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U.S. Environmental Protection Agency
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Docket ID No. EPA-HQ-OAR-2015-0827

Ms. Rebecca Yoon
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National Highway Traffic Safety Administration
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Docket ID No. NHTSA-2016-0068

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Comments for Draft TAR 2016

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Request for Comments on draft Technical Assessment Report of the 2022-2025 CAFE-GHG standards

Dear Mr. Lieske, Ms. Yoon, and Mr. McCarthy:

On behalf of the members of the American Coalition for Ethanol (ACE), thank you for the opportunity to submit comments on the draft Technical Assessment Report (TAR) of the 2022-2025 model year CAFE-GHG standards as the Environmental Protection Agency (EPA) and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) conduct the Midterm Evaluation (MTE) of the program.

ACE is a grassroots organization, powered by people who have built an innovative industry that sustainably delivers clean biofuel and valuable food for a growing world. More information about ACE and its members can be found at www.ethanol.org

We have been in dialogue with automakers, agricultural organizations, government researchers and many others to develop strategies and action plans to accelerate the transition of North American transportation fuels to higher-octane, lower-carbon renewable fuels such as ethanol. CAFE-GHG standards present a natural and timely opportunity for this transition to occur. Below is a brief summary of our primary comments about the TAR and request that the agencies create a compliance mechanism for high-octane, low-carbon fuels like ethanol to help meet the 2022-2025 standards.

1. Vehicle CO2 emissions are on the rise in the U.S. and will continue to get worse until EPA, NHTSA, and CARB deal with the impact fuel properties have on greenhouse gas (GHG) emissions. We encourage the agencies to acknowledge the inescapable link between fuels and vehicles and create a pathway for low-carbon, high-octane fuels like ethanol to help automakers comply with the 2022-2025 standards.

2. While the CAFE-GHG standards have spurred advancements to internal combustion engines (ICEs), the agencies have not been proactive about improving the octane composition of the fuel these new ICE technologies depend upon in the real-world. The goals of the CAFE-GHG program will go unrealized until a compliance mechanism is set in motion for higher-octane fuel.

3. Automobile engineers and U.S. government scientists who have researched engine technologies and fuel properties agree that ethanol is a low-cost, low-carbon, high-octane fuel that delivers the GHG and engine efficiency benefits necessary to accomplish the goals of the CAFE-GHG program.

We also submit comments encouraging the agencies to restore meaningful credits for Flexible Fuel Vehicles (FFVs) and consider the establishment of a new incentive for ICEs optimized for high-octane, low carbon fuels. Finally, we urge that fixes are made to the MOVES2014 model and R-factor, and that the goals of the CAFE-GHG program and Renewable Fuel Standard are harmonized.

1. **Vehicle CO2 emissions are on the rise in the U.S. and will continue to get worse until EPA and NHTSA deal with the impact fuel properties have on GHG emissions. We encourage the agencies to acknowledge the inescapable link between fuels and vehicles and create a pathway for low-carbon, high-octane fuels like ethanol to help automakers comply with the 2022-2025 standards.**

Chapter 1 of the MTE TAR indicates that "the relationship between improving fuel economy and reducing CO2 tailpipe emissions is very direct and close." The same can be said for the relationship between fuel and reducing CO2 tailpipe emissions. Indeed, according to research by Derek Splitter of the U.S. Department of Energy's (DoE) Oak Ridge National Laboratory (ORNL), "Beginning in the late 1910s through the 1930s, researchers identified engine and fuel relationships between knock, compression ratio, performance, and efficiency (Horning 1919, 1923; Ricardo, 1922; Cummings, 1927; Edgar, 1927; Campbell et al., 1930; Boyd, 1950; Gibbs, 1993)."[1]

Dirty and low quality (low octane) fuel will increase GHG emissions, especially in the type of new engine technologies that are beginning to dominate the marketplace. On the other hand, cleaner and higher-octane fuel will reduce CO2 tailpipe emissions and improve fuel economy.

