POET

HEADQUARTERS
[redacted]
Sioux Falls, SD 57104
[redacted]
poet.com

Draft Scoping Plan Comments
NYSERDA
17 Columbia Circle
Albany, NY 12203-6399

July 1, 2022

Dear NYSERDA Official:

POET, LLC is pleased to submit the attached comments on the New York State Climate Action Council Draft Scoping Plan. If you have any questions, please contact me at [redacted] or [redacted]

Sincerely,

Matthew Haynie
Senior Regulatory Counsel
POET, LLC

POET, LLC's Comments on the New York Climate Action Council's Draft Scoping Plan

I. Executive Summary

POET, LLC ("POET") commends the thoughtful and diligent efforts of the Climate Action Council ("CAC" or "Council") in preparing the Draft Scoping Plan ("DSP"),[1] which sets forth a comprehensive, sector-by-sector roadmap for New York State to achieve its ambitious decarbonization goals. POET appreciates the opportunity to contribute to this effort and work with stakeholders to assist New York in its transition to a carbon-free economy.

We submit these comments to explain the crucial role that biofuels such as bioethanol can play in decarbonizing the State's transportation sector, and how policy support for biofuels would complement the DSP's core transportation recommendations, including accelerating electrification and reducing vehicle miles traveled ("VMT").

Even under the most aggressive electrification scenarios, New York will have a significant number of liquid-fueled vehicles on the road for the next 10 to 20 years. Increasing the use of gasoline with higher biofuel blends could significantly cut greenhouse gas emissions and reduce local air pollution from the liquid-fueled fleet. Presently, New York vehicles predominantly run on gasoline that is 10% ethanol (*i.e.*, "E10"). Increasing that blend to 15% ("E15") (which has a lower carbon intensity than both non-ethanol gasoline ("E0") and E10) in a phased manner would reduce emissions across the State by 10.8 to 23.9 million metric tons of carbon-dioxide equivalent ("MMTCO_2e") through 2050 depending on the DSP scenario and pace of electrification.[2] Far from competing with electrification efforts or support for public transit or bicycle infrastructure, increasing the use of biofuels would fill a distinct policy gap in the DSP: how to reduce emissions associated with liquid fueled-vehicles on the road. What's more, POET's proposed policies would save drivers money, would not require significant buildout of new infrastructure, and would not need a dedicated taxpayer or ratepayer subsidy.

Specifically, we propose that New York should consider incorporating the following policies into the Final Scoping Plan:

- Incentivize and/or facilitate the use of E15 (gasoline blends that are 15% bioethanol) which would reduce emissions over both pure gasoline and E10, the predominant gasoline-ethanol blend currently on the market;[3]

- Develop a properly structured Low Carbon Fuel Standard or Clean Fuel Standard as recommended in the DSP,[4] which would cost-efficiently incentivize the adoption of both zero-emission and lower carbon intensity fuels; and

[1] New York State Climate Action Council Draft Scoping Plan (Dec. 30, 2021) ("**DSP**").
[2] Appendix A: Edgeworth Economics, *Evaluation of the Potential Economic and Carbon-Emission Benefits Associated with the Conversion of E10 to E15 in New York*, at 11-12 ("**Edgeworth Economics**").
[3] U.S. Dep't of Agriculture, *Assessing Future Market Opportunities and Challenges for E15 and Higher Ethanol Blends* (May 2022), at 6 ("Of the gasoline sold in the United States, approximately 95 to 98 percent is sold with concentrations of E10").
[4] DSP at 118 (Recommendation T12).

- Provide support for Flex Fueled Vehicles to leverage the advantages of increased biofuel availability

To the extent there is any doubt as to the benefits of biofuels or the feasibility of the above policies, we encourage the Council, in consultation with the Department of Environmental Conservation ("DEC"), the New York State Energy Research and Development Authority ("NYSERDA") and other relevant State entities, to study and report on how the New York could implement these policies.

II. Background on POET

POET's vision is to create a world in sync with nature. As the world's largest producer of biofuels and a global leader in sustainable bioproducts, POET creates plant-based alternatives to fossil fuels that utilize the power of agriculture and cultivate opportunities for America's farm families. Founded in 1987 and headquartered in Sioux Falls, South Dakota, POET operates 33 bioprocessing facilities across eight states and employs more than 2,200 team members.

POET supports all technologies that replace petroleum including the policies set forth in the DSP. With a suite of bioproducts including Dakota Gold and NexPro feed, Voilà corn oil, purified alcohol, renewable CO2 and JIVE asphalt rejuvenator, POET is committed to innovation and advancing solutions to some of the world's most pressing challenges. POET holds more than 80 patents and continues to break new ground in biotechnology, yielding ever-cleaner and more efficient renewable energy. In 2021, POET released its inaugural Sustainability Report pledging carbon neutrality by 2050.[5]

III. CLCPA and the Council's Draft Scoping Plan

Enacted in 2019, the Climate Leadership and Community Protection Act ("CLCPA") mandates that New York State achieve an economy-wide 40% reduction in emissions below 1990 levels by 2030 and at least an 85% reduction in emissions by 2050.[6] The CLCPA created the CAC, an entity that is charged with preparing and approving a Scoping Plan that sets forth pathways for the State to reach the CLCPA's emission reduction goals and informs the State energy planning board's adoption of an updated State Energy Plan in accordance with Energy Law § 6-104.[7] In compliance with the CLCPA's mandated timeline, the CAC released its DSP on December 30, 2021, which will be subject to public comments up to July 1, 2022.[8]

The DSP found that the transportation sector is the second largest source of carbon emissions in New York State after buildings. Transportation was responsible for "approximately 28% of the State's emissions in 2019, which includes on-road transportation (59%), non-road such as aviation (12%), emissions from imported fuels (26%), and HFCs used in vehicle air-conditioning and refrigeration (3%)."[9] The DSP further noted that the transportation sector's

---

[5] POET, *Sun, Soil & Seed: Cultivating the Road to Zero-Carbon Biofuels & Bioproducts (Sustainability Report)* (Sept. 2021), https://poet.com/resources/documents/POET-sustainability-report.pdf.
[6] *See* CLCPA, 2019 N.Y. Sess. Laws Ch. 106, § 2 (codifying Environmental Conservation Law § 75-0107).
[7] *See* CLCPA, 2019 N.Y. Sess. Laws Ch. 106, § 2 (codifying Environmental Conservation Law § 75-0103).
[8] DSP at 95.
[9] *Id.*

emissions were about 16% higher than they were in 1990,[10] and that it remained "largely dependent on petroleum-based fuels such as gasoline, diesel, and jet fuel."[11]

To improve upon this baseline, the DSP proposes a series of measures to decarbonize the transportation sector under four main themes: (i) transitioning to zero-emission vehicles ("ZEVs") and equipment, (ii) enhancing public transportation and mobility alternatives, (iii) smart growth and mobility-oriented development, and (iv) market-based solutions and financing.[12]

Whereas only 1.5% of New York's over 9 million registered light-duty vehicles ("LDVs") were ZEVs as of November 2021,[13] the DSP's recommended policies are "expected to result in as many as three million ZEVs (about 30% of LDVs and 10% of medium- and heavy-duty ("MHD") vehicles]) on the road by 2030."[14] "By 2030 nearly 100% of LDV sales and 40% or more of MHD vehicle sales must be ZEVs and a substantial portion of personal transportation in urbanized areas would be required to shift to public transportation and other low-carbon modes."[15] The DSP proposed to achieve these targets by, among other things, requiring 100% light-duty ZEV sales by 2035, enhancing ZEV purchase incentives funding by fees on fossil-fueled sales, and reducing sales barriers for ZEVs.

This array of policies "will reduce the State's reliance on fossil fuels for transportation as expeditiously as possible," but as these projections indicate, and as the DSP acknowledges, even "under the most aggressive scenarios identified for transitioning to zero-emission technologies, fossil fuels are expected to constitute most of the fuel mix until the mid- or late-2030s."[16] Even if New York successfully implements the DSP's recommended policies, approximately 7 million liquid-fueled vehicles will be on the road in New York in 2030, comprising approximately 70% of all light-, medium-, and heavy-duty vehicles at that time.[17] That is, even if by 2030 "nearly 100% of LDV sales and 40% or more of MHD vehicle sales" are ZEVs, the vast majority of remaining New York vehicles will be running on liquid fuels.[18]

Accordingly, "[s]ubstituting sustainable renewable fuels for a portion of this remaining fossil fuel combustion will reduce GHGs and other emissions."[19] To this end, the DSP recommends increasing the use of Low Carbon Renewable Fuels through the establishment of a Clean Fuel Standard.[20] According to the DSP, such a policy could "facilitate decarbonization of transportation fuels by requiring the providers of fossil fuels to reduce the carbon content of the fuels they provide by either blending lower carbon fuels or by acquiring credits from providers

---

[10] *Id.*
[11] *Id.*
[12] DSP at 101-118.
[13] DSP at 94.
[14] DSP at 95.
[15] *Id.* (emphasis added).
[16] DSP at 118.
[17] DSP at 19.
[18] DSP at 95.
[19] DSP at 118.
[20] The other component is "Clean Fuel Infrastructure" under which [t]he State should fund incentives for infrastructure for cleaner fuels, such as green hydrogen, where market support is needed." *Id.*

of lower-carbon fuels into the stream of commerce."[21] Responding to concerns of the Climate Justice Working Group, the DSP notes that since the other policies expedite electrification "as much as reasonably feasible," "any GHG emission reductions from the use of renewable fuels are in addition to the emission reductions from accelerated electrification."[22] It further notes that while "that renewable fuels still emit air pollutants, some renewable fuels have lower emissions of [particulate matter]."[23]

Though a Clean Fuel Standard would likely incentivize the use of higher bioethanol blends, the DSP does not fully consider the integral, complimentary role that biofuels such as bioethanol play in displacing gasoline or the benefits increased use of higher bioethanol blends would produce. The DSP suggests that there are mixed health benefits of replacing gasoline with bioethanol, but as demonstrated by the peer-reviewed, meta-analysis of Environment Health & Engineering, Inc. ("EH&E"), as summarized in **Appendix B**, the bulk of the current scientific literature on this subject demonstrates that the associated positive health benefits of higher bioethanol use vastly outweigh any negative effects.[24] Higher bioethanol blends reduce the emissions of the vast majority of pollutants, including benzene and particulate matter, and are associated with negligible increases in a small number of pollutants such as acetaldehyde. And for this latter category, transportation emissions are minor in comparison to other environmental sources such that the actual incremental effect on air quality is minimal.

Apart from the Clean Fuel Standard, the DSP states biofuels will have a "limited but strategic role" of replacing hard-to-replace carbon emissions sources.[25]

IV. Introduction to Biofuels and their History in New York

A. A New York-Based Industry Poised to Expand

New York already has a local ethanol and biofuel industry, though there is ample room to grow. Western New York Energy, a locally owned upstate company, owns and operates a large-scale biofuel plant in Medina, New York. The facility began production in 2007 and currently produces more than 60 million gallons of fuel grade bioethanol annually, which is blended with gasoline mainly in Western New York.[26] In many ways, the plant showcases how bioethanol plants can support local and regional in-state farm operations. The plant serves as a significant customer for New York's corn farmers, but the facility also supplies animal feed to farms in New York. Specifically, the facility produces distillers grains as a co-product of the bioethanol production process. Distillers grains are rich in the protein, fat, minerals and vitamins that animals need, making distillers grains a highly desired feed ingredient for livestock and poultry diets.

---

[21] DSP at 118.
[22] *Id.*
[23] *Id.*
[24] *See* Appendix B, Environment Health & Engineering, Inc., *Comments on the New York State Climate Action Council Draft Scoping Plan* (July 1, 2022) ("**EH&E**"); DSP at 63.
[25] *See, e.g.*, DSP at 227-228 (Recommendation AF20, "Develop a Sustainable Biomass Feedstock Action Plan and Expand the Use of Bioenergy Products").
[26] *See* Western New York Energy, https://www.wnyenergy.com/.

B. Current Biofuel Contributions to New York

The vast majority of New Yorkers, like most Americans, currently fuel their cars and trucks, not with pure petroleum-based gasoline, but with E10 – a blend comprised of 10% bioethanol and 90% petroleum-based gasoline. In the United States, E10 accounts for 95 to 98% of all purchased gasoline.[27]

Though New Yorkers consume less petroleum per capita than any other state in the nation, New York was the fifth-largest consumer of petroleum among the states in 2019, according to the U.S. Energy Information Administration ("EIA").[28] The EIA estimated that New York transportation consumed 162,177 gallons of petroleum (including ethanol blends) in 2020.[29] The DSP estimates that fuel for cars, trucks, buses, and medium-duty and heavy-duty vehicles produced 892 trillion BTUs of energy in 2018, comprising 80 percent of the energy used in the transportation sector.[30]

Because E10 has a lower carbon intensity than pure gasoline, its near ubiquity in New York results in a lower emissions profile of the State's transportation sector than existed prior to its introduction. As a result, E10 has lowered the greenhouse gas baseline that the DSP and CLCPA currently seek to improve upon. This is one of the reasons that New York's 2018 transportation sector emissions are "only" 16% higher than they were in 1990.[31] If New Yorkers were fueling their LDV with pure gasoline instead of E10 today, emissions would be 4.5% higher or 2.9 MMTCO_2e per year at present rates of fuel consumption.[32] Conversion to E15 would reduce carbon emissions further by approximately 2.2 percent.[33]

Thus, in evaluating the pros and cons of a given transportation policy, one must consider that New York currently uses ethanol-blended fuel as the baseline fuel in the State. The question is not whether bioethanol should be introduced as a new fuel into New York or incorporated into the State's fuel mix; it is already here and displacing fossil fuels. Instead, the question is whether *increased* bioethanol or fuel blends with a higher percentage of bioethanol should be pursued.

New York, in recently legalizing the sale of E15 and high-ethanol fuel blends, has begun to answer that question in the affirmative. On November 20, 2019, the New York Department of Agriculture and Markets finalized a rule that enables sales of the 15% ethanol/85% gasoline fuel blend.[34] New York currently has 120 fueling stations offering E85, a blend of gasoline and 50-

---

[27] *See* U.S. Dep't of Agriculture, *Assessing Future Market Opportunities and Challenges for E15 and Higher Ethanol Blends* (May 2022), at 6.
[28] U.S. Energy Information Administration ("EIA"), *New York State Profile and Energy Estimates*, https://www.eia.gov/state/?sid=NY (last updated Oct. 21, 2021).
[29] EIA, *Table F16: Total Petroleum Consumption Estimates, 2020*; https://www.eia.gov/state/seds/data.php?incfile=/state/seds/sep_fuel/html/fuel_use_pa html&sid=US&sid=NY.
[30] DSP, Appendix G, Annex I (Tab: Trans_Sector Coverage).
[31] DSP at 25.
[32] Appendix A: Edgeworth Economics at 11.
[33] *Id.*
[34] New York State Register, *Rule Making Activities* (Nov. 20, 2019), https://dos ny.gov/system/files/documents/2019/12/nov20.pdf.

85% ethanol,[35] but few, if any, offering E15, despite its recent legalization and comparative environmental benefits over both pure gasoline and E10.[36] One of the reasons greater adoption of E15 has lagged is that fueling stations supplied by integrated oil and gas companies are not incentivized to offer E15 as it would harm their supplier's upstream business producing petroleum-based fossil fuel. Even though offering E15 would be economically advantageous from the standpoint of the retail fueling station owner, since bioethanol displaces petroleum, it also displaces petroleum sales of the fueling station's fuel supplier.

Another reason is market inertia. Though as we explain further, the costs associated with transitioning to E15 are minimal and manageable, New York only recently legalized E15 and higher blended fuels in 2019 and it typically takes a bit of time for any industry to adopt and upgrade new equipment and product offerings. Finally, New York has not established a comprehensive policy focused on E15 in New York that either would provide greater economic incentives for its adoption and use, or identify and mitigate industry transition pain points at the retail fueling station level.

Other states that have legalized E15, including non-corn producing East Coast states such as Pennsylvania and Florida, have seen more expansive growth, indicating that the costs to transition are not a significant impediment to greater adoption.[37] Nationwide, there are now approximately 2,600 gasoline stations that offer E15 across 30 different states, a figure that has more than doubled in just the last four years.[38]

C. New York Requires Cleaner Liquid Fuels than Other States

New York is also unique in that gasoline and gasoline alcohol blends sold in much of the State must meet stricter volatility requirements than required by EPA, as measured by a metric known as Reid Vapor Pressure ("RVP") and expressed in pounds per square inch ("psi"). Regulating the sale of higher-volatility is one way the Environmental Protection Agency ("EPA") exercises its authority under the Clean Air Act ("CAA") to control fuel-related emissions during particular seasons.[39] The federal CAA and EPA regulations promulgated thereunder ban the sale of gasoline with an RVP above 9.0 psi in CAA attainment areas during the summer (May 1 to September 15). However, both the CAA and EPA regulations also allow a 1-psi waiver for "fuel blends containing gasoline and 10 percent denatured anhydrous ethanol."[40] This 1-psi waiver allows qualifying fuels to be sold during the summer months at 10.0 psi.[41]

New York is one of four states whose EPA-approved State Implementation Plan does not contain a 1-psi waiver for E10. Thus, all gasoline blends in the State must meet the 9.0-psi level

[35] E85 is not gasoline, as such term is defined in the applicable regulations, and as such is not subject to the same RVP requirements.
[36] Appendix A: Edgeworth Economics at 2.
[37] *Id.* at 6 (Table 1). Florida and Pennsylvania have 186 and 155 gas stations offering E15, respectively, representing 2.3% and 3.7% of all gas stations in the state, respectively.
[38] *Id.* at 5-6.
[39] *See* 42 U.S.C. §§ 7545(h)(1), (h)(6) (The subsection "shall apply only to the 48 contiguous States and the District of Columbia."); *see also* 40 C.F.R. § 1090.215 (Gasoline RVP standards).
[40] 42 U.S.C. § 7545(h)(4).
[41] *See* 40 C.F.R. § 1090.215(b).

during the summer months.[42] This is stricter than the federal standard that governs most of the country. To meet the more stringent New York standard, refiners have adapted by using a lower-RVP blendstock for E10. While this makes the E10 consumed in New York slightly more expensive, the upshot is that there is no additional federal waiver needed to expand the use of E15.[43] As a result, the transition to E15 can take place on a smoother path.[44]

V. Biofuel Benefits and Contributions to the CLCPA Climate Targets

Biofuels such as bioethanol can significantly reduce greenhouse gas emissions and thus contribute to CLCPA's targets.

A. Biofuels Can Help Decarbonize Transportation Sectors that are Difficult to Electrify

The DSP rightly recognizes biofuels' ability to reduce greenhouse gas emissions in difficult-to-electrify sectors of the economy, such as aviation, shipping, and long-haul trucking. "For harder to electrify vehicles and equipment," the DSP is anticipating reliance "in part, on the increased use of lower carbon renewable fuels, including renewable diesel, renewable jet fuel, and/or green hydrogen."[45] One the DSP's key finding is that low-carbon fuels such as bioenergy "may help to decarbonize sectors that are challenging to electrify."[46]

This is particularly the case with respect to sustainable aviation fuels – a sector that has witnessed significant amounts of technological innovation and capital deployment in recent years. According to the DSP, aviation in 2019 accounted for 12 percent and 3.3 percent of New York's transportation-related and total emissions, respectively.[47] Along with landfills and animal feeding, it is expected to be one of the three largest remaining sources of emission in 2050.[48] Companies such as LanzaJet have pioneered the conversion of ethanol to jet fuel and their sustainable aviation fuel was successfully use on commercial flight in 2018.[49] LanzaJet is currently constructing a 10 million gallons-per-year facility in Georgia, set to come online this

---

[42] *See* 6 NYCRR § 225-3.3(a) ("No person shall sell or supply a gasoline to a retailer or wholesale purchaser-consumer, having a Reid vapor pressure greater than 9.0 pounds per square inch (psi) as sampled and tested by methods acceptable to the commissioner, during the period May 1st through September 15th of each year beginning 1989."). 6 NYCRR §225-3.3 has no corollary to 40 C.F.R. § 1090.215(b) that provides a 1-psi waiver for E10. *See also* 40 C.F.R. § 1090.215(b)(3) ("SIP-controlled gasoline that does not allow for the ethanol 1.0 psi waiver does not qualify for the special regulatory treatment specified in paragraph (b)(1) of this section."). Certain counties in New York must utilize reformulated gasoline ("RFG"). *See* https://www.epa.gov/gasoline-standards/reformulated-gasoline. Like the conventional gasoline regions of New York State, E15 does not face a regulatory barrier compared to E10 in RFG regions because RFG applies the same more stringent RVP specifications to both E10 and E15.

[43] This also holds true in the Reformulated Gasoline ("RFG") areas of New York State.

[44] The irony is that E15 has a lower RVP than E10, though it is not eligible for the 1-psi waiver. *See Am. Fuel & Petrochemical Mfrs. v. EPA*, 3 F.4th 373 (D.C. Cir. 2021).

[45] DSP at 118.

[46] DSP at 74.

[47] DSP at 25.

[48] DSP at 75.

[49] *See* LanzaJet, *Virgin Atlantic and LanzaTech Celebrate as Revolutionary Sustainable Fuel Project Takes Flight* (Oct. 4, 2018), https://www.lanzajet.com/virgin-atlantic-and-lanzatech-celebrate-as-revolutionary-sustainable-fuel-project-takes-flight/.

year, and has recently signed a memorandum of understanding with Marquis Sustainable Aviation Fuel to construct a 120 million gallons-per-year integrated sustainable fuels plant using low-carbon intensity feedstocks to produce sustainable aviation fuel and renewable diesel.[50]

Long-haul trucking is another promising application for biofuels. For example, ClearFlame, a company based in Illinois, has developed a technology that enables the use of E85 or E100 in compression ignition engines. The technology has clear applications in the long-haul trucking space where OEMs can leverage their existing fueling infrastructure to decarbonize their diesel-fueled trucking fleets without minimal disruptions to their operations and maintenance.[51]

Although the DSP assumes the trucking sector will be fully electrified by 2050, it has appropriately acknowledged a role for biodiesel, stating that until such complete electrification has occurred, "the replacement of diesel with renewable diesel . . . will reduce harmful PM2.5 emissions in Disadvantaged Communities."[52]

B. Higher Bioethanol Blends Can Reduce Transportation Emissions from New York's Existing Vehicle Fleet Through 2030 and 2050

As the DSP notes in several places,[53] while higher ethanol blends do not result in zero tailpipe emissions, they do reduce emissions in virtually all categories below current gasoline. This includes lifecycle greenhouse gas emissions.

