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Submitted online via: https://aq.ecology.commentinput.com/?id=KTPeV

RE: POT Washington State Clean Fuels Program Rule Comments

Dear Ms. Assink,

POET, the world's largest producer of biofuels, appreciates the opportunity to submit these comments to the Washington Department of Ecology in support of the agency's Clean Fuels Program rulemaking pursuant to the Clean Fuel Standard.[1] POET supports the Washington Clean Fuel Standard's goal of reducing greenhouse gas ("GHG") emissions from the Washington transportation sector. Increasing renewable alternatives aligns with POET's mission and is essential to mitigating climate change and protecting human health and the environment.

About 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, POET operates 33 bioprocessing facilities across eight states and employs more than 2,200 team members. With a suite of bioproducts including Dakota Gold and NexPro feed, Voilà corn oil, purified alcohol, renewable CO_2 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.

I. Executive Summary

Washington's Clean Fuels Program aims to "support the deployment of clean transportation fuel technologies" and "reduce greenhouse gas emissions associated with transportation fuels."[2] To that end, the legislation requires fuel suppliers to reduce the carbon intensity ("CI") of transportation fuels to 20% below 2017 levels by 2038.[3] It directs the

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[1] RCWA, Transportation Fuel—Clean Fuels Program, § 70A.535 (2021).
[2] RCW, Transportation Fuel—Clean Fuels Program, § 70A.535.005(3) (2021).
[3] *Id.* at § 70A.535.025(5)(a).

Washington State Department of Ecology ("Ecology") to "adopt rules that establish standards that reduce carbon intensity in transportation fuels used in Washington."[4] Ecology subsequently engaged in a series of stakeholder meetings throughout 2021 and into 2022.[5] On July 1, 2022, Ecology released a third-party cost benefit analysis of the proposed clean fuels program.[6]

On July 18, 2022, Ecology published a proposed rule ("Proposed Rule"), in response to which POET submits these comments.

Biofuels provide a crucial means for achieving Washington's CI reduction goals from the transportation sector. However, the Proposed Rule does not accurately account for the CI of bioethanol – or biofuels more generally – and as a result does not incentivize producers to implement numerous greenhouse gas ("GHG") reduction measures. The Proposed Rule saddles corn ethanol with a higher CI score than the current scientific literature would support, and contrary to what Ecology's own expert report recommended in this rulemaking proceeding.[7] It further does not appear to allow for bioethanol producers to get credit for key carbon reduction measures throughout the fuel production process – from sustainable agricultural practices to the use of renewable process electricity.

Accordingly, POET recommends that Ecology address the following issues in its final rule for the Clean Fuels Program. At the very minimum, it should ensure that Tier 2 pathways are more than a dead letter and serve as a viable pathway for recognition of innovative, GHG-reducing production methods. In the Clean Fuels Program regulations, Ecology should:

- Adopt an indirect land use change value for corn ethanol that accurately reflects the latest scientific research
- Accurately account for low-carbon process energy and practices
- Clarify that entities may opt for a WA-GREET 3.0-determined carbon intensity score even if it is possible to use a California or Oregon-based CI value
- Allow offsite renewable electricity to lower the carbon intensity of production process energy, just as it does for electricity used as a vehicle fuel
- Ensure timely and viable use of Tier 2 pathways
- Expand methane avoidance credits to methane sources beyond dairy/swine manure
- Award CI reduction credit to CO_2 captured and utilized in commercial applications that result in a net reduction in GHG emissions

Conventional bioethanol has the capacity to generate substantial CI reductions (and corresponding credits) under the Clean Fuels Program. As detailed below, its displacement of petroleum-based gasoline provides myriad ancillary benefits, including lowering greenhouse gas emissions in hard-to-decarbonize transportation sectors, reducing fuel costs for drivers and

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[4] *Id.* at § 70A.535.025(1).

[5] *See* https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC-173-424-455.

[6] *See* https://ecology.wa.gov/DOE/files/22/22790fe6-fc3a-414d-b3ba-036af0975258.pdf.

[7] *See* Stefan Unnasch, Life Cycle Associates, LLC, *Indirect Land Use Conversion for Washington Clean Fuels Standard* (Apr. 4, 2022), at 6, https://ecology.wa.gov/DOE/files/be/be3e311f-34de-4001-a055-b6dd07d25ead.pdf.

retailers, and decreasing other harmful air pollutants such as BTEX compounds (benzene, toluene, ethylbenzene, and xylene) and PM2.5.

II. The Proposed Indirect Land Use Change (iLUC) Penalty for Corn Ethanol Does not Reflect the Latest Scientific Research and Thus Skews the Clean Fuels Program in a Manner that Will Not Optimize GHG Reductions

The Proposed Rule indicates a LUC Value (gCO2e/MJ) for Corn Ethanol of 19.80,[8] significantly higher than the 7.6 value proposed by the Ecology-commissioned analysis of Life Cycle Associates and which is the same value currently used in Oregon.[9]

Ecology's Preliminary Regulatory Analysis ("PRA") states that using Oregon's indirect land use conversion value of 7.6 for corn ethanol "would not have met the goals and objectives of the authorizing statute."[10] According to the PRA, "The proposed rule incorporates California's value for corn ethanol (and the underlying indirect land use conversion value), since this value is within the range of estimates in the current scientific literature and was determined after expert analysis and a robust and thorough stakeholder engagement process."[11] No further explanation is provided.

The PRA does not provide any support for how the value is "within the range of estimates in the current scientific literature," nor does it offer any justification for the significant deviation from the most recent and growing scientific consensus, i.e., the previously recommended 7.6 value. We have included as Exhibit A to these comments an analysis by Environmental Health & Engineering, Inc.("EH&E") – a multi-disciplinary team including environmental health scientists and engineers from Harvard and Tufts University – that explains in greater detail how a LUC value of 19.80 gCO2e/MJ ignores recent scientific studies including the recommendation of Ecology's own commissioned-study by Life Cycle Associates in this proceeding. There is no explanation for why the 7.6 LUC value – a figure more squarely within the current scientific consensus – was passed over.

If not remedied, this arbitrary rule will lead to distorted market signals in the Clean Fuels Program, resulting in fewer and/or more costly transportation fuel emission reductions than would otherwise occur. On the margin, fuel producers will eschew bioethanol in favor of fuels that in reality have a higher CI. Whereas a 7.6 CI value would send an accurate signal to fuel producers and align the program with the goals and objectives of Chapter 70A.535 RCW, the proposed LUC value of 19.80 would not.

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[8] Proposed Rule (WAC 173-424-900, Table 5, Washington Land Use Change CI Values for Biofuels CI Determination); *see also id.* Table 8, Washington Temporary Fuel Pathway Code (showing a CI for corn ethanol of 90, which also "[r]eflects an iLUC value of 19.8.").

[9] Stefan Unnasch, Life Cycle Associates, LLC, *Indirect Land Use Conversion for Washington Clean Fuels Standard* (Apr. 4, 2022), at 6, https://ecology.wa.gov/DOE/files/be/be3e311f-34de-4001-a055-b6dd07d25ead.pdf.

[10] Washington State Department of Ecology, *Preliminary Regulatory Analyses: Chapter 173-424, WAC Clean Fuels Program Rule, Chapter 173-455, WAC Air Quality Fee Rule*, Publication 22-02-029 (July 2022) ("Preliminary Regulatory Analysis" or "PRA") § 6.3.4.

[11] *Id.*

The PRA claims that a 7.6 value would not have met the goals and objectives of the authorizing statute. This is not supported by the record in this proceeding. Among other things, Chapter 70A.535 RCW established a goal of supporting "the deployment of clean transportation fuel technologies through a carefully designed program;" and reducing "greenhouse gas emissions associated with transportation fuels."[12] An inflated and inaccurate CI score for corn bioethanol is neither carefully designed, nor would it serve to reduce GHGs, as the CI reduction benefits of corn-based bioethanol would be unfairly discounted in the program's accounting.

Moreover, as we explain further in Section VI (C), bioethanol that displaces conventional gasoline reduces "levels of conventional air pollutants from diesel and gasoline that are harmful to public health."[13] This is another statutory goal and objective frustrated by using the inaccurate 19.80 CI score. Less bioethanol consumed will likely result in fewer reductions of local pollutants.

Chapter 70A.535 RCW also requires that Ecology's proposed rule harmonize the Clean Fuel Program with the rules and requirements of other states that have adopted low carbon fuel standards and that supply significant quantities of transportation fuel to Washington, or to which Washington supplies significant quantities of transportation fuel.[14] Oregon borders Washington and has an low carbon fuel standard that adopted a 7.6 LUC value. The PRA does not explain how having a separate value from that of Oregon would serve the goal of harmonizing state policies. Such different CI values, instead, would create inconsistencies and impose additional burdens on covered entities. In a separate section, the PRA cites state policy harmonization as a reason for not adopting the most recent version of the GREET model published by Argonne National Laboratory.[15] It does not explain why such logic would not equally apply to the CI score of corn ethanol.

III. The Clean Fuels Program Should Accurately Account for Low-Carbon Process Energy and Practices

A. Ecology Should Clarify that Entities may opt for a WA-GREET 3.0-Determined CI Score Even if it is Possible to use a California or Oregon-based CI Value

Pursuant to Proposed WAC 173-424-600(5), it appears that an entity can only receive a Washington-specific CI score using the WA-GREET 3.0 model if it does not already have a pathway score from California or Oregon. Subsection 5 of that rule states that a pathway can receive a WA-specific score "[i]f it is not possible to identify an applicable carbon intensity under either subsection (3) or (4) of this section."[16] Subsection 3, in turn, assigns default scores to fossil fuels and electricity, whereas Subsection 4 provides a process for utilizing the California Air Resources Board ("CARB") or Oregon Department of Environmental Quality ("DEQ") CI

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[12] RCW 70A.535.005(3).

[13] *See* RCW 70A.535.005(3).

[14] RCW 70A.535.060(1).

[15] *See* PRA § 6.3.8.

[16] Proposed Rule (WAC 173-424-600(5)).

values in Washington.[17] Subsection 4 does provide for an adjustment to match WA-GREET 3.0,[18] but it is not clear to what degree this adjustment would provide for variables that are not accounted for in the California and Oregon models, such as scoring for renewable electricity use or low-carbon agricultural practices.

Ecology should clarify that an entity has the option of receiving a score under the Washington Clean Fuels Program – that is as determined by the WA – GREET 3.0 model – rather than be forced to utilize a California- or Oregon-based score that deviates from that model. Doing so will allow Washington to correct mistakes made by other jurisdictions, and tailor the program to best suit the needs and aims of Washington State stakeholders.

B. The Proposed Rule Should Allow Offsite Renewable Electricity to Lower the CI of Production Process Energy, Just as it does for Electricity used as a Vehicle Fuel

The Proposed Rule expressly (and appropriately) allows for credit generators and aggregators to retire certain renewable energy certificates ("RECs") associated with offsite renewable generation to "lower the carbon intensity of electricity claimed as a vehicle fuel in the clean fuels program."[19] Likewise, the recordkeeping section of the Proposed Rule appears to imply that the CI score will reflect and factor in the carbon intensity of process energy, but only if it such energy is "directly delivered." Proposed Rule section WAC 173-424-400(k)(ii) states, "A fuel pathway holder using directly delivered renewable electricity, biogas, or biomethane as a process energy or feedstock, must obtain and keep attestations from each upstream party collectively demonstrating that they have exclusive right to use those environmental attributes."

The Proposed Rule should be amended to expressly establish that producers will receive credit for the use of offsite renewable energy sources in the production of lower CI fuels. We encourage Ecology to amend the Proposed Rule or otherwise make clear that producers can purchase unbundled RECs or enter into power purchase agreements for their process energy, and thereby lower the CI score of the produced fuel. The RECs used for process energy could be subject to the same requirements as WAC 173-424-630(5) to ensure fair and equal treatment for all electricity carbon intensity determinations, regardless of whether the electricity is used for vehicle fuel or in the fuel production process.[20]

As POET noted in its prior comments, recognition of off-site renewable energy production to reduce GHG emissions is common in other carbon and renewable energy markets. We encourage Ecology to use its authority to encourage more renewable energy use in the transportation supply chain. This would incentivize the generation of low-CI energy through large-scale renewables projects thereby reducing the Washington transportation sector's lifecycle GHG emissions. Without such an incentive, facilities would have little impetus to make

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[17] Proposed Rule (WAC 173-424-600(3)).

