (2012) (in press, corrected proof) (finding "reduction of toxic equivalents [of the carcinogenic PAH benzo(a)pyrene (B(a)p)] when moving from gasoline to alcohol blends," including a 60-70% reduction for splash blended E10, E20, and E30 as compared to gasoline, with even better results for E85); Dutcher, et al., *supra* note 113, at 182-83 (finding lower concentrations of PAHs and lower molecular weight distribution of PAHs with increased ethanol).

¹¹⁵ See Odum, et al., *supra* note 51, at 96.

¹¹⁶ See Maricq, et al., *supra* note 90, at 581 ("EC . . . decreases slightly from 0% to 17% ethanol, but falls by ~45% for E32 and E45."); Dutcher, et al., *supra* note 114, at 187 ("The concentration of black carbon and PAHs dropped nonlinearly, with the greatest decreases resulting from the change from E00 to E20 and lesser changes from further additions of ethanol.").

¹¹⁷ Clean Air Act § 202(l), 49 U.S.C. § 7521(l).

¹¹⁸ See Partial Grant and Partial Denial of Clean Air Act Waiver Application Submitted by Growth Energy To Increase the Allowable Ethanol Content of Gasoline to 15 Percent, 75 Fed. Reg. 68094, 68096 (Nov. 4, 2010) [hereinafter "2010 E15 Waiver"] ("Scientific information supports a conclusion that [when] motor vehicles . . . operat[e] on gasoline ethanol blends . . . volatile organic compound (VOC) and carbon monoxide (CO) emissions decrease.").

energy security, decreased retail fuel prices, and—as discussed below—reduced CO₂ emissions on a life-cycle basis.

Ethanol is a motor vehicle fuel derived from renewable biomass, which removes carbon dioxide from the air as it grows. As a result, tailpipe CO₂ emissions from ethanol are offset by upstream reductions. The majority of ethanol in the U.S. market is so-called “conventional biofuel,” derived from corn starch.¹¹⁹ However, the Renewable Fuel Standard (RFS) requires significant increases in the use of advanced and cellulosic biofuels in coming years.¹²⁰ “Advanced biofuel,” often made from sugar cane, must be at least 50% less carbon-intensive than gasoline, while ethanol qualifying as “cellulosic” must be at least 60% less carbon-intensive.

According to EPA’s indirect land use analyses, corn-based ethanol is responsible for 21% less greenhouse gas pollution than gasoline on a life-cycle basis.¹²¹ However, recent studies show that EPA models may significantly underestimate the carbon sequestration effects of corn, and one study estimates that corn ethanol is actually 48% to 59% less carbon-intensive than gasoline.¹²² Similarly, a 2007 study by Argonne National Laboratory found life-cycle greenhouse gas reductions of 19% to 52% from the use of corn ethanol over gasoline, depending

¹¹⁹ See Michael Wang, et al., *Life-cycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types*, 2 Environ. Research Letters 024001, at 1 (2007) (“Virtually all of the ethanol used for transportation has been produced from corn.”), available at stacks.iop.org/ERL/2/024001.

¹²⁰ 42 U.S.C. § 7545(o)(2)(A)(i).

¹²¹ RFS2, 75 Fed. Reg. at 14670.

¹²² Adam J. Liska, et al., *Improvements in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of Corn-Ethanol*, 13 J. Indus. Ecol. 1, 9 (2009), available at http://www.ethanol.org/pdf/contentmgmt/Improvements_in_Life_Cycle_Energy_Efficiency_and_Greenhouse_Gas_Emissions_of_CornEthanol.pdf.

on the source of energy used during ethanol production.¹²³ This result is almost certainly conservative, as a nine-year USDA study of no-till corn¹²⁴ subsequently found that over half the increase in soil organic carbon (SOC) (used in the Argonne study to measure the carbon-sequestration effect of corn) occurs more than 30 cm below the surface, and that the model used in the Argonne study—which relied on samples near the soil surface—significantly underestimated corn’s carbon-sequestration benefits.¹²⁵

Corn is part of a small subset of plants known as C₄ plants, meaning that the first product of carbon fixation in corn is a molecule with four carbon atoms, in contrast to most other plants, which produce a molecule having three carbon atoms (C₃). The C₄ pathway was discovered in the 1960s,¹²⁶ and it represents a major evolutionary efficiency gain over the more common C₃ photosynthesis pathway.¹²⁷ Because C₄ plants such as corn more efficiently absorb CO₂ in photosynthesis, they sequester more greenhouse gases proportionally than the more common C₃ plants: In fact, although only 3% of plants use C₄ photosynthesis, these plants are responsible for roughly 20% to 30% of total soil-based carbon fixation.¹²⁸ Corn’s carbon sequestration characteristics give ethanol a significant environmental advantage over fossil fuels, whose

¹²³ Wang, *supra* note 119, at 1, cited in Dep’t of Energy, *Ethanol Vehicle Emissions*, Alternative Fuels Data Center, http://www.afdc.energy.gov/vehicles/flexible_fuel_emissions.html.

¹²⁴ “No-till or minimum-till farming practices have increased in the USA because of their conservation benefits and reduced production costs.” Ronald F. Follett, et al., *Soil Carbon Sequestration by Switchgrass and No-Till Maize Grown for Bioenergy*, 5 *Bioenerg. Research* 866, 867 (2012), available at <http://www.ncga.com/upload/files/documents/pdf/Carbon%20Sequestration%20over%2010%20years.pdf>.

¹²⁵ *Id.* at 866, 873.

¹²⁶ C.R. Slack & M.D. Hatch, *Comparative Studies on the Activity of Carboxylases and Other Enzymes in Relation to the New Pathway of Photosynthetic Carbon Dioxide Fixation in Tropical Grasses*, 103 *Biochem. J.* 660 (1967), available at <http://www.biochemj.org/bj/103/0660/1030660.pdf>.

¹²⁷ Colin P. Osborne & David J. Beerling, *Nature’s Green Revolution: The Remarkable Evolutionary Rise of C₄ Plants*, 361 *Philosoph. Transactions of the Royal Soc’y B* 173, 173 (2006), available at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1626541/pdf/rstb20051737.pdf>.

¹²⁸ *Id.*

extraction and refinement result in significant carbon dioxide emissions, in addition to that produced when gasoline is burned as fuel.

Ethanol's carbon sequestration advantage over gasoline will only grow as higher levels of next-generation and cellulosic biofuels enter the market, in response to RFS requirements, while the increasing share of tar sands, oil shale, and fracking technologies will result in substantially larger carbon footprints for the same amount of gasoline.

IV. EPA Should Take Steps to Ensure a Market Transition to a Clean, High-Octane Fuel.

As discussed in greater detail below, we propose a five-part plan for supporting commercial acceptance of a splash-blended mid-level ethanol blend and the vehicles necessary to maximize its technological, environmental, and health-related benefits:

- First, EPA should approve such a fuel as an alternative certification fuel available to all vehicles capable of using it.
- Second, EPA should broaden its focus beyond the final stage of a fuel's greenhouse-gas (GHG) effect by taking ethanol's life-cycle GHG benefits into account when calculating emissions from new vehicles, thereby removing the current regulatory disincentive for FFVs and vehicles dedicated or optimized to a mid-level ethanol blend.
- Third, EPA should grant the mid-level ethanol blend the same one-pound waiver for Reid vapor pressure that E10 currently enjoys.
- Fourth, in time, EPA should require all new gasoline vehicles to be certified on this new, cleaner fuel blend.