Bioethanol reduces life cycle carbon emissions by displacing gasoline, even when emissions for land use change are accounted for. Numerous studies from have found such greenhouse gas emission reductions from displacing pure or "neat" petroleum-based gasoline, are in the range of 41 to 46 percent. For instance, according to the Department of Energy's Argonne National Laboratory, typical corn ethanol provides a 44 percent greenhouse gas savings compared to gasoline, including land use change emissions."[54] Similarly, researchers affiliated with Harvard University, MIT, and Tufts University conducted a meta-analysis that corn ethanol as of 2021 offers an average GHG reduction of 46 percent versus gasoline.[55] The California Air Resources Board ("CARB"), for its part, found that ethanol used in the state in 2020 reduced emissions by 41 percent, on average, compared to gasoline. From 2011 to 2020, CARB data show that the use of ethanol cut GHG emissions from the California transportation sector by 27

---

[50] *See* LanzaJet, *Where We Operate*, https://www.lanzajet.com/where-we-operate/; LanzaJet, *LanzaJet and Marquis Sustainable Aviation Fuel (SAF) partner to build an integrated Sustainable Fuels Plant in Illinois* (Feb. 10, 2022), https://www.lanzajet.com/lanzajet-and-marquis-sustainable-aviation-fuel-saf-partner-to-build-an-integrated-sustainable-fuels-plant-in-illinois./.
[51] *See* https://www.clearflameengines.com/.
[52] DSP at 38.
[53] *Id.* ("[T]he replacement of diesel with renewable diesel . . . will reduce harmful PM2.5 emissions in Disadvantaged Communities.").
[54] Lee, U. et al. (2021), *Retrospective analysis of the U.S. corn ethanol industry for 2005–2019: implications for greenhouse gas emission reductions*. Biofuels, Bioprod. Bioref., 15: 1318-1331. https://doi.org/10.1002/bbb.2225.
[55] Scully, M. et al (2021), *Carbon intensity of corn ethanol in the United States: state of the science*. Environ. Res. Lett. 16 043001. https://iopscience.iop.org/article/10.1088/1748-9326/abde08.

million MT CO2e, more than any other fuel used to meet the state's Low Carbon Fuel Standard ("LCFS") requirements.[56]

As noted in the Scully study – a peer-reviewed, meta-study analyzing the most up-to-date scientific literature on ethanol – estimates for the carbon intensity ("CI") of corn ethanol, as measured on a well-to-wheel life cycle basis, over the past three decades range from approximately 105 grams of carbon dioxide equivalent emission per megajoule of energy (gCO_2e MJ^{-1}) in 2009 to approximately 52 gCO_2e MJ^{-1} in more recent years.[57] EH&E illustrates these findings in the chart below:

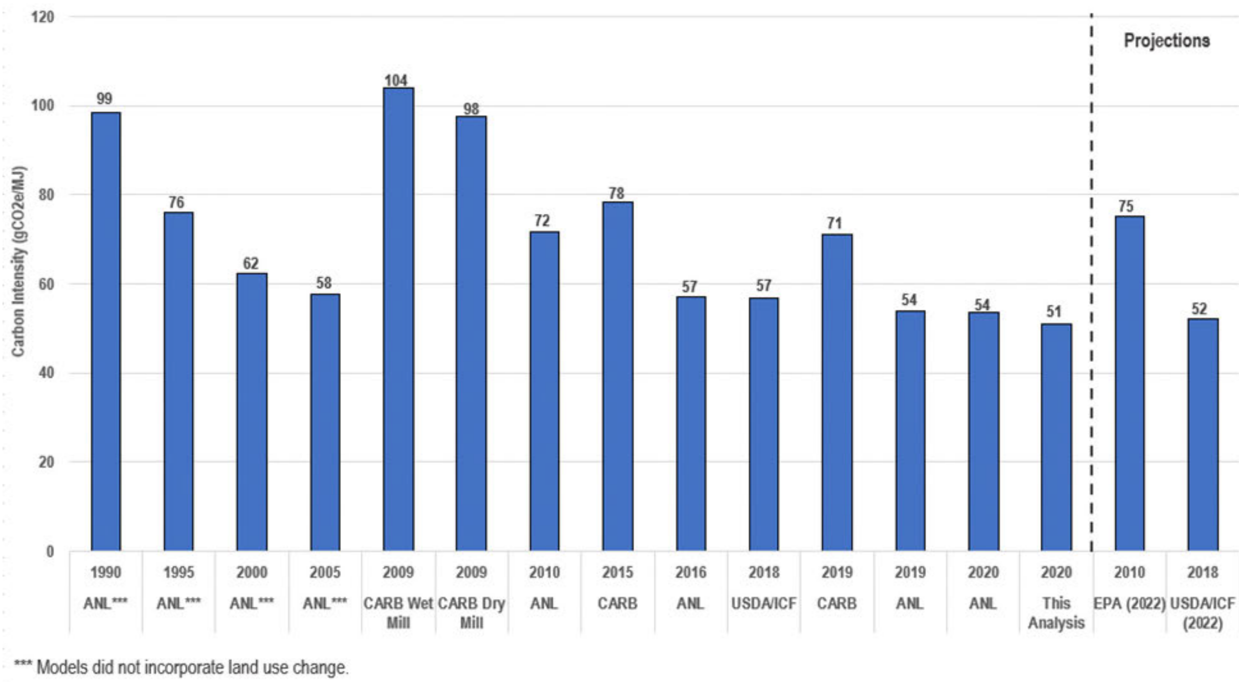


Figure 1 Timeline of estimated corn ethanol life cycle GHG emissions for 1990 through 2020 with projections out to 2022.[58]

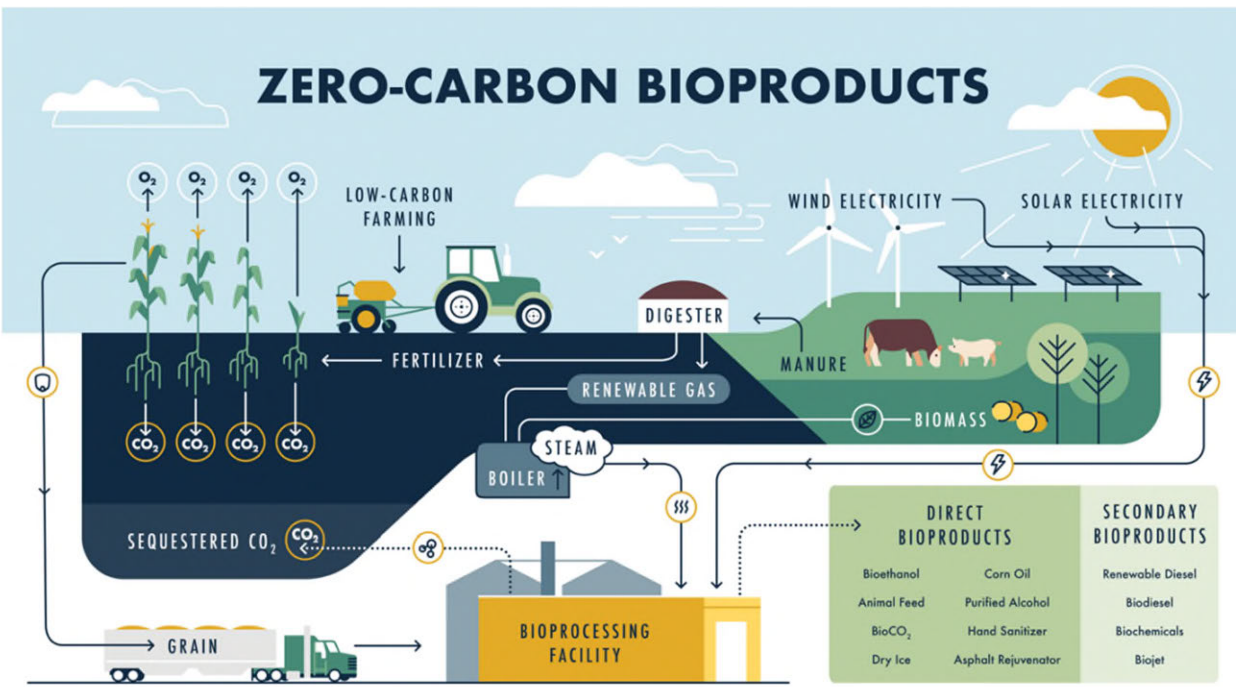
For comparison, the average CI of pure gasoline averages approximately 96 gCO_2e MJ^{-1}.[59] This decrease of measured CI of corn ethanol over the past decade or so can be attributed to (a) market-driven changes in corn production that lowered the intensity of fertilizer and fossil fuel use on farms; (b) more efficient use of natural gas and recent electric generation mix data for energy consumed at ethanol refineries, and (c) improvements in land use change analyses based on hybrid economic-biophysical models that account for land conversion, land productivity, and land intensification.[60] In other words, older estimates of bioethanol CI were incorrect and biased

[56] 3 CARB, *Low Carbon Fuel Standard Reporting Tool Quarterly Summaries*, https://ww2.arb.ca.gov/resources/documents/low-carbon-fuel-standard-reporting-tool-quarterly-summarieshttps://files.ctctusercontent.com/a8800d13601/e2f451f3-0231-4946-a8dc-33556297da63.pdf?rdr=true.
[57] Scully, M. et al (2021), *Carbon intensity of corn ethanol in the United States: state of the science*. Environ. Res. Lett. 16 043001. https://iopscience.iop.org/article/10.1088/1748-9326/abde08, at 2 (citing studies).
[58] Appendix B: EH&E at 9.
[59] Scully, M. et al (2021), *Carbon intensity of corn ethanol in the United States: state of the science*. Environ. Res. Lett. 16 043001. https://iopscience.iop.org/article/10.1088/1748-9326/abde08, at 16.
[60] *Id*. at 2.

high, and bioethanol has improved in environmental performance over time. As a result, more recent studies show much more significant benefits of bioethanol than originally thought.

This is most likely as floor rather than a ceiling. As the Scully study notes, "Market conditions that favor greater adoption of precision agriculture systems, retention of soil organic carbon, and demand for co-products from ethanol production may lower the CI of corn ethanol further."[61] According to the USDA, from 2011 to 2019, the average carbon intensity of ethanol fuel has decreased by approximately 25 percent, due to changes in how ethanol plants are producing their fuel.[62]

As one participant in this industry, POET can attest to its own R&D investments and continued progress increasing the sustainability of corn-based ethanol.[63] Since 2005, POET has reduced its annual energy use by 18 percent, increased its per bushel biofuel yield by 8 percent.[64] As detailed in its Sustainability Report and illustrated by the below graphic, POET is implementing or exploring advancements in all facets of existing and emerging technology in the bioproducts sector to meet its carbon neutrality goals.[65]



[61] *Id*. at 2.
[62] U.S. Dep't of Agriculture, *The California Low Carbon Fuel Standard: Incentivizing Greenhouse Gas Mitigation in the Ethanol Industry* (Nov. 2020), at 1, https://www.usda.gov/sites/default/files/documents/CA-LCFS-Incentivizing-Ethanol-Industry-GHG-Mitigation.pdf .
[63] POET, *Sun, Soil & Seed: Cultivating the Road to Zero-Carbon Biofuels & Bioproducts (Sustainability Report)* (Sept. 2021), at 9, https://poet.com/resources/documents/POET-sustainability-report.pdf.
[64] *Id.*
[65] *Id.* at 15.

VI. Additional Benefits of Biofuels

In addition to reducing greenhouse gas emissions, biofuels, including ethanol, provide a whole host of additional benefits to local air quality, public health, the state's agriculture industry, consumer expense, and U.S. and New York's geopolitical interests, including reduced support for authoritarian, petroleum-funded regimes.

A. High-Bioethanol Blends Save Drivers and Retailers Money, Especially Those in Environmental Justice Communities

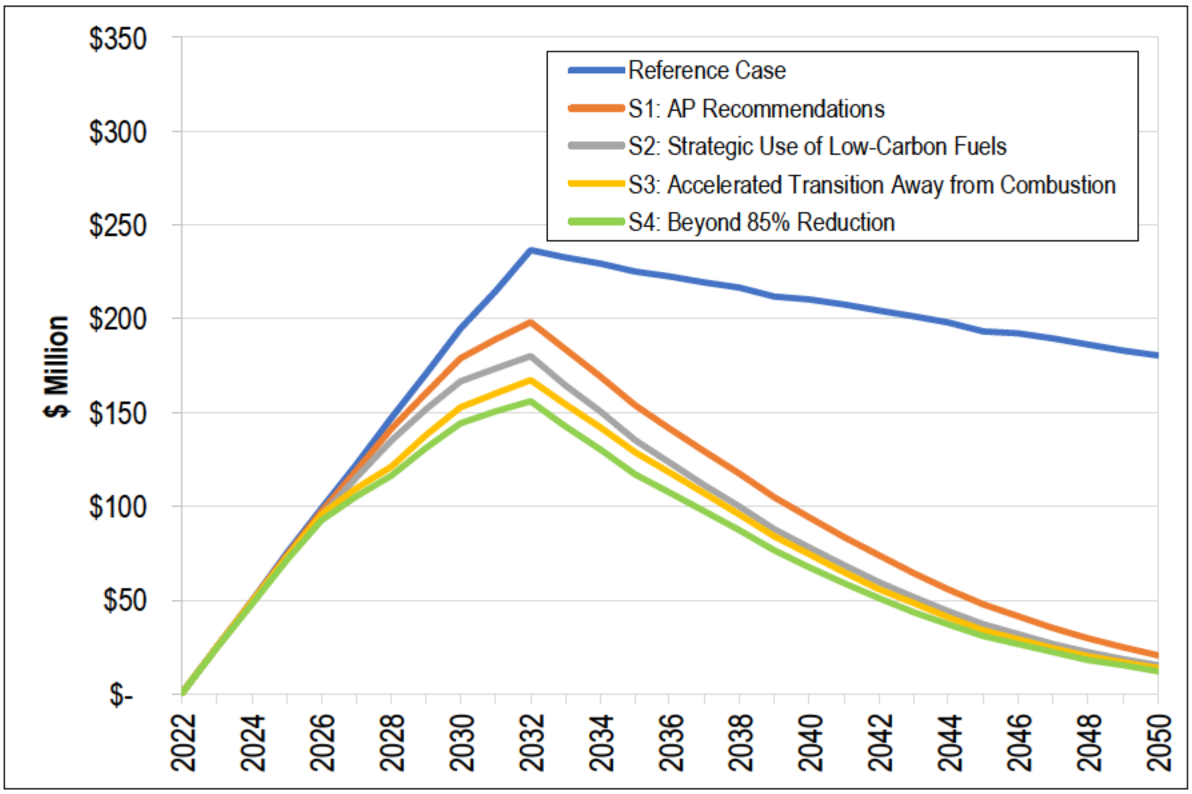
New York drivers and retailers would save tens of millions of dollars annually by converting to E15. Not only are wholesale prices for higher-bioethanol blends cheaper,[66] but they also generate credits under the national Renewable Fuel Standard program (known as Renewable Identification Numbers or "RINS"), which afford an additional value stream to fuel providers. Edgeworth Economics evaluated the potential economic and carbon-emission benefits of converting from E10 to E15 in New York, and the analysis is attached as **Appendix A** to these comments. That analysis found that when taking cheaper wholesale prices and RINS revenue into account, the producer savings from E15 relative to E10 generally have ranged up to $0.08 per gallon over the last several years.[67] In the 12-month period through June 2022, the E15 discount relative to E10 averaged $0.067 per gallon at wholesale, equal to about 1.8 percent of the average retail price of gasoline in New York during the same period ($3.18 per gallon average).[68] These wholesale prices have resulted in even greater savings for consumers at the pump based on self-reports of gas station owners, as the reported discount for E15 relative to E10 has averaged approximately $0.12 per gallon since January 2020.[69]

Given the recent spike in gas prices in 2022, one would expect the current price savings to be even higher. However, even assuming only a 1.8 percent savings from E10 translates to significant price savings under every scenario in the DSP. Edgeworth Economics studied what would happen if New York converted its liquid-fuel LDV fleet from E10 to E15, beginning in 2023 with 10 percent E15 usage, and ramping up linearly to 100 percent over a 10-year period. The analysis showed savings of $25 million (2020$) in 2023, increasing to a maximum of $237 million in 2032, and averaging $180 million annually from 2023-2050, under the no-action Reference Case.[70]

[66] According to the most recent U.S. Department of Energy Clean Cities Alternative Fuel Price report, on average, from January 1 to January 18, 2022, E85 cost about $0.31 less than E10 on a per (liquid) gallon basis. *See* U.S. Department of Energy, *Clean Cities Alternative Fuel Price Report* (Jan. 2022), at 12. Gasoline was $3.25/gallon and E85 was $0.31/gallon. In October 2021, the difference was even greater at $0.57, when gasoline was $3.35 and E85 was $2.73. *Id*. at 4. In New York, the price differential was even greater with E85, ranging from 50 to 93 cents cheaper than E10. *Id.* at 12.
[67] Appendix A: Edgeworth Economics at 3.
[68] *Id.*
[69] *Id*. at 4 (citing data self-reported by certain gasoline stations to the Renewable Fuels Association). According to AAA, the average gasoline price on June 29, 2022 in New York State was $4.94 per gallon. *See* https://gasprices.aaa.com/ (accessed June 29, 2022). Sheetz, a large Mid-Atlantic fuel retailer and convenience store operator, will price its E15 blend at $3.99/gallon and E85 at $3.49/gallon blend in a special promotion that will run through the U.S. July 4th holiday. *See* AutoBlog, *Sheetz chain lowers price for E15 gas to $3.99 for July 4 travel* (June 28, 2022), https://www.autoblog.com/2022/06/28/sheetz-gas-sale-prices-july-4-weekend/.
[70] Appendix A: Edgeworth Economics at 9.

Under the DSP's four decarbonization scenarios which call for accelerated vehicle electrification, the conversion to E15 still produced peak annual savings of $156 million to $198 million in 2032 and would average $78 million to $100 million annually over the entire 2023-2050 period (depending on the policy scenario).[71] The savings from all five scenarios are illustrated in the below chart:

Figure 1
Savings from Converting the Liquid-Fuel LDV Fleet in New York to E15 (million $ per year)
Draft Scoping Plan Reference Case and Policy Scenarios
2022 – 2050

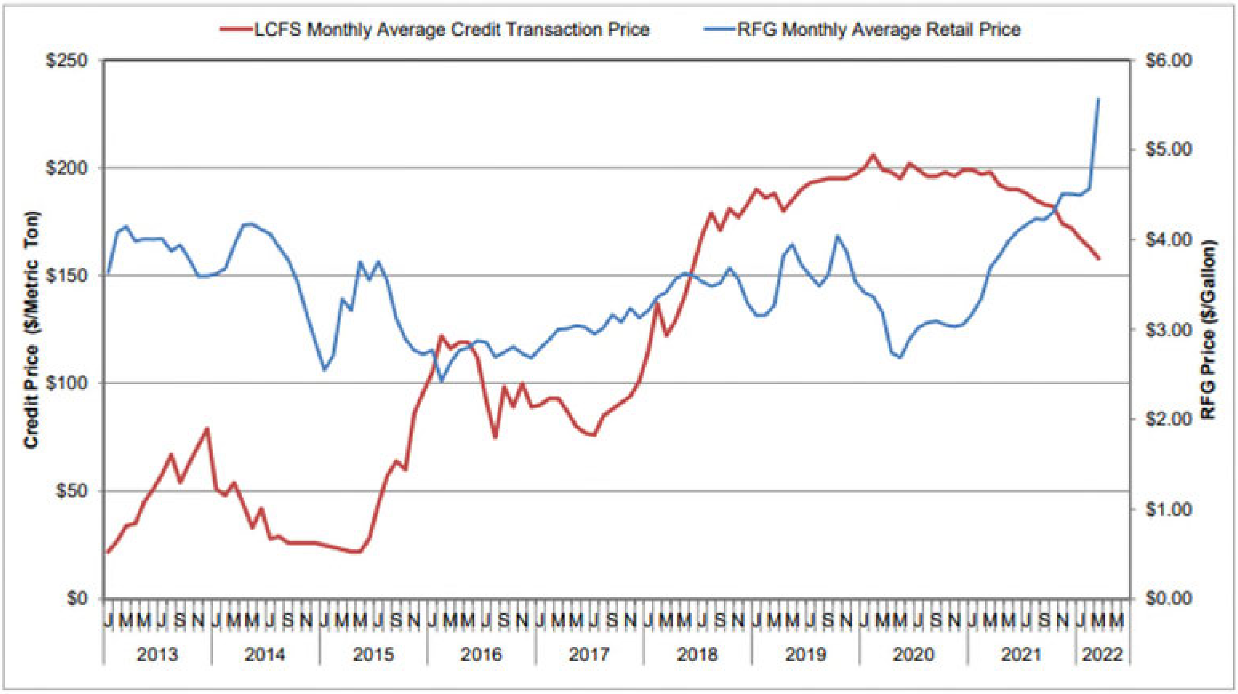


For this reason and others, policies that incentivize lower carbon fuels typically have a positive effect or at worst no effect on fuel prices. For instance, a recent study of California's LCFS, commissioned by the Low Carbon Fuels Coalition, showed "conclusively that the LCFS program price effect at the pump is not a significant driver of retail fuel prices in California."[72] The study noted that retail fuel prices in California are high relative to other states, but its assessment of observed market prices "found no statistically significant correlation between the

[71] *Id.* at 9-10.
[72] Bates White Economic Consulting, *Low Carbon Fuels Standards Market Impacts and Evidence for Retail Fuel Price Effects* (Apr. 2022), at 2, available at https://static1.squarespace.com/static/5b57ab49f407b4a7ffa44ffa/t/627ac05b10c1ae023912ca34/1652212920030/Bates+White+LCFC+Report+Updated+2022.04.21.pdf.

price of LCFS credits and the price of retail gasoline," as indicated below:[73]

Figure 1: LCFS Credit Price and Retail Gasoline Price[1]



The study further noted that "current pricing of low-carbon fuel alternatives relative to petroleum fuels offer consumers price savings."[74]

Nor is there evidence that E15 reduces fuel economy when compared to E10. Indeed, due to the higher octane content of higher-bioethanol blends, E15 may result in increased fuel economy. Bioethanol has a slightly lower energy content than pure gasoline, but it also has a higher octane value – both of these values positively influence the fuel economy of a vehicle. Thus, if the higher octane value more than offsets the lower energy density, higher bioethanol blends such as E15 may result in *increased* fuel economy.[75] The University of California Riverside conducted two recent testing programs that evaluated emissions and fuel economy differences between E10 and splash-blended E15 on very recent vehicle technologies.[76] Taken together, the studies' conclusions demonstrate that fuel economy could be from 1% lower to 6% higher on E15 than E10. We have attached a summary of those studies by Tom Darlington of Air Improvement Resources, Inc. as **Appendix C** to these comments.

---

[73] *Id*. at 2-3 (Figure 1).
[74] *Id*. at 1.
[75] While ethanol has a somewhat lower volumetric energy content than gasoline, it also has a higher octane value. Both energy content and octane can impact fuel economy.
[76] University of California Riverside, *Impacts of Ethanol and Aromatic Content on Emissions from Gasoline Direct Injection Vehicles* (April 2018); University of California Riverside, *Final Report, Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15,* prepared for California Air Resources Board, Growth Energy, Renewable Fuels Association, and USCAR (Jan. 2022).

The benefits of bioethanol have become all the more apparent in light of recent events in the oil market. Russia's ongoing war in Ukraine and the resulting increase in gas prices have demonstrated that domestic fuel prices are determined by and subject to the vicissitudes of global petroleum markets. Bioethanol does not experience the same degree of dependence. Because bioethanol is a largely domestic market, it is not as vulnerable to volatility in the globally integrated oil and gas market. When oil and gas prices increase, the higher use of bioethanol reduces this inflationary effect throughout the transportation sector, which in turn has spillover effects throughout the broader economy.