[18] Proposed Rule (WAC 173-424-600(4)).

[19] Proposed Rule (WAC 173-424-630(5)).

[20] Proposed Rule (WAC 173-424-630 (5)). Ecology may consider adjusting the requirement that RECs come from facilities located within the Western Electricity Coordinating Council ("WECC") for process energy consumed outside of the WECC.

investments to decarbonize their process energy, and likely would opt for using the cheapest electricity available on the market.

IV. The Proposed Rule Should Ensure Timely and Viable Use of Tier 2 Pathways

A. Ecology Should Expand the List of Practices Explicitly Recognized as "Innovative" Under the Tier 2 Pathway Regulation

POET encourages Washington take a more active and flexible approach to evaluating and approving Tier 2 fuel pathway applications.[21]

Under the Proposed Rule, regulated parties, credit generators, and aggregators have the option to develop their own fuel pathway and may apply for it to be certified.[22] Fuel pathway applications fall into one of two tiers: Tier 1 (for conventionally-produced alternative fuels of a type that have been well-evaluated) and Tier 2 (fuels not included in Tier 1). Tier 2 fuels include first generation or Tier 1 fuels "using innovative methods including carbon capture and sequestration or a process that cannot be accurately modeled using the simplified calculators."[23] Ecology will not be accepting Tier 2 applications until July 1, 2025, according to the proposed Rule.[24]

In our prior comments, POET recommended that Ecology modify the Tier 1 simplified calculator's treatment of process chemicals used in bioethanol pathways. The proposed calculator still does not allow the pathway applicant to specify use of low-CI process chemicals, resulting in a distortion of the CI value of POET's bioethanol.

Specifically, POET's patented BPX process uses a less carbon-intensive group of chemicals than most bioethanol producers. A simple change to the Tier 1 calculator to allow user-defined process chemical usage could cure this inaccuracy. This modification would be consistent with the calculator's accommodation of a variety of other user-defined inputs from denaturant to feedstock transportation distance. As with all CI inputs, verification requirements would apply to user-defined process chemical usage, allowing the verifier and Ecology to ensure claimed CI reductions are accurate.

Similarly, the Proposed Rule does not include a Tier 1 calculator input for GHG emissions reductions associated with the installation of a biogas control system for management of manure from non-dairy and swine farm animals such as beef cattle. Although the Proposed Rule offers such emission reductions for dairy cattle and swine farms, and includes a pathway for "[b]iomethane from landfills; anaerobic digestion of dairy and swine manure or wastewater sludge; and food, vegetative, or other organic waste,"[25] expanding this to other animals,

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[21] Proposed Rule (WAC 173-424-600 (5)(b)).
[22] Proposed Rule (WAC 173-424-610) (establishing process for obtaining carbon intensity).
[23] Proposed Rule (WAC 173-424-600 (5)(b)); *see also* id. (WAC 173-424-110 (136)) (stating that the Tier 2 calculator or WA-GREET 3.0 model is used to calculate lifecycle emissions for next generation fuels, which include, *inter alia*, "first generation fuels produced using innovative production processes.").
[24] Proposed Rule (WAC 173-424-600 (5)(b)).
[25] Proposed Rule (WAC 173-424-600(5)); *see also id.* (WAC 173-424-110(135)).

particularly beef cattle, would incentivize fuel production entities to utilize biogas from nearby farm animals as energy sources for fuel production. As we stated in our prior comments, POET views biogas from beef cattle as an opportunity to decrease emissions from bioethanol production plants. Many POET plants are located near beef cattle farms, and POET would utilize biogas from these farms where possible if Washington's Clean Fuels Program incentivized it. Increased usage of biogas from nearby farm animals would reduce fuel production emissions in Washington, lowering lifecycle GHG emissions in Washington's transportation sector.

By the same token, the Tier 1 calculator does not account for variable feedstock scoring. Different feedstocks in the fuel production process have materially different GHG-emission profiles, and expressly accounting for those differences in the CI score would recognize and incentivize the increased use of low-carbon feedstocks for transportation fuels, with respect to biofuels generally, and corn ethanol in particular.

Because the Tier 1 calculator does not appear to capture GHG-emission reduction values for (i) low-carbon chemical processes, (ii) use of biogas from non-dairy and swine sources, or (iii) low-carbon feedstocks, a Tier 2 pathway is the only feasible avenue through which a fuel producer such as POET can receive an accurate accounting for such values. Accordingly, the Proposed WAC 173-424-600 (5)(b)(viii) should expressly include the above practices as examples of innovative methods. Entities can reliably demonstrate reductions in these WA – GREET 3.0 model inputs, and incentivizing such reductions will increase the GHG benefits of the program.

B. Tier 2 Pathways Should be Viable in Practice

However, based on our experience in California, we are concerned that while the Clean Fuel Programs Rule may allow a Tier 2 Pathway on its face, the regulators in practice do not timely approve all meritorious applications due to limited staff resources and competing regulatory obligations. The Tier 2 pathway effectively becomes unviable in practice for a variety of otherwise qualifying applications.

To make sure that Tier 2 has an active role in Washington's Clean Fuels Program, we propose that Ecology amend the Proposed Rule to minimize regulatory burden on Ecology staff, but also ensure that Tier 2 pathway applications will be timely considered. We suggest the following amendments:

- Establishing a presumption of approval for an application that complies with the requirements of WAC 173-424-610, which for Tier 2 includes a "positive verification statement from CARB or OR-DEQ approved verification body" as to the data used to form the inputs for the Tier 2 calculator;

- Require that Ecology issue a determination on complete applications within 60 days, and provide a written explanation for rejecting any Tier 2 applications.

- Modify the date for receiving applications to be earlier than July 1, 2023.

- To avoid administrative burden, the above requirements would only apply if the Tier 2 applications (including those for Tier 1 fuels using innovative methods) show a CI reduction of a certain magnitude or percentage threshold from the CI of the corresponding Tier 1 fuel using traditional, non-innovative methods. This would serve to focus limited Ecology staff resources on reviewing the applications that would drive in the most significant carbon reductions.

V. The Proposed Rule Should Ensure CO_2 Generated in the Bioethanol Fermentation Process that is Sold for use in Food, Beverage, and Other Industries is not Supplanted by Extracted CO_2

The Proposed Rule does not clearly provide a pathway for carbon capture and reuse (CCR), nor does the WA -- GREET 3.0 Tier 1 calculator appear to allow users to input such information. Application of CCS at bioethanol plants has been lauded by some as one of the lowest-cost and commercially-available sequestration opportunities. In addition, many bioethanol plants capture CO2 from the bioethanol fermentation process for use in a variety of commercial products including food processing and beverage manufacturing. For example, POET is currently the fifth largest producer of commercial CO2 in the country.

To accurately value the benefits of CCR activities such as the capture and use of fermentation CO2 for commercial purposes, Washington's Clean Fuels Program should take CCR into account when establishing a fuel's CI score. Indeed, the International Sustainability & Carbon Certification system and Europe's Renewable Energy Directive recognize the carbon reduction value of CCR. Additionally, the federal Internal Revenue Service 45Q tax credit for CCS allocates credit for CCR as well as for CCS. A modest change to the WA -- GREET 3.0 calculator could address this issue, integrating CCR into a fuel's CI score. Washington's Clean Fuels Program could mirror the 45Q federal tax credit, awarding CI credit to entities that obtain IRS approval under the 45Q tax credit for CCS and/or CCR.

VI. Biofuels' Positive Externalities Underscore the Need for Accurate Treatment under the Clean Fuels Program

Biofuels such as bioethanol can significantly reduce greenhouse gas emissions and thus contribute to Washington's goal to reduce carbon pollution from the transportation sector and help achieve the state's greenhouse gas ("GHG") emissions targets. Accurately accounting for their value will not only provide more precise market signals to fuel producers, but also generate positive benefits beyond the confines of the Clean Fuels Program.

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

Biofuels can play a unique role in reducing the CI of hard-to-decarbonize sectors of the economy. 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. Companies such as LanzaJet have pioneered the conversion of ethanol to jet fuel and their sustainable aviation fuel was successfully used on commercial flight in 2018.[26] LanzaJet is currently constructing a 10 million gallons-per-year facility in Georgia, set to come online this year, and has recently signed an 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.[27]

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.[28]

Biofuels also have potential to decarbonize the shipping industry. BP and Maersk carried out a successfully marine biofuels trial using B30 (consisting of 30% fatty acid methyl esters (FAME) blended with very low sulfur fuel oil (VLSFO)) as a "drop-in-fuel" for two tankers.[29] Maersk's low emission ECO Delivery product is an ocean transport customer offering that uses green biofuels, which, according to the company, reduces CO2 emissions by more than 80%.[30] Recently, Bureau Veritas, a testing, inspection and certification company, released a new "Biofuel Ready" notation to support the wider deployment of biofuels in the shipping industry, its representative observing that biofuels were "one of the few fuel options available today to reduce greenhouse gas emissions from existing fleets."[31]

Because of the importance of biofuels in these sectors, it is especially important that Ecology recognize their full GHG benefits. Failure to do so could curtail the availability of critical climate reduction technologies in the future.

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[26] *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/.

[27] *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./.

[28] *See* https://www.clearflameengines.com/.

[29] *BP and Maersk Tankers Carry Out Successful Marine Biofuel Trials* (Dec. 17, 2021); https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-and-maersk-tankers-carry-out-successful-marine-biofuel-trials.html.

[30] *Visy opts for Maersk ECO Delivery* (June 17, 2022), https://www.maersk.com/news/articles/2022/06/17/visy-opts-for-maersk-eco-delivery.

[31] *Bureau Veritas releases new 'biofuel ready' notation for shipping industry* (Aug. 30, 2022), https://www.offshore-energy.biz/bureau-veritas-releases-new-biofuel-ready-notation-for-shipping-industry/; Global: *BV Releases New Notation to Support Wider Development of Marine Biofuels* (Aug. 30, 2022), https://www.bunkerspot.com/global/57066-global-bv-releases-new-notation-to-support-wider-development-of-marine-biofuels.

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

Washington drivers and retailers would save tens of millions of dollars annually by converting from E10 to higher ethanol blends such as E15. Not only are wholesale prices for higher-bioethanol blends cheaper, but they also generate of credits under the national Renewable Fuel Standard program (known as Renewable Identification Numbers or "RINS"), which afford an additional value stream to fuel providers that allows them to further pass on price reduction benefits to consumers.

For example, 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 to address the high fuel prices attributed to Russia's invasion of Ukraine.[32] According to the Biden Administration, at April 2022 prices, E15 could "save a family 10 cents per gallon of gas on average, and many stores sell E15 at an even greater discount."[33] Because bioethanol is a largely domestic market, it does not experience the same degree of dependence on global markets as petroleum-based gasoline and is not as vulnerable to volatility in the globally-integrated oil and gas market. When oil prices increase, increased bioethanol use reduces the inflationary effect of more expensive gasoline, which in turn has positive spillover effects throughout the broader economy, where transportation accounts for a significant proportion of overall costs.

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, despite slightly lower energy density than neat gasoline. In fact, 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.[34] Taken together, the studies' conclusions demonstrate that fuel economy could be from 1% lower to 6% higher on E15 than E10.

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.[35] A May 2021 study by ACEEE found that American households have an average gasoline burden of about 7.0% of total income, but that burden ranges from 13.8% to 14.1% for low-income households earning less than 200% of the

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[32] *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.

[33] 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.

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

[35] *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.

federal poverty level range.[36] Though the burden was slightly less for the Seattle metro area (4.98%), one could assume that disadvantaged communities in more rural and suburban parts of Washington State 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.[37] 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 Washington's ambitious climate goals given the integral role transportation plays in the State's economy. Bioethanol presents no tradeoff between economic competitiveness on the one hand, and achievement of the decarbonization goals on the other. Bioethanol is good for *both* the economy and the environment. It is a win-win opportunity for Washington's transportation sector.

C. Higher Bioethanol Blends Reduce Local Pollutants When Compared to E10 and Pure Petroleum-Based Gasoline

Numerous studies have found that higher bioethanol blends emit lower tailpipe emissions as compared to lower bioethanol blends such as E10, or pure gasoline.