- Finally, after the national fleet has substantially transitioned to new vehicles capable of running on the new fuel, EPA should exercise its authority under sections 202(l) and 211 to reduce air toxics by requiring a phase-down of the aromatic content of motor vehicle fuel, while regulating the various parameters, including T50, T90, and endpoint numbers, of the gasoline blendstock portion of the new mid-level ethanol blend so that toxic emissions are reduced to the greatest extent achievable.

A. EPA Should Approve a Splash-Blended Mid-level Ethanol Blend Certification Fuel.

Requiring automobile manufacturers to demonstrate that a fuel is “commercially available”¹²⁹ as a precondition to EPA’s approval of it as a certification fuel stifles technological progress and blocks environmental benefits, as described above.¹³⁰ By seeking comment on this requirement, EPA opens the door to the kind of Agency leadership on air toxics that Congress contemplated in section 202(l). EPA should make the first move in this direction by approving a splash-blended mid-level ethanol blend as an optional certification fuel. In due course, EPA should require all new motor vehicles to be certified on this fuel and then phase down the aromatics content of fuel in response to its obligation to reduce MSATs. In other words, the Agency should over time make a mid-level ethanol blend the standard, rather than an alternative, certification fuel.

It is important, however, to ensure that the quality of the gasoline portion of the fuel is not permitted to deteriorate before blending with ethanol, thereby reducing the environmental

¹²⁹ 40 C.F.R. § 1065.701(c)(1)(ii) (setting forth this requirement for emissions certification); 40 C.F.R. § 600.113-12 (basing fuel economy certification on grams/mile values).

¹³⁰ *See supra* Part II.

benefits of aromatics reduction. In its notice of proposed rulemaking, EPA asks for comment on whether the Agency needs “to specify more precisely the makeup of [a higher octane, higher ethanol content] fuel” in terms of “ethanol content, as well as other fuel parameters.”¹³¹ The answer is yes. Since ethanol contains only one molecule, with unvarying chemical properties, it is critical that, when regulating fuel blends for environmental purposes, EPA specify certain parameters of the gasoline “blendstock for oxygenated blending” or “BOB,” that is, the gasoline portion of the fuel to which ethanol will be added. This is crucial because the gasoline blendstock is the only portion of the fuel that has variable characteristics.

As noted above,¹³² the components of motor vehicle fuel evaporate at different temperatures, and the components that evaporate at high temperatures have the worst environmental and health effects.

Because ethanol, unlike gasoline blends, contains just one molecule, it has a single, relatively low, boiling point. Ethanol’s T50 is the same as its T90—78.4 degrees Celsius—this is the temperature at which every molecule of ethanol would evaporate at sea level. Standard gasoline, on the other hand, is capped at a T50 of 121 degrees Celsius and a T90 of 190 degrees Celsius by ASTM, a non-governmental standards-setting organization. (The ASTM limit is a ceiling, not a floor; refiners are free to create fuel blends with lower T90 values (and T50 values as low as 77 degrees Celsius), and ethanol makes this possible.) In other words, standard gasoline contains much higher distillates than ethanol and is therefore more conducive to tailpipe pollution. Mixing ethanol directly with current blendstock for oxygenate blending (“splash

¹³¹ Proposed Tier 3 Rule, 78 Fed. Reg. at 29911.

¹³² See *supra* Part III.B.5.

blending”) reduces the distillation temperatures of the finished fuel proportionally, thereby reducing tailpipe pollution.

The Agency’s EAct model,¹³³ referred to in the proposed rule only with respect to CO₂ emissions,¹³⁴ purports to measure the effects of various fuel blends on many forms of pollution. However, EAct does not model splash blending of ethanol with standard gasoline blendstock, but rather models what would happen if refiners were allowed to alter the gasoline portion of the fuel by adding dangerous levels of high-distillate aromatics before blending with ethanol. In other words, EAct models the pollution effects of ethanol blends containing high-distillate gasoline formulations that are themselves not permitted to be sold as consumer fuel.

In the real world, EPA should not allow refiners to make gasoline blendstocks more dangerous before mixing them with ethanol. If only the final fuel needs to maintain certain parameters such as octane and T50, T90, and endpoint distillation temperatures, refiners could make gasoline blendstocks dirtier and lower octane, thereby canceling out the performance and environmental benefits of ethanol. EPA should not permit this to happen. As the Agency noted with regard to E51-83, “only blendstocks (including butane and NGL) that meet [certain] specifications would ensure the final blend would always meet the standards.”¹³⁵ We agree with the Agency that in blending ethanol into motor vehicle fuel, the use of previously approved blendstocks and “gasoline that has previously been demonstrated to comply with applicable EPA specifications . . . prevents inappropriate blending components from being used in the

¹³³ EAct Results Report, *supra* note 88; Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Final Report on Program Design and Data Collection, Rep. No. EPA-420-R-13-004 (Apr. 2013) *available at* <http://www.epa.gov/otaq/models/moves/documents/420r13004.pdf>.

¹³⁴ Proposed Tier 3 Rule, 78 Fed. Reg. at 29913.

¹³⁵ Proposed Tier 3 Rule, 78 Fed. Reg. at 29937.

production” of the resulting ethanol blend.¹³⁶ Maintaining current blendstock standards is also necessary to maximize the engine performance benefits of a mid-level ethanol blend.¹³⁷ Thus, EPA should mandate that any mid-level ethanol blend approved for market and certification fuel be made up of (1) a certain percentage of ethanol by volume, and (2) a corresponding volume percentage of gasoline which itself meets all relevant EPA and ASTM standards.¹³⁸ In other words, EPA should approve a “splash-blended” mid-level ethanol fuel.

B. EPA Should Remove Regulatory Disincentives that Currently Impede the Production of Vehicles that Run on a Mid-Level Ethanol Blend.

In the proposed rule, EPA requests comment on how the Agency might “provide an incentive for, or remove obstacles to, the development of highly efficient vehicles optimized for use on higher level ethanol blends.”¹³⁹ EPA also requests comment on whether an adjustment is warranted in the compliance calculation for light-duty GHG standards.¹⁴⁰ These two questions should be viewed through the same lens. EPA should remove current regulatory disincentives to the production of vehicles designed to run on a mid-level ethanol blend, while paving the way for a national transition to this fuel by incentivizing increased production of FFVs. These incentives can be achieved without relaxing GHG emissions standards, simply by allowing auto

¹³⁶ *Id.*; see also *id.* at 29938 (seeking comment on whether EPA “should take the same approach for E16-50”).

¹³⁷ See Stein, et al., *supra* note 24, at 1 (“To provide high knock resistance, this fuel should be formulated using a blendstock that retains the octane of the current blendstock used for regular-grade E10 gasoline.”).

¹³⁸ See 40 C.F.R. § 86.113-04. Congress and EPA have regulated blendstock in the past: For instance, Congress stipulates in § 211(h) of the Clean Air Act that E10 shall be deemed to be in compliance with Reid vapor pressure (“RVP”) standards if a distributor demonstrates that “*the gasoline portion of the blend complies with the Reid vapor pressure limitations promulgated pursuant to this subsection . . .*” (emphasis added). 42 U.S.C. § 7545(h).

