POET
900 7th St. NW, Suite 820
Washington, D.C. 20001
Ph: (605) 965-2200
poet.com

March 4, 2022

California Air Resources Board
1001 I Street
Sacramento, CA 95814
Submitted via email

RE: POET COMMENTS ON JANUARY 31, 2022 CARB DRAFT STATE STRATEGY FOR THE STATE IMPLEMENTATION PLAN

Dear Ms. Chang:

POET appreciates the opportunity to provide comments on the January 31, 2022 Draft State Strategy for the State Implementation Plan (Draft SIP Strategy or Strategy) to support attainment of the federal 70 parts per billion (ppb) 8-hour ozone standard across California.

As detailed in the Draft SIP Strategy, "any and all potential reductions must be pursued"[1] through the use of "all mechanisms available"[2] to enable California to achieve the 70 ppb standard. The Strategy additionally underscores the critical need to reduce emissions of multiple pollutants, including NOx and volatile organic compounds (VOCs), as reductions of these ozone precursors are necessary to the achievement of the 70 ppb standard and other state and federal air quality standards. Further, the Strategy highlights that reducing ozone and ozone precursor levels also provides the opportunity to reduce quantities of other significant pollutants, including fine particulate matter (PM2.5) and greenhouse gases (GHG). It is critical that CARB make the most out of this SIP revision opportunity to obtain the greatest societal benefits from the reduction of various air pollutants.

California's air quality and climate challenges require fast and deep reductions from light, medium, and heavy-duty vehicles. As described in the Draft SIP Strategy, mobile sources account for about two-thirds of NOx emissions statewide. Significant emission reductions from this sector will be necessary to meet the 70ppb ozone standard and to enable necessary progress to reduce the impacts of air pollution in California's disadvantaged communities. Renewable, clean biofuels can play a key role in supporting California's efforts. Specifically, higher bioethanol blends – including E15 – can displace fossil fuel combustion in California's vehicle fleet and deliver critical air pollution, climate change, and public health benefits.

About POET

POET is deeply committed to reducing emissions from the transportation sector and developing cleaner, affordable alternatives to fossil fuels in California and across the United States. POET is the world's largest biofuels producer, currently operating 33 bioprocessing locations capable of producing three billion gallons of starch and cellulosic bioethanol. POET is continually innovating to develop the cleanest, most sustainable biofuels. Renewable clean-burning biofuels like those produced by POET cut carbon emissions by an average

[1] California Air Resources Board, Draft 2022 State Strategy for State Implementation Plan (Draft SIP Strategy), page 7, July 21, 2022.
[2] Id. at 1.

of 46% compared to gasoline and can deliver key emission reductions of harmful air pollutants, including ozone, PM, VOCs, and NOx.

Specific Comments on the CARB Draft State Strategy for the State Implementation Plan

POET fully supports California's efforts to reduce ozone and other pollutants through the SIP revision process. Although the strategy includes many ways to move toward this end, one key method is missing – the increased use of higher bioethanol blends in the state. Use of 10% bioethanol blends (E10) is already ubiquitous throughout California, and California is a national leader in promoting E85. Nonetheless, California is shortchanging the potential emissions benefits of bioethanol blends because it is one of the few states that does not currently allow for the sale of E15.[3] As discussed in greater detail below, use of E15 and higher blends reduces NOx, VOCs, and CO (and thus ozone) as well as PM2.5 and greenhouse gases. The state could be doing more to promote the replacement of petroleum by promoting even higher levels of bioethanol, starting by approving sales of E15 across the state.

CARB should proceed as expeditiously as possible to update California fuel specifications to allow for the sale of E15 blends in the state and evaluate ALL strategies that can be used to maximize the air quality benefits that higher bioethanol blends can deliver for California.

CARB is currently evaluating the benefits of modifying California fuel specifications to allow for the sale of E15 blends in the state. POET is encouraged by the focus on this important step. However, given the imperative of achieving "any and all potential reductions,"[4] we encourage CARB to move as expeditiously as possible.