The vast majority (approximately 97%) of 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. E15 and neat gasoline ("E0") are 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 and lead. Octane rating reflects the ability of a fuel to avoid premature or auto ignition.[38] Aromatics, such as benzene, toluene, ethylbenzene, m/p-xylene, and o-xylene (collectively known as "BTEX") also boost gasoline octane, but they are considered hazardous air pollutants.[39] The high-octane rating of ethanol thus also enables reduction of aromatics in the fuel.[40]

Ethanol studies have demonstrated that higher ethanol content in fuels is associated with lower emissions of key health-relevant pollutants, including particulate matter ("PM"), black carbon, particle number, and BTEX, while fuels with lower ethanol content generally showed the

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[36] 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.

[37] *Id*.

[38] 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 et al. 2012").

[39] 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 ("Clark et al. 2021").

[40] Clark et al. 2021; 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 et al. 2022a"); US EPA. 2017. *Fuel Trends Report: Gasoline 2006-2016* ("US EPA 2017").

opposite pattern.[41] One recent study showed that aromatic levels decrease by approximately 7% by volume for each 10% by volume increase in ethanol content.[42]

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.[43] Along the same lines, 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%.[44]

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.[45] Though the impact on NOx varied by

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[41] Clark et al. 2021; 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 ("Karavalakis et al. 2014"); 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 ("Kumar and Chaurasia 2019"); 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 ("Liang et al. 2020"); 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 ("Myung et al. 2020"); 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 ("Roth et al. 2020"); Sakai S, Rothamer D. 2019. *Impact of ethanol blending on particulate emissions from a sparkignition direct-injection engine*. Fuel, 236: 1548-58 ("Sakai and Rothamer 2019"); Schuchmann B, Crawford R. 2019. *Alternative Oxygenate Effects on Emissions*. Alpharetta, GA (United States) ("Schuchmann and Crawford 2019"); 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 et al. 2019a"); 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. ("Yang et al. 2019b"); 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 ("Zheng et al. 2019").

[42] Kazemiparkouhi et al. 2022a.

[43] Kazemiparkouhi F, MacIntosh D, Suh H, Clark N. 2022c. *Potential Air Quality and Public Health Benefits of Real-World Ethanol Fuels* ("Kazemiparkouhi et al. 2022c").

[44] 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 et al. 2022").

[45] Mourad M, Mahmoud K. 2019. *Investigation into SI engine performance characteristics and emissions fuelled with ethanol/butanol-gasoline blends*. Renewable Energy, 143: 762-71 ("Mourad and Mahmoud 2019"); 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 ("Badrawada and Susastriawan 2019"); Clark et al. 2021; Gunst R. 2013. *Statistical Analysis of the Phase 3 Emissions Data Collected in the EPAct/V2/E89 Program*. In.: National Renewable Energy Laboratory. ("Gunst 2013"); Karavalakis G. 2018. *Impacts of Aromatics and Ethanol Content on Exhaust Emissions from Gasoline Direct Injection (Gdi) Vehicles*. University of California, Riverside.("Karavalakis 2018"); 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 et al. 2012"), Karavalakis et al. 2022; Kazemiparkouhi et al. 2022c; Oak Ridge National Laboratory (ORNL), National Renewable Energy Laboratory

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.[46]

The reduced tailpipe emissions result in improvements in air quality. Lower PM emissions result in lower ambient PM concentrations and exposures;[47] reductions of targeted aromatics in fuel were also associated with lower summertime ozone levels.[48] 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.[49]

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.

* * *

POET strongly supports the Washington Clean Fuels Program. We appreciate Ecology's consideration of these comments and look forward to engaging in a productive dialogue with the Agency on the Clean Fuels Program and the role biofuels play in helping Washington achieve its

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(NREL), and Argonne National Laboratory (ANL). 2016. *Summary of High-Octane, Mid-Level Ethanol Blends Study*. In.: Oak Ridge National Laboratory.("ORNL et al. 2016"); 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 ("NREL 2013"); 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. ("Roso et al. 2019"); Theiss T. 2016. *Summary of High-Octane Mid-Level Ethanol Blends Study* ("Theiss 2016"); Wayson. 2016. *Evaluation of Ethanol Fuel Blends in Moves 2014 Model*. Renewable Fuels Association ("Wayson 2016").

[46] Kazemiparkouhi et al. 2022a, 2022c; 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 et al. 2022b"), Karavalakis et al. 2022.

[47] 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. ("Kheirbek et al. 2016"); 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. ("Pan et al. 2019").

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

[49] 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 ("Sommariva et al. 2011"); 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 ("Gouw et al. 2012").

GHG reduction goals. If you have any questions, please contact me at Matt.Haynie@POET.COM or (202) 756-5604.

Sincerely,

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Exhibit A

August 31, 2022

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Comments of David MacIntosh[1,2], Tania Alarcon[1,3], 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 Washington Clean Fuels Program Rule (Chapter 173-424 WAC)

We are writing to provide comments on the indirect land use change (iLUC) emission rates selected by the Washington State Department of Ecology (Ecology) for the Washington Clean Fuels Program Rule (Chapter 173-424 WAC).

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, LCA, and public health. Members of our team conducted a state of the science review of the carbon intensity (CI) for corn ethanol in the United States (U.S.)[1] and a comprehensive assessment of the impacts of corn ethanol fuel blends on tailpipe emissions.[2,3] Our experience informs the comments that follow.

BACKGROUND INFORMATION

At the request of Ecology, Life Cycle Associates prepared a report in March 2022 that reviews and recommends the iLUC values for incorporation into legislation for the State of Washington.[4]

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

[2] Kazemiparkouhi F, Alarcon Falconi TM, Macintosh DL and Clark N. 2022. Comprehensive US database and model for ethanol blend effects on regulated tailpipe emissions. *Sci Total Environ*, 812, pp.151426.

[3] Kazemiparkouhi F, Karavalakis G, Alarcon Falconi TM, Macintosh DL and Clark N. (in press). Comprehensive US database and model for ethanol blend effects on air toxics, particle number, and black carbon tailpipe emissions. *Atmospheric Environment: X*.

[4] Unnasch S, Indirect land use conversion for Washington clean fuels standard (Life Cycle Associates, LLC, 2022). https://ecology.wa.gov/DOE/files/00/00383d4b-8c0b-44e7-a88f-ba03f727e521.pdf (Accessed 30 August 2022).

For corn starch ethanol, Life Cycle Associates recommended that Ecology adopt the value of 7.6 grams of carbon dioxide equivalent per megajoule (gCO_2e/MJ) of corn starch ethanol, which is the value used by the Oregon Clean Fuels Program.

A peer review by the International Council on Clean Transportation (ICCT) provided comments on Oregon's iLUC value. Our team then submitted a letter to Ecology (Attachment A) which addresses ICCT's criticisms and shows that Oregon's value is the most appropriate selection.

During July 2022, Ecology released a Preliminary Analysis and a Proposed Rule.[5,6] The Proposed Rule utilizes the California Air Resources Board (CARB) iLUC value of 19.8 gCO_2e/MJ of corn starch ethanol instead of the Oregon value of 7.6 8 gCO_2e/MJ, the latter of which our team finds to better capture the current science.

SUMMARY

To begin our letter, we briefly introduce the goals and objectives of the authorizing statue that Ecology must follow in their Clean Fuels Program Rule, and we define the initiatives that are relevant to our scope of CI, greenhouse gas (GHG) emissions, and public health. We then describe how Oregon's iLUC value meets the elements of these requirements. In doing so, we show how estimates for the CI of corn ethanol have decreased over time after incorporating updates to models and data, and have converged on a CI value for corn ethanol that is 46% than the CI for average gasoline. We also zoom in on iLUC estimates from both the U.S. and Europe to reveal a consistent trend of decreasing iLUC estimates among studies that consider the best available science. We then give a brief overview of the relationship between increasing ethanol fuel content and the reduction of various air pollutant emissions that are associated with health risks. It is important that Ecology consider the best available science to fully capture the GHG emissions reductions from biofuel use and the potential public health benefits.

Next, we revisit comments we previously submitted regarding the ICCT peer review of Life Cycle Associates' proposal to adopt the Oregon iLUC value. In particular, ICCT critiqued the selected model, which is an updated version of the older GTAP-BIO model that CARB 2015 relies on, but still recommended using the CARB 2015 iLUC value. We summarized our comments to ICCT critiques and demonstrated that the adoption of Oregon's iLUC value is appropriate.

Our next section examines the CARB 2015 iLUC value that Ecology has selected in its latest proposal. We demonstrate how the CARB 2015 iLUC value does not fall within the range of

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[5] Patora K. 2022. Preliminary regulatory analyses. https://apps.ecology.wa.gov/publications/documents/2202029.pdf (Accessed 30 August 2022).

[6] State of Washington. 2022. Chapter 173-424 WAC clean fuels program rule (Department of Ecology). https://ecology.wa.gov/DOE/files/e9/e97a5150-9ed2-4512-a4fd-6b0317f907dc.pdf (Accessed 30 August 2022).

current best estimates. Plus, the CARB 2015 iLUC value relies on an outdated version of GTAP-BIO. We give examples that show how model improvements and updated data impact GTAP-BIO results. In turn, we assert that the CARB 2015 iLUC value does not reflect the best available science.

We close our letter with brief notes on comments that other organizations have submitted to Ecology regarding the proposed rulemaking.

GOALS AND OBJECTIVES OF THE AUTHORIZING STATUE

The authorizing statute guiding the Transportation Fuel section of the Clean Fuels Program is Chapter 70A.535 of the Revised Code of Washington. This legislation defines goals (in Section 70A.535.005) and outlines objectives (in Section 70.535.025) that Ecology's rulemakings and standards must meet.[7,8] Ecology's July 2022 Preliminary Regulatory Analysis paraphrases these requirements within Section 6.2.

In the subsections that follow, we quote Ecology's presentations of the goals and objectives that are related to CI, GHG emissions, and public health. We then show how the Oregon value satisfies each of these principles. As there is overlap between the topics described in the goals and objectives, we have combined the relevant elements of the two lists into two major themes: 1) CI and GHG Emissions Reduction and 2) Public Health.

Note that we do not comment on initiatives that are programmatic (and thus would not be impacted by the value assigned to iLUC for corn ethanol, such as the design of the credit program) or those that fall outside the scope of our focus on emissions and health analyses (such as job creation).

Carbon Intensity and Greenhouse Gas Emissions Reduction

Relevant Element(s) of Goals and Objectives

- *Goal: "Supporting the deployment of clean transportation fuel technologies through a carefully designed program that reduces the carbon intensity of fuel used in Washington."*[9]

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[7] State of Washington. 2021a. RCW 70A.535.005. https://app.leg.wa.gov/RCW/default.aspx?cite=70A.535.005 (Accessed 30 August 2022).

[8] State of Washington. 2021b. RCW 70A.535.025. https://app.leg.wa.gov/RCW/default.aspx?cite=70A.535&full=true#70A.535.025 (Accessed 30 August 2022).

[9] State of Washington. 2021a.

- *Goal: "Reducing greenhouse gas emissions associated with transportation fuels, which are the state's largest source of greenhouse gas emissions."*[10]
- *Objective: "Reducing the overall carbon intensity of transportation fuels used in Washington."*[11]

Oregon's Value Supports the Goals and Objectives

Using higher ethanol blends for gasoline-powered vehicles is an important pathway to reduce the CI impacts of the transportation sector. To quantify these GHG reductions, we conducted a state of the science review of the CI for corn ethanol in the U.S., applied objective criteria limited to the U.S. regulatory context, and derived an evidence-based central CI estimate and credible range as of 2020.[12] 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. Estimates for corn farming and production of ethanol are consistent between the most recent estimates from CARB, the U.S. Environmental Protection Agency (EPA), Argonne National Laboratory (ANL), and our analysis. The primary difference across the CI estimates for corn ethanol relates to iLUC. Note that the projections shown in Figure 1 are estimates that EPA and the United States Department of Agriculture (USDA) made of future impacts based on market and production predictions.