¹³⁹ Proposed Tier 3 Rule, 78 Fed. Reg. at 29825.

¹⁴⁰ *Id.* at 29913.

manufacturers to account for the life-cycle GHG benefits of ethanol in their GHG compliance calculation.

1. EPA Should Enable a Market for Optimized, Dedicated, and Flex-Fuel Vehicle Production through Recognition of Ethanol’s Life-Cycle GHG Benefits.

As was the case in the transition from leaded to unleaded gasoline, a mid-level ethanol blend cannot be made available nationwide, and market forces will not prompt any greater availability, until vehicles designed to run on this fuel are in widespread use. Meanwhile, legacy vehicles designed for conventional gasoline (E0) will not perform adequately on a mid-level ethanol blend, while new optimized or dedicated vehicles will not perform adequately on much lower-octane, conventional E10 fuel. EPA, however, can break through this impasse by encouraging automobile manufacturers to equip new vehicles (beginning in model year 2017) with FFV capabilities that enable the vehicles to run on both conventional fuel and the new mid-level ethanol blend (as well as higher ethanol blends such as E85), thereby opening the door to a new generation of engines optimized for the new fuel as it becomes available (and eventually standard).¹⁴¹

FFV technology is both widely available and relatively inexpensive, and it can build a bridge to a cleaner fuel standard by solving the transitional problem of engine and fuel compatibility that must precede an aromatics phase-down. Manufacturers can equip any new vehicle with FFV technology that senses the alcohol content of the fuel being used and adjusts

¹⁴¹ Again, we reiterate that manufacturers themselves are powerless to make a fuel commercially available. EPA, in contrast, has wide authority to regulate toxic compounds in motor vehicle fuel, thereby ensuring that cleaner fuels are available, just as it did in the lead phase-out. In this case, EPA has authority—and indeed the responsibility—to mandate aromatics reductions under sections 202(*l*) and 211.

the engine's timing accordingly. With the right incentives, this technology could be installed in every new vehicle in the country. This would avoid potential legacy fleet issues when automobile manufacturers begin to optimize or dedicate all vehicles to run on cleaner fuel and when EPA begins to require aromatics reductions in standard market fuel. Legacy vehicles would, at that point, be mostly FFVs capable of running on the new fuel.

In order to begin to phase in a cleaner, higher-ethanol fuel that significantly reduces air toxics and other dangerous pollutants, while at the same time helping manufacturers design more efficient engines to reduce GHG pollution, EPA should allow all vehicles capable of running on a mid-level ethanol blend (dedicated, optimized, or FFV) to be certified for purposes of GHG emissions and fuel economy on the new high-octane, mid-level ethanol blend.

The flex-fuel equipment that enables a shift to a new, cleaner mid-level ethanol standard fuel is cost-effective, but its cost is not negligible. Therefore, EPA should provide a reasonable and effective incentive, without relaxing real-world GHG reductions, by correcting the compliance calculation of any vehicle certifying on this fuel to account for the life-cycle GHG emissions benefits of the fuel—*i.e.*, by taking into account the carbon dioxide sequestration effect of the corn or other material from which the ethanol portion of the fuel is derived, for purposes of EPA's greenhouse gas regulations. Because EPA estimates in its 2010 Changes to Renewable Fuel Standard Program (RFS2) that corn ethanol is 21% less carbon-intensive than gasoline,¹⁴² and that sugar-cane and cellulosic ethanol, which will see significantly increased use in coming years, are 61% and 110% less carbon-intensive than gasoline, respectively,¹⁴³ 50% would represent a reasonable good-faith estimate of the life-cycle GHG benefits of ethanol. This

¹⁴² 75 Fed. Reg. at 14786.

¹⁴³ *Id.* at 14790, 14792.

number is well within the Argonne study's conservative estimate¹⁴⁴ and below many other recent studies' estimates for the life-cycle GHG benefits of corn ethanol. The carbon dioxide tailpipe emissions of any car certifying on the new mid-level ethanol blend should reflect this calculation. For example, if E30 were approved for certification and commercial use, vehicles designed to use that fuel would be deemed to emit no more than 85% of the CO₂ grams per mile figure achieved through initial tailpipe CO₂ calculations—*i.e.*, after multiplying the tailpipe CO₂ emissions of the ethanol portion of the fuel by 50% and leaving the emissions of the gasoline portion of the fuel unaltered $[(0.30 \times 0.5) + (0.70 \times 1) = 0.85]$, the fuel would be deemed to emit no more than 85% of tailpipe emissions, in recognition of ethanol's upstream reductions.

To be an effective incentive for automakers, this adjustment for vehicles certifying on a higher-ethanol blend fuel must apply to all vehicles designed to use the new fuel, whether or not those vehicles are also capable of running on lower ethanol blends, during the initial years of the transition. Although FFVs may sometimes operate on E10, they may also operate on E85, so a GHG credit based on general use of E30 or another mid-level blend is likely to track actual usage fairly well. This recalibration of GHG emissions is necessary to prompt automobile manufacturers to produce and sell more FFVs. Until a mid-level blend is widely available in the marketplace, manufacturers are unlikely to produce vehicles designed to run on a mid-level blend, and they are particularly unlikely to incur the cost of non-optimized FFV technology, which does not provide all of the efficiency benefits possible with an optimized or dedicated car. Yet only after the national fleet has become largely compatible with the new mid-level ethanol blend will this fuel become more available in the marketplace—hence the need for incentives during a transition period. EPA could give automakers and fuel distributors certainty by

¹⁴⁴ See *supra* Part III.C, note 122 and accompanying text.

choosing a definite time in the future by which the Agency will require the certification of all new light-duty motor vehicles on a mid-level ethanol blend and the phase-out of higher aromatic-content fuel under its statutory duty to reduce MSAT pollution. In this way, the market would be encouraged to provide both the technology and the distribution chain necessary for the production and marketing of a cleaner fuel, and the Agency could be assured that today's FFV fleet will, at some point in the future, run 100% of the time on a mid- or high-level ethanol blend.

2. EPA Should Correct the Fuel Economy Calculation to Remove Unnecessary Disincentives to Certification on a Mid-Level Ethanol Blend.

Because ethanol is less energy-dense than gasoline, its energy content is lower than that of gasoline on a volumetric basis. As a result, manufacturers certifying vehicles on a mid-level ethanol blend would, if fuel economy calculations were made on a purely volumetric basis, be penalized for creating an engine that is more efficient than a standard gasoline engine but designed to run on a less energy-dense fuel.¹⁴⁵ Fuel economy calculations already contain an adjustment for the energy content of the fuel, which is meant to solve this problem—however, the current equation reduces this necessary adjustment by a fixed percentage, known as the “R-factor,” to account for the fact that “the change in fuel economy is not directly proportional to the

¹⁴⁵ See Proposed Tier 3 Rule, 78 Fed. Reg. at 29913 (“Because ethanol has a lower energy content than gasoline, i.e., fewer British thermal units (Btus) or joules per gallon, and fuel economy is defined in terms of miles per gallon of fuel, it is almost certain that the same vehicle tested on a test fuel with 15 percent ethanol content will yield a lower fuel economy value relative to the value if it were tested on the current test fuel with zero ethanol content.” (footnote call omitted)).

change in energy content of the test fuel.”¹⁴⁶ As EPA notes in its proposed rule, “manufacturers have suggested that a higher value may be more appropriate.”¹⁴⁷ We agree.

