THE HIGH OCTANE-LOW CARBON FUEL ALLIANCE

September 26, 2021

Submitted via the Federal eRulemaking portal: http://www.regulations.gov

The Honorable Michael Regan
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

RE: Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards (Docket ID No. EPA-HQ-OAR-2021-0208)

Dear Administrator Regan:

The High Octane, Low Carbon (HOLC) Alliance appreciates the opportunity to provide comments to the U.S. Environmental Protection Agency (EPA) on the *Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards Proposed Rule (the "Proposed Rule").*[1] The HOLC Alliance, led by former Senate Majority Leader Tom Daschle, is a group of stakeholders representing a wide range of transportation and agricultural interests with a specific focus on transportation fuels. The HOLC Alliance is committed to advancing the use of higher octane, lower carbon transportation fuels as a viable and affordable solution for improving fuel economy and reducing greenhouse gas (GHG) emissions. Our membership includes the National Farmers Union, the Clean Fuels Development Coalition, the National Corn Growers Association, and the Renewable Fuels Association.

As stakeholders with considerable experience and expertise in areas relating to the interaction of fuel properties and vehicle performance, fuel cycle carbon intensity, and light-duty transportation policy, we are deeply disappointed by the EPA's failure to at least reference high octane, low carbon fuels as one tool for advancing the reduction of GHG emissions and improving the fuel efficiency of light-duty passenger vehicles. For as long as internal combustion engines remain on the road during the next 30 years, high octane, low carbon fuels will be needed, delivering significant reductions in carbon emissions today and providing a critical bridge to an electrified

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[1] U.S. Environmental Protection Agency, "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards," 86 *Fed. Reg.* 43726 (Aug. 10, 2021).

future. We strongly urge the agency to finalize the most stringent standards for model year (MY) 2026, and we urge the agency to signal in the final rule its intentions for 2027 and beyond to enable automakers to optimize the benefits of higher octane, lower carbon fuels in both new and existing internal combustion engines.

Our comments highlight the mounting body of evidence confirming that higher octane, lower carbon fuels have the ability to contribute significantly to achieving the Biden-Harris Administration's goals of reducing carbon emissions by half by 2030 and reaching a net zero economy by 2050. Indeed, such fuels would achieve greater emissions reduction at less cost than the standards in the Proposed Rule. In particular, our comments focus on – 1) the potential of high octane, low carbon fuel as an enabler of GHG emissions reductions and fuel-efficient technology; 2) the toxic impact of gasoline emissions on public health and their disproportionate effect on communities of color; and 3) the steps the EPA must take to encourage the widespread adoption of higher octane, lower carbon fuel.

The HOLC Alliance requests that the EPA closely review our comments, and we look forward to working with the agency throughout this rulemaking process.

If you have any questions, please do not hesitate to contact Tiffani V. Williams at tiffani@daschlegroup.com.

Sincerely,
Tom Daschle
Chair, HOLC Alliance

HOLC Comments

I. Higher Octane, Lower Carbon Fuel Can Reduce GHG Emissions and Improve Fuel Efficiency for Light-Duty Vehicles in MYs 2023 and Beyond

A. Overview

As noted by the EPA in the Proposed Rule, the transportation sector is the largest contributor to U.S. GHG emissions. For that reason, the EPA has focused its attention on the growing shift to electric vehicles (EVs) to achieve the administration's goal of cutting carbon emissions in half by 2030 and reaching a net zero economy by 2050. Both the administration and automakers have committed to significant investments to transition from widely available internal combustion engines to electrification. However, automakers also acknowledge that "the average age of a vehicle in the U.S. is now roughly 12 years",[2] and, therefore, a large portion of vehicles will rely on liquid fuels in the coming decades. In 2021 alone, approximately 270 million light-duty vehicles will consume 120 billion gallons of gasoline containing 25 percent aromatics. Therefore, automakers are "continuing to invest in vehicle improvements that increase fuel economy and reduce [GHG] in internal combustion engine vehicles" – many of which "can be enhanced or complemented with the use of high octane, low carbon liquid fuels."[3] Liquid fuel will continue to be the predominant source of transportation energy, along with its GHG emissions and toxic byproducts, for years to come.

Reducing GHG emissions and improving the fuel efficiency of vehicles, therefore, requires a more immediate clean fuel solution, such as higher octane, lower carbon fuels. While EVs offer tremendous potential for helping reach net zero emissions, decarbonizing liquid fuels would deliver immediate emissions reductions in the meantime. Making today's engines and fuels as efficient, low carbon, and clean as possible now will have significant near-term benefits.

Increasing the use of biofuels such as ethanol with a lower carbon footprint than gasoline would unlock direct and indirect benefits for the climate. Specifically, increasing the ethanol fraction in

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[2] Julia M. Rege, Alliance for Automotive Innovation, Letter to Senator Tom Daschle, Chairman, High-Octane Low-Carbon Alliance, June 11, 2021.

[3] *Ibid.*

our transportation fuel would reduce GHG emissions from light-duty vehicles by more than 12 percent, roughly 123 million metric tons annually, principally by enabling vehicles to operate more efficiently – a greater reduction than would be achieved by the new vehicle standards in the Proposed Rule. Enabling the wider use of mid-level ethanol blends would also support the more stringent vehicle standards for MY 2026 contemplated in the Proposed Rule and enable automakers more easily to comply.

B. Higher Ethanol Blends are Critical to Reducing GHG Emissions in Half by 2030

A 2017 assessment by the consulting firm ICF concluded that life-cycle GHG emissions associated with producing corn-based ethanol in the U.S., using today's practices in a typical natural gas-powered refinery, are almost 43 percent lower than those of gasoline on an energy-equivalent basis.[4,5] This estimate is consistent with more than 15 years of life-cycle analysis at Argonne National Laboratory, recently reaffirmed in a retrospective analysis.[6,7] It is also more than twice as large as the 21 percent reduction predicted by the EPA for an average natural gas-fired plant in 2022 in the agency's 2010 life-cycle analysis for ethanol.[8] Argonne senior scientist

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[4] M. Flugge *et al.,* "A Life-Cycle Analysis of the Greenhouse Gas Emissions from Corn-Based Ethanol," Report prepared by ICF for the U.S. Department of Agriculture (2017): p. 166: https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2623&context=usdaarsfacpub (accessed Feb. 24, 2021). Similarly: J. Rosenfeld *et al.* (2018), p. 99: https://www.usda.gov/sites/default/files/documents/LCA_of_Corn_Ethanol_2018_Report.pdf (accessed Feb. 24, 2021).

[5] Jan Lewandrowski *et al.,* "The greenhouse gas benefits of corn ethanol – assessing recent evidence," *Biofuels* (2018): 11(3): pp. 361-75: https://www.tandfonline.com/doi/full/10.1080/17597269.2018.1546488 (accessed Feb. 24, 2021).

[6] Argonne National Laboratory, "More about GREET" (The greenhouse gases, regulated emissions, and energy use in transportation (GREET) model), online fact sheet: https://greet.es.anl.gov/homepage2 (accessed Feb. 24, 2021).

[7] Uisung Lee *et al.,* "Retrospective analysis of the U.S. corn ethanol industry for 2005–2019: implications for greenhouse gas emission reductions," *Biofuels, Bioproducts and Biorefining* (2021): https://onlinelibrary.wiley.com/doi/10.1002/bbb.2225 (accessed June 11, 2021).

[8] U.S. Environmental Protection Agency, "Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis" (2010): pp. 468-70: https://nepis.epa.gov/Exe/ZyPDF.cgi/P1006DXP.PDF?Dockey=P1006DXP.PDF (accessed Feb. 24, 2021).