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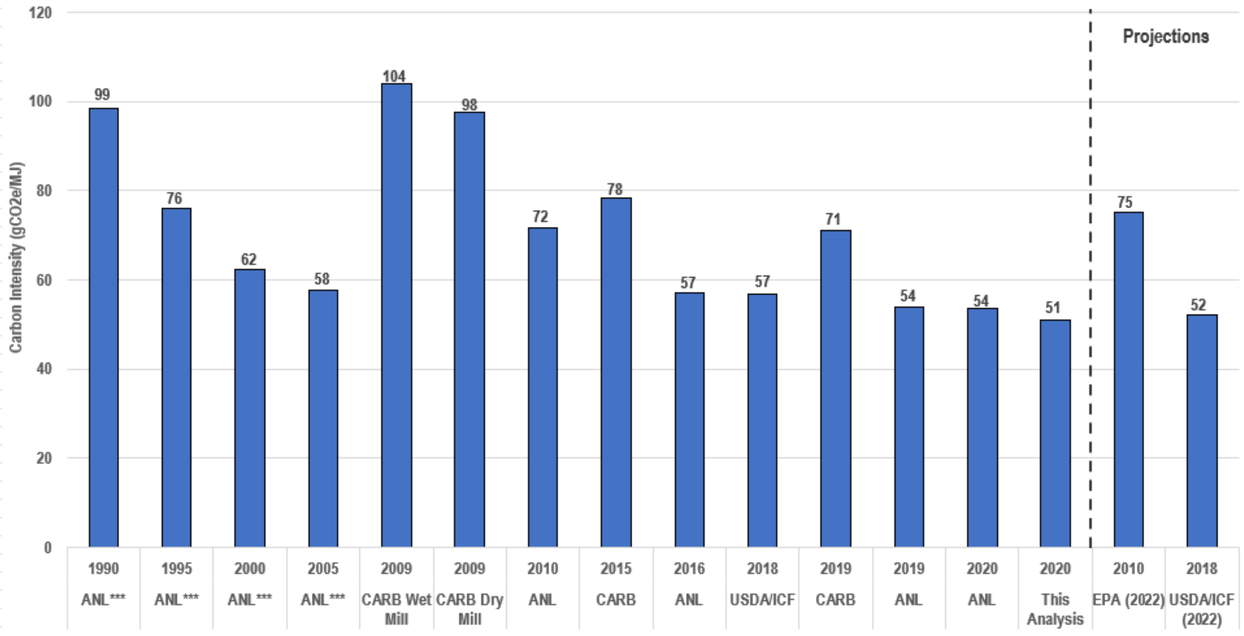
[10] Ibid.
[11] State of Washington. 2021b..
[12] Scully et al. 2021a.



*** Models did not incorporate land use change.

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.[13,14,15,16,17] 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 U.S. (blue dots) are in good agreement with those from Europe (red dots). The iLUC emission rate adopted by Oregon and originally proposed for Washington falls at the approximate mid-point of the values from the best available science.

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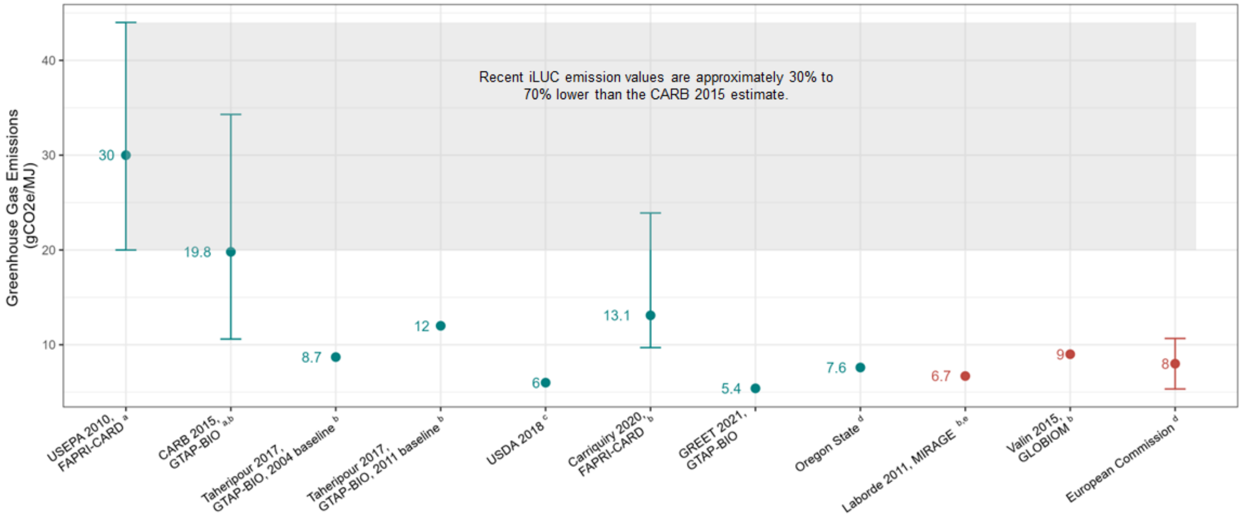
[13] Carriquiry M, Elobeid A, Dumortier J and Goodrich R. 2020. Incorporating sub-national Brazilian agricultural production and land-use into U.S. biofuel policy evaluation. *Applied Economic Perspectives and Policy*, 42, pp.497-523.

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

[15] 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.

[16] Taheripour F, Mueller S and 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.

[17] Scully et al. 2021a.



a Use older versions of the model
b Indirect and direct land use change
c Based on a review of primary land use change analyses
d Policy based on primary land use change analyses
e Adjusted to a 30-year amortization period

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

In summary, our published research concludes that assessments of GHG intensity for corn ethanol have decreased by approximately 50% over the prior 30 years and converged on a current central estimate value of about 51 gCO2e/MJ. This is a 46% reduction compared to the average baseline CI of gasoline, which is approximately 96 gCO2e/MJ.[18,19,20] It is important that Ecology consider the best available science on iLUC to fully capture the GHG emissions reductions from biofuel use.

Public Health

Relevant Element(s) of Goals and Objectives

- *Goal: "Reducing levels of conventional air pollutants from diesel and gasoline that are harmful to public health."*[21]

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[18] US Environmental Protection Agency (EPA). 2010a. Renewable Fuel Standard program (RFS2) regulatory impact analysis

Report No.: EPA-420-R–10–006 (Washington, DC: United States Environmental Protection Agency, Assessment and Standards Division Office of Transportation and Air Quality US Environmental Protection Agency)

[19] Argonne National Laboratory (ANL). 2019. GREET WTW calculator energy systems (available at: greet.es.anl.gov/index.php?content=sampleresults)

[20] California Air Resource Board (CARB). 2020. LCFS pathway certified carbon intensities (available at: w2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities)

[21] State of Washington. 2021a.

Oregon's Value Supports the Goals and Objectives

We have extensively discussed the air quality and public health implications of ethanol fuel blending in our previous letter to Ecology (Attachment A) and in a white paper (Attachment B). In this section, we provide a short summary of our findings.

Under cold start conditions, tailpipe emissions of particulate matter (PM), carbon monoxide (CO), and total hydrocarbons (THC) generally decreased with increasing ethanol fuel content, while oxides of nitrogen (NOx) emissions did not change.[22] Air toxic emissions showed lower BTEX, 1-3 butadiene, black carbon, and particle number emissions with increasing ethanol content in summer market fuels.[23] These findings are consistent with a recent CARB study that assessed the impact of splash-blending E10 to E15 on PM and other air pollutant emissions for late model year vehicles (2016-2021).[24,25]

Numerous studies have shown that lower PM emissions result in lower ambient PM concentrations and exposures, [26,27] which, in turn, are causally associated with lower risks of total mortality and cardiovascular effects.[28,29,30,31] Our findings demonstrate the potential for policies that encourage higher concentrations of ethanol in gasoline to improve public health.

ICCT REVIEW OF OREGON'S ILUC VALUE

In its peer review for Ecology, ICCT critiqued Oregon's iLUC value of 7.6 gCO2e/MJ and recommended Ecology adopt the 2015 CARB iLUC value of 19.8 gCO2e/MJ instead. We

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[22] Kazemiparkouhi et al. 2022.

[23] Kazemiparkouhi et al.[in press].

[24] Karavalakis G, Short D, Vu D, Russell RL, Asa-Awuku A, Jung H, Johnson KC, Durbin TD. 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, pp.168-179.

[25] 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.

[26] 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.

[27] 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.

[28] 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.

[29] 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.

[30] EPA. 2019. Integrated Science Assessment for Particulate Matter. Center for Public Health and Environmental Assessment.

[31] 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 US Medicare beneficiaries. *Environmental Health*, 19(1), pp.1-12.

disagree with the ICCT conclusion. In our prior letter to Ecology (Attachment A), we reviewed the ICCT critiques and demonstrated that the adoption of Oregon's iLUC value is appropriate.

Below we summarize our comments on each of ICCT's criticisms toward Life Cycle Associates' iLUC recommendation.

- The review from ICCT is incomplete as it only shares the perspectives of critics of the model.
- ICCT critiques the choice of model, yet the selected model (GTAP) is widely accepted, regularly updated, and relied up on by ANL and CARB, among others.
- ICCT calls out limitations of the emissions factors used, even though the estimates are in line with techniques used by the Intergovernmental Panel on Climate Change and are based on evidence from U.S. Department of Agriculture (USDA) statistics.
- ICCT states that the model used does not make unmanaged forest available to be used as cropland. However, some unmanaged forests are in fact included in the accessible forest areas that the model considers. Regardless, the inclusion or exclusion of unmanaged forests would have a small impact on iLUC.
- ICCT describes the chosen estimated price-induced corn yield (YDEL) as outside of a justifiable range, but we find that a review of recent studies places the selected YDEL value right inside the acceptable span.
- ICCT takes issue with the inclusion of double cropping; we explain that the model includes a land intensification factor to properly determine harvest frequency based on regional factors and land use change observed over the period of rapid expansion of U.S. ethanol production.
- ICCT criticizes the classification of cropland pasture. This may have been an accurate comment for previous model versions but has been resolved with better functionality of recent versions of the selected model.

CARB 2015'S VALUE

The July 2022 Preliminary Regulatory Analysis states that California's iLUC "value is within the range of estimates in the current scientific literature and was determined after expert analysis and a robust and thorough stakeholder engagement process". However, the 19.8 gCO2e/MJ iLUC value from CARB 2015 falls outside the range of current best estimates and is based on an outdated version of GTAP-BIO that has been superseded and no longer represents the best available science.

As discussed in our previous comments (Attachment A) on the Draft Clean Fuels Program Rule, most current iLUC estimates for corn starch ethanol, including models developed in the U.S. and Europe, have decreased and are substantially lower than findings published by CARB in 2015

(Figure 2). Several publications recognize that estimates of iLUC impacts for corn starch ethanol over the last decade have trended downward.[32,33,34,35]

iLUC estimates have changed because the models and data that go into them have improved over time. Our publication on LCA of corn ethanol[36] and our reply to comments on the paper,[37] as well as a recent retrospective analysis of corn ethanol LCAs by Lee et al.,[38] summarize the enhancements made to GTAP-BIO, the iLUC model used in the CARB 2015 analysis. Briefly, the changes in estimates of iLUC impacts are attributable to: (1) addition of new modules that allow for more accurate simulation of real-world agricultural practices, (2) addition of more spatially resolved information on land cover, and (3) tuning of parameters that describe rates of land conversion and land transformation. Details on important changes made over time to GTAP-BIO are available in the literature.[39,40,41,42]

An early example of refinements to models and data that lead to substantial changes in estimated GHG impacts for iLUC is found within CARB's analysis. In 2015, CARB "reviewed published articles, contracted with academics, and consulted with experts, all of which led to significant improvements to the GHG modeling methodologies and analysis completed in 2009."[43] Table 1 shows that CARB's central estimate of iLUC emissions decreased by approximately 30% when using an updated version of GTAP-BIO. Thus, CARB's own prior work demonstrates that advancement of models and data can impact their output and lead to substantial changes in estimated GHG impacts for iLUC.

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[32] Lee et al. 2021.

[33] Dunn et al. 2013.

[34] Taheripour F and Tyner W. 2013. Biofuels and land use change: applying recent evidence to model estimates. *Applied Science*, 3(1), pp.14–38.

[35] Carriquiry et al. 2020.

[36] Scully et al. 2021a.

[37] Scully MJ, Norris GA, Alarcon Falconi TM, MacIntosh DL. 2021b. Reply to comment on 'Carbon intensity of corn ethanol in the United States: state of the science. *Environmental Research Letters*, 16(11), pp.118002.

[38] Lee et al. 2021.

[39] EPA. 2010b. Renewable Fuel Standard program (RFS2) regulatory impact analysis (RIA) Report No.: EPA-420-R–10–006 (Washington, DC: United States Environmental Protection Agency, Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency).

[40] Babcock BA, Iqbal Z. 2014. Using recent land use changes to validate land use change models. Staff report 14-SR 109. Center for Agricultural and Rural Development, Iowa State University.

[41] Taheripour F, Zhao X and Tyner W E. 2017. The impact of considering land intensification and updated data on biofuels land use change and emissions estimates. *Biotechnology for biofuels*, 10(1), pp.1-16.