Allowing for the sale of E15 blends would achieve immediate air pollution and climate benefits and is fully in accord with CARB's "multi-pollutant planning effort that identifies the pathways forward to achieve the State's many air quality, climate, and community risk reduction goals."[5] Applied across the California light and medium-duty fleets, the emission benefits of displacing fossil fuels with clean-burning bioethanol are significant. As detailed below, increased bioethanol blends deliver critically needed air quality and public health benefits in furtherance of California's efforts to meet federally required air quality standards. In addition, the benefits of increased bioethanol blends extend to California's climate efforts, as shifting from E10 to E15 in California would annually cut 1.8 million metric tons of GHG emissions from the state's transportation sector – the equivalent of removing 411,000 cars off the road each year.[6]

Renewable fuel blends, like E15, also provide meaningful cost savings to California drivers. These benefits are particularly important to the millions of low-income Californians that live in non-attainment areas. As described in the Draft SIP Strategy, "more than 21 million out of over 39 million Californians live in areas that exceed the federal ozone standards; within these areas there are many low-income and disadvantaged communities that are exposed not only to ozone, but also particulate and toxics."[7] As the state transitions toward electrification of the vehicle fleet, it is critical to ensure that the millions of Californians that live in highly impacted, low-income and disadvantaged communities have affordable access to clean transportation options as well.

In light of the acknowledged challenges that the state will face in meeting SIP requirements, we urge CARB to thoroughly explore ALL strategies that have the potential to maximize air quality and public health benefits for Californians. In addition to moving swiftly to update fuel specifications to allow for E15 in California, CARB

---

[3] California, Montana, the greater Phoenix metro area, are the only geographic areas that have not approved the sale of E15.
[4] Draft SIP Strategy at 7.
[5] Id. at 2.
[6] GHG Benefits of 15% Ethanol Use in the United States. Air Improvement Resource, Inc. November 30, 2020.
[7] Draft SIP Strategy at 9.

should be actively evaluating options, tools and approaches to displace as much fossil fuel use as possible in the state vehicle fleet, including the role that flex fuel vehicles (FFVs) that perform on significantly higher bioethanol blends can play.

Higher bioethanol blends provide immediate air quality and public health benefits in California

A recent analysis from leading national experts demonstrates air quality and public health benefits from higher bioethanol blends, particularly in disadvantaged communities. The study is the first large-scale analysis of data from light-duty vehicle emissions that examines real-world impacts of bioethanol-blended fuels on regulated air pollutant emissions, including PM, NOx, carbon monoxide (CO), and total hydrocarbons (THC).

Specifically, the analysis demonstrates bioethanol-associated reductions in emissions of primary PM, NOx, CO, and THC.[8] Key findings of the study include:

- PM emissions decreased with increasing bioethanol content under cold-start conditions. Primary PM emissions decreased by 15-19% on average for each 10% increase in bioethanol content under cold-start conditions. Cold start PM emissions have consistently been shown to account for a substantial portion of all direct tailpipe PM emissions from motor vehicles.
- NOx, CO and THC emissions were significantly lower for higher bioethanol fuels for PFI engines under cold-start conditions. THCs include VOCs, meaning that all three of these ozone precursors decreased with higher bioethanol blends.
- Lower PM emissions result in lower ambient PM concentrations and exposures, which, in turn, are causally associated with lower risks of total mortality and cardiovascular effects.
- Higher blends of bioethanol fuels may be particularly beneficial for disadvantaged communities with high traffic density and congestion and are thus exposed to disproportionately higher concentrations of PM emitted from motor vehicle tailpipes. Vehicle trips within these communities tend to be short in duration and distance, with approximately 50% of all trips in dense urban communities under three miles long. As a result, a large proportion of these vehicle trips occur under cold start conditions when PM emissions are highest.

The air quality benefits demonstrated from these results can be key contributors to CARB's efforts to achieve federal and state air quality standards.