At the least, EPA should set the R-factor to 1, giving fuel with lower energy content a level playing field when it comes to fuel economy testing. If the policy goal is energy efficiency, rather than volumetric efficiency, there is no reason to deprive manufacturers of the full efficiency benefits of a less energy-dense fuel. It is important to note, however, that any change in R-factor must be accompanied by a recalibration of the fuel economy equation to that new R-factor, such that comparable results are achieved with baseline 1975 test fuel. Therefore, to account for fuel economy on an energy efficiency basis, the current equation¹⁴⁸:

Fuel Economy

$$= \frac{CWF_{test\ fuel} \times SG_{test\ fuel} \times 5174 \times 10^4}{(CWF_{test\ fuel} \times HC + 0.429 \times CO + 0.273 \times CO_2)(5471 + 0.6NHV_{test\ fuel} \times SG_{test\ fuel})}$$

must be adjusted by both setting the R-factor to 1 and deleting the constant, 5471, from the denominator, in order to obtain the following equation:

*Fuel Economy*_{calibrated to R=1}

$$= \frac{CWF_{test\ fuel} \times SG_{test\ fuel} \times 5174 \times 10^4}{(CWF_{test\ fuel} \times HC + 0.429 \times CO + 0.273 \times CO_2)(NHV_{test\ fuel} \times SG_{test\ fuel})}$$

Since the constant, 5471, represents calibration to an R-factor of 0.6, setting the R-factor to 1 without deleting this constant would provide inconsistent results and penalize all auto

¹⁴⁶ *Id.*

¹⁴⁷ *Id.*

¹⁴⁸ See 40 C.F.R. § 600.113-12(h).

manufacturers using the new formula. In addition, because the current formula assumes that the carbon weight fraction (CWF) of the hydrocarbon (HC) portion of the exhaust is identical to the CWF of the test fuel, the current equation allows reduced stringency for fuel and engine combinations that produce HC emissions with a higher proportional carbon content, while unfairly penalizing fuel/energy combinations that produce HC emissions with a lower carbon content. The equation would be more correct if the $CWF_{\text{test fuel}}$ in the denominator were replaced with the CWF of the HC portion of the exhaust, or if the entire equation were replaced with a volumetric or weight-based measure adjusted for the energy density of each fuel.¹⁴⁹

A further incentive should also be considered: Since fuel economy standards are designed to reduce reliance on gasoline, EPA could use its authority to “calculate average fuel economy” under 49 U.S.C. § 32904(c) to decide that, for the purposes of fuel economy calculations, one gallon of E30 is equivalent to 0.7 gallons of gasoline (because it actually contains 0.7 gallons of gasoline).¹⁵⁰ This would allow automobile manufacturers to divide the fuel economy of a vehicle certified on E30 by 0.7 for the purposes of corporate average fuel economy calculations—with no limit on the fleetwide fuel economy benefit this calculation would produce. Paired with recognition of the life-cycle benefits of ethanol, this recognition of the lower gasoline content of the new fuel would provide a strong incentive for manufacturers to produce more FFVs in the short term, and in the longer term to produce vehicles optimized for the new “standard” high-octane fuel.

¹⁴⁹ For a more detailed discussion of the suggested changes to the fuel economy equation, see Appendix I.

¹⁵⁰ See 49 U.S.C. § 32904(c) (“The [EPA] Administrator shall decide on the quantity of other fuel that is equivalent to one gallon of gasoline.”).

3. EPA Should Grant the New Mid-Level Ethanol Blend the Same One-Pound RVP Waiver Congress Granted to E10.

As gasoline evaporates, VOCs enter the atmosphere, producing PM and contributing to pollution.¹⁵¹ The Reid vapor pressure (RVP) of gasoline refers to the tendency of gasoline to evaporate and is measured in pounds per square inch (psi). In order to prevent VOCs from forming ozone and PM pollution in the presence of sunlight (“photochemical smog”), Congress required gasoline to be limited to a maximum RVP of 9.0 psi during the summer ozone season as part of the 1990 Clean Air Act Amendments.¹⁵² In addition, Congress authorized EPA to set more stringent standards for certain non-attainment areas or former non-attainment areas.¹⁵³ EPA limits “high-volatility non-attainment” areas to a maximum RVP of 7.8 psi during the summer ozone season.¹⁵⁴ During the summer ozone season, about 75% of gasoline is 9.0 psi.

In its neat form (when not blended with gasoline), ethanol’s RVP is much lower than that of conventional gasoline (pure ethanol’s RVP is approximately 2.0 psi). However, due to an azeotropic effect when blended in small percentages with gasoline, ethanol can increase the overall blend’s volatility.¹⁵⁵ As a result, ethanol splash-blended with gasoline at 10% has a tendency to raise vapor pressure by approximately one pound.¹⁵⁶ Because of this effect,

¹⁵¹ See *supra* Parts III.B.1-B.2.

¹⁵² 42 U.S.C. § 7545(h)(1).

¹⁵³ *Id.* § 7545(h)(1)-(2).

¹⁵⁴ 40 C.F.R. § 80.27(a)(2).

¹⁵⁵ See Proposed Tier 3 Rule, 78 Fed. Reg. at 29938 (“As the ethanol level increases, the volatility increase caused by blending ethanol with gasoline begins to decline, such that at E30 there is only about a 0.5-psi RVP increase.”).

¹⁵⁶ See *id.*

Congress also stipulated in the Clean Air Act Amendments that gasoline containing 10% ethanol would be permitted to exceed the applicable maximum RVP by one psi (the “one-pound waiver”).¹⁵⁷ In its regulations implementing this section of the statute, EPA specified that the waiver only applies to blends containing “at least 9% and no more than 10%” ethanol¹⁵⁸—a distinction that was not particularly relevant at that time. In the Proposed Rule, however, EPA asks whether it should “allow E16 to E50 blends to have higher RVP levels than otherwise required by our regulations for gasoline.”¹⁵⁹ Our answer is ‘yes.’ It is important that EPA, consistent with the terms of the statute, treat the new mid-level ethanol blend the same as E10, granting it a one-pound waiver of the RVP limit, but requiring that the gasoline portion of the fuel meet the applicable RVP standard.

Because ethanol’s effect on RVP is azeotropic, and not due to a higher RVP of ethanol itself, adding ethanol beyond 10% is likely to lower, rather than raise, RVP.¹⁶⁰ Nevertheless, allowing the one-pound waiver would remove uncertainty for distributors and also ensure compliance with the statutory mandate that “fuel blends containing gasoline and 10 percent denatured anhydrous ethanol” (which would include any mid-level ethanol blend) receive the one-pound waiver.¹⁶¹ The tailpipe emissions reductions achieved by a mid-level ethanol blend will be greater than those achieved by E10, and will more than compensate for any slight

¹⁵⁷ 42 U.S.C. § 7545(h)(4) (“Ethanol Waiver. For fuel blends containing gasoline and 10 percent denatured anhydrous ethanol, the Reid vapor pressure limitation under this subsection shall be one pound per square inch (psi) greater than the applicable Reid vapor pressure limitations established under paragraph (1).”).

¹⁵⁸ 40 C.F.R. § 80.27(d)(2); *see also id.* § 80.28(g)(8) (providing as a defense for a noncompliant E10 blend that its blendstock met the RVP standard).