As the agencies work to determine whether the 2022-2025 model year CAFE-GHG standards set in 2012 are achievable, the fact that vehicles now emit more GHG emissions in the U.S. than power plants needs to be taken into consideration. Lower fuel prices and consumer preferences for larger, less fuel-efficient vehicles have clearly contributed to an increase of GHG emissions despite the standards the agencies have set. One of the best ways to reduce GHGs from the transportation sector is to provide a pathway for low-carbon, high-octane biofuels such as ethanol to play a more significant role in the transportation fuel mix. Whether or not the agencies maintain or tighten the

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[1] A Historical Analysis of the Co-evolution of Gasoline Octane Number and Spark-Ignition Engines. Splitter D, Pawlowski A, and Wagner R. Front. Mech. Eng. 1:16. DOI: 10.3389/fmech2015.00016 (2016).

2022-2025 standards, we encourage a pathway for high-octane, low carbon fuel as a tool to help reduce GHGs and achieve those standards.

Dan Nicholson, Vice President of Global Propulsion Systems for General Motors (GM), said the following about high-octane fuel at the 2016 CAR Management Briefing Seminars. "Higher octane fuels are the cheapest CO2 reduction on a well-to-wheels analysis…Fuels and engines must be designed as a total system. It makes absolutely no sense to have fuel out of the mix of engine technology discussions."[2]

Added DoE's Splitter, "…with the looming emphasis on unprecedented increases to fuel economy in the current CO2 age, it is hard to argue that the current stagnant fuel octane number can be sustained over the long term. Therefore, increasing fuel octane number offers significant motivation to achieve fuel economy and CO2 targets."[3]

Automakers agree with the agencies that more electrification will be needed to meet future standards, but they also indicate internal combustion engines (ICEs) will dominate the marketplace for decades. Octane is the most important fuel property for achieving maximum efficiency in ICEs.

Tony Ockelford, Director of Product and Business Strategy at Ford Powertrain, said the following about octane and engine efficiency at the 2016 CAR Management Briefing Seminars. "Raise the compression ratio and you are raising the efficiency of the engine. One thing everyone would agree: 100 RON, if ever you could get there, is a nice place."[4]

The agencies make an implicit admission that fuel octane is an essential ingredient for successfully meeting the 2022-2025 CAFE-GHG standards based on some of the testing and engine modeling in the TAR. Page 5-509 of the TAR indicates: "All the turbocharged direct injection engines described below have been developed using 93 octane. NHTSA understands that using such fuel might lead to overestimating the effectiveness of this technology, especially for high BMEP engines." It should also be noted that the EPA gasoline turbocharged direct injection package was tested with 96 RON fuel and pages 5-284 through 5-285 of the TAR refer to fuel specifications with 98 RON indolene.

As you know, automakers use 91 RON (87-88 AKI) fuel for certification, instead of the high-octane 96-98 RON (93 AKI) fuel the agencies relied upon for some of the engine testing and modeling. Automakers are understandably concerned by the agencies' inconsistent application of fuel octane and properties for non-premium required vehicles in the TAR. If the agencies optimistically predict the 2022-2025 standards can be met with existing powertrain technologies and no changes in fuel, why do those predictions rely in part upon modeling simulations that used high-octane fuel for downsized and turbocharged engines?

The agencies' dependence on high-octane fuel in making predictions about meeting the standards seems to support our position that a pathway needs to be established for low-carbon, high-octane fuels like ethanol to help automakers comply with the 2022-2025 standards. If agency modeling relies upon high-octane fuel to test and verify that future standards can be met, it is imperative that

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[2] CAFE Standards: What's Biomass Got to do with it? Rebecca Chillrud. EESI. September 10, 2016.

[3] A Historical Analysis of the Co-evolution of Gasoline Octane Number and Spark-Ignition Engines. Splitter D, Pawlowski A, and Wagner R. Front. Mech. Eng. 1:16. DOI: 10.3389/fmech2015.00016 (2016).

[4] OEMs Continue Push for High-Octane Gas. Wards Auto. April 20, 2016. Tom Murphy.

there is real-world availability of these high-octane fuels. If high-octane fuels aren't available, the standards won't be met.