Conclusion

Higher biofuel blends, including E15, can play a key role in California's efforts to meet critical air quality standards, protect public health and address climate change in ways that give all Californians access to cleaner and more affordable transportation options. The Draft SIP Strategy is an important opportunity for CARB to include all strategies that will support these efforts.

We thank CARB for this opportunity to comment and look forward to working with CARB staff to make the 2022 State Implementation Plan a success.

Sincerely,

Michael Walz
Vice President of Public Affairs
POET, LLC

---

[8] Tufts University Department of Civil and Environmental Engineering, Air Quality and Public Health Comments to RFS, February 3, 2022.

GHG Benefits of 15% Ethanol (E15) Use in the United States

Air Improvement Resource, Inc.
November 30, 2020

GHG Benefits of 15% Ethanol (E15) Use in the United States
AIR, Inc.
November 30, 2020

Introduction

The EPA has allowed E15 blends to be used in 2001 and later passenger cars, passenger trucks, and light commercial trucks. Ethanol generates less greenhouse gases (GHG) on a lifecycle basis than gasoline. The purpose of this report is to estimate nationwide GHG benefits of an expansion of ethanol use from E10 (i.e., 10% volume ethanol) to E15.

Based on our analysis, we estimate that if the United States transitioned from E10 to E15 in the nation for 2001 and later model year vehicles, GHG emissions would be lower by 17.62 million tons per year, which is the equivalent of removing approximately 3.85 million vehicles from the road.

Method

The method involved a 3-step process:

1. Using MOVES2014b, estimate the energy use in mmBTU in 2001 and later vehicles in 2020 for the sum of cars, light passenger trucks, and light commercial trucks in the U.S.
2. Estimate the GHG emissions difference in lifecycle emissions between E10 and E15 in g/mmBTU.
3. Multiply the energy use in Step 1 by the difference in lifecycle emissions in Step 2.

Step 1 – Energy Use

Table 1 shows the national energy use by vehicle type for calendar year 2020. We obtained these estimates by running the EPA MOVES2014b model.

Table 1. National Energy Use Using MOVES2014b for 2001 and Later Vehicles

Source	Joules	BTU	mmBTU
Passenger Car	5.86E+18	5.55E+15	5.55E+09
Passenger Truck	4.87E+18	4.61E+15	4.61E+09
Light Commercial Truck	1.23E+18	1.16E+15	1.16E+09
Total	1.20E+19	1.13E+16	1.13E+10

Step 2 – Lifecycle Emissions Difference Between E10 and E15

Table 2 shows lifecycle emission estimate of gasoline and ethanol. The gasoline value is from EPA's Renewable Fuel Standard (RFS).[1] The ethanol value is from a recent U.S. Department Agriculture Report.[2] The lifecycle emissions for E10 and E15 are obtained by weighting the values for gasoline and ethanol by the energy fraction of gasoline and ethanol in E10 and E15. The energy fraction of gasoline in E10 is 0.930, and in E15 is 0.893.[3] The emissions benefit of E15 compared to E10 is 1,411 g/mmBTU.

Table 2. Lifecycle GHG Emissions of Ethanol, Gasoline, E10 and E15	
Fuel	Lifecycle GHG Emissions (g GHG/mmBTU)
Gasoline	98,000
Ethanol	59,776
E10	95,314
E15	93,903
Difference (E10-E15)	1,411

Step 3 – Estimate Lifecycle GHG Reductions for the United States for E15

Combining the information from Tables 1 and 2, the lifecycle benefit of GHG in 2020 in the U.S. is 17.621 million tons.

We also estimated the equivalent number of vehicles that would be removed from the road that would achieve the same benefit as E15. MOVES2014b indicates that there are 208.13 million 2001 and later cars, passenger trucks, and light commercial trucks on the road in the United States in 2020, and that these vehicles emit 952.8 million tons of GHG in 2020. Thus, on average, each vehicle emits 4.58 tons per year of GHG. Dividing the benefit of 17.621 million tons by 4.58 tons per year gives a result of 3.85 million vehicles.