Michael Wang estimates that the use of corn ethanol resulted in a total GHG reduction in the U.S. of more than 500 million metric tons between 2005 and 2019.[9]

In contrast, for electric and plug-in hybrid vehicles EPA has used "tailpipe-only values to determine vehicle GHG emissions, without accounting for upstream emissions" in the Proposed Rule.[10] This is misleading: EPA notes on its website that the power used to charge EVs may create carbon pollution. Further, EPA and the U.S. Department of Energy's (DOE's) "Beyond Tailpipe Emissions Calculator" is offered to help individuals "estimate the greenhouse gas emissions associated with charging and driving an EV or a plug-in hybrid electric vehicle."[11]

The benefits of increased ethanol use can be achieved quickly. The proven technology used by today's ethanol industry enables rapid scale-up. The industry tripled its production capacity in just four years – from 4.4 billion gallons a year in 2005 to 14.5 billion in 2009.[12] U.S. ethanol production capacity today is 17.4 billion gallons.[13] The transportation fuel infrastructure has also adapted to the increased use of ethanol in cars and light trucks. New gas pumps are now certified for mid-level ethanol blends.[14]

The Energy Information Administration projects that demand for gasoline will decline from 137.5 billion gallons per year in 2021 to 127 billion gallons in 2050, due to increased vehicle

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[9] Kathryn Jandeska, Argonne National Laboratory, "Corn ethanol reduces carbon footprint, greenhouse gases," *Science X*, May 24, 2021: https://phys.org/news/2021-05-corn-ethanol-carbon-footprint-greenhouse.html (accessed Aug. 18, 2021).

[10] 86 *Fed. Reg.* at 43746.

[11] U.S. Environmental Protection Agency, "Electric Vehicle Myths" in "Green Vehicle Guide," online fact sheet: https://www.epa.gov/greenvehicles/electric-vehicle-myths (accessed Aug. 18, 2021).

[12] U.S. Department of Energy, Alternative Fuels Data Center, "U.S. Ethanol Plant Count, Capacity, and Production" (2020): https://afdc.energy.gov/data/10342 (accessed Feb. 24, 2021).

[13] Renewable Fuels Association, "Essential Energy" (2021): p. 3: https://ethanolrfa.org/wp-content/uploads/2021/02/2021-Pocket-Guide.pdf (accessed Feb. 24, 2021).

[14] "UL Announces Midlevel Certification for Ethanol Fuel Dispensers," *CSP* (2009): https://www.cspdailynews.com/fuels/ul-announces-midlevel-certification-ethanol-fuel-dispensers (accessed Feb. 24, 2021).

efficiency and greater use of electric vehicles.[15] Fueling the 2050 fleet with higher-level blends such as 30 percent ethanol blends (E30) would, therefore, require little more than a doubling of today's ethanol capacity. Demand will fall further if EVs are adopted more rapidly than currently envisioned.

Additionally, increased use of ethanol would bring a national security benefit. U.S. ethanol production in recent years has averaged more than 1 million barrels per day. Increasing that level to support an E30 market would displace more oil than the standards in the EPA and U.S. National Highway Transportation Safety Administration (NHTSA) Proposed Rules would save – producing an oil security premium valued at more than $1 billion per year.[16,17]

C. Higher Ethanol Blends Provide Clean, Affordable Octane to Improve Fuel Efficiency of Light-Duty Vehicles

Octane is needed in gasoline to prevent premature combustion of the fuel mixture ("knock"), which can damage engines.[18] Higher octane enables greater engine efficiency and improved vehicle performance through higher compression ratios and/or more aggressive turbocharging and downsizing – also facilitated by ethanol's cylinder "charge cooling" effect due to its high

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[15] U.S. Energy Information Administration, "Annual Energy Outlook 2021," Table 11. Petroleum and Other Liquids Supply and Disposition (Reference case): https://www.eia.gov/outlooks/aeo/data/browser/#/?id=11-AEO2021&region=0-0&cases=ref2021&start=2019&end=2050&f=A&linechart=ref2021-d113020a.3-11-AEO2021&chartindexed=0&sourcekey=0 (accessed Feb. 24, 2021).

[16] U.S. Energy Information Administration, "U.S. fuel ethanol production capacity increased by 3% in 2019," *Today in Energy*, Sept. 29, 2020: https://www.eia.gov/todayinenergy/detail.php?id=45316 (accessed Aug. 18, 2021); National Highway Traffic Safety Administration, U.S. Department of Transportation, "Corporate Average Fuel Economy Standards for Model Years 2024-2026 Passenger Cars and Light Trucks," proposed rule (Aug. 5, 2021): https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-08/CAFE-NHTSA-2127-AM34-Preamble-Complete-web-tag.pdf (accessed Aug. 18, 2021).

[17] U.S. EPA, "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards," *op. cit., supra* note 1: Table 49, p. 43792.

[18] "Engine knocking," in Wikipedia: https://en.wikipedia.org/wiki/Engine_knocking (accessed Feb. 24, 2021).

heat of vaporization.[19] Raising the engine's compression ratio from 10:1 to 12:1 could increase vehicle efficiency by 5 to 7 percent.[20,21]

To increase octane enough to achieve these efficiency gains (*i.e.,* to a "premium" rating of 94 AKI (anti-knock index) at the gas pump), there are two principal options – aromatics or alcohols.[22] Both have much higher octane ratings than base refinery gasoline.

Since 2016, researchers at nine National Laboratories participating in the DOE's Co-Optimization of Fuels & Engines initiative (known as Co-Optima) have explored how simultaneous innovations in fuels and engines can boost fuel economy and vehicle performance, while reducing emissions.[23] The initiative identified 10 candidate fuels from four chemical families – alcohols, olefins, furans, and ketones – with the greatest potential to increase vehicle efficiency. Seven of them were alcohols.[24]

A team at Oak Ridge National Laboratory found that intermediate alcohol-gasoline blends, particularly E30, "exhibit exceptional antiknock properties and performance beyond that

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[19] J.E. Anderson *et al*., "High octane number ethanol-gasoline blends: Quantifying the potential benefits in the United States," *Fuel* (2012): 97: pp. 585-94: https://www.sciencedirect.com/science/article/pii/S0016236112002268 (accessed Feb. 24, 2021).

[20] David S. Hirshfeld *et al*., "Refining Economics of U.S. Gasoline: Octane Ratings and Ethanol Content," *Environmental Science & Technology* (2014): 48(19): p. 11064-71: https://pubs.acs.org/doi/pdf/10.1021/es5021668 (accessed Feb. 24, 2021).

[21] Thomas G. Leone *et al*., "The Effect of Compression Ratio, Fuel Octane Rating, and Ethanol Content on Spark-Ignition Engine Efficiency," *Environmental Science & Technology* (2015): 49(18): pp. 10778-89: https://pubs.acs.org/doi/abs/10.1021/acs.est.5b01420 (accessed June 17, 2021).

[22] Petroleum Equipment Institute, "Octane Number," https://www.pei.org/wiki/octane-number (accessed Aug. 23, 2021). The AKI rating is used on U.S. gas pumps, while the Research Octane Number (RON) is used in Europe. A U.S. octane rating of 94 is roughly equivalent to 98 RON: http://www.pencilgeek.org/2009/05/octane-rating-conversions.html (accessed Aug. 23, 2021).

[23] Magnus Sjöberg, Sandia National Laboratories, "An Introduction to DOE's Co-Optima Initiative," presentation at International Workshop on Fuel & Engine Interactions, Aug. 23, 2017: https://www.osti.gov/servlets/purl/1466483 (accessed Feb. 24, 2021).