[42] Taheripour et al. 2013.

[43] CARB. 2015. Staff report: initial statement of reasons for rulemaking. Proposed readoption of the Low Carbon Fuel Standard. Appendix I: detailed analysis for indirect land use change. https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/iluc_assessment/iluc_analysis.pdf (Accessed 30 August 2022).

Table 1 CARB's Central Estimates of Indirect Land Use Change Associated with Corn Ethanol for Biofuel Over 30 Years. Modeled greenhouse gas emissions were estimated with an older version of GTAP ("GTAP with Woods Hole") and a newer version ("GTAP-BIO with AEZ-EF") that has significant improvements, including updates to land cover structure.[a]

Model Version	Study Year	GTAP-BIO Economic Database (Baseline Year)	Central Estimate of iLUC Emissions (g CO_2e per MJ)
GTAP with Woods Hole	2009	GTAP-BIO 6, 2001	30[b]
GTAP-BIO with AEZ-EF	2015	GTAP-BIO 7, 2004	19.8[c]

CARB	California Air Resources Board
GTAP	Global Trade Analysis Project model
GTAP-BIO	Global Trade Analysis Project-biofuel model
g CO2e per MJ	gram carbon dioxide equivalent emissions per megajoule

[a] Leland A, Hoekman SK, Liu XV. 2018. Review of modifications to indirect land use change modeling and resulting carbon intensity values within the California Low Carbon Fuel Standard regulations. *Journal of Cleaner Production*, 180(2018), pp.698-707.

[b] California Air Resources Board (CARB). 2009. Staff report: initial statement of reasons. Proposed regulation to implement the low carbon fuel standard volume I. https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2009/lcfs09/lcfsisor1.pdf (Accessed 30 August 2022).

[c] CARB. 2015. Staff report: initial statement of reasons for rulemaking. Proposed readoption of the Low Carbon Fuel Standard. Appendix I: Detailed analysis for indirect land use change. https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/iluc_assessment/iluc_analysis.pdf (Accessed 30 August 2022).

Additional updates to GTAP-BIO since CARB's 2015 analysis provide another example of decreases in estimated iLUC that result from model development and refinement. Taheripour et al.[44] describe updates to the land use module of GTAP-BIO that among other items included land transformation elasticities tuned to trends in regional land cover data across the globe observed from 2003 – 2013. As shown in Table 2, the updated version of GTAP-BIO, which was tuned to observed land cover change for 2003 – 2013, produced estimates of LUC GHG impacts approximately 40% lower than those from the prior (untuned) version of GTAP-BIO.

Table 2 GTAP-BIO Central Estimates of Total Land Use Change Associated with Corn Ethanol Biofuel Over 30 Years. Modeled greenhouse gas emissions were estimated with an older version of GTAP-BIO ("Untuned land use module") and a newer version ("Updated land use module") that has parameters tuned to observed changes in cropland and harvested area in the U.S., Brazil, and other regions of the world.

GTAP-BIO Model Version	GTAP-BIO Economic Database (Baseline Year)	Ethanol Expansion (billion gallons)	Land Use Change Emissions (g CO_2e per MJ)	Reference
Untuned land use module	Version 7 (2004)	11.59 BG (3.41 to 15 BG)	13.4	a, b
Updated land use module			8.7	a, b

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[44] Taheripour et al. 2017.

Untuned land use module	Version 9 (2011)	1.07 BG (13.93 to 15 BG)	23.3	a, b
Updated land use module			12.0	b

GTAP-BIO Global Trade Analysis Project-biofuel model
g CO2e per MJ gram carbon dioxide equivalent emissions per megajoule
BG billion gallons

[a] Taheripour F, Cui H, Tyner WE. 2016. An exploration of agricultural land use change at the intensive and extensive margins: implications for biofuels induced land use change. In: Qin Z, Mishra U, Hastings A, editors. *Bioenergy and land use change*, pp.19-37. American Geophysical Union (Wiley).

[b] Taheripour F, Zhao X, Tyner WE. 2017. The impact of considering land intensification and updated data on biofuels land use change and emissions estimates. *Biotechnology for Biofuels* 10(1), pp.1-16.

In consideration of the preceding discussion and examples, we find strong evidence that current versions of iLUC models produce substantially lower estimates of GHG emissions compared to earlier versions of these same models used by CARB in 2015 to prepare its estimate of iLUC impacts. By relying only on the CARB 2015 LUC analysis for the current rulemaking, Ecology is not giving due consideration to the best available science. We encourage Ecology to consider recent LUC modeling tools, data, and/or results for purposes of the current rulemaking.

COMMENTS FROM OTHER ORGANIZATIONS

The Washington Environmental Council (WEC) submitted comments to Ecology in March and April that were critical of a low iLUC for corn ethanol.[45,46] WEC references a 2022 publication by Lark et al.[47] which says that ethanol's impact may be greater than gasoline. However, this Lark et al. study is fundamentally flawed, as is detailed in comments by researchers at ANL.[48]

Comments from the Union of Concerned Scientists disagree with the use of CCLUB to determine emissions factors because ANL is not a regulatory body.[49] Yet, if we narrow our focus to only regulatory bodies, there is still more than one regulatory body to consider, including the State of Oregon which has adopted a value using CCLUB.

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[45] Ponzio R, Krenn C. 2022a. Letter to Rachel Assink, March 25. Re: proposed WA-GREET model for chapter 173-424 WAC, Clean Fuels Program Rule. https://scs-public.s3-us-gov-west-1.amazonaws.com/env_production/oid100/did1008/pid_202037/assets/merged/vz05i2z_document.pdf?v=PCF8HAMJ9 (Accessed 30 August 2022).

[46] Ponzio R, Krenn C. 2022b. Letter to Rachel Assink, April 25. Re: informal comment of chapter 173-424 WAC, Clean Fuels Program Rule. https://scs-public.s3-us-gov-west-1.amazonaws.com/env_production/oid100/did1008/pid_202037/assets/merged/jy0kipf_document.pdf?v=PCF8HAMJ9 (Accessed 30 August 2022).

[47] Lark, T.J., Hendricks, N.P., Smith, A., Pates, N., Spawn-Lee, S.A., Bougie, M., Booth, E.G., Kucharik, C.J. and Gibbs, H.K., 2022. Environmental outcomes of the US renewable fuel standard. Proceedings of the National Academy of Sciences, 119(9), p.e2101084119.

[48] Taheripour F, Mueller S, Kwon H, Khanna M, Emery I, Copenhaver K, Wang M. 2022. Comments on "Environmental outcomes of the US Renewable Fuel Standard." https://greet.es.anl.gov/publication-comment_environ_outcomes_us_rfs (Accessed 30 August 2022).

[49] Martin JI. 2022. Letter to Rachel Assink, April 25. Comments on chapter 173-424 WAC rulemaking, Clean Fuels Program Rule. https://scs-public.s3-us-gov-west-1.amazonaws.com/env_production/oid100/did1008/pid_202037/assets/merged/l00nind_document.pdf?v=FQ6RSY8C4 (Accessed 30 August 2022).

CONCLUSION

In closing, we reaffirm that Oregon's iLUC value is the most appropriate choice for the Washington Clean Fuels Program Rule. First, as we have detailed, Oregon's value supports the emissions reductions and public health goals and objectives required by the authorizing statute. Increasing ethanol fuel content is associated with reduced emissions of air pollutants that harm health, and estimates for the CI of corn ethanol, in particular estimates of iLUC, have been decreasing with improvements to models and data. Further, using Oregon’s value meets an additional goal of the authorizing statute by harmonizing Washington’s value with the neighboring state of Oregon.

Second, the grounds for Oregon's iLUC value is strengthened as we readdress each of the previous comments from ICCT's review. In particular, ICCT's criticisms of the GTAP-BIO model are immaterial when the selected CARB 2015 value uses an older version of the same model.

Third, exploring the CARB 2015 iLUC value included in Ecology's latest draft reveals that this value does not represent the best available science, as it falls outside the accepted range and is based on an outdated model version.

And, finally, we urge consideration that some comments submitted to Ecology may be based on a flawed study or selective logic. It is important that rulemakings from Ecology incorporate the best available science on iLUC to fully capture the CI reductions from biofuel use. This is why we continue to support Life Cycle Associate's recommendation of selecting Oregon's value for the iLUC of corn ethanol.

Enclosures
Attachment A— EHE Comment on WA Draft Clean Fuels Program Rule, April 25, 2022
Attachment B— Kazemiparkouhi F, MacIntosh D, Suh H, Clark N. 2022. Potential Air Quality and Public Health Benefits of Real-World Ethanol Fuels.

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April 25, 2022

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Comments of David MacIntosh[1,2], Tania Alarcon[1,3], Fatemeh Kazemiparkouhi[1], Brittany Schwartz[1]
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RE: Comments on the draft Washington Clean Fuels Program Rule (Chapter 173-424 WAC)

We are writing to provide comments on the indirect land use change (iLUC) emission rates recommended to Washington Department of Ecology (WDE) by its contractor, Life Cycle Associates, Inc. (LCAInc), and its peer reviewer, International Council on Clean Transportation (ICCT), for the draft Washington Clean Fuels Program Rule (Chapter 173-424 WAC). Following those comments, we provide additional information on our recent published research on tailpipe emissions of regulated pollutants and air toxics from the combustion of ethanol fuel blends in light-duty vehicles.

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, LCA, and public health. Members of our team conducted a state of the science review of the carbon intensity (CI) for corn ethanol in the United States (U.S.)[1] and a comprehensive assessment of the impacts of corn ethanol fuel blends on tailpipe emissions.[2,3] Our experience informs the comments that follow.

Our comments compare the proposed Washington (WA) iLUC emissions with the best available science, review the ICCT report that critiques the proposed WA iLUC, and demonstrate why

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

[2] Kazemiparkouhi F, Alarcon Falconi TM, Macintosh DL and Clark N. 2022a. Comprehensive US database and model for ethanol blend effects on regulated tailpipe emissions. *Sci Total Environ*, 812, 151426.

[3] 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].

adoption of the proposed WA iLUC value is appropriate. We also discuss the relationship between ethanol, tailpipe emissions, and health. Our detailed comments on those topics are presented following the summary.

SUMMARY

In reviewing the information presented by LCAInc, we find that their suggestion to incorporate an iLUC value of 7.6 gCO2e per MJ ethanol is in line with current research. ICCT, in their peer review, recommends that WDE consider a value generated by the California Air Resources Board (CARB) in 2015 instead. Yet, when looking at iLUC estimates generated by researchers in both US and Europe, the value from CARB falls outside the range of other results, as does the 2010 estimate from the U.S. Environmental Protection Agency (USEPA). The value proposed by LCAInc, however, lines up nearly in the middle of these recent results.

We examined the ICCT comments in detail and found their review to be incomplete. Still, in this letter we address each of ICCT's criticisms toward LCAInc's iLUC recommendations. First, ICCT critiques the choice of model, yet the selected model is widely accepted, regularly updated, and relied up on by Argonne National Laboratory, among others. Second, ICCT calls out limitations of the emissions factors used, even though the estimates are in line with techniques used by the Intergovernmental Panel on Climate Change and are based on evidence from U.S. Department of Agriculture (USDA) statistics. The ICCT report states that the model used does not make unmanaged forest available to be used as cropland; however, some unmanaged forests are in fact included in the accessible forest areas that the model considers and would have a small impact on iLUC anyway. Next, ICCT describes the chosen estimated price-induced corn yield (YDEL) as outside of a justifiable range, but we find that a review of recent studies places the selected YDEL value right inside the acceptable span. The ICCT report also takes issue with the inclusion of double cropping; we explain that the model includes a land intensification factor to properly determine harvest frequency based on regional factors and land use change observed over the period of rapid expansion of U.S. ethanol production. Finally, ICCT provides criticism on the classification of cropland pasture, which may have been an accurate comment for previous model versions but has been resolved with better functionality of recent versions of the selected model.

We close our letter by recognizing that the present yet manageable uncertainty around iLUC estimates must not hinder policy decisions, which should rely on the best available science. To support this, we give examples of policies implemented by public health organizations in the presence of uncertainty. We then explain how gasoline-powered light-duty vehicles will still be used by most individuals in the U.S. over the next 10 years. While electric vehicle (EV) sales are anticipated to increase, many individuals will find financial barriers to their uptake and continue to rely on gasoline-powered vehicles. We expect that shifting some of this gasoline use to higher ethanol blends will benefit the communities which are disproportionally impacted by exposure to traffic pollution and, thus, policy supporting this shift should not be delayed.