Table 3 shows state-by-state emission reductions and equivalent vehicles removed. These values were obtained by running MOVES2014b in by-state mode.

---

[1] *Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program*, US EPA, March 26, 2010, page 14788 (FR Vol 75, No. 58).

[2] *A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol*, by ICF for USDA, September 15, 2018, www.usda.gov/sites/default/files/documents/LCA_of_Corn_Ethanol_2018_Report.pdf

[3] According to the Argonne GREET model, gasoline has an energy density of 112,194 BTU/gal and ethanol a value of 76,330 BTU/gal. Thus, E10 has an energy density of 108,608 BTU/gal and E15 has an energy density of 106,814 BTU/gal. Gasoline's energy fraction in E10 is therefore 0.930 (0.9*112,194/108,608), and in E15 is 0.893 (0.85*112,194/106,814).

Table 3. State-by-State GHG Reductions and Vehicles Removed						
State	GHG Reduced (1000 tons/yr)	Vehicles Removed (1000s)		State	GHG Reduced (1000 tons/yr)	Vehicles Removed (1000s)
AK	29.0	6.3		NC	623.1	136.1
AL	377.5	82.5		ND	52.0	11.4
AR	187.0	40.8		NE	109.3	23.9
AZ	363.4	79.4		NH	75.7	16.5
CA	1,882.1	411.1		NJ	410.0	89.6
CO	274.5	60.0		NM	146.3	32.0
CT	177.6	38.8		NV	148.4	32.4
DC	25.2	5.5		NY	773.9	169.1
DE	54.0	11.8		OH	746.0	163.0
FL	1,206.9	263.6		OK	275.1	60.1
GA	621.5	135.8		OR	190.5	41.6
HI	62.5	13.6		PA	591.5	129.2
IA	180.2	39.4		PR	121.6	26.6
ID	89.5	19.5		RI	49.6	10.8
IL	634.5	138.6		SC	280.8	61.3
IN	454.9	99.4		SD	50.7	11.1
KS	173.0	37.8		TN	413.2	90.3
KY	279.8	61.1		TX	1,429.3	312.2
LA	273.7	59.8		UT	159.7	34.9
MA	317.7	69.4		VA	487.7	106.5
MD	328.0	71.7		VI	2.4	0.5
ME	81.1	17.7		VT	40.5	8.8
MI	580.0	126.7		WA	334.7	73.1
MN	332.3	72.6		WI	331.3	72.4
MO	349.9	76.4		WV	100.7	22.0
MS	222.6	48.6		WY	52.4	11.4
MT	66.1	14.4		Total	17,621.0	3,849.1

February 3, 2022

Docket Number: EPA-HQ-OAR-2021-0324

Comments of Drs. Fatemeh Kazemiparkouhi,[1] David MacIntosh,[2] Helen Suh[3]
[1] Environmental Health & Engineering, Inc., Newton, MA
[2] Environmental Health & Engineering, Inc., Newton, MA and the Harvard T.H. Chan School of Public Health, Boston, MA
[3] Tufts University, Medford, MA

We are writing to comment on issues raised by the proposed RFS annual rule, the Draft Regulatory Impact Analysis (December 2021; EPA-420-D-21-002), and the supporting Health Effects Docket Memo (September 21, 2021; EPA-HQ-OAR-2021-0324-0124), specifically regarding the impact of ethanol-blended fuels on air quality and public health. We provide evidence of the air quality and public health benefits provided by higher ethanol blends, as shown in our recently published study[1] by Kazemiparkouhi et al. (2021), which characterized emissions from light duty vehicles for market-based fuels. Findings from our study demonstrate ethanol-associated reductions in emissions of primary particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO), and to a lesser extent total hydrocarbons (THC). Our results provide further evidence of the potential for ethanol-blended fuels to improve air quality and public health, particularly for environmental justice communities. Below we present RFS-pertinent findings from Kazemiparkouhi et al. (2021), followed by their implications for air quality, health, and environmental justice.