[24] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, "Co-Optimization of Fuels & Engines: Scientific Innovation For Efficient, Clean, And Affordable Transportation" (2019): https://www.energy.gov/sites/prod/files/2019/04/f61/CoOptimization_FactSheet_2019%20PRESS%20QUALITY_0.pdf (accessed Feb. 24, 2021).

indicated by the octane number tests,"[25] and that engine and vehicle optimization could offset the reduced fuel energy content of such blends and likely reduce vehicle fuel consumption and tailpipe carbon dioxide (CO_2) emissions.[26,27] The use of E30 in one test vehicle enabled a 13:1 compression ratio, reducing CO_2 emissions by 6 to 9 percent.[28]

Enabling use of high octane, mid-level ethanol blends would significantly reduce the cost of stronger fuel economy standards, a 2016 analysis by AIR, Inc., found.[29] In a recent letter, the Alliance for Automotive Innovation, a group of automakers that produce nearly 99 percent of the new light-duty vehicles sold in the U.S., said:

> [A]s automakers invest significantly in the transition to expanded vehicle electrification, the auto industry is also continuing to invest in vehicle improvements that increase fuel economy and reduce greenhouse gases in internal combustion engine vehicles. Many of the technologies being used to make these improvements can be enhanced or complemented with the use of high octane, low carbon liquid fuels. These fuels would simultaneously support vehicle performance, including fuel economy, and further reduce greenhouse gas emissions during vehicle use. Such benefits would be realized by new and existing internal combustion engines and therefore should be encouraged as additional solutions as soon as possible to maximize environmental benefits across the fleet. Given the timespan over which combustion technology will continue to be sought by new car shoppers, and the timespan that those vehicles will remain in the field, low

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[25] Derek A. Splitter and James P. Szybist, "Experimental Investigation of Spark-Ignited Combustion with High-Octane Biofuels and EGR. 2. Fuel and EGR Effects on Knock-Limited Load and Speed," *Energy Fuels* (2014): 28(2): pp. 1432-45: https://pubs.acs.org/doi/pdf/10.1021/ef401575e (accessed Feb. 24, 2021).

[26] Derek A. Splitter and James P. Szybist, "Experimental Investigation of Spark-Ignited Combustion with High-Octane Biofuels and EGR. 1. Engine Load Range and Downsize Downspeed Opportunity," *Energy Fuels* (2014): 28(2): pp. 1418-31: https://pubs.acs.org/doi/10.1021/ef401574p (accessed Feb. 24, 2021).

[27] Tim Theiss *et al*., "Summary of High-Octane, Mid-Level Ethanol Blends Study" (2016): ORNL/TM-2016/42: https://info.ornl.gov/sites/publications/Files/Pub61169.pdf (accessed Feb. 24, 2021).

[28] Thomas Leone *et al*., "Effects of Fuel Octane Rating and Ethanol Content on Knock, Fuel Economy, and CO2 for a Turbocharged DI Engine," *SAE International Journal of Fuels and Lubricants* (2014): 7(1): pp. 9-28: https://www.sae.org/publications/technical-papers/content/2014-01-1228/ (accessed Feb. 24, 2021).

[29] Air Improvement Resource, "Evaluation of Costs of EPA's 2022-2025 GHG Standards With High Octane Fuels and Optimized High Efficiency Engines" (2016): http://www.mncorn.org/wp-content/uploads/2016/09/1079-16EU-Final-Report-091616.pdf (accessed Aug. 18, 2021).

> carbon liquid fuels are an increasingly important technology pathway to help achieve carbon reductions while the electric vehicle market continues to grow.[30] *(emphasis added)*

U.S. consumption of gasoline adds roughly 1 billion metric tons of CO_2 to the atmosphere each year.[31] Based on current consumption rates of gasoline, increasing vehicle fuel economy by 7 percent with the higher octane of an E30 blend would reduce annual U.S. emissions by 70 million metric tons per year.[32] Reducing the share of aromatics in gasoline by 40 percent – with E30 fuel that is 40 percent less emitting – would reduce U.S. emissions by another 32 million metric tons per year.[33] GHG emissions from oil refineries would also fall, due to reduced demand for their most intensively refined products. Lower throughput and intensity would reduce refinery CO_2 emissions and crude oil consumption, at a modest additional cost of 1-2 cents per gallon.[34] One assessment found that refinery GHG emissions would decline by 12 percent to 27 percent for various E30 cases, due to both lower crude oil throughput and differences in the severity of refining operations.[35] Since the refinery sector emits 180 million

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[30] Julia M. Rege, *op. cit., supra* note 2.

[31] U.S. Energy Information Administration, "Monthly Energy Review" May 2020, Table 11.5, Carbon Dioxide Emissions From Energy Consumption: Transportation Sector: https://www.eia.gov/totalenergy/data/monthly/pdf/sec11_8.pdf (accessed Feb. 24, 2021).

[32] CO_2 emissions from U.S. light-duty vehicles in 2018 totaled 1050 million metric tons (MMT). A 7% reduction would be 70 MMT per year. U.S. Environmental Protection Agency, "Fast Facts: U.S. Transportation Sector Greenhouse Gas Emissions, 1990-2018," online fact sheet: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100ZK4P.pdf (accessed Feb. 24, 2021).

[33] Aromatics comprise 20% of U.S. gasoline consumption by light-duty vehicles [U.S. Environmental Protection Agency, "Fuel Trends Report: Gasoline 2006 - 2016" (2017): https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100T5J6.pdf (accessed Feb. 24, 2021)], producing 200 MMT of CO_2 annually. Replacing 40% of the aromatics, or 80 MMT, with fuel that produces 40% less CO_2 per gallon would reduce total U.S. CO_2 emissions by 32 MMT per year.

[34] Hirshfeld *et al*., *op. cit., supra* note 20: p. 11070.

[35] Vincent Kwasniewski *et al*., "Petroleum refinery greenhouse gas emission variations related to higher ethanol blends at different gasoline octane rating and pool volume levels," *Biofuels, Bioproducts & Biorefining* (2016): (10)1: pp. 36-46: https://onlinelibrary.wiley.com/doi/full/10.1002/bbb.1612 (accessed Feb. 24, 2021).

metric tons per year,[36] that would mean a further reduction in U.S. GHG emissions of at least 21 million metric tons per year.

Thus, the total reduction in U.S. GHG emissions from adoption of E30 blends – combining fuel economy gains, the replacement of aromatics with a lower-carbon substitute, and the change in refinery operations – would total 123 million metric tons per year. That would be a cut of more than 12 percent in emissions from light-duty vehicles, which comprise 58 percent of the emissions from the transportation sector.[37] It would also exceed the GHG reductions from the Proposed Rule for new cars, which reach only 117 million tons in 2050.[38]

Valuing the social cost of those avoided emissions at $25 per ton would imply a benefit of more than $3 billion per year. Using the "interim" rate of $51 per ton put forward by the administration in 2021, the benefits would come to more than $6 billion per year.[39] At the rate of $76 per ton used in the NHTSA Proposed Rule, the benefits would exceed $9 billion per year.[40]

California is in the vanguard of the transition to electric vehicles in the U.S., with a goal of limiting new-car sales in 2035 to zero-emission vehicles.[41] But under the state's Low Carbon Fuel Standard (LCFS) program to date (since 2011), ethanol has reduced GHG emissions nearly three times more than electricity. As more electric vehicles enter the market, that ratio is

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[36] U.S. Environmental Protection Agency, "GHGRP Refineries" in "Greenhouse Gas Reporting Program," online fact sheet: https://www.epa.gov/ghgreporting/ghgrp-refineries (accessed Feb. 24, 2021).

[37] U.S. EPA, "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards," *op. cit., supra* note 1: p. 43779.

[38] *Ibid*., Table 43, p. 43778.

[39] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990" (2021): Figure ES-1: Frequency Distribution of SC-CO2 Estimates for 2020, p. 5: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf (accessed Mar. 1, 2021)

[40] National Highway Traffic Safety Administration, *op. cit., supra* note 16.