On April 12, 2022, President Biden traveled to POET's Menlo facility and announced a plan to waive the regulatory bar on summertime sales of E15 gasoline. While this waiver is not needed and would not apply to New York since, under state law, both E10 and E15 must be manufactured to meet the more stringent RVP standard of 9 psi, the Biden announcement provides support for the economic and geopolitical advantages of E15. According to the Biden Administration, at current prices as of April 2022, "E15 can save a family 10 cents per gallon of gas on average, and many stores sell E15 at an even greater discount."[77] And the waiver was issued to address the high fuel prices attributed to Russia's invasion of Ukraine and promise of $100 million investment in biofuel infrastructure.[78]

Given the current price of gasoline, consumer relief at the pump would be a virtue in and of itself, particularly for drivers with low and moderate income for whom fuel costs comprise a larger percentage of their disposable income.[79] A May 2021 study by ACEEE found that American households have an average gasoline burden of about 7.0% of total income, but that gasoline burdens for low-income households that earn less than 200% of the federal poverty level range from 13.8% to 14.1%.[80] Though the burden was slightly less for the New York City, NY-NJ metro area (5.31%), one could assume that disadvantaged communities in more rural and suburban parts of New York would have a higher burden. ACEEE's further analysis confirmed that Black, Hispanic, and Native American communities bear greater gasoline burdens than their White counterparts.[81] The recent spike in gasoline relative to other household expenses has almost certainly increased this disparate burden since the study was published.

These progressive benefits from price savings are also relevant to the ultimate success of the CLCPA given the integral role transportation plays in New York's economy. The DSP recognized the need to approach CLCPA transportation policy "strategically and with an eye toward recognizing the opportunity and delicate balance of facilitating transportation's role in

---

[77] White House Statements and Releases, *Fact Sheet: Using Homegrown Biofuels to Address Putin's Price Hike at the Pump and Lower Costs for American Families* (Apr. 12, 2022) ("White House Fact Sheet"), https://www.whitehouse.gov/briefing-room/statements-releases/2022/04/12/fact-sheet-using-homegrown-biofuels-to-address-putins-price-hike-at-the-pump-and-lower-costs-for-american-families.

[78] *Id.*; NPR, *Biden will ease restrictions on higher-ethanol fuel as inflation hits a 40-year high* (Apr. 12, 2022), https://www.npr.org/2022/04/12/1092222231/in-an-exception-to-the-clean-air-act-biden-will-allow-e15-gas-to-be-sold-this-su.

[79] *See* ACEEE, *Analysis: Gasoline Costs Consume Nearly 20% of Some Household Budgets* (May 20, 2021), https://www.aceee.org/blog-post/2021/05/analysis-gasoline-costs-consume-nearly-20-some-household-budgets.

[80] Shruti Vaidyanathan, Peter Huether, and Ben Jennings, *Understanding Transportation Energy Burdens, ACEEE White Paper* (May 2021), https://www.aceee.org/sites/default/files/pdfs/transportation_energy_burdens_final_5-13-21.pdf.

[81] *Id*.

economic growth with the need to address adverse community, environmental, and human health impacts."[82] Bioethanol presents no such tradeoff between economic competitiveness on the one hand, and achievement of the CLCPA's requirements on the other. Bioethanol is good for ***both*** the economy and the environment. It is a win-win opportunity for New York's transportation sector.

B. E15 Reduces Local Pollutants When Compared to E10 and Pure Petroleum-Based Gasoline

Numerous studies have found higher bioethanol blends to emit lower tailpipe emissions as compared to lower bioethanol blends such as E10, or pure gasoline ("E0"). Attached as Appendix B hereto are comments from EH&E – a multi-disciplinary team including environmental health scientists and engineers from Harvard and Tufts University – which provide a comprehensive state of the science assessment of the impacts of corn ethanol fuel blends on tailpipe emissions, regulatory pollutants, and air toxics in LDVs.

According to EH&E, ethanol studies demonstrated that higher ethanol content in fuels was associated with lower emissions of key health-relevant pollutants, including particulate matter ("PM"), black carbon, particle number, and benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene (collectively known as "BTEX"), while fuels with lower ethanol content generally showed the opposite pattern.[83]

Primary PM emissions, a significant cause of cardiovascular disease and asthma, decreased by 15-18% on average for each 10% increase in ethanol content under cold-start conditions.[84] This trend holds true for replacing E10 with E15. For instance, a 2022 CARB study that assessed the impact of E15 (splash-blended from E10) on air pollutant emissions for late model year vehicles (2016-2021) found that switching from E10 to E15 reduced PM emissions by 18%, with cold-start emissions being reduced by 17%.[85]

Ethanol blended fuels are also consistently shown to emit lower amounts of carbon monoxide, total hydrocarbons, and non-methane hydrocarbons as compared to non-ethanol blended fuels, consistent with their cleaner combustion.[86] Though the impact on oxides of nitrogen ("NOx") varied by study, EH&E's recent study of low- to mid-ethanol fuel blends (E0 to E30) and CARB's 2022 study show that NOx did not change with increasing ethanol content. Acrolein emissions also did not change with increasing ethanol content, while formaldehyde emissions showed little to no significant change.[87]

---

[82] DSP at 94.
[83] *See* Appendix B: EH&E at 4 (citing Clark et al. 2021; Karavalakis 2018. Karavalakis et al. 2014; Kumar and Chaurasia 2019; Liang et al. 2020; Myung et al. 2020; Roth et al. 2020; Sakai and Rothamer 2019; Schuchmann and Crawford 2019; Yang et al. 2019a, 2019b; Zheng et al. 2019).
[84] *Id.* (citing Kazemiparkouhi et al. 2022c).
[85] *Id.* (Karavalakis et al. 2022).
[86] *Id.* (citing Badrawada and Susastriawan 2019; Clark et al. 2021; Gunst 2013; Karavalakis 2018; Karavalakis et al. 2012, 2022; Kazemiparkouhi et al. 2022c; Mourad and Mahmoud 2019; ORNL et al. 2016; NREL 2013; Roso et al. 2019; Theiss 2016; Wayson 2016).
[87] *Id.* (citing Kazemiparkouhi et al. 2022a, 2022b, 2022c; Karavalakis et al. 2022).

The DSP relies primarily on studies conducted prior to 2008 to support its contrary statement that alcohol-based fuels have higher emissions of respiratory irritants, carcinogens, acrolein, formaldehyde, and acetaldehyde than petroleum-based fuels.[88] These older studies may not account for changes in the vehicle fleet and advances in ethanol fuels that have shown key reductions in local air pollutants.[89] We urge the Council to reconsider their inclusion in the final scoping plan.

Indeed, in 2021, EH&E found that levels of aromatics like BTEX decrease by approximately 7% by volume for each 10% by volume increase in ethanol content.[90] Ethanol is used as a fuel additive in gasoline to boost octane without the harmful impacts posed by previous fuel additives such as methyl tert-butyl ether ("MTBE") and lead. Octane rating reflects the ability of a fuel to avoid premature or auto ignition.[91] Aromatics, such as BTEX, also boost gasoline octane, but are considered hazardous air pollutants.[92] The high octane rating of ethanol thus also enables reduction of otherwise harmful aromatics in the blended fuel.[93]

The reduced tailpipe emissions result in measureable improvements in air quality. Lower PM emissions result in lower ambient PM concentrations and exposures; reductions of targeted aromatics in fuel were also associated with lower summertime ozone levels.[94] Less well studied is the impact of ethanol-based fuels on acetaldehyde and formaldehyde concentrations; however, atmospheric measurements indicate that use of E10 and other ethanol blends do not increase concentrations of acetaldehyde and formaldehyde above background levels in ambient air, indicating that emissions from other sources are larger than from LDVs.[95]

Reductions in local pollutants are a key concern of environmental justice communities, which have borne and continue to bear a disproportionate environmental burden from fossil-fueled vehicle pollution. Bioethanol and other biofuels do not create additional local pollution when compared with gasoline-fueled vehicles; indeed, they reduce such pollution.

C. E15 Strengthens Energy Independence

Another benefit of increasing the use of higher-bioethanol blends is that they are domestically made and manufactured, and typically serve a U.S. market. By displacing gasoline, high-bioethanol blends also reduce New York's reliance on foreign sources of petroleum and thereby benefit and strengthen state and national security interests.

Recently, in the aftermath of Russia's invasion of Ukraine, Governor Hochul issued two executive orders that that directed state agencies and authorities to divest public funds supporting

[88] *See id.* at 3; DSP at 63 (citing Tang 2007; Vieira da Silva 2017; and as cited in the Renewable Fuels Roadmap (Wojnar 2010): He et al. 2003; Jacobson 2007; Karman 2003; Niven 2005; Winebrake et al. 2000, 2001).
[89] *See* DSP at 63 (citing NYSERDA Renewable Fuels Roadmap, which concluded in 2010 and was last updated in 2012).
[90] Appendix B: EH&E at 2-3 (citing Kazemiparkouhi et al. 2021).
[91] *Id.* at 2 (citing Anderson et al. 2012).
[92] *Id.* at 2 (citing Clark et al. 2021).
[93] *Id*. at 2-3 (citing Clark et al. 2021; Kazemiparkouhi et al. 2022a; US EPA 2017).
[94] *Id.* at 5.
[95] *Id.* (citing Sommariva et al. 2011; de Gouw et al. 2012).

Russia and refrain from contracting with businesses conducting business in Russia.[96] According to the Orders, New York State "will not permit its activities as a participant in the marketplace to support an unjustified war by Russia and the killing of innocent Ukrainians."[97] "Protecting New York from financing discrimination against the Ukrainian people" furthermore is "a compelling State interest."[98]

Russia's main source of funding is its sale of oil and gas sales, which are part of a globally integrated market. Reducing domestic demand for petroleum through greater use of domestic biofuels over the next decades will aid New York and the United States' national security and geopolitical interests, not just with respect to the current war in Ukraine, but also with respect to future conflicts with authoritarian regimes funded by petro-dollars.

D. E15 does not Diminish Vehicle Performance

Vehicles that operate on E10 – the predominant fuel in New York – would run just as well on E15.

In June 2011, EPA approved blends of 15 volume percent ethanol in gasoline for use in model year 2001 and newer passenger cars, light-trucks and medium-duty vehicles.[99] In 2012, the U.S. Department of Energy conducted a rigorous test of E15 across a range of engine types and found no adverse impact on any measure of performance, including fuel economy as well as maintenance, stating:

> The Energy Department testing program was run on standard gasoline, E10, E15, and E20. The Energy Department test program was comprised of 86 vehicles operated up to 120,000 miles each using an industry-standard EPA-defined test cycle (called the Standard Road Cycle). The resulting Energy Department data showed no statistically significant loss of vehicle performance (emissions, fuel economy, and maintenance issues) attributable to the use of E15 fuel compared to straight gasoline.

According to recent report from the U.S. Department of Agriculture, "It is estimated that 93 percent of the vehicles on the road, consuming 97 percent of gasoline, are approved

[96] Governor Hochul, *Executive Order No. 14 of 2022* ("Directing State Agencies and Authorities to Divest Public Funds Supporting Russia" (Feb. 27, 2022), at 1. Governor Hochul, *Executive Order No. 16* ("Prohibiting State Agencies and Authorities from Contracting with Businesses Conducting Business in Russia") (Mar. 22, 2022), at 1.
[97] *Id*.
[98] *Id*.
[99] In 2010 and 2011, EPA determined that E15 would not impair certain motor vehicles' emission controls under Subsection 7545(f)(4) and by waivers approved the use of E15 in light-duty motor vehicles made after 2000. *See Partial Grant of Clean Air Act Waiver Application Submitted by Growth Energy To Increase the Allowable Ethanol Content of Gasoline to 15 Percent*, 76 Fed. Reg. 4,662 (Jan. 26, 2011); *Partial Grant and Partial Denial of Clean Air Act Waiver Application Submitted by Growth Energy To Increase the Allowable Ethanol Content of Gasoline to 15 Percent*, 75 Fed. Reg. 68,094 (Nov. 4, 2010); *see also Grocery Mfrs. Ass'n v. EPA*, 693 F.3d 169, 173 (D.C. Cir. 2012).

to use E15."[100] That same report stated that by 2020, automakers that warrant all models for E15 use sold 83 percent of new cars in the United States.[101] Indeed, non-flex fuel vehicles have been shown to adapt up to 30 percent ethanol blended ("E30") gasoline without compromising engine performance or fuel efficiency.[102]

VII. Policy Proposals

To capitalize on the benefits biofuels can provide New York as it strives to meet its ambitious decarbonization goals under the CLCPA, we propose three distinct policies.

Each of these policies complements the other two, and more importantly, can operate in parallel with other recommended transportation measures set forth in the DSP. Electrifying the State's vehicle fleet will take years to fully implement, even on the accelerated timeline proposed in the DSP. Despite unprecedented efforts to reduce vehicle miles travelled, according to the DSP there still will be millions of liquid-fueled cars on the road for the next decade and beyond.

Increasing biofuel use allows New York to reduce greenhouse gas emissions from its liquid fueled fleet for as long as such vehicles are on the road. In so doing, biofuels not only reach sources that other polices cannot in the near term, but also act as an insurance policy against the risk of failure or delay of other New York transportation decarbonization policies. If it takes longer to electrify the transportation sector than expected, or if the VMT-reduction policies falter, it will be all the more important to reduce transportation emissions from the liquid-fueled vehicles on the road.

A. Incentivize and/or Facilitate at least 15% Bioethanol for Gasoline Fuel Blends

Building on its recent legalization, New York could incentivize or facilitate the use of E15 for liquid fueled vehicles currently running on E10, and ensure consumers have access to this fuel. This measure would replace E10 as the most prominent liquid fuel in the state and thereby displace a greater portion of the petroleum-based gasoline, while still giving consumers who desire to use E10 or even E0 the ability to do so. This is a no-regrets, administrable near term solution that can be implemented with minimal upgrades to existing liquid-fuel infrastructure or business practices. We urge that this policy be adopted as soon as possible.

1. **Reduces Greenhouse Gases**: Switching to E15 will materially reduce New York's greenhouse gas emissions under any scenario contemplated in the DSP, regardless of the pace of electrification. As set forth in Section V(B), greenhouse gas emission reductions from displacing pure or "neat" petroleum-based gasoline with bioethanol are in the range of 41 to 46 percent. Edgeworth Economics found

[100] U.S. Dep't of Agriculture, *The California Low Carbon Fuel Standard: Incentivizing Greenhouse Gas Mitigation in the Ethanol Industry* (Nov. 2020), at 8, https://www.usda.gov/sites/default/files/documents/CA-LCFS-Incentivizing-Ethanol-Industry-GHG-Mitigation.pdf.
[101] *Id.*
[102] Alsiyabi, A., Stroh, S., & Saha, R. (2021). *Investigating the effect of E30 fuel on long term vehicle performance, adaptability and economic feasibility*. Fuel. Retrieved from https://www.sciencedirect.com/science/article/pii/S0016236121015106.

that using a central estimate of 43 percent lower carbon intensity for bioethanol meant that a full conversion to E15 would reduce carbon emissions from the component of New York's LDV fleet that currently utilizes E10 by approximately 2.2 percent.

If New York phased in usage of E15 from 10% in 2023 to 100% by 2032, emissions would be reduced by **23.9 MMTCO$_2$e (1.8% of all LDV emissions and 0.4% of total economy-wide emissions)** under the DSP's no-action Reference Case,[103] and **10.8 to 13.7 MMTCO$_2$e (0.8–1.0% of all LDV emissions and 0.2–0.3% of total economy-wide emissions**) through 2050 under the DSP's four action scenarios that contemplate accelerated electrification of the transportation sector. Using the DSP's value of carbon figures, this would equate to $3.6 billion through 2050 ($128 million average per year) under the no-action scenario, and range from $1.5 billion to $2.0 billion through 2050 under the DSP's four action scenarios ($55 million to $71 million average per year).[104]

2. **Reduces Local Air Pollution**: This change would also benefit public health, especially those in disadvantaged communities, by improving local air quality and reducing harmful emissions from petroleum-based gasoline.

   As set forth in Section VI(B), higher bioethanol content in fuels was associated with lower emissions of key health-relevant pollutants, including PM, black carbon, particle number, and benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene (collectively known as BTEX). Other pollutants saw negligible no increases or negligible increases. The net result is a significant improvement in local air quality as a result of increased use of higher-bioethanol blends.

3. **Requires No Change in Consumer Behavior**: Unlike other policies, it will not require additional cost to the average consumer, or require changes in customer behavior or habits. Drivers would continue fill up their tanks of cars and trucks they already drive, but now with a cleaner alternative.

4. **Lowers Fuel Prices:** To the extent, most drivers would notice a shift from E10 to E15, it would be the reduced cost of gasoline at New York fueling stations. Producer savings range from $0.00 and $0.08 per gallon, and drivers typically experience a $0.12 per gallon savings. If E15 was gradually phased in from 2023-2032, and assuming the 2021 with a E15 average discount relative to E10 of $0.051 per gallon, New Yorkers would save $23 million (2020$) increasing to a maximum of $219 million in 2032, and averaging $166 million annually from 2023-2050 under the status quo reference case. Though lower under the four action scenarios, this deflationary effect would have benefits throughout the wider economy.

[103] Appendix A: Edgeworth Economics at 11-12 ("Based on the assumption that conversion of "gasoline" (as defined in the Plan, presumed to be 100 percent E10) to E15 results in a reduction of CI of 2.1 gCO2e/MJ (0.0022 MMTCO2e/Tbtu) and a linear ramp-up of conversion . . . .").

[104] Appendix A: Edgeworth Economics at 11-12.

5. **Easy for Businesses to Implement**: Unlike electrification efforts, the transition costs of switching to higher blended bioethanol gasoline would be relatively minimal for New York's transportation sector. Whereas electrifying the vehicle fleet requires the significant deployment of EV charging infrastructure, constructing upgrades of utility distribution systems to accommodate increased load, taxpayer or ratepayer funded incentives to catalyze the market, and utility rate design changes that may entail cost-shifts to ratepayers in the near term, outfitting fueling stations to offer E15 instead of E10 is a relatively easy lift. States such as Pennsylvania and Florida that have seen a significant rise in E15 post-legalization demonstrate that these transition costs are manageable, and could be accelerated with moderate policy support to ease pain points. A recent report by the USDA noted that for gas stations with compatible equipment, the cost of increasing blending to E15 would be around $13,000.[105]

   Other stations could have higher retrofit costs depending on their equipment, but these can be accommodated. Federal incentives are available to help fueling stations update their equipment to offer E15.[106] Iowa's recently passed legislation requiring fueling stations with two or more pumps to offer E15 beginning in 2026 may serve as a model for how to expand consumer choice.[107] That law, House File 2128, took into account the costs of offering E15, offering exemptions for station owners without compatible equipment, and allowing a retailer to submit a waiver describing why its equipment cannot support the higher bioethanol blend.[108] Waivers are also available for small fueling stations whose average total gasoline was limited to 300,000 gallons or less.[109]

   Ontario through regulation also recently required fuel suppliers to maintain an average volume of renewable content in regular grade gasoline, which will increase in amount each calendar year: 11% in 2025; 13% in 2028; and 15% in 2030.[110]

6. **Easy for the State to Implement**: Depending on its structure, Department of Agriculture and Markets, DEC, and/or NYSERDA likely could implement an E15 incentive through regulation under those entities' existing authority. There is no need for agencies to set up a new or complex regulatory apparatus to administer this policy; it only requires promulgating new rule and enforcing it.

---

[105] U.S. Dep't of Agriculture, *Assessing Future Market Opportunities and Challenges for E15 and Higher Ethanol Blends* (May 2022), at 17.
[106] Appendix A: Edgeworth Economics at 14.
[107] *House File 2128, an Act relating to renewable fuels, including ethanol blended gasoline and biodiesel blended fuel used to power internal combustion engines* (signed May 17, 2022), https://www.legis.iowa.gov/legislation/BillBook?ga=89&ba=hf2128.
[108] *Id.*
[109] *Id.*
[110] *O. Reg. 663/20: Cleaner Transportation Fuels: Renewable Content Requirements for Gasoline and Diesel Fuels* (filed Nov. 25, 2020) under Environmental Protection Act, R.S.O. 1990, c. E.19; https://www.ontario.ca/laws/regulation/r20663; *see also* https://ero.ontario.ca/notice/013-4598.

7. **Complements Electrification and VMT-Reduction Efforts**: Moreover, E15 would complement rather than compete with the State's other initiatives. Greater E15 use would not interfere with the other eleven key recommendations in the DSP centered on electrification efforts and reducing VMTs. Nor would it compete for taxpayer or ratepayer incentives to accelerate those efforts, since there would be no need for a dedicated subsidy E15 or E85; both fuel-blends are already cheaper than E10 and E0.

In sum, POET highlights this policy first because it truly is the low hanging fruit among transportation climate policies; it materially reduces greenhouse gas emissions in a hard-to-decarbonize subsector, saves consumers money, improves air qualify, compliments other decarbonization efforts -- all with minimal disruptions to status quo behaviors and practices.

B. Implement a Properly Structured, Technology-Neutral Clean Fuel Standard (CFS) program

For a more comprehensive, cost-efficient, and long-term solution to encourage low carbon fuels, as well as ZEVs, New York should follow the DSP's recommendation and create a properly structured, technology-neutral Clean Fuel Standard ("CFS"). We strongly support this initiative and urge its speedy implementation.

1. Rationale for a CFS

The DSP's recommendation for "Lower Carbon Renewable Fuels" recognized the integral role that lower carbon renewable fuels will play in achieving the CLCPA's goals. Despite the eleven key recommendations designed to "reduce the State's reliance on fossil fuels for transportation as expeditiously as possible," there will still be many liquid-fueled vehicles and equipment in use in 2030 and beyond. As stated in the DSP:

> Given the service life of current vehicles and equipment under the most aggressive scenarios identified for transitioning to zero-emission technologies, fossil fuels are expected to constitute most of the fuel mix until the mid- or late-2030s. Substituting sustainable renewable fuels for a portion of this remaining fossil fuel combustion will reduce GHGs and other emissions.[111]

Because the DSP "expedites electrification as much as reasonably feasible, any GHG emission reductions from the use of renewable fuels are in addition to the emission reductions from accelerated electrification."[112] As discussed in Section VI (B), though renewable fuels still emit some air pollutants, their displacement of petroleum-based gasoline is associated with lower emissions of PM and other local pollutants.

2. CFS Program Design and Benefits

[111] DSP at 118.
[112] *Id.*

The DSP puts forth the CFS as the main policy to harness the environmental benefits of renewable fuels while at the same time encouraging the adoption of ZEVs, which would likewise be incentivized.

California's LCFS and Oregon's CFS have successfully reduced transportation emissions and stimulated innovations in those states and across the country. Washington State is currently in the process of implementing its own LCFS.[113]

Though there is room for design improvements, these programs have cost-efficiently driven down greenhouse gas emissions from transportation. California's LCFS program has resulted in over 77 million metric tons of avoided carbon as of May 2021.[114] Particularly notable is the increased use of biodiesel and renewable diesel, which made up 27 percent of all on-road diesel sold in the state, displacing nearly 900 million gallons of fossil fuel-derived diesel – a reduction of 17 million metric tons of carbon dioxide in 2019.[115]

From the beginning of Oregon's program in 2016 through 2020, approximately 5.3 million metric tons of greenhouse gas emissions have been reduced because of the program as illustrated in the figure below:[116]

[113] Washington's Clean Fuel Standard law requires fuel suppliers to gradually reduce the carbon intensity of transportation fuels to 20 percent below 2017 levels by 2038. The Washington Department of Ecology announced rulemaking for the Clean Fuels Program Rule in July 2021. The program will begin in January 2023. *See* https://ecology.wa.gov/Air-Climate/Climate-change/Reducing-greenhouse-gases/Clean-Fuel-Standard; *see also Transportation Fuel – Clean Fuels Program* Chapter 317, Laws of 2021 (partial veto) 67th Legislature, 2021 Regular Session (July 25, 2021), https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Session%20Laws/House/1091-S3.SL.pdf?q=20210716000002.