Summary of Kazemiparkouhi et al. (2021)

Our paper is the first large-scale analysis of data from light-duty vehicle emissions studies to examine real-world impacts of ethanol-blended fuels on regulated air pollutant emissions, including PM, NOx, CO, and THC. To do so, we extracted data from a comprehensive set of emissions and market fuel studies conducted in the US. Using these data, we (1) estimated composition of market fuels for different ethanol volumes and (2) developed regression models to estimate the impact of changes in ethanol volumes in market fuels on air pollutant emissions for different engine types and operating conditions. Importantly, our models estimated these changes accounting for not only ethanol volume fraction, but also aromatics volume fraction, 90% volume distillation temperature (T90) and Reid Vapor Pressure (RVP). Further, they did so

[1] https://doi.org/10.1016/j.scitotenv.2021.151426

under both cold start and hot stabilized running conditions and for gasoline-direct injection engines (GDI) and port-fuel injection (PFI) engine types. Key highlights from our paper include:

- ***Aromatic levels in market fuels decreased by approximately 7% by volume for each 10% by volume increase in ethanol content*** (Table 1)**.** Our findings of lower aromatic content with increasing ethanol content is consistent with market fuel studies by EPA and others (Eastern Research Group, 2017, Eastern Research Group, 2020, US EPA, 2017). As discussed in EPA's Fuel Trends Report, for example, ethanol volume in market fuels increased by approximately 9.4% between 2006 and 2016, while aromatics over the same time period were found to drop by 5.7% (US EPA, 2017).

  We note that our estimated market fuel properties differ from those used in the recent US EPA Anti-Backsliding Study (ABS), which examined the impacts of changes in vehicle and engine emissions from ethanol-blended fuels on air quality (US EPA, 2020). Contrary to our study, ABS was based on hypothetical fuels that were intended to satisfy experimental considerations rather than mimic real-world fuels. It did not consider published fuel trends; rather, the ABS used inaccurate fuel property adjustment factors in its modeling, reducing aromatics by only 2% (Table 5.3 of ABS 2020), substantially lower than the reductions found in our paper and in fuel survey data (Kazemiparkouhi et al., 2021, US EPA, 2017). As a result, the ABS's findings and their extension to public health impacts are not generalizable to real world conditions.

Table 1. Estimated market fuel properties

Fuel ID	EtOH Vol (%)	T50 (^oF)	T90 (^oF)	Aromatics Vol (%)	AKI	RVP (psi)
E0	0	219	325	30	87	8.6
E10	10	192	320	22	87	8.6
E15	15	162	316	19	87	8.6
E20	20	165	314	15	87	8.6
E30	30	167	310	8	87	8.6