[41] Governor of California, Executive Order N-79-20 (2020): https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-text.pdf (accessed Feb. 24, 2021).

dropping sharply, but even last year, ethanol reduced GHG emissions by one third more than electricity – despite being limited mostly to E10 blends.[42]

II. Higher Ethanol Blends Can Replace the Toxic Aromatics in Gasoline to Improve Public Health and its Impact on Communities of Color

A. Toxic Aromatics in Gasoline are Harming Our Environment and Health

A shift from the standard formulation of gasoline today (E10) to a higher-level blend (E30) would displace an estimated 40 percent of the toxic aromatics in the fuel[43] – also the most carbon-intensive fraction of gasoline.[44] Aromatics are hydrocarbons built around one or more benzene rings. Often referred to by the acronym BTEX, they include not just benzene itself, a known carcinogen, but also toluene, ethylbenzene, xylenes, and other compounds similar to benzene in their behavior in the environment.[45] Aromatics are derived from petroleum during the refining process and blended into gasoline to increase octane. The use of aromatics increased

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[42] California Air Resources Board, "2020 LCFS Reporting Tool (LRT) Quarterly Data Summary: Report No. 4" (2021): https://ww2.arb.ca.gov/sites/default/files/classic//fuels/lcfs/dashboard/quarterlysummary/20210430_q4datasummary.pdf (accessed June 21, 2021).

[43] Hirshfeld *et al*., *op. cit., supra* note 20: Supporting Information, Table S15: Summary of Refinery Modeling Results: E10/E85 Cases with 20 vol% and 30 vol% Ethanol in the Gasoline Pool: p. SI-34: https://pubs.acs.org/doi/suppl/10.1021/es5021668/suppl_file/es5021668_si_001.pdf (accessed Feb. 24, 2021).

[44] M.A. DeLuchi, "Emissions of Greenhouse Gases from the Use of Transportation Fuels and Electricity" (1993), Argonne National Laboratory, ANL/ESD/TM-22, Vol. 2, Table C.2: Analysis of Petroleum Products: p. C-6: https://www.osti.gov/servlets/purl/10119540 (accessed Feb. 24, 2021).

[45] Emma P. Popek, "Environmental Chemical Pollutants" in *Sampling and Analysis of Environmental Chemical Pollutants* (second edition), Elsevier (2018), p. 36: https://www.sciencedirect.com/science/article/pii/B9780128032022000021 (accessed Feb. 24, 2021).

dramatically during the 1980s when the previously used additive, tetraethyl lead, was phased out due to health concerns.[46,47]

The level of aromatics in gasoline is capped at 25 percent in regions required to use reformulated gasoline (areas that have high levels of ozone pollution, roughly 30 percent of the U.S. market).[48] From 1997 to 2006, aromatics made up roughly 25 percent of the U.S. gasoline pool. That level fell to 20 percent over the next 10 years[49] as ethanol's share of the market rose from 3 percent to nearly 10 percent. This 20 percent level equates to 25.3 billion gallons of aromatics used in cars and light-duty vehicles per year.[50]

The BTEX chemicals are characterized as hazardous air pollutants "known or suspected to cause cancer or other serious health or environmental effects."[51] They are identified as mobile source air toxics and formed in four ways, of which the first two are most pertinent. According to the EPA:

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[46] Francesca Lyman, "The Gassing of America," in *The Washington Post,* April 13, 1990: https://www.washingtonpost.com/archive/lifestyle/1990/04/13/the-gassing-of-america/bce94f4d-c8a1-47e5-8c9c-d0a6befd8b80/ (accessed Feb. 24, 2021).

[47] U.S. Environmental Protection Agency, "Examples of Successful Lead Phaseouts: United States," in *Implementer's Guide to Phasing Out Lead in Gasoline* (1999), pp. 10-11: https://archive.epa.gov/international/air/web/pdf/epa_phase_out.pdf (accessed Feb. 24, 2021).

[48] 42 U.S. Code, sec. 7545, "Regulation of fuels," at (k)(3)(A)(ii): P.L. 101-549, sec. 219, enacted Nov. 15, 1990: https://www.law.cornell.edu/uscode/text/42/7545 (accessed June 17, 2021).

[49] U.S. EPA, "Fuel Trends Report," *op. cit., supra* note 33, Table 6: Summary of Annual Average Gasoline Properties Between 1997 and 2016: EPA-420-R-17-005: p. 27.

[50] U.S. Energy Information Administration, "Gasoline explained – use of gasoline", online fact sheet: "Light-duty vehicles (cars, sport utility vehicles, and small trucks) account for about 92% of all gasoline consumption in the United States": https://www.eia.gov/energyexplained/gasoline/use-of-gasoline.php (accessed Feb. 24, 2021). EIA projects gasoline use in 2021 to total 137.5 billion gallons, or 126.5 billion gallons for light-duty vehicles: U.S. Energy Information Administration, "Annual Energy Outlook 2021," Table 11. Petroleum and Other Liquids Supply and Disposition (Reference case): https://www.eia.gov/outlooks/aeo/data/browser/#/?id=11-AEO2021&region=0-0&cases=ref2021&start=2019&end=2050&f=A&linechart=ref2021-d113020a.3-11-AEO2021&chartindexed=0&sourcekey=0 (accessed Feb. 24, 2021).

[51] U.S. Environmental Protection Agency, "What are Hazardous Air Pollutants?", online fact sheet: https://www.epa.gov/haps/what-are-hazardous-air-pollutants (accessed Aug. 29, 2021).

> "First, some air toxics are present in fuel and are emitted to the air when it evaporates or passes through the engine as unburned fuel. Benzene, for example, is a component of gasoline. Cars emit small quantities of benzene in unburned fuel, or as vapor when gasoline evaporates.
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> "Second, mobile source air toxics are formed through engine combustion processes. A significant amount of automotive benzene comes from the incomplete combustion of compounds in gasoline such as toluene and xylene that are chemically very similar to benzene."[52] *(emphasis added)*

According to a review of the literature by the Health Effects Institute: "It is estimated that about 50 [percent] of the benzene produced in the exhaust is the result of decomposition of aromatic hydrocarbons in the fuel. … [Two] studies showed that lowering aromatic levels in gasoline significantly reduces toxic benzene emissions from vehicle exhausts."[53]

A recent General Motors study found that nearly 96 percent of the PM emissions from gasoline are caused by the aromatics in the fuel. Due to an increase in heavy aromatics in the U.S. gasoline pool in the last three years, the gasoline particulate index has increased by more than 30 [percent] since 2016 and now is worse than in the EU and China. The authors observed: "Fuel quality improvements are not only important for new vehicles, which are designed for it, but also will benefit the whole fleet of legacy vehicles in the market and off-highway engines."[54]

Aromatics contribute about 10 percent of global anthropogenic emissions of non-methane organic gases (NMOG), the major source being car exhaust from gasoline-powered

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[52] U.S. Environmental Protection Agency, "Control of Emissions of Hazardous Air Pollutants from Mobile Sources; Final Rule," *Federal Register* (2001): 66(61): pp. 17235-39: https://www.govinfo.gov/content/pkg/FR-2001-03-29/pdf/01-37.pdf (accessed Feb. 24, 2021).

[53] Health Effects Institute, Panel on the Health Effects of Traffic-Related Air Pollution, "Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects" (Special Report 17): Chapter 2, "Emissions from Motor Vehicles," Appendix B: "Fuel Composition Changes Related To Emission Controls" (2010): pp. 3-4: https://www.healtheffects.org/system/files/SR17TrafficReviewChapter2AppendixB.pdf (accessed Aug. 24, 2021).