ILUC CARBON EMISSION RATES

Background

Life Cycle Associates, under contract with WDE, assessed multiple iLUC estimates for corn starch ethanol and recommended WDE adopt the iLUC estimate of 7.6 gCO2e per MJ ethanol used in the Oregon Clean Fuels Program.[4,5] As explained below, this carbon emission rate is consistent with current iLUC estimates observed across numerous frequently relied upon analyses.

iLUC and associated carbon emissions associated with use of corn starch ethanol in light-duty vehicles has been a subject of active research since at least 1990. iLUC emissions result from a market-mediated (economic) dynamics and land (e.g., biomass) characteristics that manifest at different rates and to different degrees at different locations. Hence, iLUC emissions cannot be observed or measured directly. iLUC emissions are therefore simulated using: (1) a class of mathematical models often termed agroeconomic models to estimate indirect land use change in response to demand for a biofuel combined with (2) databases of emission factors (EF) that describe the amount of carbon dioxide equivalent emissions per area of land converted from its current use to a new use.

The agroeconomic models relied upon most commonly by government authorities for estimates of iLUC in response to biofuel demand are Global Trade Analysis Project-biofuel model (GTAP-BIO-ADV), Food and Agricultural Policy Research Institute-Center for Agricultural and Rural Development (FAPRI-CARD), MIRAGE, and Global Biosphere Management Model (GLOBIOM), with the first two used primarily in the United States and the latter two used primarily in the European Union. The EF databases relied upon most commonly are CENTURY, Winrock, and AEZ. Extensive documentation of these models and databases is available in the peer-reviewed literature and reports. Here, we address aspects of the models and databases that are most relevant to the recommendation from LCAInc and peer review of ICCT.

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[4] Unnasch S. 2022. Indirect Land Use Conversion for Washington Clean Fuels Standard. [Presentation] https://ecology.wa.gov/DOE/files/26/26c03a09-487d-4b7f-a568-d88c5981423a.pdf

[5] State of Oregon Department of Environmental Quality. 2020. Notice of Proposed Rulemaking: Clean Fuels Program Electricity 2021 Rulemaking. https://www.oregon.gov/deq/Regulations/rulemaking/RuleDocuments/CFPE2021Notice.pdf

Best Available Science on ILUC

We assessed the best available science on iLUC emissions associated with corn starch ethanol as applied to biofuel policy in the U.S. and published our findings in a peer-reviewed journal in January 2021.[6] Since then, we have expanded our assessment to include the most recent U.S.-based estimates and iLUC results from modeling tools used in the European Union (EU) and adopted by the European Commission (EC).

The plot in Figure 1 presents iLUC estimates for the ~12 billion gallon increase in U.S. demand for corn starch ethanol from 2004 – 2010 that meet our criteria for best available science[7] in comparison to prior and now superseded estimates from the U.S. Environmental Protection Agency (USEPA) in 2010 and California Air Resources Board (CARB) in 2015. [8],[9],[10],[11],[12] The current estimates of iLUC GHG impacts are 2-fold to 4-fold lower than the earlier estimates from USEPA and CARB. iLUC emission estimates from the most current modeling efforts and policy in the U.S. (blue dots) are in good agreement with those from Europe (red dots).

Of note for WDE, the iLUC emission rate adopted by Oregon and proposed for Washington falls at the approximate mid-point of the values from the best available science.

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[6] Scully et al. 2021a.

[7] Our criteria include use of (1) the latest available measurable and observable inputs such as energy consumption and fertilizer use during feedstock and ethanol production and (2) generally accepted, frequently used, fully documented, and calibrated or tuned methods for estimation of direct and indirect land use change.

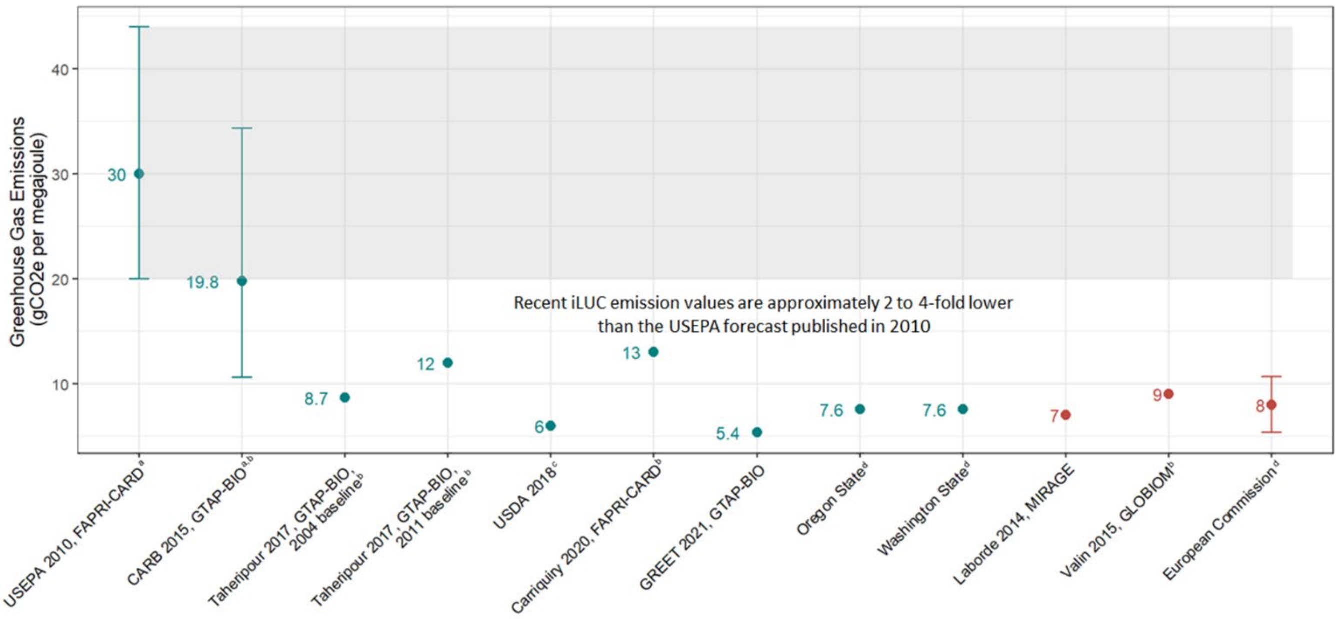
[8] Lee U, Hoyoung K, Wu M, Wang M. 2021. Retrospective analysis of the U.S. corn ethanol industry for 2005-2019: implications for greenhouse gas emission reductions. *Biofuels, Bioproducts & Biorefining*, 15(5), pp.1318-1331.

[9] 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.

[10] Taheripour F, Mueller S, Kwon H. 2021a. 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.

[11] 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.

[12] Scully et al. 2021a.



[a] Use older versions of the model
[b] Indirect and direct land use change
[c] Based on a review of primary land use change analyses
[d] Policy based on primary land use change analyses

Figure 1 Comparison of Washington State's proposed iLUC with relevant most recent studies and values used in the regulatory context in the U.S. and Europe

Like many models that are relevant to scientific discovery or policy, the tools used to characterize iLUC emissions have been further developed and refined over time with the goal of providing more accurate and reliable estimates. The observed changes in estimates of iLUC impacts over time are attributable primarily to: (1) addition of new modules that allow for more accurate simulation of real-world agricultural practices, (2) addition of more spatially resolved information on land cover, and (3) tuning of parameters that describe rates of land conversion and land transformation.[13,14,15,16,17,18] Our publication on LCA of corn ethanol[19] and our reply to comments on the paper,[20] as well as a recent retrospective analysis of corn ethanol LCAs by

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[13] USEPA 2010 Renewable Fuel Standard program (RFS2) regulatory impact analysis (RIA) Report No.: EPA-420-R–10–006 (Washington, DC: United States Environmental Protection Agency, Assessment and Standards Division Office of Transportation and Air Quality U.S. Environmental Protection Agency).

[14] Babcock BA, Iqbal Z. 2014. Using recent land use changes to validate land use change models. Staff report 14-SR 109. Center for Agricultural and Rural Development, Iowa State University.

[15] Carriquiry et al. 2020.

[16] Taheripour F, Zhao X, Tyner WE. 2017. The impact of considering land intensification and updated data on biofuels land use change and emissions estimates. *Biotechnology for biofuels*, 10(1), pp.1-16.

[17] Taheripour F, Tyner W. 2013. Biofuels and land use change: applying recent evidence to model estimates. *Applied Science,* 3(1), pp.14–38.

[18] Kwon H, Liu X, Dunn J B, Mueller S, Wander MM, Wang M. 2020. Carbon calculator for land use and land management change from biofuels production (CCLUB) Argonne National Library, Division ES September 2020.

[19] Scully et al. 2021a.

[20] Scully MJ, Norris GA, Alarcon Falconi TM, MacIntosh DL, 2021b. Reply to comment on 'Carbon intensity of corn ethanol in the United States: state of the science. *Environmental Research Letters*, 16(11), pp.118002.

Lee et al.,[21] summarize the enhancements made to FAPRI and GTAP-BIO, two iLUC models used in U.S. regulatory contexts for evaluation of corn ethanol.

In its peer review for WDE, ICCT critiqued the iLUC value of 7.6 gCO2e/MJ proposed to WBE by LCAInc and recommended WDE adopt the 2015 CARB iLUC value of 19.8 gCO2e/MJ instead. Its opinion appears to largely rely on criticisms of recent advances in the agroeconomic models and EF databases. As described in the next section, we disagree with the ICCT conclusion and note the CARB 2016 analysis that it recommends used an outdated version of GTAP-BIO which no longer represents the best available science.

ICCT Review

ICCT raised six main concerns in their critique of LCAInc's iLUC approach: (1) choice of agroeconomic model; (2) choice of land conversion EF database; (3) conversion of unmanaged forests; (4) price-induced corn yield (YDEL); (5) double cropping; and (6) classification of cropland pasture. We provide comments on each area of concern in the sections below. However, we first comment on the completeness of the review provided in the ICCT report.

Completeness of the ICCT peer review

Information on the strengths and weaknesses of GTAP-BIO-ADV presented in the ICCT peer review report is incomplete for it only presents perspectives held by critics of the model. The six areas of concern identified by ICCT (see preceding paragraph) were raised in two prior publications; one is an original paper, and the other is a published commentary on an original paper.[22,23] The ICCT report simply repeats criticisms that appear in those two publications. However, the report does not incorporate perspectives of the model developers including the rationale for the updates and discussion of their strengths and weaknesses.[24] The report also does not present perspectives of analysts and researchers who use the model and that have been published in the peer-reviewed scientific literature,[25,26] including publications prepared specifically in response to criticisms levied against the model and the modeling results.[27,28] For

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[21] Lee et al. 2021.

[22] Malins C, Plevin R, Edwards R. 2020. How robust are reductions in modeled estimates from GTAP-BIO of the indirect land use change induced by conventional biofuels?. *Journal of Cleaner Production*, 258, p.120716.

[23] Spawn-Lee SA, Lark TJ, Gibbs HK, Houghton RA, Kucharik CJ, Malins C, et al. 2021. Comment on 'Carbon intensity of corn ethanol in the United States: state of the science'. *Environmental Research Letters*, 16(11), pp.118001.

[24] For example, Taheripour et al. 2017.

[25] Lee et al. 2021.

[26] Scully et al. 2021a.

[27] Scully et al. 2021b.

[28] Taheripour F, Mueller S, Kwon H. 2021b. 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, p.127431.

these reasons, we find that the ICCT peer review of the iLUC emission rate proposed by Washington, and adopted by Oregon, is incomplete.