¹⁵⁹ Proposed Tier 3 Rule, 78 Fed. Reg. at 29938.

¹⁶⁰ *See id.*

¹⁶¹ 42 U.S.C. § 7545 (h)(4).

increase (over E0) in evaporative emissions that may occur because of the higher RVP of the blended fuel.¹⁶² As a result, a mid-level ethanol splash blend would be superior to both E0 and E10 on all counts: Its toxic, hydrocarbon, and NO_x tailpipe emissions would be lower, and, due to the higher concentration of ethanol, its evaporative emissions would be lower as well.¹⁶³

C. EPA Should Use its MSAT Authority to Phase Down Aromatics in Motor Vehicle Fuel.

Finally, EPA should use its authority under sections 202 (*l*) and 211 to require a phase-down in the aromatic content of all gasoline blends, thereby ensuring that a cleaner, mid-level ethanol blend becomes widely available in the marketplace. As described above,¹⁶⁴ EPA is not currently meeting its statutory obligation to reduce air toxics in motor vehicle exhaust to the greatest extent achievable. However, no practical barrier remains, and a high-octane mid-level ethanol blend offers a ready alternative. Meanwhile, the extensive body of credible science detailing the serious environmental and health effects of aromatics in motor vehicle fuel makes the problem one of deadly import. EPA should require all new gasoline vehicles to certify on this new, cleaner fuel blend and then use its statutory authority to reduce the allowable aromatics content in gasoline blends—thus cutting both air toxics-related pollution and greenhouse gas pollution.

¹⁶² See Fann, *supra* note 58, at 176, fig. 4 (ranking PM and VOCs according to the dollar/ton benefit of their respective reductions).

¹⁶³ Proposed Tier 3 Rule, 78 Fed. Reg. at 29938 (“The evaporative emission increase caused by E30 would . . . be less than for E10.”).

¹⁶⁴ See *supra* Part III.A.

V. Conclusion

The Agency's requests for comment demonstrate its awareness of the benefits of a mid-level ethanol blend. However, approving a new certification fuel is not enough. We urge EPA to take the initiative to shepherd a nationwide transition to this cleaner, more efficient, renewable fuel in order to realize its benefits to air quality and public health, automotive performance, and consumer costs, while meeting the Agency's obligation to regulate air toxics in motor vehicle fuel. Although critically important, a new certification fuel should be only the first step in a comprehensive plan to make a mid-level ethanol blend available at pumps across the country and to enable the production of vehicles designed to maximize its benefits. We appreciate the opportunity to offer such a plan, and we look forward to providing any additional information or assistance that might be useful to EPA as it strives to protect air quality and public health for all Americans.

APPENDIX I

R Factor and Federal Test Procedures for Fuel Economy Calculations

I. Fuel Economy Calculations on Standard 1975 Test Fuel

Fuel economy is measured in miles per gallon (mpg). However, historically, it was difficult to test how many gallons of fuel had been consumed during test procedures.¹⁶⁵ As a result, the federal test procedure (FTP) calculations used a formula to derive the mpg fuel economy by estimating the grams of carbon in a gallon of fuel and then dividing this figure by the grams of carbon in exhaust per mile. Together, these two calculations produce an estimate for miles per gallon:

$$mpg = \frac{\frac{\text{grams carbon}}{\text{gallon fuel}}}{\frac{\text{grams carbon in exhaust}}{\text{mile}}}$$

(Eq. 1)¹⁶⁶

In order to calculate the grams of carbon in a gallon of test fuel (the numerator of Eq. 1), EPA estimates the carbon weight fraction (CWF) and specific gravity (SG) of the fuel, and then multiplies by a constant (the density of water in grams/gallon) to convert into units of grams/gallon. In order to calculate the grams of carbon emitted per mile (the denominator of Eq.1), EPA multiplies the per-mile exhaust figures for hydrocarbons (HC), carbon monoxide (CO), and carbon dioxide (CO₂) (obtained for each vehicle in the test procedure) by the carbon weight fraction of each of those molecules. In sum, the FTP attempts to measure the gallons of fuel consumed per mile by estimating the grams of carbon in each gallon of fuel and the grams of carbon that are emitted from the tailpipe each mile. This is known as the “carbon balance technique.”¹⁶⁷

Initially, EPA did not require auto manufacturers to test the CWF and SG of the test fuel. Therefore, the fuel economy equation required in initial years took these constants into account and was defined as follows:

¹⁶⁵ See Aron Butler, “Analysis of the Effects of Changing Fuel Properties on the EPA Fuel Economy Equation and R-Factor,” Memorandum to the Tier 3 Docket #EPA-HQ-OAR-2011-0145 (Feb. 28, 2013).

¹⁶⁶ See Fuel Economy Test Procedures; Proposed Revision of Fuel Economy Calculation Equation and Consideration of Light Truck Fuel Economy Adjustments To Compensate for Test Procedure Changes, 50 Fed. Reg. 27188 (proposed Jul. 1, 1985).

¹⁶⁷ *Id.*

$$\text{Fuel Economy}(mpg) = \frac{2421}{0.866HC + 0.429CO + 0.273CO_2}$$

(Eq. 2)¹⁶⁸

The agency established the following properties of baseline 1975 test fuel:¹⁶⁹

$$SG_{1975 \text{ fuel}} = 0.739$$

$$CWF_{1975 \text{ fuel}} = 0.866$$

II. Fuel Economy Calculations for MY 1988 and Later

Because test fuel did not remain constant throughout the 1970s and '80s, automobile manufacturers complained to EPA that they were being penalized for using the new fuel, which had different energy content and specific gravity than the fuel used in 1975. The manufacturers noted that the Energy Policy and Conservation Act (EPCA) requires the EPA Administrator to “use the same procedures for passenger automobiles the Administrator used for model year 1975 . . . or procedures that give comparable results.”¹⁷⁰ In response, the agency issued a series of rulemakings from 1983 to 1986 changing the fuel economy calculation procedure.

General Motors submitted a comment to one of these rulemakings, suggesting an equation that would “convert” from the SG, CWF, and energy content of current test fuel to obtain a result comparable to the baseline test.¹⁷¹ Although GM’s comment letter is not available online, in 1983 EPA adopted a new equation to measure fuel economy based on GM’s letter, and this equation is still used:

¹⁶⁸ 40 C.F.R. § 600.113-78(d). Note that although the carbon weight fractions for CO and CO₂ are fixed (0.429 and 0.273, respectively, because CO always contains an equal number of carbon atoms and oxygen atoms, and CO₂ always contains one carbon atom for every two oxygen atoms), the CWF of HC can vary depending on the carbon content of the hydrocarbons in question. EPA chose a CWF of 0.866 for gasoline HC, assuming that the hydrocarbon portion of the exhaust had a CWF identical to that of the gasoline itself. This figure would lead to miscalculation of fuel economy, and *less stringent test requirements*, if any fuel and engine combination produced HC with a higher proportion of carbon, and *more stringent test requirements* for any fuel and engine combination that produced HC with a lower proportion of carbon, since EPA would assume in the latter case that more grams of carbon exited the tailpipe than actually did.

¹⁶⁹ Fuel Economy Test Procedures; CAFE Adjustments To Compensate for Changes in 1975 Test Procedures, 50 Fed. Reg. 27172, 27179 (Jul. 1, 1985).