[54] Elana Chapman *et al.*, "Global Market Gasoline Quality Review: Five Year Trends in Particulate Emission Indices," *SAE International* (2021): SAE Technical Paper 2021-01-0623: https://saemobilus.sae.org/content/2021-01-0623/ (accessed June 17, 2021).

vehicles.[55] Aromatics are also responsible for an estimated 30-40 percent of the ozone and other photooxidants in urban atmospheres, making them the most important class of hydrocarbons with regard to photochemical ozone formation.[56]

B. Toxic Emissions from Gasoline are Causing Premature Deaths and Long-Lasting Health Effects

Organic aerosol is a major component of fine particle pollution. Primary organic aerosol (POA) is directly emitted from fossil fuel combustion and other sources, while secondary organic aerosol (SOA) is formed from the oxidation of these emissions in the air.[57] Tailpipe emissions from on-road gasoline vehicles are an important source of SOA in urban environments, where SOA concentrations often exceed POA levels. For most vehicles, SOA formation exceeds POA emissions after a few hours of atmospheric oxidation. Controlling SOA precursor emissions is necessary to reduce human exposure to fine particulate matter.[58] A study of SOA formation during a severe photochemical smog event in Los Angeles found that exhaust from gasoline engines represented the single-largest anthropogenic source of SOA, and SOA in turn has been shown to be a large fraction, if not the largest, of gasoline vehicular PM.[59]

According to EPA's 2011 National Air Toxics Assessment, secondary formation is the largest contributor to cancer risks nationwide, accounting for 47 percent of the risk. On-road mobile sources contribute the most cancer risk from directly emitted pollutants (about 18 percent) and

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[55] I. Barnes and K.H. Becker, "Aromatic Hydrocarbons," in Tropospheric Chemistry and Composition, *Encyclopedia of Atmospheric Sciences* (2003): p. 2376: https://www.sciencedirect.com/science/article/pii/B0122270908004243 (accessed Feb. 24, 2021).

[56] *Ibid.*

[57] J. L. Jiminez *et al.*, "Evolution of Organic Aerosols in the Atmosphere," *Science* (2009): 326(5959): pp. 1525-29: https://science.sciencemag.org/content/326/5959/1525 (accessed Feb. 24, 2021).

[58] Yunliang Zhao *et al.*, "Reducing secondary organic aerosol formation from gasoline vehicle exhaust," *Proceedings of the National Academy of Sciences of the United States of America* (2017): 114(27): pp. 6984–89: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5502599/ (accessed Feb. 24, 2021).

[59] Michael J. Kleeman *et al.*, "Source apportionment of secondary organic aerosol during a severe photochemical smog episode," *Atmospheric Environment* (2007): 41(3): pp. 576-91: https://www.sciencedirect.com/science/article/abs/pii/S1352231006008582?via%3Dihub (accessed Feb. 24, 2021).

the most to non-cancer risks (34 percent).[60] A recent study found higher toxicity in combustion aerosols than non-combustion aerosols, with emissions from vehicle engine exhaust scoring higher on overall toxicity than even those from coal combustion.[61]

In 2005, EPA said that "[a]romatic compounds … 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. … The experimental work of Odum and others showed that the secondary organic aerosol formation potential of gasoline could be accounted for solely in terms of its aromatic fraction."[62] *(emphasis added).* One study estimated that SOA from aromatics in gasoline is responsible for 3,800 annual premature deaths and annual social costs of $28.2 billion in 2006 dollars.[63]

Additionally, the effect of aromatics on SOA is not linear. Increasing the level of aromatics in test fuels by less than 30 percent (from 28.5 percent to 36.7 percent) was shown to cause a 3- to 6-fold increase in SOA formation.[64] Reducing aromatics would have a similarly disproportionate effect.

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[60] U.S. Environmental Protection Agency, "Overview of EPA's 2011 National Air Toxics Assessment," online fact sheet (2015): https://www.epa.gov/sites/production/files/2015-12/documents/2011-nata-fact-sheet.pdf (accessed Feb. 24, 2021).

[61] Minhan Park *et al*., "Differential toxicities of fine particulate matters from various sources," *Nature, Scientific Reports* (2018): 8(17007): https://www.nature.com/articles/s41598-018-35398-0 (accessed Feb. 24, 2021).

[62] Daniel Grosjean and John H. Seinfeld, "Parameterization of the formation potential of secondary organic aerosols," *Atmospheric Environment* (1967): 23(8): pp. 1733-47: https://www.sciencedirect.com/science/article/abs/pii/0004698189900589 (accessed Feb. 24, 2021) and J.R. Odum *et al*., "The atmospheric aerosol-forming potential of whole gasoline vapor," *Science* (1997): 276(5309): pp. 96-9: https://pubmed.ncbi.nlm.nih.gov/9082994/ (accessed Feb. 24, 2021), cited in U.S. Environmental Protection Agency, "Proposed Rule To Implement the Fine Particle National Ambient Air Quality Standards," *Federal Register* (2005): 70(210): p. 65996: https://www.govinfo.gov/content/pkg/FR-2005-11-01/pdf/05-20455.pdf (accessed Feb. 24, 2021).

[63] Katherine von Stackelberg *et al*., "Public health impacts of secondary particulate formation from aromatic hydrocarbons in gasoline," *Environmental Health* (2013): 12(19): https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-12-19 (accessed Feb. 24, 2021).

[64] Jianfei Peng *et al*., "Gasoline aromatics: a critical determinant of urban secondary organic aerosol formation," *Atmospheric Chemistry and Physics* (2017): 17: pp. 10743-52: https://www.atmos-chem-phys.net/17/10743/2017/acp-17-10743-2017.pdf (accessed Feb. 24, 2021).

Further, there is a growing concern in the public health community about the contribution of ultrafine particles (UFPs) to human health. Despite their modest mass and size, they dominate in terms of the number of particles in the ambient air. UFPs contain large amounts of toxic components, and their adverse health effects potential would not be predicted from their mass alone. Particle number, surface area, and chemical composition are more important than mass as a health-relevant metric.[65]

A particular concern about UFPs is their ability to reach the most distal lung regions (alveoli) and circumvent primary airway defenses. Moreover, UFPs have a high surface area and a capacity to adsorb a substantial amount of toxic organic compounds. Harmful systemic health effects of PM_{10} or $PM_{2.5}$ are often due to the UFP fraction.[66] High levels of aromatic components in fuel have been conclusively shown to increase PM emissions measured by particle number, an aromatic ring being an early stage of the fundamental particulate formation process.[67]

The ability of inhaled particles to be captured within the human body, called the deposition efficiency, is a function of particle size, with the particle deposition efficiency rapidly increasing as the particles become smaller and smaller.[68] UFPs can cross biological membranes, and their mobility within the body is thought to be high. There is considerable evidence to show that

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[65] Paul A. Solomon, U.S. Environmental Protection Agency, "An Overview of Ultrafine Particles in Ambient Air," *EM: The Magazine for Environmental Managers* (2012): 5: pp. 20-21: https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NERL&dirEntryId=241266 (accessed Feb. 24, 2021).

[66] Hyouk-Soo Kwon *et al*., "Ultrafine particles: unique physicochemical properties relevant to health and disease," *Experimental & Molecular Medicine* (2020): 52: pp. 318-28: https://www.nature.com/articles/s12276-020-0405-1.pdf (accessed June 11, 2021).

[67] Mohsin Raza *et al*., "A Review of Particulate Number (PN) Emissions from Gasoline Direct Injection (GDI) Engines and Their Control Techniques," *Energies* (2018): 11(6), 1417: p. 18: https://www.mdpi.com/1996-1073/11/6/1417/htm (accessed Feb. 24, 2021).