Selection of agroeconomic model

ICCT provides a critique of GTAP-BIO-ADV (hereafter "GTAP"), the agroeconomic model used to calculate WA's proposed iLUC, noting that inputs may not reflect real-world conditions and that its underlying datasets are incomprehensive.[29] GTAP is a computable general equilibrium (CGE) model that addresses land intensification and expansion on regional and national scales globally. The model predicts LUC for specific land types based on both economic and physical data. In 2010, USEPA stated that "since its inception in 1993, GTAP has rapidly become a common 'language' for many of those conducting global economic analysis."[30] GTAP is used by major corn ethanol life cycle analysis (LCA) modeling groups such as Argonne National Laboratory (ANL), CARB, and USEPA. Moreover, the model is generally accepted as evidenced by the numerous peer-reviewed publications that use it in evaluations of the global implications of biofuel production and policy and other environmental and trade topics.[31, 32, 33, 34, 35, 36, 37]

A distinguishing advantage of GTAP is its ability to account for linkages of the biofuel industry with other economic activities on a global scale.[38]

In addition to being widely used and generally accepted, GTAP is regularly updated to generate more refined and accurate estimates of LUC, including those associated with biofuels.[39, 40] Briefly, since 2010 GTAP has been updated to include: market mediated factors; co-products of biofuel refining such as animal feed (distillers' dried grains with solubles), regional extensive margins by agroeconomic zone (AEZ); 2004, 2007, and 2011 economic databases; land

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[29] ICCT. 2022. Washington Clean Fuels Standard – Carbon Intensity Model Peer Review. https://ecology.wa.gov/DOE/files/3f/3ff97fb5-9ba4-4507-8741-4be625e4e690.pdf

[30] USEPA. 2005. Renewable fuel standard (RFS1): final rule.

[31] Lee U et al. 2021.

[32] Taheripour et al. 2017.

[33] Hertel TW, Golub AA, Jones AD, O'Hare M, Plevin RJ, Kammen DM. 2010. Effects of US maize ethanol on global land use and greenhouse gas emissions: estimating market-mediated responses. *BioScience*, 60(3), pp.223-231.

[34] Tyner W, Taheripour F, Zhuang Q, Birur D, Baldos UL. 2010. Land use changes and consequent CO2 emissions due to US corn ethanol production: A comprehensive analysis.

[35] Taheripour and Tyner 2013.

[36] Dunn et al. 2013.

[37] Wang M, Han J, Dunn JB, Cai H, Elgowainy A. 2012. Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use. *Environmental research letters*, 7(4), p.045905.

[38] Kretschmer B and Peterson S. 2010. Integrating bioenergy into computable general equilibrium models—A survey. *Energy Economics*, 32(3), pp.673-686.

[39] Taheripour et al.2017.

[40] Taheripour et al. 2021b.

transformation elasticities on a regional scale; region-specific multiple cropping; and land cover nesting structure that includes idled cropland.[41]

Limitations of CCLUB

ICCT criticizes the choice of CCLUB as the emissions factor model primarily because CCLUB uses CENTURY and Winrock EF as the default for characterizing carbon in biomass and soil organic carbon (SOC) rather than Agro-ecological Zone Emission Factors (AEZ-EF).[42] An advantage of the CENTURY EF is their potential to account for a broad range of soil characteristics, climate, and management conditions. [43] The CENTURY approach to EF "is consistent with the technique of the Intergovernmental Panel on Climate Change of continuously updating carbon stock change factors based on such factors as management activities and various yield scenarios."[44]

The ICCT report also challenges how the CENTURY EF in CCLUB treat emissions associated with transitioning cropland pasture to cropland and recommend using instead the AEZ-EF.[45] The AEZ-EF simply assume converting cropland pasture to cropland releases 50% of the emissions associated with converting pasture to cropland.[46] However, emissions associated with conversion of cropland pasture to cropland are likely to be lower due to periodic tilling since cropland pasture typically "shifts back and forth between cropland and grassland depending on the net returns". [47] The treatment of cropland pasture in CENTURY appears to be more evidence-based than the method utilized by AEZ-EF, since it is informed by USDA statistics.[48]

Conversion of unmanaged forests

ICCT calls out that, in GTAP, unmanaged forests are treated as unavailable for conversion to cropland.[49] However, this criticism has no material bearing on iLUC estimates as GTAP accounts for accessible forest area, which includes managed forests and some unmanaged forests, where accessibility is a function of distance to infrastructure.[50] The absence of an

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[41] Ibid.

[42] ICCT 2022.

[43] Taheripour et al. 2021b.

[44] Ibid.

[45] ICCT 2022.

[46] Plevin RJ, Gibbs HK, Duffy J, Yui S, Yeh S. 2014. Agro-ecological zone emission factor (AEZ-EF) model (v47) (No. 1236-2019-175).

[47] Claassen R, Carriazo F, Cooper J C, Hellerstein D, Ueda J. 2011 Grassland to cropland conversion in the northern plains: the role of crop insurance, commodity, and disaster programs. ERR-120. U.S. Dept. of Agri., Econ. Res. Serv. 1–77.

[48] Taheripour et al. 2021b.

[49] ICCT 2022.

[50] Hertel, T., Golub, A., Jones, A., O'Hare, M., Plevin, R. and Kammen, D., 2009. Global land use and greenhouse gas emissions impacts of US Maize ethanol: the role of market-mediated responses.

explicit compartment for unmanaged forest has no effect on EF because emissions factors that distinguish between managed and unmanaged forest have yet to be developed.[51, 52]

Price-induced yield

ICCT critique the use of a YDEL factor of 0.25 because it is "greater than the high-end range estimated by expert reviewers, and is only justified on the basis that it implicitly includes the yield effects of double cropping." [53] These concerns have been raised and addressed in previous publications.[54, 55, 56, 57] We briefly discuss YDEL here and address the potential for double cropping in the next section.

In our state of the science review of the CI for corn ethanol in the U.S., we conducted a literature review to identify raw YDEL values, calculated the average of those values (0.23), and compared that average to the commonly used YDEL of 0.25.[58] A YDEL of 0.25 appears to be commonly used as our analysis showed that 17 of the 27 LUC estimates we considered were derived using a YDEL of 0.25 (see Supplemental materials for Scully et al. 2021a). Separately, the CARB expert work group on YDEL also recommended a YDEL of 0.25.[59] The CARB expert group also opined on when a range of YDEL values, in consideration of multiple cropping, may be appropriate: "If differentiation [in YDEL] can occur by country, then setting the price elasticity to 0.175 for countries with no double cropping, 0.25 for the U.S. and 0.3 for Brazil and Argentina [with higher rate of double cropping] will provide a more reasonable approximation to reality".[60, 61]. Subsequently, Taheripour et al. expanded upon the CARB expert work group's recommendation by analyzing global, region-specific land use data to develop "a full set of regional YDEL values based on the observed regional yields obtained from the FAO data set from 2003-2013".[62] Based on these considerations, we concluded that the current most credible YDEL range is 0.175-0.325, since it was supported by CARB's expert group, is inclusive of the commonly used value of 0.25, and is corroborated by the average YDEL calculated from 20 relevant studies on corn YDEL dating from 1976-2017. Our review of the state of the science thus shows that a YDEL of 0.25 is appropriate and lower than the high end of the current most credible range.

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[51] Plevin et al.2014.
[52] Kwon et al.2020.
[53] ICCT 2022.
[54] Malins et al.2020.
[55] Spawn-Lee et al.2021.
[56] Scully et al. 2021b.
[57] Taheripour et al. 2021b.
[58] Scully et al. 2021a.
[59] Babcock B, Gurgel A, Stowers M. Final Recommendations From Elasticity Values Subgroup. ARB LCFS Expert Workgroup; 2011.
[60] Taheripour et al.2021a.
[61] Babcock et al.2011.
[62] Taheripour et al.2021a.

Double cropping

According to ICCT, a YDEL of 0.25 “can only be justified if double cropping is not explicitly included in the modeling to minimize the risk of underestimating ILUC emissions.”[63] Their critique is focused on the LUC values that were calculated by Taheripour et al. (2017) which applied regional land intensification parameters in addition to regional YDELs.[64] This concern was raised and addressed in previous publications, and we encourage WDE to review those papers for details on this topic.[65,66,67] Briefly, GTAP was updated with a land intensification parameter to “represent improvement in harvest frequency due to multiple cropping and/or conversion of idled cropland to crop production”.[68] The land intensification parameter is empirically-based and parameterized using regional “FAO data based on actual observations on regional harvested area and cropland area”.[69,70] The region-specific land intensification parameter in addition to region-specific YDELs allows GTAP to account for observed corn yield response, harvest frequency, and conversion of idled cropland to crop production, informed by empirical data.[71] Inclusion of the land intensification parameter improved agreement between model estimates and empirical information for cropland extensification on a regional scale across the globe.[72]

Classification of cropland pasture

The ICCT report challenges how GTAP treats cropland pasture conversion, primarily because of recent model updates that include adjusted land transformation elasticities.[73] Land transformation elasticities “reflects the ease of land transition from one state to another”.[74] Updates to GTAP included using two “United Nations FAO land cover data sets [from 1990-2010] to develop region-specific land transformation elasticities”, rather than using a single land transformation elasticity value for the globe.[75,76] Additionally, older versions of GTAP assumed the costs for converting pasture and forest to cropland were identical, while “often the opportunity costs of converting forest to cropland is higher than the economic costs of converting

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[63] ICCT 2022.
[64] Taheripour et al.2017.
[65] Ibid.
[66] Malins et al.2020.
[67] Taheripour et al.2021a.
[68] Taheripour et al. 2021b.
[69] Taheripour et al.2017.
[70] Taheripour et al. 2021b.
[71] Taheripour et al.2017.
[72] Taheripour et al. 2021b.
[73] ICCT 2022.
[74] Kwon et al.2020.
[75] Taheripour and Tyner 2013.
[76] Kwon et al.2020.

pastureland to cropland”.[77] Taheripour and Tyner updated GTAP to categorize regions as having a low, medium, or high land transformation elasticity and reflect the greater cost of converting forest to cropland than converting pastures based on empirical data and real world observations.[78,79] These model updates resulted in GTAP “producing results more consistent with historical observations”.[80]

UNCERTAINTY IN ILUC

ICCT’s peer review notes that “ILUC emissions remain uncertain due to data limitations as well as disagreements on model choice, scenario design, and risk tolerance.” While we agree that uncertainty exists, we note that the distribution of uncertainty around central estimates of iLUC is reasonably well characterized in the literature. The level of uncertainty present around iLUC does not warrant that government agencies disregard updated data and models when making policy decisions.

USEPA and others have used Monte Carlo and similar simulation methods to characterize the effects of parameter uncertainty on estimated iLUC impacts.[81,82] These analyses report distributions of uncertainty about iLUC estimates for corn ethanol that are approximately symmetric or moderately right-skewed with a coefficient of variation of approximately 20%. Although the formal uncertainty analyses were performed as part of older studies, we are not aware of a reason why uncertainty about present iLUC emission estimates would be greater than the prior estimates. This amount of uncertainty is comparable to uncertainty in other environmental public health analyses. For example, the accepted irreducible error in standard environmental measurements is typically approximately 15%. Another example relates to exposure to chemical hazards: the dose-response relationships for chemicals hold relatively high uncertainty, typically in the range of 100-fold (10,000%) to 1,000-fold (100,000%).[83,84,85] In both of these cases, regulatory agencies, such as USEPA, are able to accept the uncertainty and use estimates to implement policy and provide guidance to the public.

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[77] Taheripour and Tyner 2013.

[78] Taheripour and Tyner 2013.

[79] Kwon et al.2020.

[80] Taheripour et al.2021a.

[81] USEPA 2010 Final Rule, Table V.C-5.

[82] Laborde et al. 2014.

[83] USEPA. Reference Dose (RfD): Description and Use in Health Risk Assessments. Background Document 1A. https://www.epa.gov/iris/reference-dose-rfd-description-and-use-health-risk-assessments#1.3.2

[84] USEPA. 2021. External Peer Review Draft, Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) in Drinking Water, U.S Environmental Protection Agency, ed. Washington, DC.

[85] USEPA. 2021a. External Peer Review Draft, Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for perfluorooctane sulfonic acid (PFOS) in Drinking Water, D. Washington, ed.

While uncertainty may always be present when calculating iLUC emissions, there are signs of uncertainty reduction given the converging iLUC estimates, as we discussed in our section on the Best Available Science on iLUC above. Current central estimates of iLUC impacts are of similar magnitude despite being the product of models with different methods, designs, data, and parameter values. We showed above that the proposed WA iLUC emission estimate is in good agreement with the most current modeling efforts and policy in the U.S. and in Europe (Figure 1). In contrast, the estimated iLUC values from CARB 2015 are based on an outdated version of GTAP-BIO that has been superseded and no longer represents the best available science. When considering uncertainty in iLUC, we recommend WDE review studies that represent best available science and not rely on those that use outdated models.