EPA has the legal authority to regulate the octane composition of fuel and the Tier 3 rule contemplates a potential certification pathway for high-octane fuel. Moreover, in a briefing related to Energy Future Coalition et al. v. EPA, the agency recognized that it has discretion to approve an alternative test/certification fuel that is not currently on the market. We encourage EPA and NHTSA to use the MTE timeframe and upcoming Proposed Determination to initiate a pathway for low-carbon, high-octane fuels like ethanol to help automakers comply with the 2022-2025 standards.

2. **While the CAFE-GHG standards have spurred advancements to ICEs, the agencies have not been proactive about improving the octane composition of the fuel these new ICE technologies depend upon in the real-world. The goals of the CAFE-GHG program will go unrealized until a compliance mechanism is set in motion for higher-octane fuel**

Automakers have responded to the CAFE-GHG standards with an impressive array of technologies such as variable valve timing, multi-valve engines, turbocharging, engine downsizing, improved aerodynamics, light-weighting, low rolling resistance tires, stop-start features, and improved air conditioning systems.

Despite this wave of innovation, vehicle GHG emissions are on the rise because the fuel used to power new engine technologies in the real-world is of insufficient quality and octane content to mitigate dangerous $CO2$ emissions. The draft TAR includes an impressive but incomplete list of factors considered relevant to the 2022-2025 CAFE-GHG standards, including:

- Powertrain improvements for gasoline and diesel engines
- Batter developments for hybridization, electrified vehicles
- Technology costs
- Vehicle light-weighting and impacts on safety
- Market penetration of fuel efficient technologies
- Fuel prices
- Fleet mix (cars v. trucks)
- Employment impacts
- Infrastructure for electric vehicle charging, alternative fuels
- Consumer acceptance
- Consumer payback periods
- Any other factors deemed relevant

The one obvious factor that the agencies have failed to take into consideration as part of the MTE TAR is fuel. Light-duty vehicles account for 63 percent of petroleum use and 61 percent of GHG emissions.
According to a recent report by Chris Gearhart, the Director of the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) Transportation and Hydrogen Systems Center, the only way ICEs can be used to reach the White House goal of cutting GHG emissions 80 percent by 2050 is if a significant amount of gasoline is replaced with biofuels.[5]

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[5] Implications of sustainability for the United States light-duty transportation sector. Chris Gearhart , National Renewable Energy Laboratory , Transportation and Hydrogen System Center
DOI: http://dx.doi.org/10.1557/mre.2016.8

Automakers have wanted EPA to increase the octane rating of gasoline for several years. Mitch Bainwol, President and CEO of the Alliance of Automobile Manufacturers, made the following request of then-EPA Administrator Lisa Jackson in an October 6, 2011 letter. "Furthermore, to help achieve future requirements for the reduction of greenhouse gas emissions, we also recommend increasing the minimum market gasoline octane rating, commensurate with increased use of ethanol. Adding ethanol to gasoline increases its octane rating. To attain necessary octane levels, it is important that refiners not be permitted to reduce base gasoline octane ratings in light of the additional octane contribution from higher ethanol."[6]

Most of the low-hanging fruit has already been picked in the form of many of the aforementioned powertrain technology innovations. Certain changes present diminishing returns. For example, there comes a point where vehicle weight cannot continue to be reduced because it presents safety issues.

"Gasoline Direct Injection (GDI) engines have increased market share by more than a factor of five in model year 2010 to 46 percent in model year 2015. Turbochargers, which often are used in conjunction with GDI, have also increased market share by more than a factor of five since model year 2010. Nearly all vehicles using turbocharged spark-ignition engines also used GDI to improve suppression of knocking combustion" according to EPA itself in the MTE TAR.