[68] Felipe Rodriguez *et al*., "Recommendations for Post-Euro 6 Standards for Light-Duty Vehicles in the EU" (2019), International Council on Clean Transportation, p. 8: https://theicct.org/sites/default/files/publications/Post_Euro6_standards_report_20191003.pdf (accessed June 11, 2021).

inhaled UFPs can gain access to the bloodstream and are then distributed to other organs in the body. They can even cross the placental barrier.[69]

An important recent study co-authored by Nobel Prize winner Mario Molina found "remarkable formation of UFPs from urban traffic emissions"[70] – which have a disproportionate effect on communities of color: "Photooxidation of vehicular exhaust yields abundant UFP precursors, and organics dominate formation of UFPs under urban conditions." Chamber studies showed high levels of aromatics, including toluene and C8 and C9 aromatics.[71] The authors concluded: "Recognition of this source of UFPs is essential to assessing their impacts and developing mitigation policies. Our results imply that reduction of primary particles or removal of existing particles without simultaneously limiting organics from automobile emissions is ineffective and can even exacerbate this problem."[72] *(emphasis added)*

Polycyclic aromatic hydrocarbons (PAHs) are among the worst of the UFPs. The EPA has classified seven PAHs as probable human carcinogens.[73] A subset of polycyclic organic matter (POM), PAHs consist of three to seven benzene rings. Among all sources, vehicular exhaust is the major source for PAH air pollution in most urban areas, the product of incomplete

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[69] C. Vyvyan Howard, "Particulate Emissions and Health" (2009): pp. 12-15: http://www.durhamenvironmentwatch.org/Incinerator%20Health/CVHRingaskiddyEvidenceFinal1.pdf (accessed Feb. 24, 2021).

[70] Song Guo *et al*., "Remarkable nucleation and growth of ultrafine particles from vehicular exhaust," *Proceedings of the National Academy of Sciences of the United States of America* (2020): 117(7): pp. 3427-32: https://www.pnas.org/content/117/7/3427 (accessed June 11, 2021).

[71] *Ibid.*

[72] *Ibid.*

[73] U.S. Environmental Protection Agency, "Polycyclic Organic Matter," online fact sheet: https://www.epa.gov/sites/production/files/2016-09/documents/polycyclic-organic-matter.pdf (accessed June 17, 2021).

combustion of aromatic hydrocarbons in gasoline.[74,75] More than 95 percent of the lung deposition of PAHs is due to fine particles, and ultrafine particles are responsible for 10 times more PAH deposition in the alveolar region than their share of PM mass.[76]

PAHs are commonly divided into two categories based on their size. PAHs with two to three fused aromatic rings are considered low molecular weight PAHs, while those with four and more fused rings are high molecular weight PAHs, including the most carcinogenic PAH, benzo[a]pyrene (BaP).[77] The larger PAHs are of greatest concern for human health due to their recalcitrance to degradation, persistence, bioaccumulation, carcinogenicity, genotoxicity and mutagenicity.[78] Since these high molecular weight PAHs exist almost exclusively on fine particles, they travel deep into the human respiratory system and pose a serious health risk.[79] Combustion of vehicle fuels appears to be the principal source of inhalation exposure for the larger PAHs, such as BaP, that are associated with particulate matter.[80] Motor vehicles account

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[74] U.S. Environmental Protection Agency, "Polycyclic Organic Matter," online fact sheet: https://www.epa.gov/sites/production/files/2016-09/documents/polycyclic-organic-matter.pdf (accessed June 17, 2021).

[75] Z. Fan and L. Lin, "PAHs" in "Exposure Science: Contaminant Mixtures," *Encyclopedia of Environmental Health (Second Edition)* (2011), Elsevier Reference Collection in Earth Systems and Environmental Sciences: pp. 805-15: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/polycyclic-aromatic-hydrocarbon (accessed June 21, 2021).

[76] Youhei Kanawaka *et al*., "Size Distributions of Polycyclic Aromatic Hydrocarbons in the Atmosphere and Estimation of the Contribution of Ultrafine Particles to Their Lung Deposition," *Environmental Science & Technology* (2009): 43(17): p. 6855: https://pubmed.ncbi.nlm.nih.gov/19764259 (accessed Feb. 24, 2021).

[77] Stephen Richardson, "Polycyclic Aromatic Hydrocarbons (PAH)": https://www.enviro.wiki/index.php?title=Polycyclic_Aromatic_Hydrocarbons_(PAHs) (accessed Feb. 24, 2021).

[78] M.N. Igwo-Ezikpe *et al*., "High Molecular Weight Polycyclic Aromatic Hydrocarbons Biodegradation by Bacteria Isolated from Contaminated Soils in Nigeria," *Research Journal of Environmental Sciences* (2010): 4: pp. 127-37: https://scialert.net/fulltext/?doi=rjes.2010.127.137 (accessed Feb. 24, 2021).

[79] Yan Lv *et al*., "Size distributions of polycyclic aromatic hydrocarbons in urban atmosphere: sorption mechanism and source contributions to respiratory deposition," *Atmospheric Chemistry and Physics* (2016): 16: p. 2976: https://acp.copernicus.org/articles/16/2971/2016/acp-16-2971-2016.pdf (accessed Feb. 24, 2021).

[80] Health Effects Institute Air Toxics Review Panel, "Polycyclic Organic Matter" in *Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects*, HEI Special Report 16 (2007): pp. 117-33: https://www.healtheffects.org/system/files/SR16-Polycyclic_Organic_Matter.pdf (accessed Feb. 24, 2021).

for as much as 90 percent of the particle-bound PAH mass in the urban air of major metropolitan areas.[81]

Fetal exposure to PAHs, as measured by prenatal air monitoring for the marker PAH benzo[*a*]pyrene during the third trimester of pregnancy, was assessed in a long-term observational epidemiological study in New York. Exposure levels were characterized relative to a median of 2.66 nanograms per cubic meter (ng/m^3) – 100,000 times less than the OSHA air standard of 0.2 mg/m^3.[82] Fetal exposure above the median was associated with developmental delay at age 3 years and reduced IQ at age 5 years, as well as increased anxiety and depression, possibly by interfering with knowledge acquisition or slowing cognitive processing.[83] The observed decrease in full-scale IQ is similar to that reported for children with elevated concentrations of lead in their blood.[84]

DNA adducts are a form of DNA damage caused by attachment of a chemical entity to DNA. Adducts that are not removed by the cell can cause mutations that may give rise to cancer.[85] The formation of PAH-DNA adducts has been widely studied in experimental models and has been

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[81] A. Polidori *et al.*, "Real-time characterization of particle-bound polycyclic aromatic hydrocarbons in ambient aerosols and from motor-vehicle exhaust," *Atmospheric Chemistry and Physics* (2008): 8: pp. 1277-91: https://www.atmos-chem-phys.net/8/1277/2008/acp-8-1277-2008.pdf (accessed Feb. 24, 2021).

[82] Frederica P. Perera *et al.*, "Effects of Transplacental Exposure to Environmental Pollutants on Birth Outcomes in a Multiethnic Population," *Environmental Health Perspectives* (2003): 111(2): p. 203: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241351/pdf/ehp0111-000201.pdf (accessed Feb. 24, 2021).

[83] Frederica P. Perera *et al.*, "Prenatal Polycyclic Aromatic Hydrocarbon (PAH) Exposure and Child Behavior at Age 6–7 Years," *Environmental Health Perspectives* (2012): 120(6): pp. 921-26: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3385432/ (accessed Feb. 24, 2021).

[84] Frederica P. Perera *et al.*, "Prenatal Airborne Polycyclic Aromatic Hydrocarbon Exposure and Child IQ at Age 5 Years," *Pediatrics* (2009): 124(2): pp. e195-e202: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2864932/ (accessed Feb. 24, 2021).

[85] "DNA adducts," *Nature.com:* https://www.nature.com/subjects/dna-adducts (accessed Feb. 24, 2021).

documented in human tissues.[86] Higher levels of PAH-DNA adducts found in umbilical cord blood were associated with reduced scores on neurocognitive tests.[87]

A long-term study in California also found an association between exposure to airborne PAHs during the last 6 weeks of pregnancy and early preterm birth – with median exposure at the extremely low level of 3.6 ng/m^3.[88] Preterm birth is a predictor of infant mortality and later-life morbidity. Despite recent declines, the rate of preterm birth remains high in the U.S. Research increasingly suggests a possible relationship between a mother's exposure to common air pollutants, including $PM_{2.5}$ and preterm birth of her baby. [89]

Based on numerous experimental studies, PAHs are also widely accepted to be precursors for soot, or black carbon – a major contributor to climate change.[90,91] Products of toluene combustion (one of the BTEX aromatics) are known precursors of PAHs that are involved in soot formation.[92] Black carbon is considered the second most important human emission in terms of

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[86] M. Margaret Pratt *et al*., "Polycyclic Aromatic Hydrocarbon (PAH) Exposure and DNA Adduct *Semi*-Quantitation in Archived Human Tissues," *International Journal of Environmental Research and Public Health* (2011): 8(7): pp. 2675-91: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3155323/ (accessed Feb. 24, 2021).