IMPLICATIONS OF HIGHER ETHANOL FUEL BLENDS

To emphasize why agencies must use the best available science and not allow uncertainty to hinder policy decisions, we provide a brief summary of how using higher ethanol blends for gasoline-powered vehicles is an important pathway to reduce the CI of the transportation sector. While the market-share of gasoline-powered light-duty vehicles is expected to decrease over the next 10 years, they still account for a majority of the vehicles driven by the U.S. population. Sales of electric vehicles (EV) in the U.S. accounted for only 1.7% of new car sales in 2020 [86] and are estimated to reach 30% by 2030.[87] Additionally, EVs have higher upfront costs than gasoline powered vehicles ($19,000 higher on average) [88] which may limit their market penetration until prices become more comparable.[89] Given the financial barriers to acquire an EV and the disproportionate exposure to traffic pollution for the environmental justice (EJ) communities,[90] alternatives such as using higher ethanol blends may provide significant benefits to these communities.

Most gasoline used for light duty vehicles in the U.S. is E10, which contains a blend of 10% (by volume) ethanol with a gasoline blendstock. We recently evaluated the impacts of ethanol fuel blending on tailpipe emissions,[91,92] and summarized the results and discussed implications for

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[86] Oak Ridge National Laboratory. 2021. https://tedb.ornl.gov/wp-content/uploads/2021/05/Table6_02_04302021.xlsx (accessed 22 April 2022).

[87] EVAdoption. https://evadoption.com/ev-sales/ev-sales-forecasts/ (accessed 22 April 2022).

[88] Hearst Autos Research. https://www.caranddriver.com/research/a31544842/how-much-is-an-electric-car/. (accessed 22 April 2022)

[89] Muehlegger E and Rapson D. 2019. Understanding the Distributional Impacts of Vehicle Policy: Who Buys New and Used Electric Vehicles? UC Davis: National Center for Sustainable Transportation. http://dx.doi.org/10.7922/G21Z42N Retrieved from https://escholarship.org/uc/item/1q259456

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

[91] Kazemiparkouhi et al. 2021a.

[92] Kazemiparkouhi et al. 2021b.

air quality and public health in a white paper (Attachment A).[93] We provide a short summary of that work in this letter. We found that tailpipe emissions of particulate matter (PM) decreased with increasing ethanol content under cold-start conditions.[94] Emissions of carbon monoxide (CO) and total hydrocarbons (THC) also generally decreased with increasing ethanol fuel content under cold running conditions, while oxides of nitrogen (NOx) emissions did not change.[95] Air toxic emissions showed lower BTEX, 1-3 butadiene, black carbon, and particle number emissions with increasing ethanol content in summer market fuels.[96] Notably, our findings are consistent with a recent CARB study that assessed the impact of splash-blending E10 to E15 on PM and other air pollutant emissions for late model year vehicles (2016-2021).[97,98]

The estimated reductions in air pollutant emissions, particularly of PM, indicate that increasing ethanol content offers opportunities to improve air quality and public health. Numerous studies have shown that lower PM emissions result in lower ambient PM concentrations and exposures, [99,100] which, in turn, are causally associated with lower risks of total mortality and cardiovascular effects.[101,102,103,104] 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.

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

[94] Kazemiparkouhi et al. 2021a.

[95] Ibid.

[96] Kazemiparkouhi et al. 2021b.

[97] Karavalakis G, Short D, Vu D, Russell RL, Asa-Awuku A, Jung H, Johnson KC, Durbin TD. 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, pp.168-179.

[98] 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.

[99] 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.

[100] 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.

[101] 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.

[102] 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.

[103] USEPA 2019. Integrated Science Assessment for Particulate Matter. Center for Public Health and Environmental Assessment.

[104] 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 US Medicare beneficiaries. *Environmental Health*, 19(1), pp.1-12.

CONCLUSION

The ICCT peer review offers numerous comments on the GTAP-BIO-ADV model and CCLUB default EF used by numerous analysts to estimate iLUC associated with demand for corn starch ethanol and which form the foundation of the iLUC emission rate proposed by WDE. Their comments do not incorporate scientific writings and perspectives of subject matter experts other than those who are critical of this approach. In this letter, we summarized key elements of the views held by those other subject matter experts on the subjects raised by ICCT with the aim of providing WDE a more complete picture of the state of the science for estimation of iLUC emissions. We also present herein our own analysis which demonstrates that uncertainty of iLUC emission estimates, while still present, has decreased over time in step with advancements in methodology and presently is no greater for iLUC than other parameters that are important to protection of human health and resources.

As experienced environmental scientists, engineers, and analysts ourselves, we of course recognize both strengths and weaknesses in GTAP-BIO-ADV and CCLUB EF in comparison to alternative approaches to estimation of iLUC. But more importantly in our view, we also recognize that the iLUC emission rate estimated through GTAP-BIO-ADV and CCLUB EF is highly consistent with estimates from the leading alternative modeling systems – FAPRI, MIRAGE, and GLOBIOM – as described in the first section of this letter. This consistent set of results is strikingly different from estimates generated by earlier, less complete, less tested versions of the same modeling systems. Moreover, the updates made to the modeling systems are rational, explained clearly, and documented in the peer-reviewed and gray scientific literature. The consistency in results observed among current modeling systems is particularly important because replication is a hallmark of reliable science. In our scientific judgement, these characteristics of the iLUC emission rate proposed by WDE outweigh the limitations of GTAP-BIO-ADV and CCLUB default EF posited by ICCT.

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

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

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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

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[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 market fuel properties

Fuel ID	EtOH Vol (%)	T50 (^{o}F)	T90 (^{o}F)	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

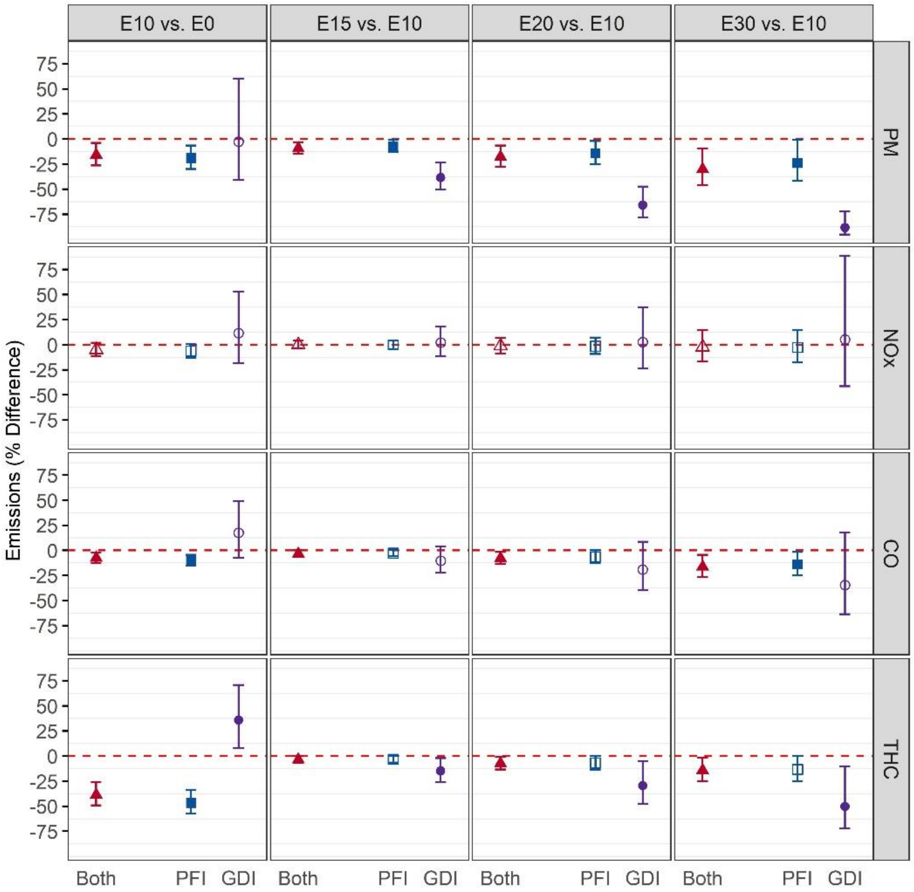
Abbreviations: EtOH = ethanol volume; T50 = 50% volume distillation temperature; T90 = 90% volume distillation temperature; Aromatics=aromatic volume; AKI = Anti-knock Index; RVP = Reid Vapor Pressure.

- ***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, US EPA, 2013). The cold start contribution to total PM vehicle emissions, together with our findings of emission reductions during cold starts, suggest that a ***10% increase in ethanol fuel content from E10 to E20 would reduce total tailpipe PM emissions from motor vehicles by 6-8%.***

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

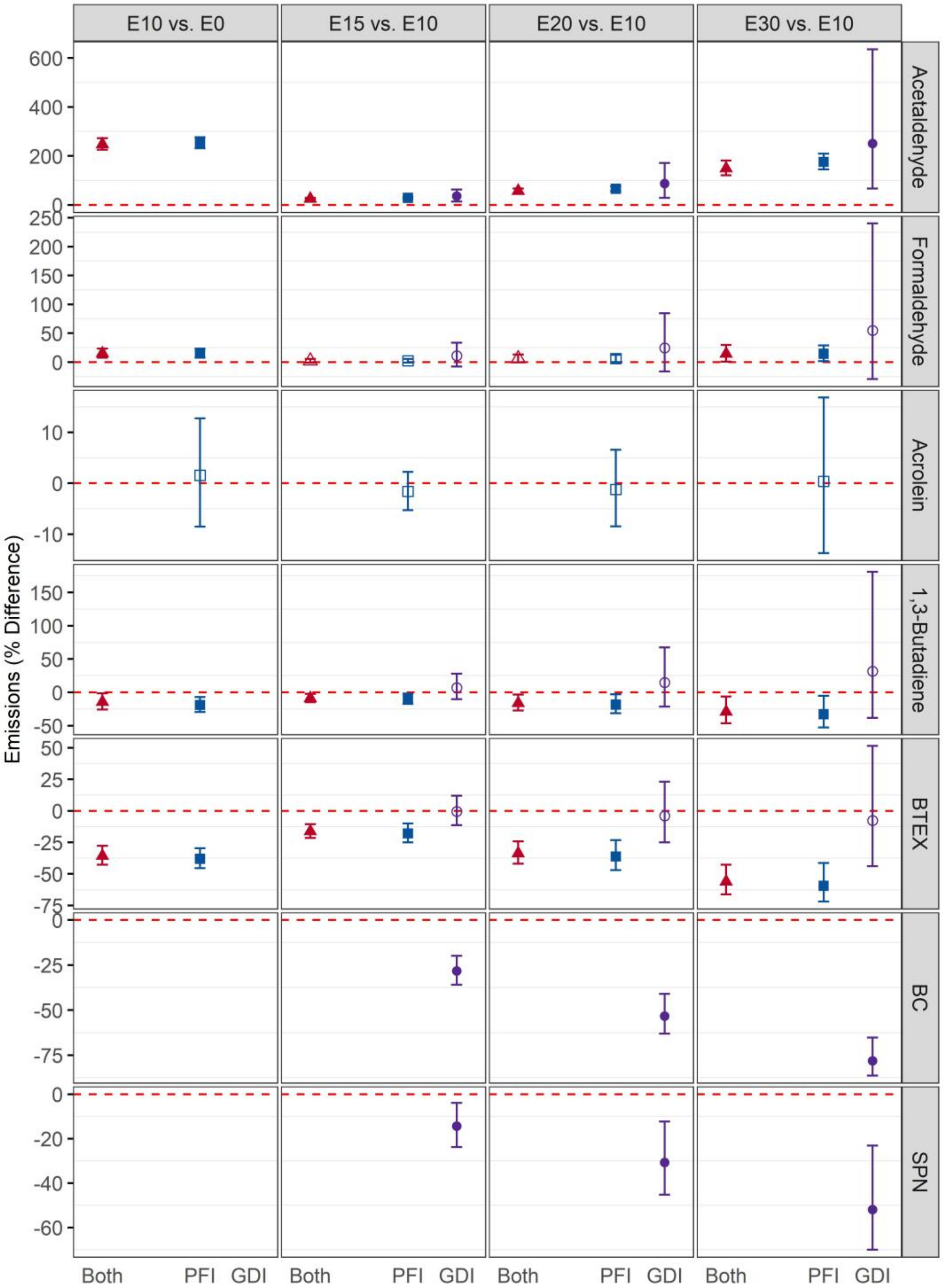


[a] Emissions were predicted from regression models that included ethanol and aromatics volume fraction, T90, and RVP as independent variables (Kazemiparkouhi et al., 2022a)

- ***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 content*** in summer market fuels (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 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

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.

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