¹⁷⁰ 49 U.S.C. § 32904(c).

¹⁷¹ See Fuel Economy Test Procedures; Additional Proposed Procedures for Adjustment of CAFE Results to Compensate for Changes in Test Procedures, 49 Fed. Reg. 48024 (proposed Dec. 7, 1984).

Fuel Economy (mpg)

$$= \frac{CWF_{test\ fuel} \times SG_{test\ fuel} \times 5174 \times 10^4}{(CWF_{test\ fuel} \times HC + 0.429 \times CO + 0.273 \times CO_2)(5471 + 0.6NHV_{test\ fuel} \times SG_{test\ fuel})}$$

Where: $NHV_{test\ fuel}$ = net heating value of the test fuel.

(Eq. 3)¹⁷²

Equation 3 is derived from Eq. 2 above, with the following changes to account for the variable properties of the test fuel:

First, rather than presenting a set figure of 0.866 for the carbon weight fraction of the fuel, EPA now requires auto manufacturers to obtain this coefficient experimentally—however, since the formula still assumes the CWF of the HC portion of the exhaust is identical to the CWF of the fuel itself, the current equation will still lead to miscalculations in fuel economy if the actual proportional carbon content of HC emissions produced by a given fuel/engine combination differs from the CWF of the fuel itself.¹⁷³

Second, EPA adds a correction for the energy content of the test fuel to the denominator of the equation: $(5471 + 0.6NHV_{test\ fuel} \times SG_{test\ fuel})$. The 0.6 figure is referred to as the “R factor,” and its presence in the above formula results in a calculation that only “corrects” for 60% of the energy content difference of the test fuel with respect to baseline fuel. The constant 5471 represents calibration to an R factor of 0.6.

Third, EPA substitutes the variables $CWF_{test\ fuel}$ and $SG_{test\ fuel}$ for the constants incorporated in Eq. 2:

$$2421 = 0.739 \times 0.866 \times 3783$$

(Eq. 4)

(where 3783 is the constant used to convert to units of grams/gallon) and then multiplies by 1.3677×10^4 to maintain units of miles/gallon and ensure that Eq. 3 maintains the same result as Eq. 2 when using baseline 1975 test fuel:

$$1.3677 \times 10^4 = 5471 + 0.6NHV_{1975} \times SG_{1975}$$

(Eq. 5)

(The equation above holds true at the SG of 0.739 and NHV of 18,507 Btu/lb given for 1975 test fuel by EPA,¹⁷⁴ and thus these changes amount to multiplying the fuel economy equation by 1 on baseline 1975 fuel, thereby maintaining consistency.)

¹⁷² 40 C.F.R. § 600.113-87; *see also* 50 Fed. Reg. 27188, 27193.

¹⁷³ *See supra* note 168.

¹⁷⁴ Fuel Economy Test Procedures; CAFE Adjustments To Compensate for Changes in 1975 Test Procedures, 50 Fed. Reg. at 27179.

The R factor of 0.6 was chosen following experimental data showing that increasing the energy content of fuel by 10% only increases the fuel economy by approximately 6%. Therefore, EPA chose to factor in only 60% of the energy differential in this equation. We recommend changing course and allowing manufacturers to account for the full energy content difference of the test fuel, such that fuel with half the energy content of 1975 gasoline would have its fuel economy multiplied by two. This can be achieved through an R factor of 1.

However, because Eq. 3 is calibrated to an R factor of 0.6, the coefficient 5471 is no longer correct when an R factor of 1 is used, because

$$1.3677 \times 10^4 \neq 5471 + NHV_{1975} \times SG_{1975} \quad (Eq. 6)$$

(Compare with Eq. 5). Therefore, to maintain consistency, and to ensure that fuel with half the energy content of 1975 fuel would have its mpg figure doubled (to fully account for the Btu differential), it is necessary to remove the coefficient in the denominator which serves to calibrate to the 0.6 R factor.

Plugging in the NHV and SG of 1975 test fuel, the energy content portion of the denominator now equals:

$$18507 \times 0.739 = 1.3677 \times 10^4 \quad (Eq. 7)$$

Therefore, this indeed maintains consistency for 1975 test fuel: multiplying the 3783 grams per gallon conversion factor (see Eq. 4) by this calibration constant, we have:

$$3783 \times 1.3677 \times 10^4 = 5174 \times 10^4 \quad (Eq. 8)$$

which is, of course, the same constant used in the current equation. Therefore, to calibrate to an R factor of 1, only the R factor and the constant which precedes it must be deleted. As a result, the new equation should read:

$$\begin{aligned} & \text{Fuel Economy}_{\text{calibrated to } R=1} \\ &= \frac{CWF_{\text{test fuel}} \times SG_{\text{test fuel}} \times 5174 \times 10^4}{CWF_{\text{test fuel}} \times HC + 0.429 \times CO + 0.273 \times CO_2} (NHV_{\text{test fuel}} \times SG_{\text{test fuel}}) \end{aligned} \quad (Eq. 9)$$

Note also that the equation would be more correct if the $CWF_{\text{test fuel}}$ in the denominator were replaced with the CWF of the HC portion of the exhaust, or if the entire equation were replaced with a volumetric measure adjusted for the energy density of each fuel.

APPENDIX II

The Factual Basis for EPA's Decision Not to Regulate Aromatics in 2007 Is No Longer Applicable.

When EPA declined to regulate air toxics in its 2007 MSAT Rule, the Agency offered several context-dependent justifications for its decision, adding that “[t]here may be compelling reasons to consider aromatics control in the future.”¹⁷⁵ These prior justifications have each been proven factually incorrect or rendered obsolete by the passage of time:

First, EPA predicted that “increased use of ethanol in response to current market forces” would “contribute to lower aromatics levels” by simple dilution, without any need for regulation.¹⁷⁶ The succeeding six years have shown that prediction to be too optimistic. As described above, the ethanol content of standard motor vehicle fuel is effectively frozen at the artificial “blendwall” caused by the interaction of a statute banning new commercial fuel that is not “substantially similar” to an existing certification fuel, and EPA’s current regulatory regime requiring automobile manufacturers to establish that a fuel is commercially available before it will be approved as a certification fuel.¹⁷⁷ In addition, EPA’s current volatility standards effectively prevent a mid-level ethanol blend by limiting to E10 the necessary one-pound waiver on the RVP requirement.¹⁷⁸ EPA’s 2007 vision of a market-driven surge in the ethanol content of fuel also overlooked the chicken-and-egg problem of optimization. Absent any initiative from EPA, automobile manufacturers have prudently waited for a new fuel to reach the market before trying to produce vehicles optimized for that fuel. Because the market has been prevented from spontaneously increasing the volume of ethanol in fuel, as EPA predicted it would, “lower aromatics levels” that EPA anticipated have not come to pass, beyond the reduction caused by blending 10% ethanol in current E10.¹⁷⁹

In 2007 EPA correctly predicted that ethanol use would “more than double,”¹⁸⁰ but it incorrectly predicted that “with all of this ethanol there will be excess octane in the gasoline pool,” so “refiners will make the economic decision to . . . avoid producing aromatics for the purpose of increasing octane.”¹⁸¹ Aromatics levels as a whole have decreased slightly, since

¹⁷⁵ 72 Fed. Reg. at 8478-79.

¹⁷⁶ *Id.* at 8479.