[87] Frederica P. Perera *et al*., "Polycyclic Aromatic Hydrocarbons–Aromatic DNA Adducts in Cord Blood and Behavior Scores in New York City Children," *Environmental Health Perspectives* (2011): 119(8): pp. 1176-81: https://ehp.niehs.nih.gov/doi/pdf/10.1289/ehp.1002705 (accessed Feb. 24, 2021).

[88] Amy M. Padula *et al*., "Exposure to Airborne Polycyclic Aromatic Hydrocarbons During Pregnancy and Risk of Preterm Birth," *Environmental Research* (2014): 135: pp. 221-226: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4262545/ (accessed Feb. 24, 2021).

[89] Jina J. Kim *et al*., "Preterm birth and economic benefits of reduced maternal exposure to fine particulate matter," *Environmental Research* (2019): 170: pp. 178-86: https://www.sciencedirect.com/science/article/abs/pii/S001393511830642X (accessed Feb. 24, 2021).

[90] H. Richter and J.B. Howard, "Formation of polycyclic aromatic hydrocarbons and their growth to soot – a review of chemical reaction pathways," *Progress in Energy and Combustion Science* (2000): 26(4-6), pp. 565-608: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.467.9757&rep=rep1&type=pdf (accessed Feb. 24, 2021).

[91] Qian Mao *et al*., "Formation of incipient soot particles from polycyclic aromatic hydrocarbons," *Carbon* (2017): 121: pp. 380-88: https://www.sciencedirect.com/science/article/pii/S0008622317305766 (accessed Feb. 24, 2021).

[92] Gabriel da Silva *et al*., "Toluene Combustion: Reaction Paths, Thermochemical Properties, and Kinetic Analysis for the Methylphenyl Radical + O2 Reaction," *The Journal of Physical Chemistry A* (2007): 111(35): pp. 8663-76: https://pubmed.ncbi.nlm.nih.gov/17696501/ (accessed Feb. 24, 2021).

climate forcing; only CO_2 has a greater overall effect. The short-term (20-year) global warming potential per ton of black carbon is 3200 times that of CO_2.

Unfortunately, new engine technology is not coming to the rescue: Most of the light-duty vehicles sold today have switched to gasoline direct injection technology (GDI) – for the laudable reason of increased engine efficiency and thus fuel economy – but with the unintended side effect of increasing the volume of UFPs, including PAHs, coming out of the exhaust pipe.[93] GDI was used in fewer than 3 percent of vehicles as recently as model year 2008 but was projected to be used in more than 55 percent of vehicles in model year 2020.[94] GDI engines emit UFPs and PM at levels comparable to diesel engines that do not use diesel particulate filters.[95,96] Uncontrolled GDI engines have been found to emit 10 times more particles (by mass) than previous engines and more than 100 times the number of particles.[97]

C. Low-Income and Communities of Color Face a Disproportionate Burden from Gasoline Emissions

Beyond the overall impact of gasoline emissions on the public's health, it is also worth noting the disproportionate effect on urban and low-income communities. Higher octane, lower carbon fuels have the ability to substantially increase fuel efficiency, while substantially reducing carbon

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[93] John M. Storey *et al*., Oak Ridge National Laboratory, "Novel Characterization of GDI Engine Exhaust for Gasoline and Mid-Level Gasoline-Alcohol Blends," *SAE International Journal of Fuels and Lubricants* (2014): 7(2): pp. 571-79: https://www.eenews.net/assets/2014/10/02/document_cw_01.pdf (accessed Feb. 24, 2021).

[94] U.S. Environmental Protection Agency, "Manufacturers continue to adopt a wide array of advanced technologies," in "Highlights of the Automotive Trends Report," online fact sheet: https://www.epa.gov/automotive-trends/highlights-automotive-trends-report#Highlight5 (accessed Feb. 24, 2021).

[95] Rich Kassel *et al*., Gladstein, Neandross & Associates, "Ultrafine Particulate Matter and the Benefits of Reducing Particle Numbers in the United States," A Report to the Manufacturers of Emission Controls Association (MECA) (2013): p. 8: http://www.meca.org/resources/meca_ufp_white_paper_0713_final.pdf (accessed Feb. 24, 2021).

[96] Kwon et al., *op. cit., supra* note 65.

[97] Transport & Environment, "Gasoline particulate emissions: The next auto scandal?" (2016), p. 2: https://www.transportenvironment.org/sites/te/files/publications/2016_10_Gasoline_particulate_emissions_briefing_0.pdf, citing the European Commission's Joint Research Centre: A. Mamakos et al., "Assessment of particle number limits for petrol vehicles" (2012): https://publications.jrc.ec.europa.eu/repository/handle/JRC76849 (accessed Aug. 18, 2021).

emissions and the particulate-borne toxics plaguing these communities. The harm to these communities, particularly communities of color, is increasingly being brought to light in both published studies and mainstream media.

Indeed, EPA notes in the Proposed Rule scientific reports by the U.S. Global Change Research Program (USGCRP), the Intergovernmental Panel on Climate Change (IPCC), and the National Academies of Science, Engineering, and Medicine that have provided evidence of environmental justice concerns. Importantly, these reports have concluded that "poorer or predominantly non-White communities can be especially vulnerable to climate change impacts because they tend to have limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies, or have less access to social and information resources."[98] Further, "[s]ome communities of color, specifically populations defined jointly by ethnic/racial characteristics and geographic location, may be uniquely vulnerable to climate change health impacts in the [U.S.]"[99]

In addition to these reports highlighted in the Proposed Rule, a recent study found that Black people are exposed to higher concentrations of $PM_{2.5}$ emissions, the most significant environmental cause of death.[100] $PM_{2.5}$ is responsible for an estimated 85,000 to 200,000 excess deaths each year in the U.S. Meanwhile people of color generally are exposed more to almost every source of pollution as compared to white people. Equally concerning was an April 2021 Environmental Integrity Project report, which found that thirteen oil refineries across the country released elevated and reportable levels of benzene into predominantly minority and low-income communities in 2020.[101]

Given the direction of Executive Order 12898 to make achieving environmental justice part of each agency's mission, it's imperative that EPA do more than recognize the historical impact of GHG emissions on low-income and minority communities. By opening the door to higher

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[98] 86 *Fed. Reg.* at 43801.

[99] *Id.*

[100] Tessum et al., PM2.5 Polluters Disproportionately and Systemically Affect People of Color in the United States, Sci. Adv. 2021, *available at* https://www.science.org/doi/10.1126/sciadv.abf4491.

[101] Environmental Integrity Project, Environmental Justice and Refinery Pollution: Benzene Monitoring Around Oil Refineries Showed More Communities at Risk in 2020, April 28, 2021, *available at* https://environmentalintegrity.org/wp-content/uploads/2021/04/Benzene-report-4.28.21.pdf.

ethanol blends, such as E30, EPA can work toward its stated goal of increasing its focus on environmental justice and equity.[102] Displacing the aromatics in gasoline with higher octane, lower carbon fuel such as ethanol enables more efficient vehicles, reduces GHG emissions, and reduces the toxic pollutants in the air.