[114] *See* Renewable Fuels Association, *The California LCFS and Ethanol: A Decade of Reducing Greenhouse Gas Emissions* (May 2021), https://ethanolrfa.org/file/9/RFA-LCFS-Report_PDF.pdf.

[115] California Air Resources Board, *Latest state Greenhouse Gas Inventory shows emissions continue to drop below 2020 target* (July 28, 2021), https://ww2.arb.ca.gov/news/latest-state-greenhouse-gas-inventory-shows-emissions-continue-drop-below-2020-target.

[116] State of Oregon Department of Environmental Quality, *Oregon Clean Fuels Program: Program Review* Submitted to: 2022 Oregon Legislature (Feb. 1, 2022), https://www.oregon.gov/deq/ghgp/Documents/CFP-ProgramReview.pdf.

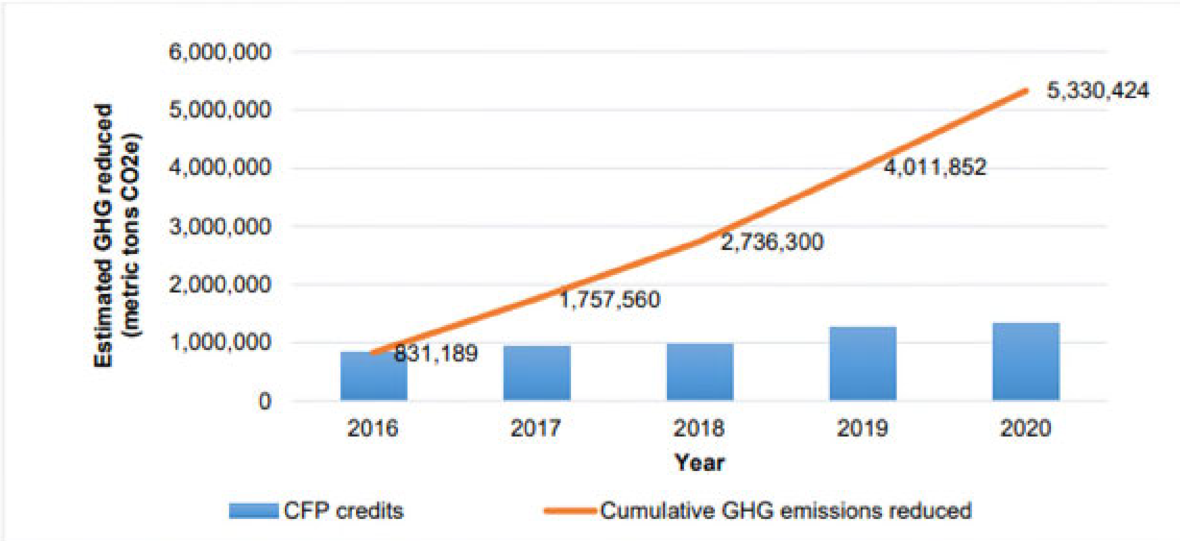


Figure 3. Estimated greenhouse gas reductions between 2016–2020

California's LCFS successfully incentivized the corn ethanol production process itself to become less carbon intensive. Since the LCFS began in 2011 to 2019, the average carbon intensity of ethanol fuel has decreased by approximately 25 percent, due to changes in how ethanol plants are producing their fuel.[117]

As stated in the DSP, a typical CFS requires "the providers of fossil fuels to reduce the carbon content of the fuels they provide by either blending lower carbon fuels or by acquiring credits from providers of lower-carbon fuels into the stream of commerce." Such a CFS on the one hand would place a cost on petroleum fuels, encouraging adoption of cleaner alternatives and promote the use of fuels that have a lower fuel cycle carbon intensity. But at the same time, the funds received under the program could be devoted to further accelerate transition to lower carbon fuels by providing a revenue stream to those alternative fuel or electricity providers.

It is a cost-efficient policy that allows those actors who can most easily transition to lower carbon fuels to be amply rewarded for doing so, while allowing those for whom transitioning would be prohibitively expensive or unfeasible in the near term an alternative form of compliance – *i.e.*, purchasing credits from providers of lower-carbon fuels. That is, businesses that can execute carbon reduction measures at low cost are able to generate many credits cheaply. Businesses that cannot transition due to cost or would have the option of buying those cheap credits. The end result is that the total emissions associated with the transportation sector are reduced at the lowest overall cost to businesses and their customers.

Properly designed, a CFS can lessen or eliminate completely the need for the allocation taxpayer or ratepayer funding. Credit purchases paid by petroleum fuel providers under the

[117] U.S. Dep't of Agriculture, *The California Low Carbon Fuel Standard: Incentivizing Greenhouse Gas Mitigation in the Ethanol Industry* (Nov. 2020), https://www.usda.gov/sites/default/files/documents/CA-LCFS-Incentivizing-Ethanol-Industry-GHG-Mitigation.pdf.

program would finance the use of lower carbon fuels including ZEVs. Given New York's increasingly decarbonized grid, the incentives for electric vehicles and other ZEVs would actually increase as the carbon intensity of electricity decreases.

Nor would it need to be limited to private vehicles or fleets. As noted in the DSP, the DEC could structure the program to reward public transportation providers, providing them with resources to electrify their rolling stock and build out the needed infrastructure. Aviation fuel providers could opt in on a voluntary basis expanding the reach of the program, reducing emissions in this difficult-to-electrify subsector.

Because such a program would be a comprehensive policy framework, it would unlock even greater benefits from biofuels such as bioethanol. In addition to the features noted in the DSP, a CFS would unlock the following benefits:

- A CFS would foster the in-state development of clean fuel technologies. As noted before, New York already has a large-scale biofuel plant in Medina, New York, which has been operating since 2007.[118] And New York should encourage further innovation in the clean fuels sector by incentivizing further improvements to the carbon intensity of corn-based bioethanol. Additionally, a CFS can incentivize other clean fuel technology development in New York, such as carbon capture or direct air capture of CO_2 when the CO_2 is then utilized to make fuels. A number of entities are implementing the conversion of CO_2 to ethanol, for example, which can then be combined with other sources of ethanol to create sustainable aviation and other liquid fuels.

- A CFS could incentivize low carbon farming and forestry practices by creating a value chain with which to compensate farmers and forest owners for sustainable behaviors. The DSP, in a separate section, recommends "develop[ing] low carbon fuel strategies for hard to electrify applications" to "[i]ncreas[e] market access for NY low-carbon products."[119] A CFS would complement these efforts by DEC and NYSERDA.

- A CFS could also encourage carbon sequestration projects by rewarding carbon capture and sequestration associated with the transportation sector, as California currently does in its LCFS program. A CFS could also create a value chain for waste methane collection and conversion to useful products, helping to address one of the most difficult to decarbonize sectors of the economy. The DSP puts forward a suite of policies under its "sustainable biomass feedstock action plan for 2050 hard-to-decarbonize products."[120] A CFS could enhance these efforts by providing incentive for such products.

[118] *See* Western New York Energy, https://www.wnyenergy.com/.
[119] DSP, Appendix A, at 94.
[120] DSP, Appendix A, at A-147, A-148.

- If designed properly, a CFS would have emission benefits by incentivizing the adoption of low carbon-intensity fuels, even if ZEV adoption accelerates faster than the DSP anticipates.
- A CFS could be designed and implemented in tandem with an E15 incentive as well as policies to encourage Flex-Fuel Vehicles.

3. <u>Implementation and Timeline</u>

The DSP lays out reasonable regulatory steps and anticipated timelines to implement a CFS in New York. The DSP correctly notes that most if not all of this policy could be implemented through regulatory action by the DEC under its existing authority.

We agree with the DSP that New York could look to existing programs in other states such as California and Oregon for lessons learned. But in doing so, New York should carefully balance the reduction in administrative cost with importing aspects of those programs that may not fit the New York market or are not settled.

For instance, the carbon intensity scores in California's LCFS, cited in the DSP, are the subject of going stakeholder discussion. California's LCFS credits greenhouse gas reductions at ethanol facilities, but does not yet credit reductions achieved through farmer adoption of agriculture practices that reduce carbon intensity in feedstock production such as tillage, nutrient management, and where appropriate, cover crops. New York should consider incentivizing such actions to make the LCFS promote sustainable agriculture and land use practices statewide. By allowing fuel producers to pay farmers to implement lower carbon intensive practices (*e.g.*, using less fertilizer) or agricultural products (*e.g.*, lower carbon feedstocks), the LCFS can lower the already lower CI of bioethanol, and drive further GHG reductions in the both the transportation and agricultural sectors.

Second, we would caution against wholesale importation of the CI values form the California LCFS, which are currently under refinement. In 2020, the average CI value for ethanol was 58.6 g/MJ, compared to 100.8 g/MJ for gasoline—a 42% GHG reduction. Oregon approved the following average carbon intensity of approved pathways for ethanol from 2016 – 2021: 62.45, 61.51, 58.85, 57.57, 57.12, 51.70.[121] Note that the measured CI of ethanol has decreased since the beginning of Oregon's program.

C. Incentive for Flex-Fuel Vehicles

Finally, to maximize the benefits of an CFS or E15 incentives, New York should consider pursuing policies to increase the amount of Flex-Fuel Vehicles that are capable of running on E85. This would increase the number of vehicles that can take advantage of higher fuel blends, and further leverage the decarbonization benefits of greater availability of higher-bioethanol blends in New York.

---

[121] State of Oregon Department of Environmental Quality, *Oregon Clean Fuels Program: Program Review* Submitted to: 2022 Oregon Legislature (Feb. 1, 2022), https://www.oregon.gov/deq/ghgp/Documents/CFP-ProgramReview.pdf, at 11 (as measured in gCO_2E/MJ).

This policy can be pursued in tandem with an E15-specific incentive and/or establishment of a properly designed, technology-neutral CFS.

VIII. Conclusion

Bioethanol and biofuels can play an integral role in reducing New York's greenhouse gases while bringing a whole host of ancillary benefits, including lower fuel prices, improved air quality, and greater national security. To fully unlock this potential, the Council's final scoping plan should provide firm policy guidance that will bring these benefits to fruition. The Council need not sacrifice or alter its plans to electrify the transportation sector or reduce VMT through increased investments in public transit and bicycle infrastructure. All these policies can proceed on parallel paths – each complementing the progress of the others.

We are grateful for the opportunity to provide these comments and look forward to working together with the Council and other stakeholders to decarbonize New York's transportation sector in the years ahead.

Appendix A

Evaluation of the Potential Economic and Carbon-Emission Benefits Associated with the Conversion of E10 to E15 in New York

Edgeworth Economics

EVALUATION OF THE POTENTIAL ECONOMIC AND CARBON-EMISSION BENEFITS ASSOCIATED WITH THE CONVERSION OF E10 TO E15 IN NEW YORK

Edgeworth Economics

June 29, 2022

I. Introduction

In December 2021, the New York State Climate Action Council published a "Draft Scoping Plan" (the "Plan") that provides potential pathways for shifts in economic activity that would allow the State to meet the targets for greenhouse-gas ("GHG") emissions through 2050 set by the Climate Leadership and Community Protection Act. The Plan addresses all key sectors, including transportation. Regarding the transportation sector, the Plan provides various proposals and analyses to address that sector's contributions to potential reductions in GHG emissions through shifts in fuel use and other mitigation strategies. Although the Plan recognizes that renewable fuels with lower carbon emissions compared to conventional gasoline may exist for both light-duty vehicles ("LDVs") and heavier-duty commercial vehicles, the Plan focuses primarily on conversion of the LDV fleet to zero-emission vehicles ("ZEVs")—i.e., electric vehicles—essentially ignoring the potential for a shift to lower-carbon liquid fuels for the LDV fleet.[1] However, since the strategies proposed by the Plan assume that new liquid-fuel LDVs will continue to be sold in New York through 2035, and that some of those vehicles will remain on the road until at least 2050, conversion to lower-emission liquid fuels could provide a beneficial intermediate strategy for New York before attaining full electrification.[2]

Renewable ethanol, in particular, provides a lower-carbon alternative to petroleum-based or "neat" gasoline. Moreover, blending ethanol into gasoline provides a variety of other benefits for consumers and the economy more generally. Domestically produced ethanol already has largely replaced other fuel additives (which may be harmful to health, more expensive, and/or less effective) in gasoline, reducing the demand for imported crude oil, reducing carbon emissions, and generating savings for consumers and retailers due to the lower cost to produce gasoline. Essentially all standard gasoline sold at retail today is a blend known as "E10" which contains approximately 10 percent ethanol combined with petroleum-based gasoline blendstock.[3]

The benefits associated with the inclusion of ethanol in gasoline, however, are not limited to a 10-percent ethanol blend. Increasing the share of ethanol in gasoline is a trend that has accelerated around the U.S. in recent years, with the introduction of a 15-percent blend ("E15") as an alternative to E10 as well as the

---

[1] Draft Scoping Plan, pp. 101-103.

[2] Draft Scoping Plan, pp. 94-97 and Appendix G, p. 37.

[3] DOE website, www.eia.gov/todayinenergy/detail.php?id=26092.

expansion of the availability and consumption of higher blends such as "E85."[4] Increasing the blend for standard gasoline up to 15 percent results in a fuel with comparable quality to E10, while providing proportionately more of the benefits noted above. In 2012, the U.S. Department of Energy (DOE) conducted a rigorous test of E15 across a range of engine types for model year 2001 and newer vehicles and found no adverse impact on any measure of LDV performance, including fuel economy as well as maintenance, stating:[5]

> The Energy Department testing program was run on standard gasoline, E10, E15, and E20. The Energy Department test program was comprised of 86 vehicles operated up to 120,000 miles each using an industry-standard EPA-defined test cycle (called the Standard Road Cycle). *The resulting Energy Department data showed no statistically significant loss of vehicle performance (emissions, fuel economy, and maintenance issues) attributable to the use of E15 fuel compared to straight gasoline.*

Consistent with these findings, essentially all major automobile manufacturers have approved their new vehicles to use E15.[6] According to the U.S. Department of Agriculture (USDA), approximately 93 percent of LDVs in operation, responsible for 97 percent of gasoline consumption, are so approved.[7]

Currently, E15 is offered for sale at gasoline stations in more than half of the states across the U.S., including several on the East Coast such as Pennsylvania, Maryland, and Virginia. As of the January of this year, no gasoline stations in New York had yet begun to offer E15 following approval in November 2019. However, the apparent benefits of E15, as well as the trends of E15 growth in other states that introduced the fuel earlier, indicate that the introduction and expansion of sales in New York likely will occur soon, even with no further policy changes. However, various policy approaches—such as an E15 mandate, incentives for introduction by gasoline stations, or incentives for consumption—could accelerate the transition from E10 to E15 in New York, leading to increased and accelerated cost-savings for consumers and/or gasoline retailers as well as reduced carbon emissions, compared to a business-as-usual approach.

This paper analyzes trends in E15 sales across the U.S. and assesses the potential benefits for New York consumers and retailers, as well as carbon-related benefits, from the introduction and expansion of the market for that fuel blend.

---

[4] In 2011, the U.S. Environmental Protection Agency (EPA) approved E15 for use in model year 2001 and newer LDVs. [DOE website, afdc.energy.gov/fuels/ethanol_e15.html] The product known as "E85" actually may contain a range of ethanol blends from 51 percent to 83 percent—depending on location, season, and other considerations. E85 can be used in LDVs designated as "flex-fuel" vehicles, which comprise a relatively small, but growing, share of the overall LDV fleet. [DOE website, afdc.energy.gov/fuels/ethanol_e85.html]

[5] DOE, "Getting It Right: Accurate Testing and Assessments Critical to Deploying the Next Generation of Auto Fuels," May 16, 2012 (emphasis added), available at www.energy.gov/articles/getting-it-right-accurate-testing-and-assessments-critical-deploying-next-generation-auto. Although ethanol has a lower energy density than neat gasoline, the improved oxygenate characteristics of ethanol offset this factor at relatively low blend levels. Thus, modest increases in blending percentage above E10 have no adverse impact on fuel economy for LDVs. [See also, Environmental and Energy Study Institute website, www.eesi.org/papers/view/fact-sheet-high-octane-fuels-challenges-opportunities]

[6] USDA, "Assessing Future Market Opportunities and Challenges for E15 and Higher Ethanol Blends," May 2022, pp. 8-9.

[7] USDA, "Assessing Future Market Opportunities and Challenges for E15 and Higher Ethanol Blends," May 2022, p. 8.

II. Cost-Related Benefits of E15 to Consumers and Gasoline Retailers

As noted above, in addition to benefits related to energy security and sustainability, the use of E15 provides potential savings for consumers and retailers based on the difference between the wholesale cost of the components of E15 relative to E10. In particular, ethanol generally sells for less, per gallon, than conventional gasoline blendstock ("CBOB"). Moreover, the generation of credits under the national Renewable Fuel Standard program (known as Renewable Identification Numbers or "RINS") when blending ethanol into gasoline provides additional value from increasing the proportion of ethanol in retail gasoline. The savings generated by E15 relative to E10 can be calculated from the wholesale prices of gasoline blendstock, ethanol, D6 (conventional) RINs as follows:

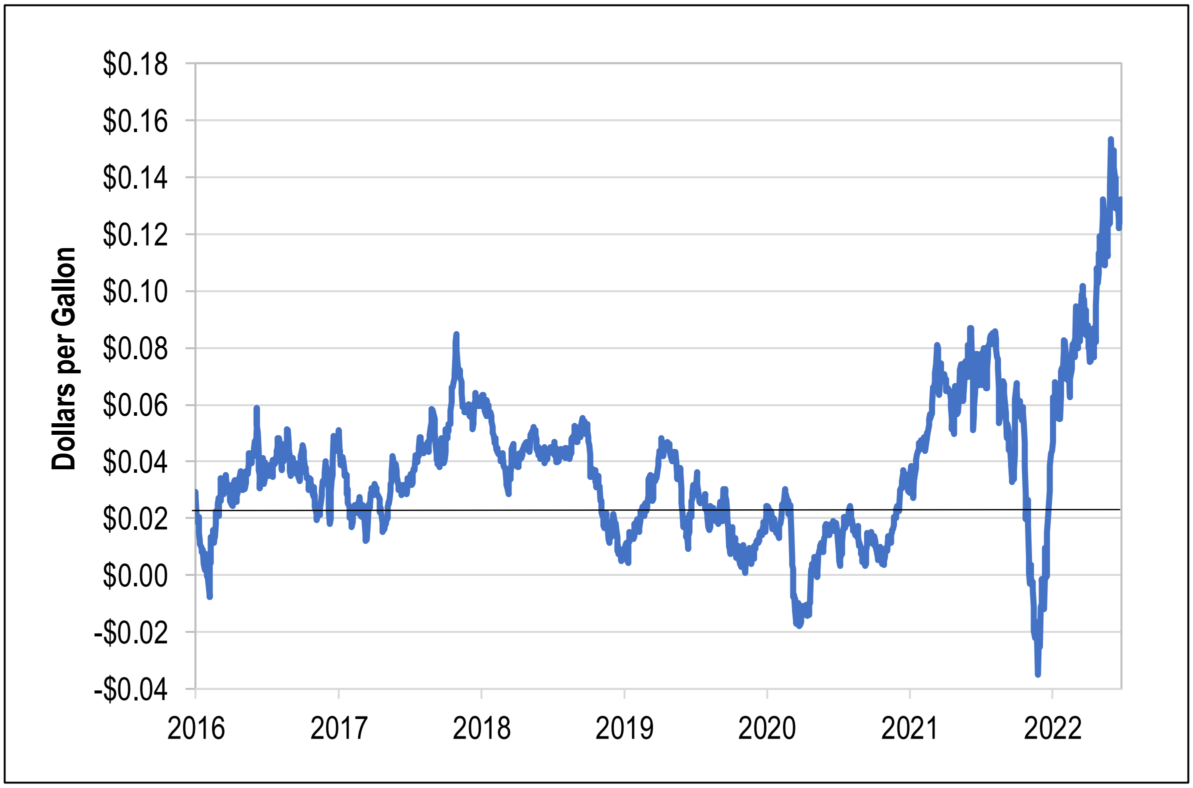
E15 Savings Relative to E10 per Gallon of Gasoline = (CBOB Price - Ethanol Price + RIN Price) × 5%

Using this formula, the savings from E15 relative to E10 generally have fluctuated between zero and 8 cents per gallon over the last several years, with levels reaching over 10 cents in recent months as petroleum prices have escalated, as shown in Figure 1.[8] In the 12-month period through June 2022, the E15 discount relative to E10 averaged $0.067 per gallon at wholesale, equal to about 1.8 percent of the average retail price of gasoline in New York during the same period.[9]

[8] As shown in Figure 1, for brief periods the discount for E15 relative to E10 has fallen below zero due to temporary increases in the prices of ethanol relative to gasoline blendstock, two fuels which otherwise generally move in similar directions. A variety of circumstances can lead to these conditions; but they usually last for short periods and usually are related to the higher volatility of gasoline blendstock prices relative to ethanol prices. For example, CBOB prices fell substantially in March-April 2020 due to conditions associated with the COVID pandemic, while ethanol prices were affected less significantly. The opposite circumstances occurred in late-2021, when CBOB prices rose significantly for about two months, while ethanol prices remained relatively flat.