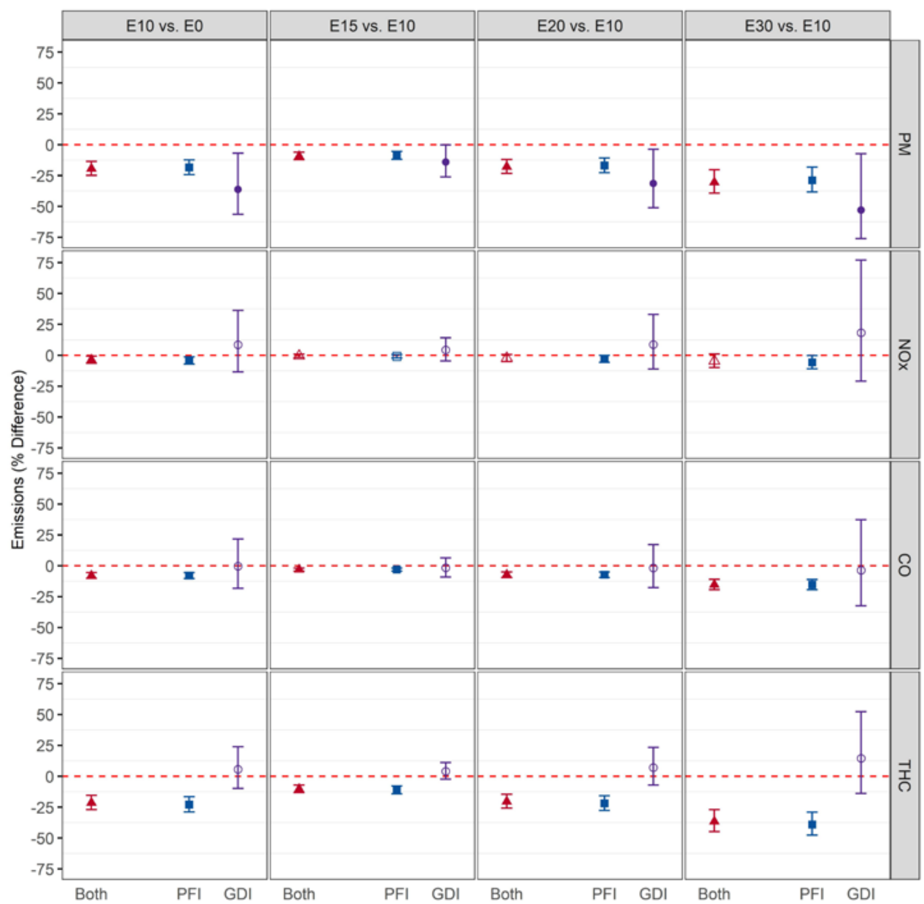
Abbreviations: EtOH = ethanol volume; T50 = 50% volume distillation temperature; T90 = 90% volume distillation temperature; Aromatics=aromatic volume; AKI = Anti-knock Index; RVP = Reid Vapor Pressure.

- ***PM emissions decreased with increasing ethanol content under cold-start conditions.*** Primary PM emissions decreased by 15-19% on average for each 10% increase in ethanol content under cold-start conditions (Figure 1). While statistically significant for both engine types, PM emission reductions were larger for GDI as compared to PFI engines, with 53% and 29% lower PM emissions, respectively, when these engines burned E30 as compared to E10. In contrast, ethanol content in market fuels had no association with PM emissions during hot-running conditions.

  Importantly, our findings are consistent with recent studies that examined the effect of ethanol blending on light duty vehicle PM emissions. Karavalakis et al. (2014), (2015), Yang et al. (2019a), (2019b), Schuchmann and Crawford (2019), for example, assessed the influence of different mid-level ethanol blends – with proper adjustment for aromatics – on the PM emissions from GDI engines and Jimenez and Buckingham (2014) from PFI engines. As in our study, which also adjusted for aromatics, each of these recent studies found higher ethanol blends to emit lower PM as compared to lower or zero ethanol fuels.

Together with these previous studies, our findings support the ability of ethanol-blended fuels to offer important PM emission reduction opportunities. **Cold start PM emissions have consistently been shown to account for a substantial portion of all direct tailpipe PM emissions from motor vehicles**, with data from the EPAct study estimating this portion to equal 42% (Darlington et al., 2016, US EPA, 2013). The cold start contribution to total PM vehicle emissions, together with our findings of emission reductions during cold starts, suggest that a **10% increase in ethanol fuel content from E10 to E20 would reduce total tailpipe PM emissions from motor vehicles by 6-8%.**

Figure 1. Change (%) in cold-start emissions for comparisons of different ethanol-content market fuels[a]



[a] Emissions were predicted from regression models that included ethanol and aromatics volume fraction, T90, and RVP as independent variables

- **NOx, CO and THC emissions were significantly lower for higher ethanol fuels for PFI engines under cold-start conditions**, but showed no association for GDI engines (Figure 1). CO and THC emissions also decreased under hot running conditions for PFI and for CO also for GDI engines (results not shown). [Note that NOx emissions for both PFI and GDI engines were statistically similar for comparisons of all ethanol fuels, as were THC emissions for GDI engines.] These findings add to the scientific evidence demonstrating emission reduction benefits of ethanol fuels for PM and other key motor vehicle-related gaseous pollutants.