III. The EPA Must Act Now to Leverage the Climate, Public Health, and Economic Benefits of Higher Octane, Lower Carbon Fuels

A. EPA has the Statutory Authority to Promote Higher Ethanol Blends to Control the Hazardous Emissions from Transportation Fuel

In the Proposed Rule, EPA notes its authority to regulate the emission of air pollutants from all mobile sources under section 202(a) of the Clean Air Act (CAA).[103] EPA highlights the multiple factors the agency must take into consideration to revise the forthcoming GHG emission standards for light-duty vehicles, including technological feasibility, compliance cost, and lead time. EPA may also consider factors, such as the impact on the auto industry, fuel savings by consumers, oil conservation, energy security and other energy impacts, and safety.

Despite the weight given to these factors in past rulemaking, we applaud EPA for recognizing the statutory intent of section 202(a) – reducing air pollution to protect the public's health and welfare. Notably, EPA makes clear that given the statutory purpose of this section, "the Administrator finds it is appropriate to place greater weight on reducing emissions and to adopt standards that, when implemented, would result in significant reductions of light duty vehicle emissions both the near term and over the longer term."[104] *(emphasis added)*. In doing so, EPA is requiring that the Proposed Rule's primary goal should be to address GHG emissions by reducing the threat posed to our health and environment from hazardous emissions. However, the Proposed Rule fails to accomplish this goal.

To effectively improve our public health and welfare, EPA should use its authority under section 211(c)(1) of the CAA to regulate gasoline octane levels. Under the CAA, EPA can set a national

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[102] 86 *Fed. Reg.* at 43785.

[103] *Id.* at 43751.

[104] *Id.* at 43786.

minimum octane level of 98-100 RON to enable more efficient high-compression engines and reduce GHG emissions. As a cleaner, lower cost, and more fuel-efficient alternative to our fossil fuel supply, a national minimum octane level of 98-100 RON would open the door to increased ethanol blended fuels such as E30 fuel. Internal combustion engines and the fuels they use comprise a single system, requiring the availability of higher ethanol blends to enable the optimization of more fuel-efficient vehicles.

Importantly, ethanol is readily available based on our domestic supply without increased land use or competing with our food supply. Ethanol producers have the capacity to supply any needed supply for years to come. And our existing infrastructure is capable of supplying higher ethanol blends to the market without substantial investment, unlike the case with the eventual transition to electrification.

B. EPA Must Remove the Regulatory Barriers to Higher Ethanol Blends

In addition to setting a national minimum octane standard, there are other steps EPA can take to level the playing field and enable ethanol to compete in the market. Specifically, we urge the EPA to take the following actions:

- **Comply with the Mandatory Toxic Reduction Provisions in Section 202(l) of the CAA:** EPA action is required under Section 202(l) of the CAA Amendments of 1990 to control aromatic/BTEX content in order to reduce mobile source air toxics (MSAT) emissions "to the greatest degree … achievable."[105] Action on this requirement is mandatory;[106] it was enacted concurrently and was explicitly based on the same provision of Section 202(a) under which EPA has justified the Proposed Rule, based on "the magnitude and benefits of reducing emissions that endanger public health and welfare."[107] Without a minimum toxic reduction baseline enforced, refiners will find loopholes to allow them to backslide on the aromatic content in gasoline in reformulated gasoline (RFG) areas and/or be forced to dump gasoline with higher priced and higher

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[105] 42 U.S. Code, sec. 7521, "Emission standards for new motor vehicles or new motor vehicle engines," P.L. 101-549, sec. 206, enacted Nov. 15, 1990: https://www.law.cornell.edu/uscode/text/42/7521 (accessed Feb. 24, 2021).

[106] 86 *Fed. Reg.* at 43751-2.

[107] *Id.* at 43729.

volumes of aromatic-laced gasoline into non-RFG areas. The debilitating health impacts of these carcinogens has been ignored by EPA and must be addressed.

- **Correct the Agency's Interpretation of 211(f) Substantially Similar Rule:** As of January 1, 2017, E10 became the nation's certification fuel. When that happened, ethanol became an additive used in certification; therefore, it should not be controlled under section 211(f). In addition, in light of EPA not finalizing the Renewables Enhancement and Growth Support (REGS) Rule, its "sub-sim" position on ethanol has not been codified. Correcting this interpretation will reduce unnecessary regulations, time to market, and reduce MSATs. If EPA wishes to control the use of higher blends in standard (non-FFV) vehicles, the legal burden of proof is on the agency to prove that higher than 15 percent ethanol blends damage emissions control systems or exacerbate tailpipe emissions. EPA cannot do so factually.

- **Extend the 1 psi Reid Vaper Pressure (RVP) Waiver for E10 and E15 to Higher Blends:** EPA should extend the RVP waiver of ethanol blends because the RVP decreases as the level of ethanol increases, supporting the transition to higher octane fuels by opening market access to such fuels in the summer months. Overall emission reduction gains from adding ethanol to gasoline far outweigh concerns that focus only on reducing gasoline volatility, would lower MSATs and help meet the requirements of CAA Section 202(l) requirements.

- **Approve a Mid-Level Ethanol Blend Certification Fuel:** EPA should expeditiously approve the use of a mid-level ethanol certification fuel (*e.g.,* E30) to provide automakers with the added justification to design optimized, high compression vehicles that can make use of 98–100 RON gasoline. The certification of E30 fuel will help automakers cost effectively meet Corporate Average Fuel Economy (CAFE) and GHG requirements by improving engine efficiency, reducing CO_2, and reducing MSATs.

- **Update and Reform the Agency's MOVES2014 Model:** EPA should suspend the use of the MOVES2014 model because the research literature shows that the model relied on an analysis that unfairly and inaccurately attributes higher emissions to ethanol rather than added aromatics. The MOVES model analysis has been proven to be contrary to what happens in real-world retail gasoline/ethanol blending, which is "splash blending." By updating the model, states currently using the MOVES2014 Model for State Implementation Plan (SIP) compliance will no longer be deterred from using higher blends of ethanol to reduce MSATs and meet ozone attainment goals that restrict the development of new business and roads.

- **Update the 2007 MSAT Cost-Benefit Analysis (CBA):** The assumptions used in EPA's 2007 MSAT rule (*e.g.,* $19/barrel crude oil, $0.85 gasoline, and a 2:1 ethanol octane replacement value for toluene/BTEX/aromatics) inaccurately create the impression that replacing toxic aromatic hydrocarbons with higher octane, lower cost ethanol would not be cost effective. An updated CBA will show that ethanol provides positive MSAT reduction at a lower cost.

- **Update and Reform the Agency's Life Cycle Assessment (LCA):** Updating EPA's outdated 2010 LCA of ethanol's carbon emissions would align the agency's data with the continually updated and widely accepted Argonne National Laboratory GREET model, which shows double the GHG benefit identified by EPA. EPA's LCA model also should recognize the ability of high-yield corn to restore soil organic matter, which transforms corn acres into substantial carbon sinks, and therefore adjust its carbon intensity (CI) factors for corn ethanol downward. This adjustment would accelerate the penetration of higher ethanol blends in states and countries that do or will adopt high-octane low-carbon fuel standards. This will support EPA's responsibility to successfully implement the Renewable Fuel Standard (RFS) and help automobile manufacturers meet the requirements of CAFE and GHG standards.

- **Reinstate Flexible-Fuel Vehicle (FFV) Type Credits:** EPA should provide the regulatory roadmap and supporting data to help stakeholders interested in reinstating meaningful vehicle credits to incentivize automakers to design engines to utilize high-octane low-carbon fuels (*e.g.,* E30). Similar to the transition to unleaded gasoline, this regulatory action would send a clear investment signal to automakers that have expressed interest in being able to pro-rate FFV-type credits (previously established and based on E85 ethanol volumes) and recalculate them for the use of high octane, low carbon midlevel ethanol blends (*e.g.,* E30). These credits will help justify and offset the cost of investing in retooling and testing to meet CAFE and GHG requirements and will also leverage the DOE's investment into E85 refueling infrastructure by increasing the renewable/alternative fuel throughput to meet the objectives of that program.

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