[9] Based on an average retail price of gasoline in New York of $3.18 per gallon. [DOE website, www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_sny_dpg&f=m]

Figure 1
E15 Savings Relative to E10 (Wholesale), January 2016 – June 2022

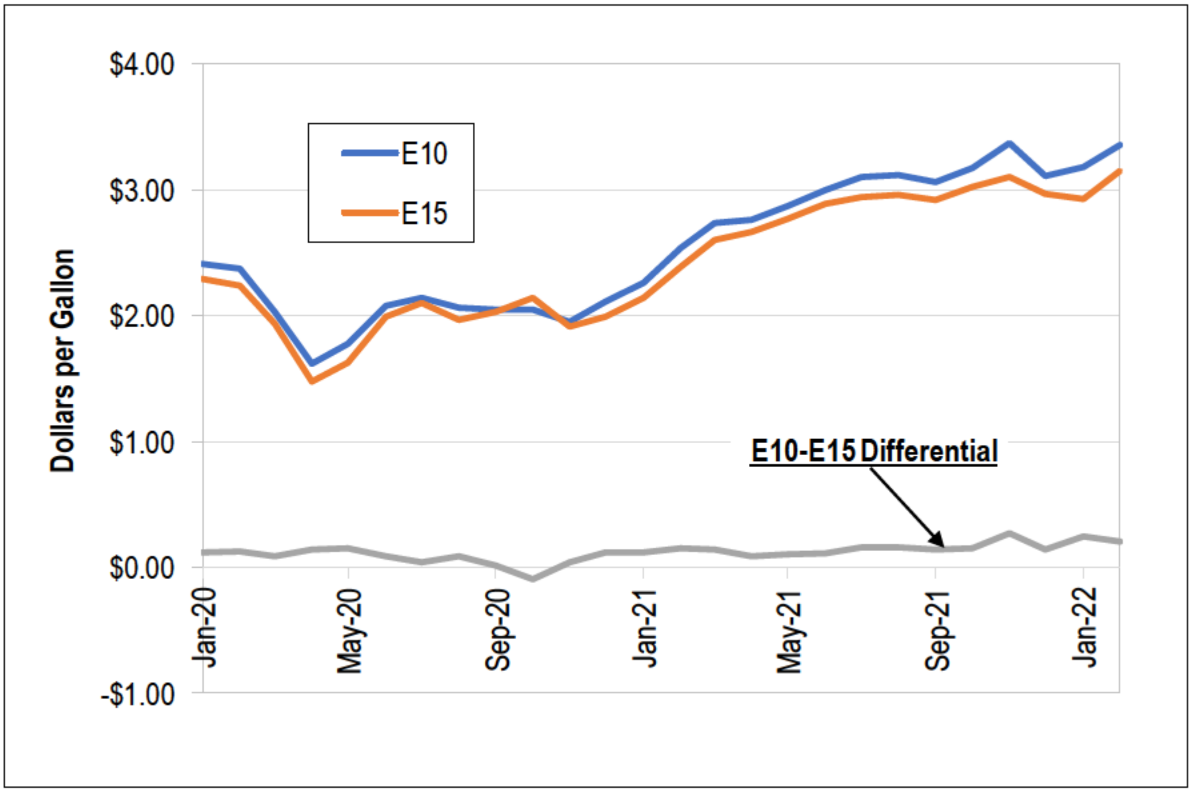


Source: OPIS data for the Chicago market and Edgeworth Economics calculations (see text).

Moreover, these savings apparently are being passed on to consumers, as retail price differentials have generally equaled, if not exceeded, the wholesale differentials in recent months. As shown in Figure 2, according to data self-reported by certain gasoline stations to the Renewable Fuels Association ("RFA"), the discount for E15 relative to E10 has averaged approximately $0.12 per gallon since January 2020.[10]

[10] There are a variety of reasons why reported retail discounts for E15 may exceed the wholesale values, as calculated above. For example, some stations may choose to price E15 below the notional spread from E10 as a loss leader. Other stations may expect different assessments by consumers regarding the octane value of ethanol-based fuels. Finally, the stations reporting E15 prices to RFA may not be representative of the entire industry due to regional factors or particular marketing strategies.

Figure 2
Average E10/E15 Differential at Retail, January 2020 – February 2022



Source: RFA website, e85prices.com.
Note: These averages are based on self-reporting to RFA by dozens of gasoline stations across approximately 20 states.

III. Trends in Gasoline Stations Offering E15 and Sales of E15

The experiences from a number of states across the U.S. demonstrate the potential for E15 growth in New York. Following approval by the EPA in 2011, E15 was introduced in a few states in 2012, with gasoline stations in more states launching the fuel each subsequent year. Growth in terms of the number of gasoline stations offering the product as well as sales per station began to accelerate around 2016/2017. While corn-producing states in the Midwest have led the industry, with some states now offering E15 at more than 5 percent and even more than 10 percent of all stations, significant gains have been seen in many other states, including large states distant from the corn-growing region such as Florida and Pennsylvania. Nationwide, there are now approximately 2,600 gasoline stations that offer E15 across 30 different states (see Table 1). This figure has more than doubled in just the last four years, as shown in Figure 3.

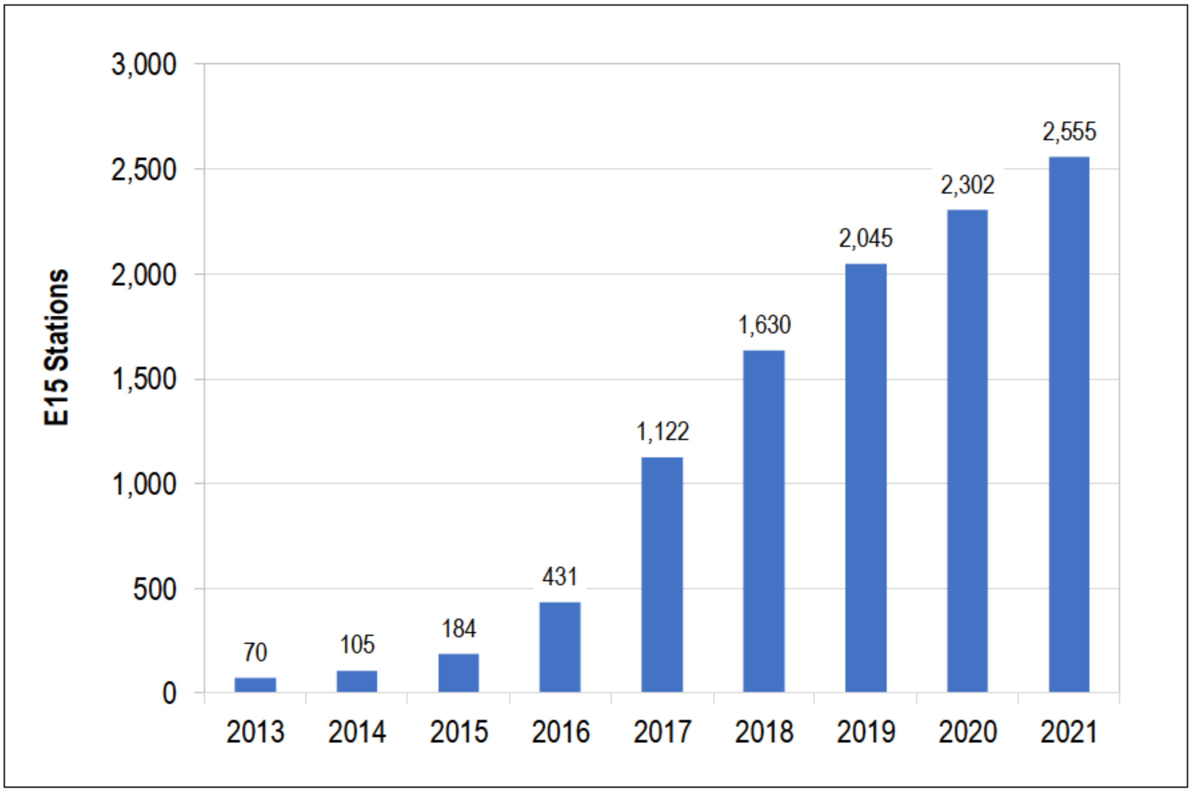
Table 1
Gas Stations Offering E15, by State, as of January 2022

State	Stations Offering E15	% of All Stations in the State
MN	372	14.4%
WI	302	9.1%
IA	274	12.6%
TX	196	1.6%
FL	186	2.3%
PA	155	3.7%
IL	135	3.8%
NE	110	7.8%
GA	95	1.2%
NC	85	1.5%
AL,AR,CO,IN,KS,KY,LA,MD,MI,MO,MS,ND,NM, OH,OK,SD,TN,VA,WV,WY	653	1.3%
AK,AZ,CA,CT,DC,DE,HI,ID,MA,ME,MT,NH,NJ, NV,NY,OR,RI,SC,UT,VT,WA	0	0.0%
U.S. Total	**2,563**	**1.8%**

Sources: RFA station list, as of January 2022; DOE website, afdc.energy.gov/files/u/data/data_source/10333/10333_gasoline_stations_year.xlsx.

Note: Total number of gas stations is based on 2012 data from the NACS, extrapolated to 2022 based on the 2007-2012 trend.

Figure 3
Total Number of Gasoline Stations in the U.S. Offering E15, 2013 – 2021



Source: RFA.

Two states, Iowa and Minnesota, have tracked E15 sales at the station level and publish data that allows a more granular assessment of these trends. As shown in Table 2, over the last few years, these two states have seen rapid increases in both the number of gasoline stations offering E15 as well as the volume of E15 sales per station, resulting in compound annual growth rates ("CAGR") for total E15 sales in the range of 80 to 90 percent annually over the 5-year period through 2020. Prior to the COVID pandemic in 2020, which caused substantial declines in nationwide gasoline consumption, E15 growth was even more rapid, with 4-year CAGR in the two states exceeding 100 percent—i.e., more than doubling each year. As of 2020, sales of E15 in each of these two states had reached approximately 4 to 5 percent of all gasoline sales.

Table 2
Gasoline Stations Offering E15 and Total E15 Sales in Iowa and Minnesota, 2016 – 2020

	Iowa				Minnesota			
	Number of Stations Selling E15	E15 Gallons per Station	Total E15 Gallons (Million)	E15 Share of All Gasoline Sales	Number of Stations Selling E15	E15 Gallons per Station	Total E15 Gallons (Million)	E15 Share of All Gasoline Sales
2016	160	34,588	5.5	0.3%	112	50,750	5.7	0.2%
2017	226	122,604	27.7	1.8%	257	74,149	19.1	0.8%
2018	220	161,203	35.5	2.3%	337	177,149	59.7	2.6%
2019	244	200,653	49.0	3.1%	363	217,420	78.9	3.4%
2020	251	241,387	60.6	4.5%	394	190,554	75.1	3.7%
2016-19 CAGR	15.1%	79.7%	106.8%		48.0%	62.4%	140.3%	
2016-20 CAGR	11.9%	62.5%	81.9%		37.0%	39.2%	90.6%	

Sources: Minnesota Commerce Department website, mn.gov/commerce/consumers/your-vehicle/clean-energy.jsp; Iowa Department of Revenue website, tax.iowa.gov/report-category/retailers-annual-gallons; and DOE website, www.eia.gov/dnav/pet/pet_cons_prim_a_EPM0_P00_Mgalpd_m.htm.

Note: Total gasoline sales in Minnesota are from DOE estimates of Prime Supplier Sales Volumes of Motor Gasoline.

Due to resistance by the large integrated refiners, to date most of the growth in E15 sales nationwide has been generated by independent chains (*i.e.*, retailers without refinery/discovery operations) and owners of a single retail outlet or a small number of outlets. Table 3 lists the major brands currently offering E15 across the U.S.

Table 3
Retail Gasoline Station Brands Offering E15, as of January 2022

Brand	E15 Stations	% of Total
Kwik Trip	451	17.6%
Casey's General Stores	398	15.5%
Sheetz	325	12.7%
Kum & Go	178	6.9%
RaceTrac	171	6.7%
Murphy USA	75	2.9%
Thorntons	75	2.9%
Kwik Star	73	2.8%
QuikTrip	70	2.7%
Holiday	56	2.2%
Integrated Refiners (e.g., Exxon, Chevron, Shell)	102	4.0%
Other	589	23.0%
Total	**2,563**	100.0%

Source: RFA.

This tendency is likely to shift as more large states, such California, begin to incentivize conversion of the LDV fleet to lower-carbon fuels. As the integrated refiners begin to include E15 in their mix of products with more frequency, the expansion of overall sales will accelerate. In fact, it appears that some integrated refiners may be shifting towards strategies to include greater proportions and selections of biofuels in their product mix. For example, earlier this year Chevron announced that it was spending more than $3 billion to acquire Iowa-based Renewable Energy Group, a company specializing in biofuel production and marketing.[11] Renewable Energy Group currently sells both E15 and E85, and the company's website identifies the benefits of those fuels to include reduced emissions, improved engine performance, and other contributions to the U.S. economy.[12]

IV. Economic and Distributional Impacts of Converting Liquid-Fuel LDVs from E10 to E15 in New York

The pattern of growth evident in states that have allowed, and in some cases actively encouraged, sales of E15 provides evidence of the potential for the conversion of E10 to E15 in New York. Moreover, sales of E15 could ramp up even more quickly with additional incentives or mandates. Based on these considerations, it is clear that transitioning the portion of New York's LDV fleet that consumes liquid fuel from E10 to E15 would have significant economic benefits for consumers and retailers in the State, even in the policy scenarios envisioned by the Plan that target essentially full electrification by 2050.

For example, consider a scenario in which conversion of the liquid-fuel LDV fleet in New York from E10 to E15 begins in 2023 and ramps up to 100 percent over a 10-year period. In this scenario, a 1.8-percent reduction in consumer expenditures on gasoline—the average wholesale discount for E15 relative to E10 during the last 12 months, as described above—would result in savings of $25 million (2020$) in 2023 using the Plan's assumptions regarding gasoline consumption and prices.[13] Those benefits would increase to a maximum of $237 million in 2032 under the Plan's no-action Reference Case and would average $180 million annually during the entire 2023-2050 period. Under the Plan's action scenarios, E15 conversion would provide smaller economic benefits, since larger portions of New York's LDV fleet would be converted to electric. Those benefits nonetheless still would be significant. Under the Plan's four policy scenarios, conversion to E15 in the same pattern as described above would generate peak annual savings of $156 million to $198 million in 2032 (depending on the policy scenario) and would average $78 million to $100 million annually over the entire 2023-2050 period.[14] Figure 4 shows these savings on an annual basis from 2023 through 2050 for the Plan's Reference Case and the four policy scenarios.

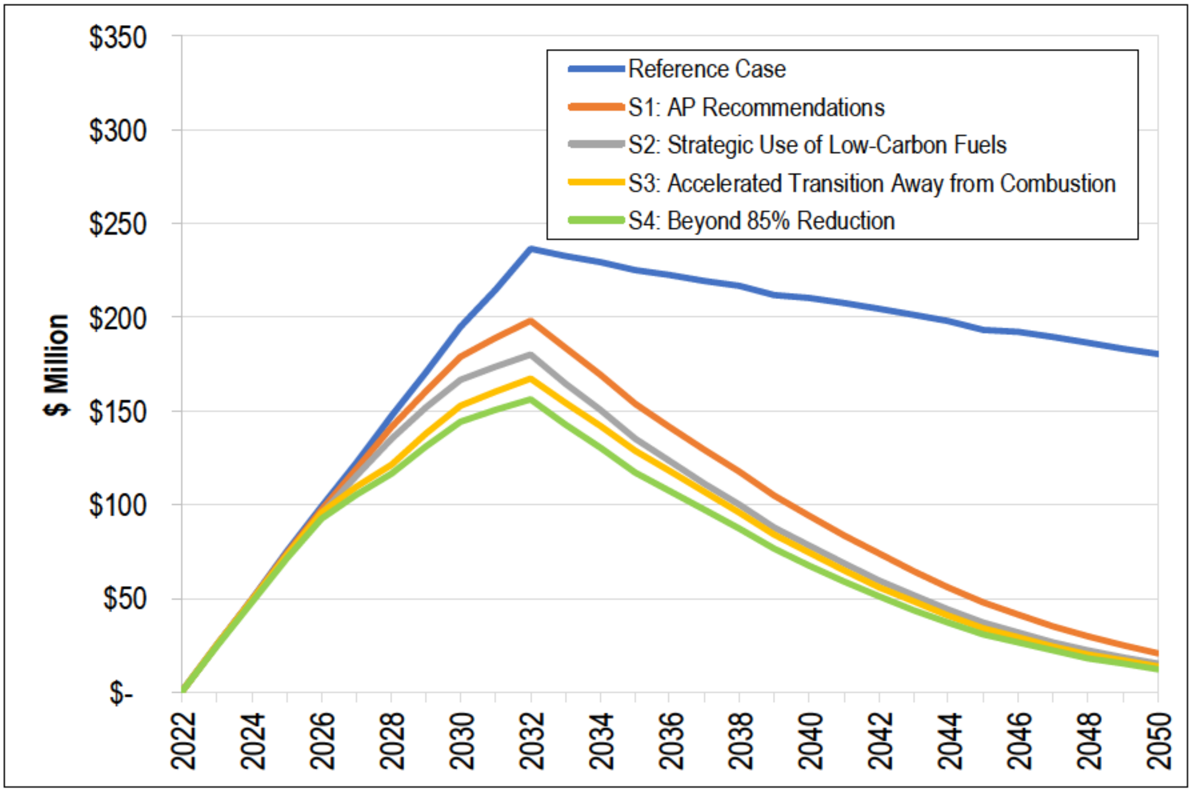
[11] Renewable Energy Group press release, "Chevron Announces Agreement to Acquire Renewable Energy Group," February 28, 2022, available at www.regi.com/blogs/blog-details/resource-library/2022/02/28/chevron-announces-agreement-to-acquire-renewable-energy-group.

[12] Renewable Energy Group website, www.regi.com/products/transportation-fuels/reg-gasoline-ethanol-blends.

[13] Based on a linear ramp-up of gasoline conversion over a 10-year period starting in 2023 (i.e., 10 percent conversion in 2023, 20 percent in 2024, etc.). The 1.8 percent reduction in expenditures on gasoline (see Section II, above) was applied to the Plan's Reference Case "Final Energy by Fuel by Sector" for gasoline in the transportation sector (measured in btu) for each year, and then multiplied by the Plan's assumptions for the price of transportation gasoline (measured in $ per btu) in each year. [Draft Scoping Plan, Appendix G: Annex 1: Inputs and Assumptions] This approach assumes that lower wholesale prices are passed on to consumers dollar for dollar. To the extent that some of the discount is retained by retailers, the benefit to consumers would be less but the overall benefit to the New York economy would be the same. If the discount for E15 is greater at retail than wholesale (see footnote 10), then benefits to consumers could be greater than indicated here.

[14] Based on the same methodology as described in footnote 13, above, applied to the Plan's four policy scenarios.

Figure 4
Savings from Converting the Liquid-Fuel LDV Fleet in New York to E15 (million $ per year)
Draft Scoping Plan Reference Case and Policy Scenarios
2022 – 2050



It is also important to consider the distributional aspects of the savings derived from increased consumption of E15 as a replacement for E10. The economic impacts associated with lower gasoline prices do not affect all households equally. To the contrary, it has been well documented in academic and policy literature that gasoline consumption tends to be inelastic with respect to income—that is, lower-income households tend to spend a greater share of their income on gasoline than higher-income households.[15] This effect similarly impacts non-White (Black, Hispanic, and Native American) households, as well as rural households, which also tend to be lower-income. That is, these groups tend to spend a greater share of their income on gasoline than White and/or urban households. Thus, encouraging the expansion of E15 in New York, resulting in lower gasoline prices, would tend to benefit lower-income, non-White, and rural households in greater proportion than higher-income, White, and urban households.

[15] See, for example, Bart Hobijn and David Lagakos, "Inflation Inequality in the United States," *Federal Reserve Bank of New York Staff Reports*, n. 173, October 2003; Antonio M. Bento, Lawrence H. Goulder, Mark R. Jacobsen, and Roger H. von Haefen, "Distributional and Efficiency Impacts of Increased US Gasoline Taxes," *American Economic Review*, v. 99, n. 3, 2009, pp. 667-699; Elisheba Spiller, Heather M. Stephens, and Yong Chen, "Understanding the Heterogeneous Effects of Gasoline Taxes Across Income and Location," *Resource and Energy Economics*, v. 50, November 2017, pp. 74-90; and American Council for an Energy-Efficient Economy, "Analysis: Gasoline Costs Consume Nearly 20% of Some Household Budgets," May 20, 2021, available at www.aceee.org/blog-post/2021/05/analysis-gasoline-costs-consume-nearly-20-some-household-budgets.

For example, consider the impact of a 1.8 percent reduction in gasoline prices due to conversion from E10 to E15, as described above. In 2021, expenditures on gasoline in New York averaged $1,956 per household.[16] Thus, conversion to E15 for a given household consuming the average amount of gasoline would generate annual savings of approximately $33 per year.[17] This amount would represent approximately 0.11 percent of the annual income for a New York household at the 25th income percentile, compared to 0.03 percent for a New York household at the 75th income percentile.[18] Thus, conversion from E10 to E15 in New York could benefit households at the 25th income percentile at a rate about four times greater than households at the 75th percentile, in terms of percentage of income. To the extent that higher-income households consume more gasoline, this differential would be mitigated, but it is clear that the benefits from conversion to E15 would be progressive in terms of income levels.

V. Potential Reductions in Carbon Emissions Due to Converting Liquid-Fuel LDVs from E10 to E15 in New York

As noted above, carbon emissions from ethanol are substantially lower than from neat gasoline. A recent peer-reviewed meta-analysis identified a central estimate for the carbon intensity ("CI") of corn-based ethanol (the primary type of ethanol blended into gasoline in the U.S.) of 55 grams of CO_2-equivalent per megajoule (gCO2e/MJ), 43 percent lower than the CI for neat gasoline, which averages about 96 gCO2e/MJ.[19] These figures indicate that the use of E10 already has reduced New York's carbon emissions relative to a scenario where the state's LDV fleet utilized E0 or an equivalent petroleum-based fuel by about 4.5 percent, or 2.9 MMTCO2e per year at present rates of fuel consumption.[20] Conversion to E15 would reduce carbon emissions further by approximately 2.2 percent.[21]

Attaining emissions reductions of this magnitude would represent a valuable contribution the overall targets established in the Plan. If New York were to begin converting to E15 starting in 2023 and were to achieve complete conversion over a 10-year period in the same manner as described above, emissions through 2050 would be reduced by 23.9 MMTCO2e under the Plan's no-action Reference Case.[22] This amount represents 1.8 percent of all LDV emissions during that period, or 0.4 percent of total energy emissions

---

[16] Based on an estimate of total expenditures on gasoline in New York in 2021 divided by the most recent U.S. Census estimate for New York of 7,417,224 households. This estimate is calculated by applying the percent change in total U.S. gasoline supply from 2020 to 2021 to actual New York expenditures in 2020. [DOE website, www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mgfupus2&f=a, www.eia.gov/state/seds/seds-data-fuel.php?sid=US, and www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epmr_pte_y35ny_dpg&f=a; and U.S. Census website, www.census.gov/quickfacts/fact/table/NY,US/HCN010212]

[17] Based on a the most recent U.S. Census estimate for New York of 7,417,224 households. [U.S. Census website, www.census.gov/quickfacts/fact/table/NY,US/HCN010212]

[18] Based on annual income figures as of 2021. [DQYDJ website, dqydj.com/income-percentile-by-state-calculator]

[19] Melissa J. Scully, Gregory A. Norris, Tania M. Alarcon Falconi, and David L. MacIntosh, "Carbon Intensity of Corn Ethanol in the United States: State of the Science," *Environmental Research Letters*, v. 16, n. 4, 2021, p. 16.

[20] Based on the figures cited above from Scully, *et al.* (2021), the average CI score for E10 is about 91.9 [0.9 × 96 + 0.1 × 55].

[21] Based on the figures cited above from Scully, *et al.* (2021), the average CI score for E15 is about 89.9 [0.85 × 96 + 0.15 × 55].