Implications for Public Health and Environmental Justice Communities

The estimated reductions in air pollutant emissions, particularly of PM and NOx, indicate that increasing ethanol content offers opportunities to improve air quality and public health. As has been shown in numerous studies, lower PM emissions result in lower ambient PM concentrations and exposures (Kheirbek et al., 2016, Pan et al., 2019), which, in turn, are causally associated with lower risks of total mortality and cardiovascular effects (Laden et al., 2006, Pun et al., 2017, US EPA, 2019, Wang et al., 2020).

The above benefits to air quality and public health associated with higher ethanol fuels may be particularly great for environmental justice (EJ) communities. EJ communities are predominantly located in urban neighborhoods with high traffic density and congestion and are thus exposed to disproportionately higher concentrations of PM emitted from motor vehicle tailpipes (Bell and Ebisu, 2012, Clark et al., 2014, Tian et al., 2013). Further, vehicle trips within urban EJ communities tend to be short in duration and distance, with approximately 50% of all trips in dense urban communities under three miles long (de Nazelle et al., 2010, Reiter and Kockelman, 2016, US DOT, 2010). As a result, a large proportion of urban vehicle trips occur under cold start conditions (de Nazelle et al., 2010), when PM emissions are highest. Given the evidence that ethanol-blended fuels substantially reduce PM, NOx, CO, and THC emissions during cold-start conditions, it follows that ethanol-blended fuels may represent an effective method to reduce PM health risks for EJ communities.

Summary

Findings from Kazemiparkouhi et al. (2021) provide important, new evidence of ethanol-related reductions in vehicular emissions of PM, NOx, CO, and THC based on real-world fuels and cold-start conditions. Given the substantial magnitude of these reductions and their potential to improve air quality and through this public health, our findings warrant careful consideration. Policies that encourage higher concentrations of ethanol in gasoline would provide this additional benefit. These policies are especially needed to protect the health of EJ communities, who experience higher exposures to motor vehicle pollution, likely including emissions from cold starts in particular, and are at greatest risk from their effects.

References

BELL, M. L. & EBISU, K. 2012. Environmental inequality in exposures to airborne particulate matter components in the United States. *Environmental health perspectives,* 120**,** 1699-1704.

CLARK, L. P., MILLET, D. B. & MARSHALL, J. D. 2014. National patterns in environmental injustice and inequality: outdoor NO2 air pollution in the United States. *PLoS One,* 9**,** e94431.

DARLINGTON, T. L., KAHLBAUM, D., VAN HULZEN, S. & FUREY, R. L. 2016. Analysis of EPAct Emission Data Using T70 as an Additional Predictor of PM Emissions from Tier 2 Gasoline Vehicles. *SAE Technical Paper*.

DE NAZELLE, A., MORTON, B. J., JERRETT, M. & CRAWFORD-BROWN, D. 2010. Short trips: An opportunity for reducing mobile-source emissions? *Transportation Research Part D: Transport and Environment,* 15**,** 451-457.

EASTERN RESEARCH GROUP 2017. Summer Fuel Field Study (prepared for Texas Commission on Environmental Quality by Eastern Research Group, Inc.).

EASTERN RESEARCH GROUP 2020. Summer Field Study (prepared for Texas Commission on Environmental Quality by Eastern Research Group, Inc.).

JIMENEZ, E. & BUCKINGHAM, J. P. 2014. Exhaust Emissions of Average Fuel Composition. Alpharetta, GA.

KARAVALAKIS, G., SHORT, D., VU, D., RUSSELL, R. L., ASA-AWUKU, A., JUNG, H., JOHNSON, K. C. & DURBIN, T. D. 2015. The impact of ethanol and iso-butanol blends on gaseous and particulate emissions from two passenger cars equipped with spray-guided and wall-guided direct injection SI (spark ignition) engines. *Energy,* 82**,** 168-179.

KARAVALAKIS, G., SHORT, D., VU, D., VILLELA, M., ASA-AWUKU, A. & DURBIN, T. D. 2014. Evaluating the regulated emissions, air toxics, ultrafine particles, and black carbon from SI-PFI and SI-DI vehicles operating on different ethanol and iso-butanol blends. *Fuel,* 128**,** 410-421.