¹⁷⁷ *See supra* Part II.

¹⁷⁸ *See supra* Part IV.B.3.

¹⁷⁹ The regulatory blendwall is also in tension with EPA’s statutory duty “to ensure that transportation fuel . . . contains at least the applicable volume [16.55 billion gallons in 2013 and increasing annually] of renewable fuel” set by Congress. 42 U.S.C. § 7545(o)(2)(A)(i).

¹⁸⁰ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

¹⁸¹ *Id.*

refiners currently produce a lower-octane gasoline blendstock to mix with ethanol in order to create E10 standard fuel (so-called “match blending”).¹⁸² However, current regulations, as well as the collective action problem inherent in moving to a new fuel standard (*i.e.*, the need for simultaneous changes in both engine technology and market fuel) have thus far prevented a market-based move to a cleaner, higher-ethanol blend. As a result, refiners have continued to use aromatics in large quantities for octane, even though these aromatics could, with EPA’s intervention, be greatly reduced by ethanol.

Refiners (for whom, it is important to note, ethanol represents a competitive threat) have little incentive to raise ethanol volumes beyond current blending levels of their own volition—particularly since they are limited to E10¹⁸³ and are not permitted to save money by reducing the octane level and quality of the gasoline portion of the fuel before combining with a higher level of ethanol. This is true despite the fact that a mid-level blend would be better for engines, consumers, and the environment, and would cost less for the consumer. As a result, standard motor vehicle fuel continues to contain large quantities of harmful aromatics, contrary to legislative direction.

In 2007 EPA also cited “the removal of MTBE [methyl tertiary butyl ether], conversion of some portion of the MTBE production volume to other high octane blendstock production, growth of ethanol use, and the rise in crude oil prices” and “uncertainty in knowing how much of the market ethanol will capture,” as factors that made it “difficult to reliably project a baseline level of aromatics for the gasoline pool with any confidence.”¹⁸⁴ Today there is no such difficulty. The aromatic content of motor vehicle fuel has remained relatively constant due to the effective 10% cap on ethanol blends¹⁸⁵ and the current inability of automobile manufacturers to certify vehicles optimized or dedicated for mid-level ethanol blends.

Additionally, EPA noted that “Presidential and Congressional proposals could easily result in 100% of gasoline being blended with ethanol.”¹⁸⁶ Indeed, the Energy Independence and Security Act of 2007 (EISA) became law ten months later, expanding upon the first Renewable Fuel Standard and major fuel-economy-calculation incentives for flexible fuel vehicles (flex-fuel vehicles or FFVs). In the intervening five years, the market has had plenty of time to adjust to the Renewable Fuel Standard, and “ethanol is now blended into almost every gallon of U.S.

¹⁸² See Tier 3 DRIA, *supra* note 47, at 3-1. However, because gasoline refiners only have to meet ASTM and EPA regulations with the final, ethanol-blended fuel, gasoline blendstock has deteriorated in terms of the type of aromatics present in the fuel, with a higher proportion of current blendstock being composed of dangerous high-distillate aromatics than would be permitted in E0. See *supra* Part III.B.5.

¹⁸³ More recently, EPA has granted a partial waiver for the introduction of E15 into commerce—but only for use in certain newer vehicles and subject to certain conditions. See 2011 E15 Waiver, 76 Fed. Reg. at 4682-83; 2010 E15 Waiver, 75 Fed. Reg. at 68149-50. E15 is not widely available, in part because EPA has failed to extend to E15 the same one-pound volatility waiver that it has granted to E10. See *supra* Part IV.B.3.

¹⁸⁴ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

¹⁸⁵ See *supra* note 183 and accompanying text.

¹⁸⁶ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

gasoline, bringing the average gasoline ethanol content to 9.3 percent by volume.”¹⁸⁷ Yet in the absence of EPA intervention, and particularly after the phase-out of FFV incentives for fuel economy purposes and EPA’s decision to calculate greenhouse gas emissions in a way that arbitrarily disincentivizes the use of ethanol, the current blendwall and the relatively small number of FFVs on the road will almost certainly prevent further progress. Today EPA has all the knowledge it needs to progress further by honoring its statutory duty to regulate dangerous air toxics and to enable annual statutory increases in the volume of renewable fuel to be met.¹⁸⁸

EPA observed in 2007 that “aromatics levels vary dramatically across refineries” and that on that basis the Agency could not regulate aromatics, because it could not “determine the greatest degree of emission reduction achievable.”¹⁸⁹ This reasoning was circular: The fact that a substance has not previously been regulated does not prove that it should not be regulated in the present; indeed, EPA regulated the benzene content of fuel in 2007 without knowing the recipe of every refinery in the country. Moreover, the Agency’s observation is beside the point: There can be no doubt that EPA can *indirectly* regulate air toxics without knowing precisely which refineries use which aromatics and in what proportions. Indeed, EPA has acknowledged in the Draft Regulatory Impact Assessment accompanying the current rule that “[t]he increase in fuel ethanol content has resulted in reduced aromatics” levels.¹⁹⁰ But the Agency’s MSAT obligation to reduce air toxics *to the greatest extent achievable* requires the agency not only to permit, but also to mandate, much more significant aromatics reductions. Approving and facilitating the use of a splash-blended, mid-level ethanol blend, formulated by mixing ethanol with gasoline that already meets all current ASTM and EPA standards, would reduce the aromatic content of motor vehicle fuel, thereby reducing emissions of air toxics.

EPA also reasoned in its 2007 MSAT Rule that “benzene control is far more cost-effective than control of total aromatics,” and that “reducing the content of other aromatics in gasoline is much less effective at reducing benzene emissions than reducing fuel benzene content.”¹⁹¹ Yet other aromatics in gasoline—notably toluene—also produce significant quantities of benzene on combustion, and the Agency must require all cost-effective measures available (and even those which can be made available) in order to reduce benzene and other air toxics to “the greatest degree . . . achievable.”¹⁹² EPA’s approach also suggests that benzene is the only air toxic of concern in section 202(l). But as we have shown, benzene is only one of many air toxics that EPA has a mandatory duty to control under that section.

Furthermore, the price information that EPA relied on for its cost-effectiveness argument was out of date at the time, and is even more woefully out of date today. For its “[c]ost estimates for aromatics control and analysis of relative benzene emissions with control of aromatics and

¹⁸⁷ Tier 3 DRIA, *supra* note 47, at 3-1.

¹⁸⁸ 42 U.S.C. § 7545(o)(2)(A)(i).

¹⁸⁹ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

¹⁹⁰ Tier 3 DRIA, *supra* note 47, at 3-3.