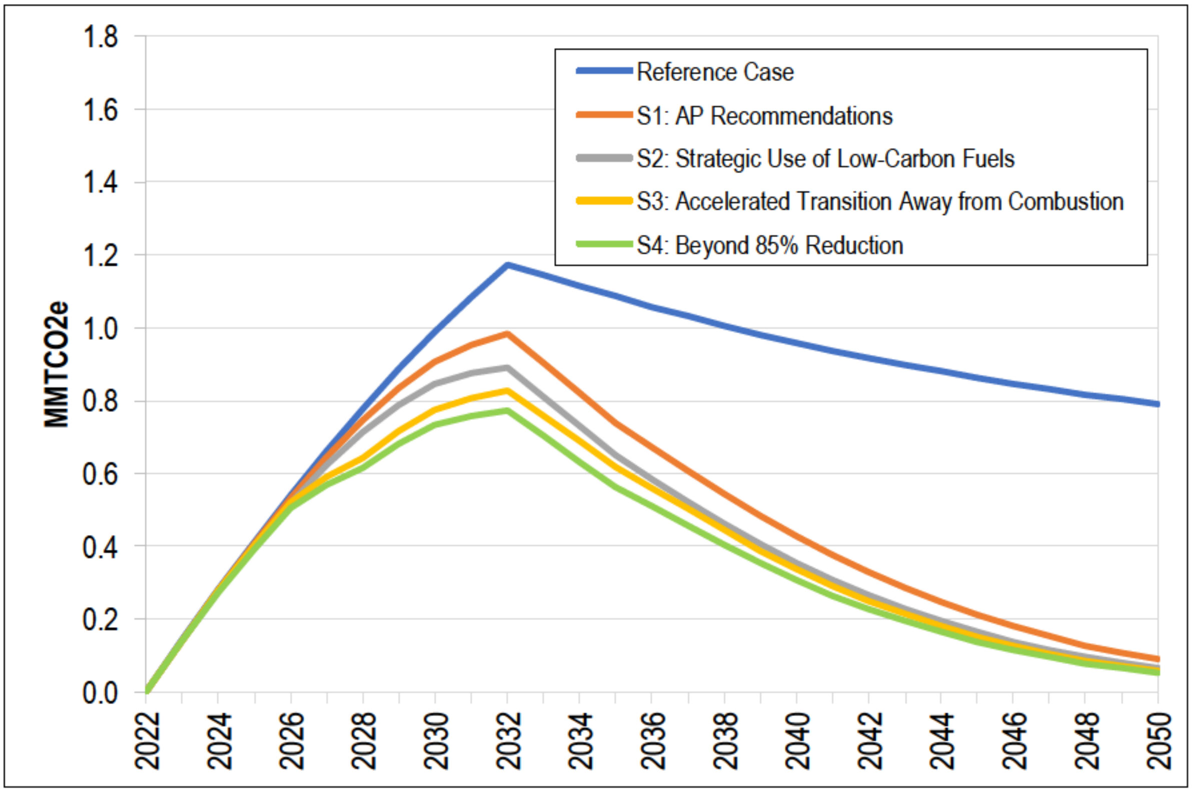
[22] Based on the assumption that conversion of "gasoline" (as defined in the Plan, presumed to be 100 percent E10) to E15 results in a reduction of CI of 2.1 gCO2e/MJ (0.0022 MMTCO2e/Tbtu) and a linear ramp-up of conversion (see footnotes 13 and 20, above). These assumptions were applied to the Plan's Reference Case and policy scenario results for "Final Energy by Fuel by Sector" and compared to the results for "Energy Emissions by Subsector." [Draft Scoping Plan, Appendix G: Annex 2: Key Drivers and Outputs]

from all sectors.[23] According to the assumptions utilized in the Plan, these emissions reductions would be valued at $3.6 billion through 2050, or about $128 million annually, an amount similar in magnitude to the cost-related benefits of E15 conversion, as described above.[24] Under the Plan's action scenarios, E15 conversion would provide smaller emissions reductions, since larger portions of New York's LDV fleet would be converted to electric. The benefits nonetheless still would be significant. Under the Plan's four policy scenarios, conversion to E15 in the same pattern as described above would generate emissions reductions in the range of 10.8 to 13.7 MMTCO2e through 2050, representing 0.8 – 1.0 percent of all LDV emissions during that period, or 0.2 – 0.3 percent of total energy emissions from all sectors. Figure 5 shows the emissions reductions on an annual basis from 2023 through 2050 for the Reference Case and the four policy scenarios. These benefits would be valued at a total of $1.5 billion to $2.0 billion through 2050 (depending on the policy scenario), or $55 million to $71 million average per year.

[23] Based on a comparison to total emissions from 2023 through 2050 for the Reference Case as shown in "Energy Emissions by Subsector". [Draft Scoping Plan, Appendix G: Annex 2: Key Drivers and Outputs]

[24] Based on the annual values, from 2023 through 2050, of "U.S. Social Cost of GHG Pollutant Mitigation by Discount Rate". [Draft Scoping Plan, Appendix G: Annex 1: Inputs and Assumptions]

Figure 5
Carbon Emission Reductions from Converting the Liquid-Fuel LDV Fleet in New York to E15
(MMTCO2e per year)
Draft Scoping Plan Reference Case and Policy Scenarios
2022 – 2050



VI. Transition Costs

The rapid growth in the number of gasoline stations offering E15 elsewhere in the U.S. indicates that transition costs are not likely to be a significant impediment to expansion in New York. Adding a new fuel blend or replacing a previously sold blend, such as a mid-grade E10, are both feasible solutions for a gas station seeking to include E15 among its choices for retail customers.[25] Pre-blended E15 also can be obtained from more than 300 suppliers at about 100 terminals across the U.S., an increase from only five terminals as of 2017.[26] These terminals store, mix, and distribute gasoline blendstock, ethanol, and other additives to trucks for delivery to both independent and integrated retail stations.[27] At present, these terminals are concentrated in the Midwest, but also are present already in some southern and eastern states such as Texas, Pennsylvania, and North Carolina. Moreover, as demand for E15 increases around

[25] See, for example, Jerry Soverinsky, "The Case for E15," *NACS Magazine*, February 2018, available at www.nacsmagazine.com/issues/february-2018/case-e15.

[26] Based on data collected by Growth Energy.

[27] More than 90 percent of the approximately 1,300 terminals across the U.S. have the capability for handling ethanol. [Kristi Moriarty, "High Octane Fuel: Terminal Backgrounder," National Renewable Energy Laboratory, Technical Report NREL/TP-5400-65760, February 2016]

the country, it is likely that more wholesalers will begin to offer pre-blended E15 at terminals in states such as New York.

Another option is for gasoline stations to blend on-site, using E85 and conventional E10. Blender pumps can be installed to replace pre-existing pumps or added in the normal course of expansion or upgrades over time. Blending on-site apparently is a common option for many stations today, as about 80 percent of the stations across the U.S. that currently offer E15 also offer E85.[28] Thus, the 120 gas stations in New York that already offer E85 would be likely candidates for early adoption of E15. The cost of a new blender pump, at about $30,000, could be recouped from the savings generated by E15 in no more than one to three years, based on the range of price differentials observed at wholesale and retail, described above.[29]

Moreover, there exist a variety of programs to assist station owners with the introduction of new biofuels. For example, USDA's Higher Blends Infrastructure Incentive Program has made available up to $100 million in grants to expand the availability of biofuels.[30] Some of these funds already have been used to install blender pumps and new tanks at gas stations seeking to offer E85 and/or E15.[31] Private initiatives, such as Growth Energy's "Prime the Pump" program, also offer support including marketing assistance and funding to help cover transition costs.[32]

If New York were to implement strategies to promote the introduction of E15 by retail gasoline stations or otherwise incentive consumption, that would further ease the transition for the retail sector, leading to more rapid introduction and expansion of E15 as a replacement for E10 across the State.

---

[28] RFA station list as of January 2022.

[29] At 200,000 gallons per year (approximately the average throughput for E15 experienced at the stations tracked in Iowa and Minnesota, as described above), savings from selling E15 could generate $10,000 to $20,000 in additional profits per year, based on current wholesale/retail differentials. Moreover, since New York gas stations generally experience greater levels of throughput than stations in those Midwestern states, payback of an initial investment in pumps likely would occur even more quickly in New York.

[30] USDA website, www.rd.usda.gov/hbiip.

[31] See, for example, Environmental and Energy Study Institute, "E15 Bill Attempts to Solve Ethanol Conundrum," June 16, 2017, available at www.eesi.org/articles/view/e15-bill-attempts-to-solve-ethanol-conundrum.

[32] Growth Energy website, growthenergy.org/wp-content/uploads/2019/11/MDEV-19022-PTP-Overview-2019-11-12.pdf.

Appendix B

Comments on the New York State Climate Action Council Draft Scoping Plan (July 1, 2022)

Environment Health & Engineering, Inc.

Environmental Health & Engineering, Inc.
180 Wells Avenue, Suite 200
Newton, MA 02459-3328
TEL 800-825-5343
781-247-4300
FAX 781-247-4305
www.eheinc.com

July 1, 2022

The New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203-6399

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

RE: Comments on the New York State Climate Action Council Draft Scoping Plan (EH&E 22493.1)

We are writing to provide comments on the New York State (NY) Climate Action Council Draft Scoping Plan (DSP). We at Environmental Health & Engineering, Inc. (EH&E) are a multi-disciplinary team of environmental health scientists and engineers with expertise in measurements, models, data science, life cycle analyses (LCAs), and public health. Our comments are largely based upon our research that have resulted in two peer-reviewed publications: one being a review of the carbon intensity (CI) for corn ethanol in the United States (US).[1] and the second is a comprehensive assessment of the impacts of corn ethanol fuel blends on tailpipe emissions of regulated pollutants. In addition, a parallel assessment of air toxics emissions in relation to ethanol blends combusted in light-duty vehicles that is currently in peer review.[2]

Our comments summarize the best available science on the relationship between ethanol, tailpipe emissions, and health. We also review the role of biofuels in NY's DSP and demonstrate why inclusion of biofuels in NY's transportation plan is important for disadvantaged communities. Our detailed comments on those topics are presented following the summary.

1. SUMMARY

We reviewed the best available science on the connection between ethanol, emissions, air quality, and health. Our review of the literature and results from our emission studies demonstrate benefits of higher ethanol fuel blends. In section 2, we show that as the percentage

[1] Scully et al. 2021.
[2] Kazemiparkouhi et al. 2022a, 2022b.

of ethanol blended with gasoline increases, the content of aromatics (hazardous air pollutants) in the fuel decrease. To the extent that ethanol is a substitute for aromatics in fuel, higher ethanol fuel blends reduce particle matter (PM), benzene, toluene, ethylbenzene, m/p-xylene and o-xylene (BTEX), 1-3 butadiene, black carbon (BC), and particle number (PN) emissions with no concomitant increase in carbon monoxide (CO), total hydrocarbons (THC), oxides of nitrogen (NOx), or acrolein emissions (section 3). Although ethanol fuel blends have higher acetaldehyde and potentially formaldehyde emissions than non-ethanol fuels, atmospheric measurements indicate that use of ethanol blends do not increase concentrations of acetaldehyde and formaldehyde above background levels in ambient air, indicating that emissions from other sources are larger than from light-duty vehicles.

Numerous studies have shown that 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. As cardiovascular disease is the leading mortality cause in NY, higher ethanol fuel blend offers a valuable opportunity to reduce PM concentrations and risk of adverse cardiovascular and respiratory outcomes (section 5). Higher ethanol fuel blends would also likely reduce benzene concentrations (an aromatic) and the associated cancer risk, since 40% of benzene emissions are attributed to the transportation sector and higher ethanol fuel content has lower aromatic emissions.

In section 6, we consider the disproportionate impact of air pollution on disadvantaged communities (DACs). DACs are more likely to be situated near dense traffic corridors and may be exposed to higher concentrations of pollutants, in particular PM. An increase in the ethanol content of fuels can decrease DACs' exposure to PM and the associated adverse health impacts.

Our final section highlights the greenhouse gas (GHG) benefits of corn ethanol. We find that, when using the best available science, the current carbon intensity (CI) estimate for corn ethanol is approximately 46% lower than the CI estimate for neat gasoline. We encourage NY to use the best available science when considering CI values that inform policy.

2. CORN ETHANOL FUEL BLENDS

Most gasoline used for light-duty vehicles in the US is E10, which contains a blend of 10% (by volume) ethanol with a gasoline blend stock, higher ethanol blends (e.g., E15), and neat gasoline (E0) sold in lesser quantities. Ethanol is used as a fuel additive in gasoline to boost octane without the harmful impacts posed by previous fuel additives such as methyl tert-butyl ether (MTBE) and lead. Octane rating reflects the ability of a fuel to avoid premature or auto ignition.[3] Aromatics, such as benzene, toluene, ethylbenzene, and BTEX also boost gasoline octane, but they are considered hazardous air pollutants.[4] The high-octane rating of ethanol thus also enables

[3] Anderson et al. 2012.
[4] Clark et al. 2021.

reduction of aromatics in the fuel.[5] In our recent study, we showed that aromatic levels decrease by approximately 7% by volume for each 10% by volume increase in ethanol content.[6] These findings are consistent with market fuel studies and with octane blending studies[7] and have implications for tailpipe emissions of light-duty vehicles, as will be discussed in the next section.

3. CORN ETHANOL FUEL BLENDS AND TAILPIPE EMISSIONS

The DSP relies primarily on studies conducted prior to 2008[8] to support its statement that alcohol-based fuels have higher emissions of respiratory irritants, carcinogens, acrolein, formaldehyde, and acetaldehyde than petroleum-based fuels.[9] These older studies may reflect a vehicle fleet composition that is not representative of current conditions. Light-duty vehicle fuel economy has increased by 32% in the US since vehicle model year 2004,[10] and emissions have decreased. For light-duty vehicles, the US Environmental Protection Agency (EPA) lowered the permissible emissions of CO, NOx, non-methane organic gases (NMOG), PM, and formaldehyde from Tier 1 standards to Tier 2 standards (which took full effect in 2004), with additional reductions (Tier 3 standards) being phased in since 2017.[11] Thus, all vehicles on the road in the US prior to 2008 were held to Tier 1 (highest permissible emissions) and Tier 2 standards, while nearly all vehicles today are held to Tier 2 and Tier 3 (lowest permissible emissions) standards.

To better reflect current ethanol impacts on vehicle emissions, we reviewed over 95 studies that characterized emissions from light-duty vehicles powered by E0 and ethanol blends, focusing on Tier 2 and higher vehicles. These studies assessed pollutant emissions from a wide variety of common vehicle models, engine types, and engine operating conditions (e.g., cold start, hot running, and hot start[12]) and were conducted by both commercial and public organizations. We also draw from our own two recent studies, which are the first large-scale analyses of data from light-duty vehicle emissions studies to examine real-world impacts of ethanol-blended fuels on air pollutant emissions.[13] We summarized the results of those studies and discussed implications for air quality and public health in the attached white paper (attachment A).[14]

[5] Clark et al. 2021; Kazemiparkouhi et al. 2022a; US EPA 2017.
[6] Kazemiparkouhi et al. 2022a.
[7] Anderson et al. 2010, 2012; Stratiev et al. 2017; US EPA 2017.
[8] Tang 2007; Vieira da Silva 2017; and as cited in the Renewable Fuels Roadmap (Wojnar 2010): He et al. 2003; Jacobson 2007; Karman 2003; Niven 2005; Winebrake et al. 2000, 2001.
[9] DSP 2021.
[10] Hula et al. 2021.
[11] EPA. 2022.
[12] Hot start or hot running conditions occur when an engine is started or is running at regular operating temperatures (i.e., during or soon after fully warmed-up operation). Cold start conditions occur when an engine is started at temperatures below regular operating conditions. Engine operating conditions impact tailpipe emissions, with cold start emissions accounting for a substantial portion of tailpipe emissions (Reiter and Kockelman 2016).
[13] Kazemiparkouhi et al. 2022a and 2022b.
[14] Kazemiparkouhi et al. 2022c.

Emission studies of ethanol fuel blends show that tailpipe pollutant emissions vary with ethanol and aromatic content. Higher ethanol content in fuels was associated with lower emissions of key health-relevant pollutants, PM, BC, PN, and BTEX, while fuels with higher aromatic fuel content generally showed the opposite pattern.[15] In our papers, we observed similar patterns of decreasing PM, BTEX, BC, and PN with increasing ethanol content.[16] Primary PM emissions, for example, decreased by 15 – 18% on average for each 10% increase in ethanol content under cold-start conditions.[17] Cold start PM emissions have consistently been shown to account for a substantial portion of all direct tailpipe PM emissions.[18] A 2022 California Air Resources Board (CARB) study that assessed the impact of E15 (splash-blended from E10) on air pollutant emissions for late model year vehicles (2016 – 2021) found that switching from E10 to E15 reduced PM emissions by 18%, with cold-start emissions being reduced by 17%.[19]

Ethanol blended fuels were also consistently shown to emit lower amounts of CO, THC, and non-methane hydrocarbons (NMHC) as compared to non-ethanol blended fuels, consistent with their cleaner combustion and higher amounts of acetaldehyde, which is produced directly from ethanol combustion.[20]

Less consistent was the impact of ethanol fuel blends on emissions of NOx, for which trends varied by study perhaps due to their reactivity and sensitivity to other species in the emission effluent. However, our recent study of low to mid ethanol fuel blends (E0 to E30) and CARB's 2022 study show that NOx did not change with increasing ethanol content. Acrolein emissions also did not change with increasing ethanol content, while formaldehyde emissions showed little to no significant change.[21]

To the extent that ethanol is a substitute for octane-enhancing aromatics in fuel (as discussed in section 2), our review of the literature and results from our emission studies demonstrate that higher ethanol fuel blends reduce emission for PM, BTEX, 1-3 butadiene, BC, and PN with no concomitant increase in emissions for CO, THC, NOx, or acrolein. A presentation by researchers at the University of California, Riverside who contributed to the CARB 2022 report further predict that "the introduction of E15 will likely reduce air toxics from current technology

---

[15] Clark et al. 2021; Karavalakis 2018. Karavalakis et al. 2014; Kumar and Chaurasia 2019; Liang et al. 2020; Myung et al. 2020; Roth et al. 2020; Sakai and Rothamer 2019; Schuchmann and Crawford 2019; Yang et al. 2019a, 2019b; Zheng et al. 2019.
[16] Kazemiparkouhi et al. 2022a, 2022b.
[17] Kazemiparkouhi et al. 2022c.
[18] Darlington et al. 2016; US EPA 2013.
[19] Karavalakis et al. 2022.
[20] Badrawada and Susastriawan 2019; Clark et al. 2021; Gunst 2013; Karavalakis 2018; Karavalakis et al. 2012, 2022; Kazemiparkouhi et al. 2022c; Mourad and Mahmoud 2019; ORNL et al. 2016; NREL 2013; Roso et al. 2019; Theiss 2016; Wayson 2016.
[21] Kazemiparkouhi et al. 2022a, 2022b, 2022c; Karavalakis et al. 2022.

vehicles."[22] Based on the currently available data, we agree with this expectation that E15 will reduce local pollutants when compared with E10 and E0.

4. CORN ETHANOL FUEL BLENDS AND AIR QUALITY

The estimated reductions in air pollutant emissions discussed above, particularly of PM, indicate that increasing ethanol content offers opportunities to improve air quality. We reviewed over 45 studies that examined issues related to ethanol blended fuel impacts on air quality and air pollutant exposures, with many of these studies conducted outside the US. Results from these studies were generally consistent with those from emissions testing studies. Numerous studies have shown that lower PM emissions result in lower ambient PM concentrations and exposures.[23] A study in Wisconsin found lower levels of CO after introduction of E10[24] were consistent with emission testing data that showed a reduction in CO emissions with higher ethanol content (as discussed in section 3). Similarly, an analysis of US-wide air quality measurements found that reductions of targeted aromatics in fuel were associated with lower summertime ozone levels.[25]

Less well studied is the impact of ethanol-based fuels on acetaldehyde and formaldehyde concentrations; however, atmospheric measurements indicate that use of E10 and other ethanol blends do not increase concentrations of acetaldehyde and formaldehyde above background levels in ambient air, indicating that emissions from other sources are larger than from light-duty vehicles.[26]

It is worth noting that we did not include results from 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 and health.[27] The ABS used fuels that are not representative of real-world fuels. The ABS used inaccurate fuel property adjustment factors in its modeling, reducing aromatics by only 2%,[28] which is substantially lower than the reductions found in our paper and in fuel survey data,[29] as discussed section 2. As a result, ABS's findings on air quality and their extension to public health impacts are not generalizable to real world conditions.

The DSP emphasizes the air quality and health concerns related to benzene.[30] In NY, benzene concentrations across the state have decreased significantly due to federal and state air pollution

[22] Tang et al. 2022.
[23] Kheirbek et al. 2016; Pan et al. 2019.
[24] Foley et al. 2003.
[25] Auffhammer and Kellogg 2011.
[26] Sommariva et al. 2011; de Gouw et al. 2012.
[27] EPA 2020.
[28] EPA 2020, Table 5.3.
[29] Kazemiparkouhi et al. 2022a; EPA 2017.
[30] DSP 2021, Appendix F.

control programs and regulations directed at reducing emissions from transportation and from stationary sources.[31] However, air monitoring stations show that benzene concentrations across the state are above the annual guidelines, which were set to reduce the cancer risk due to benzene to a maximum of one in one million.[32] Benzene has been classified as a known human carcinogen by the US EPA, the National Toxicology Program, and the International Agency for Research on Cancer. This classification is based in large part on findings from animal studies which show benzene exposures cause tumors after inhalation or ingestion and from epidemiological studies which show an excess risk of leukemia in humans exposed to benzene.[33] Given that 40% of benzene emissions are attributed to the transportation sector and that higher ethanol fuel content has been shown to have lower emissions of BTEX (which includes benzene; section 3), there is an opportunity for NY to use higher ethanol fuel blends to further reduce benzene concentrations and their associated cancer risk.

5. CORN ETHANOL FUEL BLENDS AND PUBLIC HEALTH

We identified over 20 studies that evaluated public health impacts of consumption of ethanol blends and/or E0, all of which used risk assessment approaches. We further identified seven recent epidemiological studies that examined associations between motor vehicle related exposures and cause-specific mortality, which together with results from emissions studies (section 3), help to inform human health impact assessments.

Epidemiology studies have not focused on impacts related directly to ethanol in fuels, but instead they focus on pollutants such as PM, ozone, and benzene.[34] These studies generally show adverse human health effects associated with exposure to these pollutants, e.g., PM and ozone exposures are shown to be associated with adverse respiratory and cardiovascular outcomes. Numerous studies have also shown that 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.[35] Cardiovascular disease is the leading mortality cause in NY, with approximately 44,000 deaths per year.[36] Using higher ethanol fuel blends in NY offers a valuable opportunity to reduce PM concentrations and adverse cardiovascular and respiratory outcomes.

We find considerable support from the emissions and epidemiological literature that substitution of ethanol for aromatics in automobile fuel may yield net public health benefits. For example, when considering cancer cases associated with benzene and other air toxics, Mueller et al. calculated that a full transition from E0 to E10 in Beijing would avoid approximately 90 cancer

[31] DSP 2021. Appendix F.
[32] DSP 2021. Appendix F.
[33] Filippini et al. 2019; IARC 2019.
[34] Ostro et al. 2015.
[35] Laden et al. 2006; Pun et al. 2017; EPA 2019; Wang et al. 2020.
[36] Laden et al. 2006; Pun et al. 2017; EPA 2019; Wang et al. 2020.

cases and \$6.5M in healthcare costs annually.[37] The human health benefits of converting to E10 would likely have been higher had the analysis also considered health impacts of exposure to fine particulate matter ($PM_{2.5}$) as indicated by the results of a study in the US.[38] In that US analysis, the authors estimated that secondary $PM_{2.5}$, formed from aromatic compounds in gasoline, accounted for approximately 3,800 premature mortalities nationwide annually and \$28B in total social costs.