KAZEMIPARKOUHI, F., ALARCON FALCONI, T. M., MACINTOSH, D. L. & CLARK, N. 2021. Comprehensive US database and model for ethanol blend effects on regulated tailpipe emissions. *Sci Total Environ***,** 151426.

KHEIRBEK, I., HANEY, J., DOUGLAS, S., ITO, K. & MATTE, T. 2016. The contribution of motor vehicle emissions to ambient fine particulate matter public health impacts in New York City: a health burden assessment. *Environmental Health,* 15**,** 89.

LADEN, F., SCHWARTZ, J., SPEIZER, F. E. & DOCKERY, D. W. 2006. Reduction in fine particulate air pollution and mortality: Extended follow-up of the Harvard Six Cities study. *American journal of respiratory and critical care medicine,* 173**,** 667-672.

PAN, S., ROY, A., CHOI, Y., ESLAMI, E., THOMAS, S., JIANG, X. & GAO, H. O. 2019. Potential impacts of electric vehicles on air quality and health endpoints in the Greater Houston Area in 2040. *Atmospheric Environment,* 207**,** 38-51.

PUN, V. C., KAZEMIPARKOUHI, F., MANJOURIDES, J. & SUH, H. H. 2017. Long-Term PM2.5 Exposure and Respiratory, Cancer, and Cardiovascular Mortality in Older US Adults. *American Journal of Epidemiology,* 186**,** 961-969.

REITER, M. S. & KOCKELMAN, K. M. 2016. The problem of cold starts: A closer look at mobile source emissions levels. *Transportation Research Part D: Transport and Environment,* 43**,** 123-132.

SCHUCHMANN, B. & CRAWFORD, R. 2019. Alternative Oxygenate Effects on Emissions. Alpharetta, GA (United States).
TIAN, N., XUE, J. & BARZYK, T. M. 2013. Evaluating socioeconomic and racial differences in traffic-related metrics in the United States using a GIS approach. *J Expo Sci Environ Epidemiol*, 23**,** 215-22.
US DOT 2010. National Transportation Statistics. Research and Innovative Technology Administration: Bureau of Transportation Statistics.
US EPA 2013. Assessing the Effect of Five Gasoline Properties on Exhaust Emissions from Light-Duty Vehicles Certified to Tier 2 Standards: Analysis of Data from EPAct Phase 3 (EPAct/V2/E-89): Final Report. EPA-420-R-13-002 ed.: Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency.
US EPA 2017. Fuel Trends Report: Gasoline 2006-2016.
US EPA 2019. Integrated Science Assessment for Particulate Matter. Center for Public Health and Environmental Assessment.
US EPA 2020. Clean Air Act Section 211(v)(1) Anti-backsliding Study. Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency.
WANG, B., EUM, K. D., KAZEMIPARKOUHI, F., LI, C., MANJOURIDES, J., PAVLU, V. & SUH, H. 2020. The impact of long-term PM2.5 exposure on specific causes of death: exposure-response curves and effect modification among 53 million U.S. Medicare beneficiaries. *Environ Health*, 19**,** 20.
YANG, J., ROTH, P., DURBIN, T. D., JOHNSON, K. C., ASA-AWUKU, A., COCKER, D. R. & KARAVALAKIS, G. 2019a. Investigation of the Effect of Mid- And High-Level Ethanol Blends on the Particulate and the Mobile Source Air Toxic Emissions from a Gasoline Direct Injection Flex Fuel Vehicle. *Energy & Fuels*, 33**,** 429-440.
YANG, J., ROTH, P., ZHU, H., DURBIN, T. D. & KARAVALAKIS, G. 2019b. Impacts of gasoline aromatic and ethanol levels on the emissions from GDI vehicles: Part 2. Influence on particulate matter, black carbon, and nanoparticle emissions. *Fuel*, 252**,** 812-820.