¹⁹¹ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

¹⁹² 42 U.S.C. § 7521(a)(3)(A)(i).

benzene,”¹⁹³ EPA relied on a Regulatory Impact Assessment from the 1994 Reformulated Gasoline Rule that concluded “aromatics was not a cost-effective means for reducing any of the controlled pollutants,”¹⁹⁴ because “additional reductions in toxics to meet [a proposed 25% aromatics] standard would require expensive controls.”¹⁹⁵ That conclusion was based on an estimated retail gasoline price of 85 cents per gallon that was already more than a decade old when it was cited in 2007.¹⁹⁶ Today, with gasoline retailing for more than \$4 per gallon in many areas, this cost argument is no longer even colorable; indeed, EPA now acknowledges that alternatives to aromatics are both widely available and highly economical. The Agency’s 2012 denial of an RFS Waiver, for instance, concluded that, given the current prices of oil, aromatics, and ethanol, reducing aromatics by adding ethanol actually decreases the cost of finished gasoline—even during the short-term spike in ethanol prices caused by last year’s drought.¹⁹⁷

EPA further argued in 2007 that “to broaden the program to control other aromatics would result in a significant octane loss,”¹⁹⁸ even though the use of ethanol is an obvious way to make up that loss, as EPA noted on the same page that “the increased use of ethanol . . . will contribute to lower aromatics levels.” EPA cited “uncertainty in the extent to which ethanol will penetrate the market”¹⁹⁹—an issue determined by regulatory as well as economic factors. Leaving aside the truism that the supply of ethanol naturally increases along with demand, EPA’s premise no longer holds. Most fuel in the United States is already blended with ethanol,²⁰⁰ and the ethanol industry has easily kept pace with demand. If it were to falter in the future, that would do no harm to the vehicles in the fleet, which would be able to run adequately on conventional E10 or even E0 fuel if necessary.

EPA also noted that reducing aromatics would reduce hydrogen, which “is produced when aromatics are produced,”²⁰¹ and that hydrogen is necessary for sulfur reduction. It is hard to imagine EPA declining to regulate a toxic substance because production of that substance produces some marginally beneficial byproduct (particularly one as common as hydrogen, which can be produced in many other ways). But splash-blending ethanol with the current gasoline

¹⁹³ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

¹⁹⁴ Final Regulatory Impact Analysis, Regulation of Fuels and Fuel Additives; Standards for Reformulated and Conventional Gasoline 333 (Public Docket No. A-92-12 Feb. 16, 1994).

¹⁹⁵ *Id.* at 387.

¹⁹⁶ *Id.* at 336.

¹⁹⁷ See RFS Waiver Denial, 77 Fed. Reg. at 70767 (“Ethanol blending is an economically beneficial option for refiners at this time, given the price of ethanol and the cost of production of finished gasoline.”); see also *id.* at 70759-60.

¹⁹⁸ 2007 MSAT Rule, 72 Fed. Reg. at 8479.

¹⁹⁹ *Id.*

²⁰⁰ See Maricq, et al., *supra* note 90, at 576 (“Roughly 90% of gasoline sold in the United States currently contains nearly 10% ethanol.”).

²⁰¹ *Id.*

Blendstock for Oxygenate Blending (BOB), the same fuel which is currently used to produce E10, would not lower the proportional amount of hydrogen produced by refiners anyway, since splash-blending merely decreases the volume of gasoline sold and does not change the makeup of the gasoline portion of the final fuel. In other words, splash-blending gasoline with ethanol reduces hydrogen production only as a factor of reduced demand, and thus causes no disbenefit because the need for hydrogen is also proportionally reduced. Thanks to ethanol's low sulfur emissions,²⁰² no hydrogen additions are necessary for the ethanol portion of the fuel.

Finally, EPA's 2007 MSAT Rule argued that adding ethanol to fuel would increase other MSATs, principally acetaldehyde.²⁰³ The available scientific literature makes clear that the reductions of air toxics that would result from moving to a mid-level ethanol blend would vastly outweigh any incidental and minimal increased emissions of acetaldehyde and formaldehyde. Both acetaldehyde and formaldehyde are emitted from gasoline as well as ethanol.²⁰⁴ Acetaldehyde has been classified as "possibly carcinogenic" to humans, but it is ubiquitous in nature and forms naturally in fruit, coffee and bread. It can be produced in the human body, where it is broken down into harmless acetic acid. Acetaldehyde comes last on the Department of Energy's list of air toxics,²⁰⁵ and EPA assigned acetaldehyde an Inhalation Risk Factor of 0.8—quite low compared (for example) to 1,3-butadiene's 100.0 Inhalation Risk Factor.²⁰⁶ Moreover, new engine technologies, including direct injection, will help to reduce acetaldehyde emissions. Formaldehyde is also classified as "possibly carcinogenic," although—like acetaldehyde—it is less toxic than other relevant pollutants.²⁰⁷ Notably, a study by Argonne National Laboratory found that ethanol blends do not significantly increase formaldehyde emissions.²⁰⁸ In general, aldehyde emissions occur during the initial cold-start phase and are eliminated in an active (warm) three-way catalyst.²⁰⁹ No study has found that exposure to

²⁰² See RFS Waiver Denial, 77 Fed. Reg. at 70760 ("Other properties of ethanol, such as its volatility and low sulfur and benzene content, influence its value to refiners.").

²⁰³ 2007 MSAT Rule, 72 Fed. Reg. at 8478.

²⁰⁴ Thomas Wallner, et al., *Impact of Ethanol and Butanol as Oxygenates on SIDI Engine Efficiency and Emissions Using Steady-State and Transient Test Procedures* 9 (Sept. 2010) (finding increased formaldehyde with *iso*-butanol blends, but not with ethanol blends), http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2010/thursday/presentations/deer10_wallner.pdf.

²⁰⁵ See U.S. Department of Energy, *Pollutants and Health*, Alternative Fuels Data Center, available at http://www.afdc.energy.gov/vehicles/emissions_pollutants.html?print; see also California EPA Air Resources Board, Stationary Source Division, California Test Procedures for Evaluating Substitute Fuels and New Clean Fuels in 2015 and Subsequent Years 13 (Mar. 22, 2012) [hereinafter "CARB Test Procedures"], available at <http://www.arb.ca.gov/msprog/levprog/leviii/attach13.pdf> (assigning acetaldehyde a relative potency of 0.016 compared to 1,3-butadiene's 1.0 and benzene's 0.17).

²⁰⁶ See ENVIRON International Corporation, Toxicological Analysis of Ethanol-Blend Fuels 26 (July 19, 2012).

²⁰⁷ See CARB Test Procedures, *supra* note 205, at 13 (assigning formaldehyde a relative potency of 0.035 compared to 1,3-butadiene's 1.0 and benzene's 0.17).

²⁰⁸ See Wallner, et al., *supra* note 204, at 8.

²⁰⁹ See *id.* at 19.

acetaldehyde and formaldehyde in the concentrations that would be produced by a mid-level ethanol blend fuel would have any measurable effect on human health.²¹⁰ Yet, as detailed below, there are myriad studies showing the harmful effects of current gasoline blends, which are responsible for numerous health problems and thousands of unnecessary deaths every year.

Clearly, the factual predicates that justified EPA's past decision not to regulate aromatics in 2007 no longer apply. EPA is now well positioned to regulate air toxics by approving and facilitating an increase in the ethanol content of motor vehicle fuel.

²¹⁰ See Health Effects Institute Air Toxics Review Panel, *Acetaldehyde, in Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects: Acetaldehyde*, Special Report 16 (2007) ("The data on the possible carcinogenicity of acetaldehyde in humans are inadequate, and the data on respiratory effects are limited mainly to small clinical investigations using exposure challenges with aerosols of acetaldehyde in asthmatic patients. . . . Indoor sources of acetaldehyde account for most environmental exposure, and both ambient and indoor air concentrations at present appear to be well below those that are known to produce adverse health effects. There is no conclusive evidence that acetaldehyde in ambient air, at current levels, adversely affects human health."), available at <http://pubs.healtheffects.org/getfile.php?u=388>.