Not all health impact studies were positive for ethanol, however, as a few of the studies that we reviewed found net disbenefits for ozone or PM, including one study in the US [39] and two in Brazil[40]. However, the inputs to those analyses are either outdated (e.g., emissions data reflect outdated vehicle fleet composition), or not documented fully (e.g., missing detailed descriptions of fuel properties, which have a significant impact on emissions as discussed in sections 2 and 3), which limits the reliability of their results.

6. DISCUSSION OF IMPACTS TO DISADVANTAGED COMMUNITIES IN NY

The Climate Justice Working Group identified 1,721 census tracts across New York as draft DACs, representing 35% of all census tracts. Approximately seven million people (36% of NY's population) live in DAC areas; 68% of that population are people of color (POC) and 70% live in urban areas.

The benefits to air quality and public health associated with higher ethanol fuels may be particularly great for DACs. DACs are predominantly located in urban neighborhoods with high traffic density and congestion; these communities are thus exposed to disproportionately higher concentrations of PM emitted from motor vehicle tailpipes.[41] For example, in New York, POC are exposed to more $PM_{2.5}$ from light-duty gasoline vehicles and heavy-duty diesel vehicles than average (+35% and +42%).[42]

Further, vehicle trips within urban DACs tend to be short in duration and distance, with approximately 50% of all trips in dense urban communities under three miles long.[43] As a result, a large proportion of urban vehicle operation occurs under cold-start conditions,[44] when PM emissions are highest. Given the evidence that ethanol-blended fuels substantially reduce PM

---

[37] Mueller et al. 2018.
[38] von Stackelberg et al. 2013.
[39] Jacobson 2007.
[40] Miraglia 2007; Scovronick et al. 2016.
[41] Bell and Ebisu 2012; Clark et al. 2014; Tian et al. 2013.
[42] Tessum et al. 2021.
[43] de Nazelle et al. 2010; Reiter and Kockelman 2016; US DOT, 2010.
[44] de Nazelle et al. 2010.

during cold-start conditions,[45] it follows that ethanol-blended fuels may present an effective method to reduce air pollution-related health risks for DACs.

Additionally, while the market-share of gasoline-powered light-duty vehicles is expected to decrease over the next 10 years due to electric vehicles (EVs), they still account for a majority of the vehicles driven by the US population. EVs also have higher upfront costs than gasoline powered vehicles ($19,000 higher on average) [46] which may limit their market penetration until prices become more comparable.[47] Given the financial barriers to acquire an EV and the disproportionate exposure to traffic pollution for DACs,[48] alternatives such as using higher ethanol blends may provide significant benefits to these communities.

7. CARBON INTENSITY OF CORN ETHANOL

In addition to lower emissions of key health-relevant pollutants, such as PM and BTEX, and associated benefits to air quality and health, higher ethanol fuel blends also provide significant greenhouse gas (GHG) reductions.

To quantify these GHG reductions, we conducted a state of the science review of the carbon intensity (CI) for corn ethanol in the US, applied objective criteria limited to the US regulatory context, and derived an evidence-based central CI estimate and credible range as of 2020.[49] We found that assessments of GHG intensity for corn ethanol have decreased by approximately 50% over the prior 30 years (Figure 1) and converged on a current central estimate value of approximately 51 grams of carbon dioxide equivalent emission per megajoule (gCO2e/MJ), which is about 46% lower than the average CI for neat gasoline. The decrease in GHG intensity is attributable to updates in modeling systems and input data that reflect market-driven changes that resulted in more efficient corn production and energy consumption at ethanol refineries, as well as market-based analyses of indirect land use change (iLUC). Estimates for corn farming and production of ethanol are consistent between the most recent estimates from the CARB, EPA, Argonne National Laboratory (ANL), and our analysis. The primary difference across the CI estimates for corn ethanol relates to iLUC.

[45] Kazemiparkouhi et al. 2022a.
[46] Hearst Autos Research 2021.
[47] Muehlegger and Rapson 2019.
[48] Tessum et al. 2021.
[49] Scully et al. 2021.

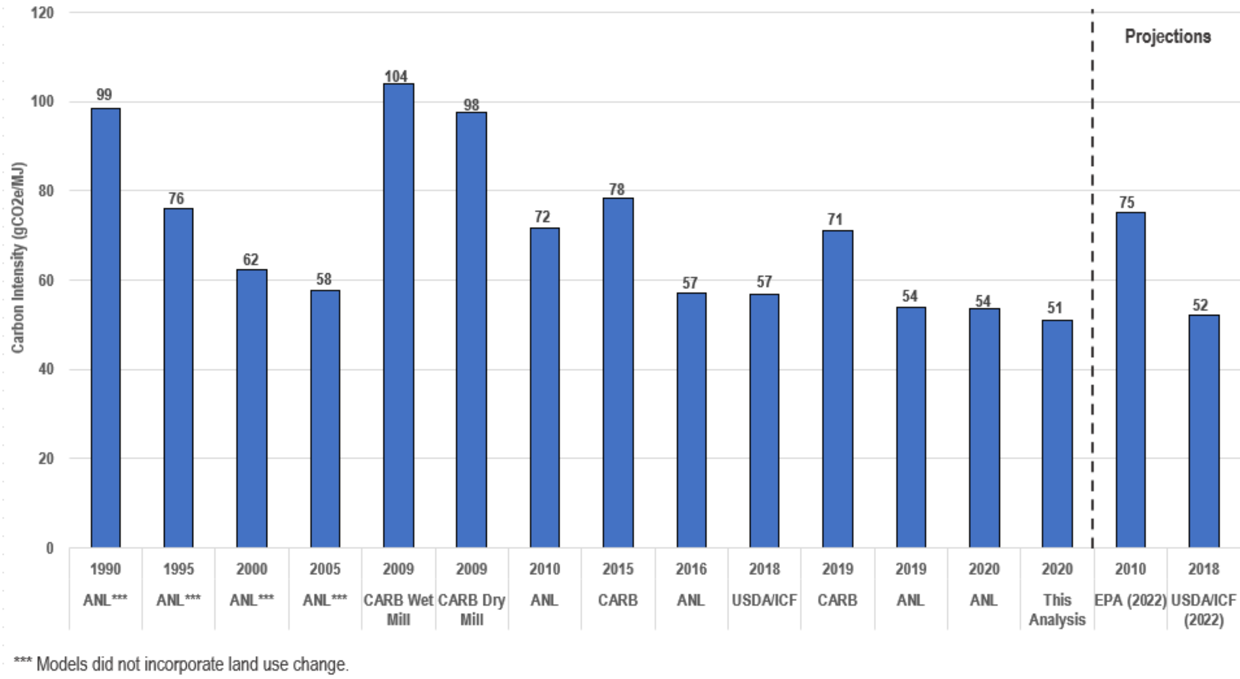


Figure 1 Timeline of estimated corn ethanol life cycle GHG emissions for 1990 – 2020 with projections out to 2022.

The plot in Figure 2 presents current iLUC estimates for corn ethanol in comparison to prior and now superseded estimates from EPA in 2010 and CARB in 2015.[50] The current estimates of iLUC GHG impacts are 2-fold – 4-fold lower than the earlier estimates from EPA and CARB. iLUC emission estimates from the most current modeling efforts and policy in the US (blue dots) are in good agreement with those from Europe (red dots).

In summary, our published research concludes that assessments of GHG intensity for corn ethanol have decreased by approximately 46% over the prior 30 years and converged on a current central estimate value of about 51 gCO2e/MJ.

[50] Carriquiry at al. 2020; Dunn et al. 2013; Lee et al. 2021; Taheripour et al. 2021; Scully et al. 2021.

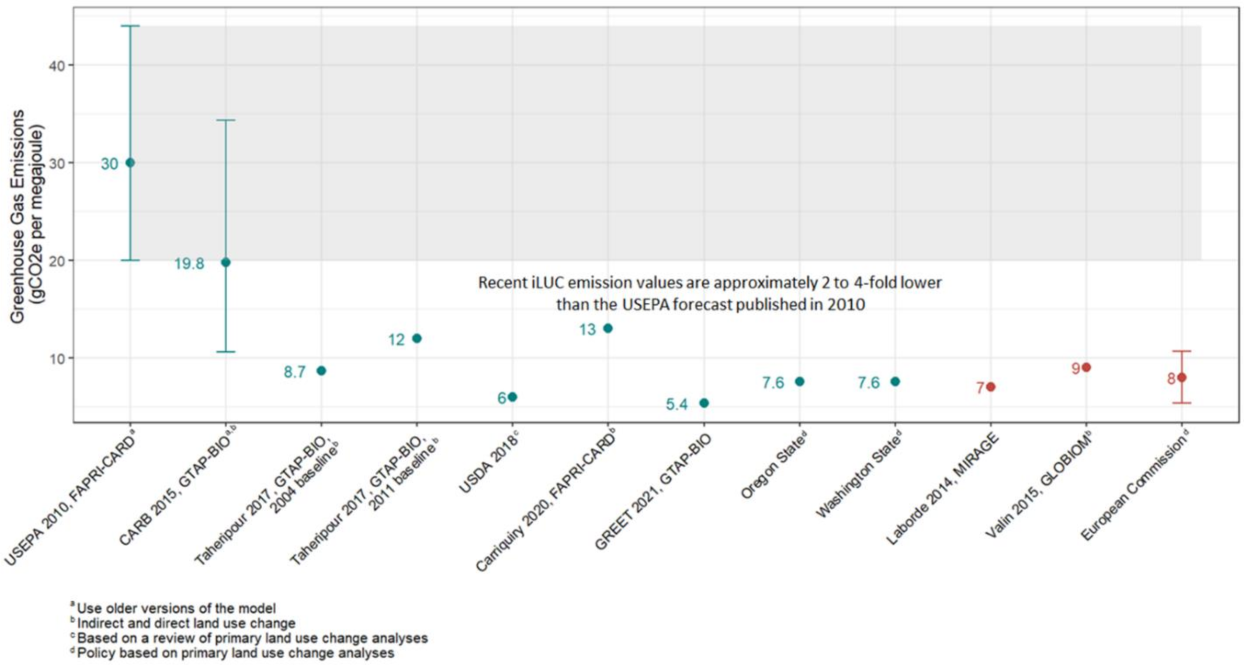


Figure 2 Comparison of accepted and proposed iLUC estimates with relevant most recent studies and values used in the regulatory context in the US and Europe

8. CONCLUSION

We summarized in these comments the best available science on the relationships between ethanol, tailpipe emissions, and health. As shown by papers we have published, a recent report from CARB, and numerous other studies, higher blends of ethanol are associated with reductions in emissions of multiple pollutants, including BTEX and PM. As discussed, these pollutants adversely impact health and disproportionately impact DACs. Thus, replacing some gasoline with increased ethanol blends can support NY's GHG reduction goals and reduce the health impacts of fuels on NY residents, including those living in DACs. We encourage NY to consider these findings when generating new policies around fuel standards.

Enclosures

Attachment A— Kazemiparkouhi F, MacIntosh D, Suh H, Clark N. 2022. Potential Air Quality and Public Health Benefits of Real-World Ethanol Fuels.

REFERENCES

Anderson JE, DiCicco DM, Ginder JM, Kramer U, Leone TG, Raney-Pablo HE, Wallington TJ. 2012. High octane number ethanol–gasoline blends: Quantifying the potential benefits in the United States. Fuel, 97: 585-94.

Anderson JE, Kramer U, Mueller SA, Wallington TJ. 2010. Octane Numbers of Ethanol− and Methanol−Gasoline Blends Estimated from Molar Concentrations. Energy & Fuels, 24, 6576-6585.

Auffhammer M, Kellogg R. 2011. Clearing the Air? The Effects of Gasoline Content Regulation on Air Quality. American Economic Review, 101 (6): 2687-2722.

Badrawada IGG, Susastriawan AAP. 2019. Influence of ethanol–gasoline blend on performance and emission of four-stroke spark ignition motorcycle. Clean Technologies and Environmental Policy, 21: 1891-96.

Bell ML, Ebisu K. 2012. Environmental inequality in exposures to airborne particulate matter components in the United States. Environmental Health Perspectives, 120, 1699-1704.

Carriquiry M, Elobeid A, Dumortier J, Goodrich R. 2020. Incorporating sub-national Brazilian agricultural production and land-use into U.S. biofuel policy evaluation. Applied Economic Perspectives and Policy, 42, pp.497-523.

Clark LP, Millet DB, Marshall JD. 2014. National patterns in environmental injustice and inequality: outdoor NO2 air pollution in the United States. PLoS One, 9, e94431.de

Clark NN, McKain Jr DL, Klein T, Higgins TS. 2021. Quantification of gasoline-ethanol blend emissions effects. Journal of the Air & Waste Management Association, 71: 3-22.

Gouw JA, Gilman JB, Borbon A, Warneke C, Kuster WC, Goldan PD, Holloway JS, Peischl J, Ryerson TB, Parrish DD, Gentner DR, Goldstein AH, Harley RA. 2012. Increasing atmospheric burden of ethanol in the United States. Geophysical Research Letters, 39.

Darlington TL, Kahlbaum D, Van Hulzen S, Furey RL. 2016. Analysis of EPAct Emission Data Using T70 as an Additional Predictor of PM Emissions from Tier 2 Gasoline Vehicles.

De Nazelle A, Morton BJ, 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.

Dunn JB, Mueller S, Kwon H-Y, Wang MQ. 2013. Land-use change and greenhouse gas emissions from corn and cellulosic ethanol. Biotechnology for Biofuels, 6(1), pp.1-3.

Filippini T, Hatch EE, Rothman KJ, Heck JE, Park AS, Crippa A, Orsini N, Vinceti M. 2019. Association between Outdoor Air Pollution and Childhood Leukemia: A Systematic Review and Dose-Response Meta-Analysis. Environmental Health Perspectives. 127(4):46002.

Foley TA, Rendahl CS, Kenski D. 2003. The effect of reformulated gasoline on ambient carbon monoxide concentrations in southeastern Wisconsin. Journal of the Air & Waste Management Association, 53: 1003-10.

Gunst R. 2013. Statistical Analysis of the Phase 3 Emissions Data Collected in the EPAct/V2/E89 Program. In.: National Renewable Energy Laboratory.

He B-Q, Shuai S-J, Wang J-X, He H. 2003. The effect of ethanol blended diesel fuels on emissions from a diesel engine. Atmospheric Environment, 37 pp. 4965–4971.

Hearst Autos Research. 2021. How Much Is an Electric Car?

Hula A, Maguire A, Bunker A, Rojeck T, Harrison S. 2021. The 2021 EPA Automotive Trends Report: Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975. EPA-420-R-21-00. Washington (DC): United States Environmental Protection Agency.

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans (IARC). 2018. Benzene. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, No. 120. 3. Cancer in Experimental Animals. Lyon (FR): International Agency for Research on Cancer.

Jacobson MZ. 2007. Effects of ethanol (E85) versus gasoline vehicles on cancer and mortality in the United States. Environmental Science & Technology, 41: 4150-7.

Karavalakis G. 2018. Impacts of Aromatics and Ethanol Content on Exhaust Emissions from Gasoline Direct Injection (Gdi) Vehicles. University of California, Riverside.

Karavalakis G, Durbin TD, Shrivastava M, Zheng Z, Villela M, Jung H. 2012. Impacts of ethanol fuel level on emissions of regulated and unregulated pollutants from a fleet of gasoline light-duty vehicles. Fuel, 93: 549-58.

Karavalakis G, Durbin TD, Tang T. 2022 Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15. Final Report. Riverside, CA: California Air Resources Board (CARB), Growth Energy Inc./Renewable Fuels Association (RFA), and USCAR.

Karavalakis G, Short D, Vu D, Villela M, Russell R, Jung H, Asa-Awuku A, Durbin T. Regulated Emissions, Air Toxics, and Particle Emissions from Si-Di Light-Duty Vehicles Operating on Different Iso-Butanol and Ethanol Blends. SAE International Journal of Fuels and Lubricants 7, no. 1 (2014): 183-99.

Karman D. 2003. Ethanol Fuelled Motor Vehicle Emissions: A Literature Review. Prepared for Air Health Effects Division, Health Canada (May).

Kazemiparkouhi F, Alarcon Falconi TM, Macintosh DL and Clark N. 2022a. Comprehensive US database and model for ethanol blend effects on regulated tailpipe emissions. Science of the Total Environment, 812, 151426.

Kazemiparkouhi F, Karavalakis G, Alarcon Falconi TM, Macintosh DL and Clark N. 2022b. Comprehensive US database and model for ethanol blend effects on air toxics, particle number, and black carbon tailpipe emissions. Atmospheric Environment: X [under review].

Kazemiparkouhi F, MacIntosh D, Suh H, Clark N. 2022c. Potential Air Quality and Public Health Benefits of Real-World Ethanol Fuels.

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(1), pp.1-14.

Kumar R, Chaurasia O. 2019. A Review on Performance and Emissions of Compression Ignition Engine Fueled with Ethanol-diesel Blend. Journal Européen des Systèmes Automatisés, 52: 205-14.

Laden F, Schwartz J, Speizer FE, Dockery DW. 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(6), pp.667-672.

Lee U, Hoyoung K, Wu M, Wang M. 2021. Retrospective analysis of the U.S. corn ethanol industry for 2005-2019: implications for greenhouse gas emission reductions. Biofuels, Bioproducts & Biorefining, 15(5), pp.1318-1331.

Liang X, Zhang S, Wu X, Guo X, Han L, Liu H, Wu Y, Hao J. 2020. Air quality and health impacts from using ethanol blended gasoline fuels in China. Atmospheric Environment, 228.

Miraglia SG. 2007. Health, environmental, and economic costs from the use of a stabilized diesel/ethanol mixture in the city of Sao Paulo, Brazil. Cad Saude Publica, 23 Suppl 4: S559-69.

Mourad M, Mahmoud K. 2019. Investigation into SI engine performance characteristics and emissions fuelled with ethanol/butanol-gasoline blends. Renewable Energy, 143: 762-71.

Muehlegger E, Rapson D. 2019. Understanding the Distributional Impacts of Vehicle Policy: Who Buys New and Used Electric Vehicles? UC Davis: National Center for Sustainable Transportation.

Mueller S, Lin J, O'Shea W. 2018. The Health Impact of Ethanol-Gasoline Blends in 5 Global Cities. In AAE Meeting. Detroit, MI: The University of Illinois at Chicago.

Myung C-L, Choi K, Cho J, Kim K, Baek S, Lim Y, Park S. 2020. Evaluation of regulated, particulate, and BTEX emissions inventories from a gasoline direct injection passenger car with various ethanol blended fuels under urban and rural driving cycles in Korea. Fuel, 262.

National Renewable Energy Laboratory (NREL). 2013. "Statistical Analysis of the Phase 3 Emissions Data Collected in the Epact/V2/E89 Program." edited by National Renewable Energy Laboratory. Golden, CO. New York State Climate Action Council Draft Scoping Plan (DSP). 2021.

Niven RK. 2005. Ethanol in gasoline: environmental impacts and sustainability review article. Renewable and Sustainable Energy Reviews 9:535–555.

Oak Ridge National Laboratory (ORNL), National Renewable Energy Laboratory (NREL), and Argonne National Laboratory (ANL). 2016. Summary of High-Octane, Mid-Level Ethanol Blends Study. In.: Oak Ridge National Laboratory.

Oak Ridge National Laboratory (ORNL). 2022. Transportation Energy Data Book, Edition 40. Table 6.2.

Ostro B, Hu J, Goldberg D, Reynolds P, Hertz A, Bernstein L, Kleeman MJ. 2015. Associations of mortality with long-term exposures to fine and ultrafine particles, species and sources: results from the California Teachers Study Cohort. Environmental Health Perspectives, 123: 549-56.

Pan S, Roy A, Choi Y, Eslami E, Thomas S, Jiang X, Gao HO. 2019. Potential impacts of electric vehicles on air quality and health endpoints in the Greater Houston Area in 2040. Atmospheric Environment, 207, pp.38-51.

Pun VC, Kazemiparkouhi F, Manjourides J, Suh HH. 2017. Long-term PM2. 5 exposure and respiratory, cancer, and cardiovascular mortality in older US adults. American journal of epidemiology, 186(8), pp.961-969.

Reiter MS, Kockelman KM. 2016. The problem of cold starts: A closer look at mobile source emissions levels. Transportation Research Part D: Transport and Environment, 43: 123-132.

Roso VR, Souza Alvarenga Santos ND, Castilla Alvarez CE, Rodrigues Filho FA, Pacheco Pujatti FJ, Molina Valle R. 2019. Effects of mixture enleanment in combustion and emission parameters using a flex-fuel engine with ethanol and gasoline. Applied Thermal Engineering, 153: 463-72.

Roth P, Yang J, Peng W, Cocker DR, Durbin TD, Asa-Awuku A, Karavalakis G. 2020. Intermediate and high ethanol blends reduce secondary organic aerosol formation from gasoline direct injection vehicles. Atmospheric Environment, 220.

Sakai S, Rothamer D. 2019. Impact of ethanol blending on particulate emissions from a spark-ignition direct-injection engine. Fuel, 236: 1548-58.

Schuchmann B, Crawford R. 2019. Alternative Oxygenate Effects on Emissions. Alpharetta, GA (United States).

Scovronick N, Franca D, Alonso M, Almeida C, Longo K, Freitas S, Rudorff B, Wilkinson P. 2016. Air Quality and Health Impacts of Future Ethanol Production and Use in Sao Paulo State, Brazil. International Journal of Environmental Research and Public Health, 13.

Scully MJ, Norris GA, Alarcon Falconi TM, MacIntosh DL. 2021. Carbon intensity of corn ethanol in the United States: state of the science. Environmental Research Letters, 16(4), pp.043001.

Sommariva R, de Gouw JA, Trainer M, Atlas E, Goldan PD, Kuster WC, Warneke C, Fehsenfeld FC. 2011. Emissions and photochemistry of oxygenated VOCs in urban plumes in the Northeastern United States. Atmospheric Chemistry & Physics, 11: 7081–96.

Stratiev D, Nikolaychuk E, Shishkova I, Bonchev I, Marinov I, Dinkov R, Yordanov D, Tankov I, Mitkova M. 2017. Evaluation of accuracy of literature gasoline blending models to predict octane numbers of gasoline blends. Petroleum Science and Technology, 35, 1146-1153.

Tang S. 2007. Unregulated Emissions from a Heavy-Duty Diesel Engine with Various Fuels and Emission Control Systems. Environmental Science and Technology. 41:5037-5043.

Tang T, Durbin TD, Johnson KC, Karavalakis G. 2022. Aiming at the increase of California's ethanol 'blend wall': gaseous and particulate emissions evaluation from a fleet of GDI and PFI vehicles operated on E10 and E15 fuels. Presentation.

Theiss T. 2016. Summary of High-Octane Mid-Level Ethanol Blends Study.

Tian N, Xue J, Barzyk TM. 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.

Taheripour F, Mueller S, Kwon H. 2021. Appendix A: supplementary information to response to 'How robust are reductions in modeled estimates from GTAP-BIO of the indirect land use change induced by conventional biofuels?' Journal of Cleaner Production., 310, pp.127431.

Tessum CW, Paolella DA, Chambliss SE, Apte JS, Hill JD, Marshall JD. 2021. PM2. 5 polluters disproportionately and systemically affect people of color in the United States. Science Advances, 7(18).

US Department of Transportation (DOT). 2010. National Transportation Statistics. Research and Innovative Technology Administration: Bureau of Transportation Statistics.

US Environmental Protection Agency (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.

US EPA. 2022. Light Duty Vehicle Emissions.

Vieira da Silva MA, Ferreira BLG, da Costa Marques LG, Murta ALS, de Freitas MAV. 2017. Comparative study of NOX emissions of biodiesel-diesel blends from soybean, palm and waste frying oils using methyl and ethyl transesterification routes. Fuel, 194: 144-156.

von Stackelberg K, Buonocore J, Bhave PV, Schwartz JA. 2013. Public health impacts of secondary particulate formation from aromatic hydrocarbons in gasoline. Environmetal Health, 12: 19.

Wang B, Eum KD, 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.

Wayson. 2016. Evaluation of Ethanol Fuel Blends in Moves2014 Model. Renewable Fuels Association.

Winebrake J, He D, Wang M. 2000. Fuel-Cycle Emissions for Conventional and Alternative Fuel Vehicles: An Assessment of Air Toxics. U.S. DOE, Argonne National Laboratory, Center for Transportation Research.

Winebrake J, Wang M, He D. 2001. Toxic Emissions from Mobile Sources: A Total Fuel-Cycle Analysis for Conventional and Alternative Fuel Vehicles. Journal of the Air & Waste Management Association 51: 10731086.

Wojnar Z. 2010. Renewable fuels roadmap and sustainable biomass feedstock supply for New York. New York State Energy Research and Development Authority (NYSERDA) Report 10-05.

Yang J, Roth P, Durbin T, Karavalakis G. 2019a. Impacts of gasoline aromatic and ethanol levels on the emissions from GDI vehicles: Part 1. Influence on regulated and gaseous toxic pollutants. Fuel, 252: 799-811.

Yang J, Roth P, Zhu H, Durbin TD, 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.

Zheng X, Wu X, He L, Guo X, Wu Y. 2019. Black Carbon Emissions from Light-duty Passenger Vehicles Using Ethanol Blended Gasoline Fuels. Aerosol and Air Quality Research, 19: 1645-54.

Environmental Health
& Engineering, Inc.
180 Wells Avenue, Suite 200
Newton, MA 02459
TEL 800-825-5343
781-247-4300
FAX 781-247-4305
www.eheinc.com

Potential Air Quality and Public Health Benefits of Real-World Ethanol Fuels

Fatemeh Kazemiparkouhi[1], David MacIntosh[1], Helen Suh[2], Nigel Clark[3]
[1] Environmental Health and Engineering, Inc., Newton, MA
[2] Tufts University, Medford, MA
[3] Consultant, Morgantown, WV

Introduction

For over twenty years, ethanol has been used as a fuel additive in gasoline to boost octane without the harmful impacts on the environment posed by previous fuel additives such as MTBE and lead. While ethanol's benefits to groundwater and lead contamination are well established, uncertainty remains regarding the impacts of ethanol on air quality and public health based on existing literature. This uncertainty largely results from the previous lack of studies that have been conducted using fuels that reflect the actual or real-world composition of gasoline with differing ethanol content.

This document addresses this uncertainty by providing new scientific evidence of the air quality and public health benefits provided by higher ethanol blends. We specifically present findings from our two recent studies, which characterized ethanol blending effects on light duty vehicle regulated emissions of criteria air pollutants[1] and air toxics. Findings from these studies demonstrate ethanol-associated reductions in emissions of key air pollutants and by extension, provide further evidence of the potential for ethanol-blended fuels to improve air quality and public health, particularly for environmental justice communities.

Impact of Ethanol-Containing Fuels on Air Pollutant Emissions

Kazemiparkouhi et al. (2022a) and Kazemiparkouhi et al. (2022b) are the first large-scale analyses of data from light-duty vehicle emissions studies to examine real-world impacts of ethanol-blended fuels on air pollutant emissions, including PM, NOx, CO, and THC (Kazemiparkouhi et al., 2022a), as well as BTEX (benzene, toluene, ethylbenzene, xylene) and 1,3-butadiene (Kazemiparkouhi et al., 2022b). In each study, we used similar approaches. 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

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

volume fraction, but also aromatic volume fraction, 90% volume distillation temperature (T90) and Reid Vapor Pressure (RVP). Further, our models examined the impacts of ethanol fuels on emissions under both cold start and hot stabilized running conditions and for gasoline-direct injection engines (GDI) and port-fuel injection (PFI) engine types. In doing so, our two papers provided important new information about real-world market fuels and their corresponding air pollutant emissions, as highlighted below.

- ***Aromatic levels in market fuels decreased by ~7% by volume for each 10% by volume increase in ethanol content*** (Table 1). Our findings of lower aromatic content with increasing ethanol content are consistent with market fuel studies by EPA and others, and with octane blending studies (Anderson et al., 2010, Anderson et al., 2012, Stratiev et al., 2017, US EPA, 2017). As discussed in EPA's Fuel Trends Report, for example, ethanol volume in market fuels increased by approximately 6.66% between 2006 and 2016, while aromatics over the same time period were found to drop by 5.4% (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 fuels with targeted properties 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., 2022a, US EPA, 2017). As a result, ABS's findings and their extension to public health impacts are not generalizable to real world conditions.

Table 1. Estimated summer 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

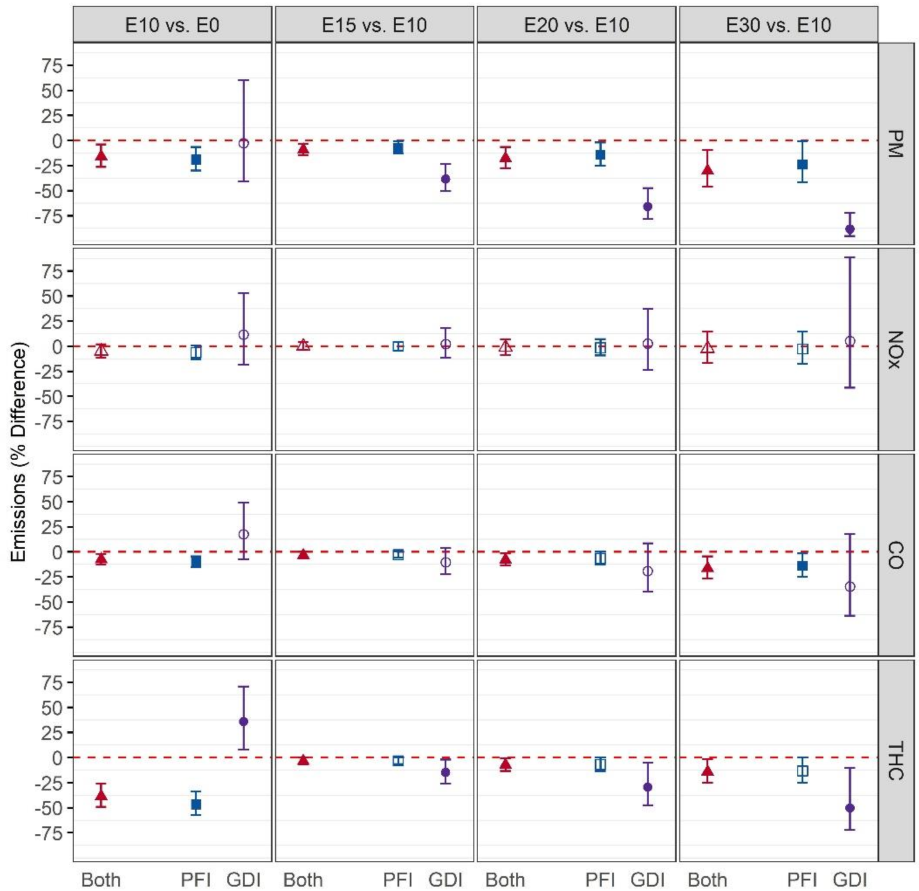
Abbreviations: EtOH = ethanol volume; T50 = 50% volume distillation temperature; T90 = 90% volume distillation temperature; Aromatics=aromatic volume; AKI = Anti-knock Index; RVP = Reid Vapor Pressure.

- ***PM emissions decreased with increasing ethanol content under cold-start conditions.*** Primary PM emissions decreased by 15-18% 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 88% and 24% lower PM emissions, respectively, when 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. Our findings of PM reductions are also consistent with recently published studies, for example from a California Air Resources Board (CARB) study (Karavalakis et al., 2022, Tang et al., 2022) that assessed the impact of splash-blending E10 to E15 on PM and other air pollutant emissions for late model year vehicles (2016-2021). The CARB study found a 16.6% reduction in cold start PM in comparison to a 23% PM reduction for E15S versus E10 in our study.

Together, 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). 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 summer market fuels[a]

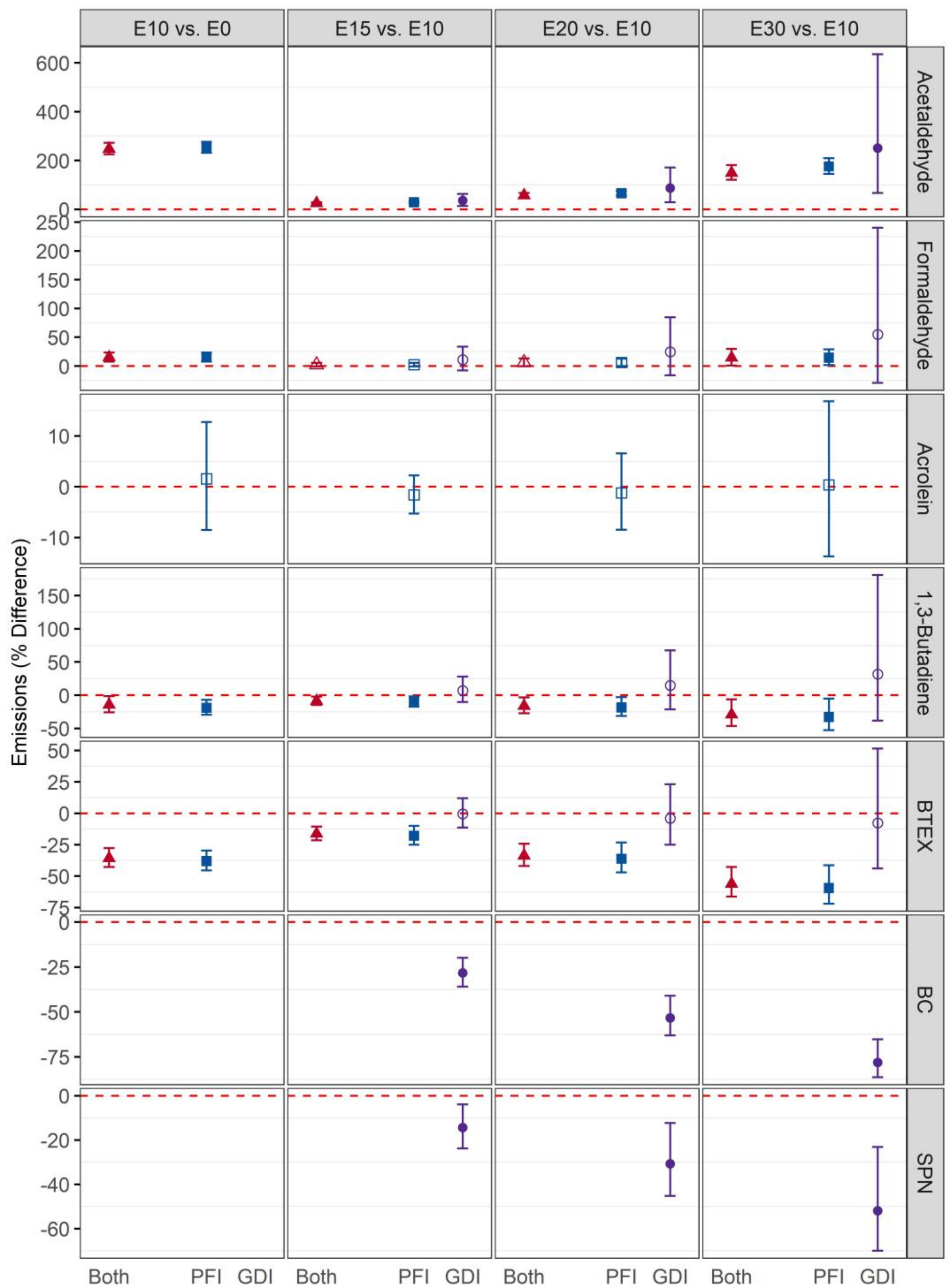


[a] Emissions were predicted from regression models that included ethanol and aromatics volume fraction, T90, and RVP as independent variables (Kazemiparkouhi et al., 2022a)

- ***Emissions of CO and THC generally decreased with increasing ethanol fuel content under cold running conditions, while NOx emissions did not change*** **(**Figure 1). The magnitude of the decrease in CO and THC emissions were comparable to those from the CARB-sponsored Karavalakis et al. (2022) study, which also found significant reductions in cold start THC and CO emissions for splash blended E15, with reductions of 6.1% and 12.1%, respectively. Under hot running conditions, CO, THC and NOx emissions were comparable for each of the examined ethanol fuels. Together, these findings add to the scientific evidence demonstrating emission reduction benefits of ethanol fuels for PM that are achieved with no concomitant increase in emissions for CO, THC, and NOx.

- ***Air toxic emissions showed lower BTEX, 1-3 butadiene, black carbon, and particle number emissions with increasing ethanol fuel content*** (Figure 2). Acrolein emissions did not vary with ethanol fuel content, while formaldehyde emissions showed little to no significant change with increasing ethanol fuel content. As expected, emissions of acetaldehyde, produced directly from ethanol combustion, increases with ethanol content. Notably, our findings are similar to those from the CARB study of splash-blended fuels (Karavalakis et al., 2022), for which ethylbenzene and xylene were significantly reduced by ~10% for splash-blended E15 (No significant change for Benzene and Toluene).

Figure 2. Change (%) in cumulative run toxics emissions for comparisons of different ethanol-content summer market fuels[a]



[a] Emissions were predicted from regression models that included ethanol and aromatics volume fraction, T90, and RVP as independent variables (Kazemiparkouhi et al., 2022a)
SPN = Solid Particle Number

The general pattern for cold-start and hot-running emissions of winter regular and summer premium fuels is in sympathy with the results for the summer fuel.

Implications for Public Health and Environmental Justice Communities

The estimated reductions in air pollutant emissions, particularly of PM, 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 operation occurs under cold start conditions (de Nazelle et al., 2010), when PM emissions are highest. Given the evidence that ethanol-blended fuels during cold-start conditions substantially reduce PM, CO, and THC emissions while keeping NOx emissions constant, 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. (2022a, 2022b) provide important, new evidence of ethanol-related reductions in vehicular emissions of PM, CO, and THC based on real-world fuels and cold-start conditions. Recent experimental data from CARB studies reinforce this evidence. Given the substantial magnitude of the emission reductions and their potential to improve air quality and through this public health, our findings demonstrate the potential for policies that encourage higher concentrations of ethanol in gasoline to improve public health. These improvements are especially needed to protect the health of EJ communities, who experience higher exposures to motor vehicle pollution and are at greatest risk from their effects.

References

ANDERSON, J. E., KRAMER, U., MUELLER, S. A. & WALLINGTON, T. J. 2010. Octane Numbers of Ethanol− and Methanol−Gasoline Blends Estimated from Molar Concentrations. Energy & Fuels, 24, 6576-6585.

ANDERSON, J. E., DICICCO, D. M., GINDER, J. M., KRAMER, U., LEONE, T. G., RANEY-PABLO, H. E., WALLINGTON, T. J. 2012. High octane number ethanol–gasoline blends: Quantifying the potential benefits in the United States. Fuel, 97, p 585-594.

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., DURBIN, T. & TANG, T. 2022. Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15. Riverside, CA (United States): California Air Resources Board (CARB), Growth Energy Inc./Renewable Fuels Association (RFA), and USCAR.

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. 2022a. Comprehensive US database and model for ethanol blend effects on regulated tailpipe emissions. *Sci Total Environ,* 812**,** 151426.

KAZEMIPARKOUHI, F., KARAVALAKIS, G., ALARCON FALCONI, T. M., MACINTOSH, D. L. & CLARK, N. 2022b. Comprehensive US database and model for ethanol blend effects air toxics, particle number, and black carbon tailpipe emissions. *Atmospheric Environment: X, [under review]*.

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).

STRATIEV, D., NIKOLAYCHUK, E., SHISHKOVA, I., BONCHEV, I., MARINOV, I., DINKOV, R., YORDANOV, D., TANKOV, I. & MITKOVA, M. 2017. Evaluation of accuracy of literature gasoline blending models to predict octane numbers of gasoline blends. Petroleum Science and Technology, 35, 1146-1153.

TANG, T., KARAVALAKIS, G., JOHNSON, K. & DURBIN, T. 2022. Aiming at the increase of California's ethanol 'blend wall': gaseous and particulate emissions evaluation from a fleet of GDI and PFI vehicles operated on E10 and E15 fuels. *32nd. CRC Real World Emissions Workshop.* San Diego, CA.

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 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.

Appendix C

Fuel Economy Changes Between E10 and E15 (June 29, 2022)

Tom Darlington

Fuel Economy Changes Between E10 and E15
June 29, 2022

I. Introduction

Ethanol blended at 10% with gasoline (i.e., E10) is used throughout the U.S. Ethanol blended at 15 vol % (E15) is also approved by EPA in 2001 and later model year vehicles. While ethanol has a somewhat lower volumetric energy content than gasoline, it also has a higher octane value. Both energy content and octane can impact fuel economy, therefore, there is interest in understanding whether there are fuel economy changes in miles per gallon between E10 and E15.

E15 is currently made using one of two methods. It can be made by splash blending an additional 5% ethanol with E10 at blending terminals, where the gasoline used for E15 is a gasoline that is designed for E10. Another method for achieving E15 is through splash blending of E85 with E10 at a gas station using a blender pump. In both cases, the gasoline to achieve E15 is actually gasoline that was designed for an E10 fuel (except for the 15% of gasoline used with E85). As a consequence, when E15 is prepared using either of these methods, it has a higher-octane value than E10.

There are have been two recent testing programs conducted by the University of California Riverside which have evaluated emissions and fuel economy differences between E10 and splash-blended E15 on very recent vehicle technologies. One testing program conducted in 2018 tested five gasoline direct injected (GDI) vehicles on an E10 EPA certification fuel and a splash-blended E15 that was made from the E10 certification fuel. The other program conducted in 2021 tested twenty vehicles on California E10 and an E15 made from California E10. Both testing programs were conducted by the University of California Riverside (UCR).

This report discusses the fuel economy differences between E10 and E15 from these two programs. The report is organized into the following sections.

- Growth Energy Testing Program
- CARB, Growth Energy, RFA, and USCAR Testing Program
- Conclusions

II. Growth Energy Testing Program on Six Vehicles[1]

Five model year 2016 and 2017 gasoline direct injection (GDI) vehicles (all passenger cars with engine sizes ranging from 1.4L to 3.6 L) were tested on 8 fuels in this study. The test cycle used was the LA92, which is more representative of in-

[1] *Impacts of Ethanol and Aromatic Content on Emissions from Gasoline Direct Injection Vehicles*, University of California Riverside, April 2018.

use driving than the EPA certification federal test procedure (FTP). The eight fuels used in this study were designed to evaluate changes in both aromatics and ethanol. There were two E0 fuels (Fuels 1 and 2), one with high and one with lower aromatics. One fuel (Fuel 3) was an E10 fuel meeting EPA certification requirements. Fuels 4 and 5 were low and high aromatic E10 fuels. Fuels 6 and 7 were low and high aromatic E15 fuels. Finally, Fuel 8 was an E20 fuel. Fuels 5 and 8 were splash blended from Fuel 3.

The average fuel economy data from the 5 vehicles for several E10 and E15 fuels are shown in Table 1. The first and most important comparison is between Fuel 3 (an E10 vehicle certification fuel) and Fuel 5, which was splash-blended from the E10. Average fuel economy increased 6% from 30.59 mpg to 32.45 mpg. This increase was statistically significant. The increase in fuel economy between Fuels 3 and 5 occurred on all 5 vehicles, although one vehicle (2017 Ford Fusion) did experience a larger increase in fuel economy than the others. Fuel 5's (E15) energy content (in BTU/gal) was 1.7% lower than Fuel 3 (E10).

The next comparison is to average the E10s and the E15s (i.e., both low and high aromatics). The average of Fuels 3 and 4 is 30.47 mpg. The average of the E15s (Fuels 5, 6, and 7) is 31.33 mpg, a 2.8% increase over the E10s. However, this comparison is again driven by the fuel economy results of Fuel 5. If we compare only Fuels 6 and 7 to 3 and 4, there appears to be a slight increase in fuel economy for E15, but the differences are probably not statistically significant.

Table 1. Fuel Economy and Octane Results

Fuel	Ethanol Type	Fuel Economy (mpg)	Octane ((RON+MON)/2)
F3	E10	30.59	87.8
F4	E10	30.34	87.0
F5	E15	32.45	89.8
F6	E15	30.81	88.9
F7	E15	30.73	87.5

III. <u>CARB, Growth Energy, RFA, and USCAR Testing Program on Twenty Vehicles</u>[2]

In this testing program, twenty 2016-2021 vehicles were tested on both E10 CaRFG and an E15 splash-blended from the E10 CaRFG. The test fleet was a mixture of cars, SUVs, and LDTs, with engine sizes ranging from 1.4L to 5.7L. The fleet included both ported fuel injected vehicles (PFI) and GDI vehicles. The test procedure used was the Federal Test Procedure (FTP).

[2] *Final Report, Comparison of Exhaust Emissions Between E10 CaRFG and Splash Blended E15,* prepared for California Air Resources Board, Growth Energy, Renewable Fuels Association, and USCAR, University of California Riverside, January 2022.

The analysis presented in Table ES-2 of the report shows that the least square means of fuel economy on E10 was 26.699 mpg and on E15 was 26.385 mpg, or 1% lower. These differences were statistically significant. A visual examination of the individual vehicle data in Figure 3-7 of the report shows a very slight reduction in fuel economy on E15 for most, but not all, of the vehicles. The E15 average volumetric energy density (in BTU/gal) declined by 2.1% from the E10. E15 octane increased by 2.3% over E10. The loss in fuel economy was less than the loss in energy content. This smaller loss in fuel economy than energy content could be due to the vehicles being able to take advantage of somewhat higher-octane levels of the E15.

The Growth Energy program referenced earlier showed an increase in fuel economy for E15, where this later 20-vehicle program shows a slight reduction in fuel economy for E15. The changes in octane values between E10 and E15 were identical. The reduction in volumetric energy density of the Growth Energy program for E15 was less than the reduction in energy density of the 20-vehicle program.

One possible reason for the difference in fuel economy effects between the two programs is the use of different test procedures – the Growth Energy program used the more “real world” LA92 test cycle, and the twenty-car program uses the FTP. The LA-92 uses higher speeds and accelerations than the FTP. It is possible that today’s vehicles are able to take advantage of a higher-octane E15 fuel more on a real world test cycle than on the FTP.

IV. Conclusions

Based on these two testing programs evaluating E15 splash blended from E10, we conclude that fuel economy could be from 1% lower to 6% higher on E15 than E10.

Tom Darlington
Air Improvement Resource, Inc.