Reuters Market Analyst John Kemp reports that the "percentage of new light-duty gasoline vehicles sold with turbocharged engines has climbed from just 3.3 percent in the 2009 model year to 17.6 percent in the 2015 model year. In 2015, the National Research Council found turbocharged engines had been installed in nearly half of all Ford's popular F-150 light trucks. By 2025, more than 80 percent of all new gasoline vehicles sold in the United States will include turbocharged engines, according to the Energy Information Administration (EIA). But to prevent fuel detonation ("knocking") engines with higher compression rations need to run on fuels with a higher octane rating."[7]

These engines will tolerate today's low octane fuel, but they will not be able to generate the substantial fuel economy and GHG reduction benefits the agencies hope to realize unless they operate on a higher-octane fuel. Achieving the ambitious standards going forward will require a higher-octane fuel that delivers lower GHG emissions and is affordable at the pump. Higher blends of ethanol can contribute to a higher RON and heat of vaporization, properties which make it an ideal fuel for new engine technologies. Ethanol can and should be part of the solution to the problem of meeting the future standards.

Splitter sums it up well in his conclusion that "...since fuel lead removal began in the mid-1970s, fuel octane number has remained stagnant while engine efficiency and performance improvements have resulted from digital controls and design refinements. This relaxation of the fundamental coupling between fuel octane number and engine compression ratio is a long-term unsustainable trajectory."

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[6] Letter from Mitch Bainwol, Alliance of Automobile Manufacturers, to The Honorable Lisa Jackson, EPA Administrator. October 6, 2011. (attachment A) https://www.regulations.gov/document?D=EPA-HQ-OAR-2010-0799-9574

[7] "Vehicle efficiency spurs premium gasoline sales, octane demand." September 7, 2016. Reuters Market Analyst John Kemp.

The role that ethanol-gasoline blends in the range of 20 to 30 percent can play as an octane enhancer is supported by a paper from J.E. Anderson et al of Ford Motor Corporation.[8] "The high octane rating of ethanol could be used in a mid-level ethanol blend to increase the minimum RON of regular grade gasoline. We estimate that large increases (4 to 7 points) in the RON of U.S. gasoline are possible by blending in an additional 10 to 20 percent by volume ethanol above the 10 percent ethanol already present. Keeping the blendstock at 88, we estimate RON would be increased to 94.3 for E15 to as much as 98.6 for E30. Even further RON increases may be achievable assuming changes to the blendstock RON and/or hydrocarbon composition. For the ethanol and blendstock RON scenarios considered, compression ratio increases were estimated to be on the order of 1 to 3 units for port fuel injected engines as well as for direct injection engines in which greater evaporative cooling can be fully utilized. It appears that substantial societal benefits may be associated with capitalizing on the inherent high octane rating of ethanol in future higher octane number ethanol-gasoline blends."

AVL Powertrain Engineering, BP North America, and GE Energy helped contribute to a paper published by SAE International which reinforces the findings of Ford above and provide further support to the use of ethanol to increase the octane rating of gasoline.[9]

EPA has said in media reports that fuel will not play a role in meeting fuel economy standards until post-2025. However, according to Mike McCarthy, the chief technology officer for CARB, "Octane will have to be part of the conversation. I think it has to be on the table."[10]

Steve Vander Griend, chair of the technical committee for the Urban Air Initiative has said "Adding ethanol to gasoline improves it in every way. It lowers carbon, reduces common air pollutants for smog formation, lessens CO2 emissions, reduces sulfur content, and provides clean octane as a replacement for toxic aromatics. In short, it makes gasoline significantly better than what would otherwise go in your tank."

If the agencies to wait until post-2025 to begin initiating a process for low-carbon, high-octane fuel to help play a role in meeting the CAFE-GHG standards, it is likely the 2022-2025 model year goals will not be met. We encourage you to set a compliance mechanism in motion as part of the Proposed Determination so fuels with clean octane can be a tool in meeting the ambitious goals set forth in the program.

3. **Automobile engineers and U.S. government scientists who have researched engine technologies and fuel properties agree that ethanol is a low-cost, low-carbon, high-octane fuel that delivers the GHG and engine efficiency benefits necessary to accomplish the goals of the CAFE-GHG program.**

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[8] "High octane number ethanol-gasoline blends: Quantifying the potential benefits in the U.S." Anderson, J.E. et al, Ford Motor Company. July 2012. http://www.sciencedirect.com/science/article/pii/S0016236112002268

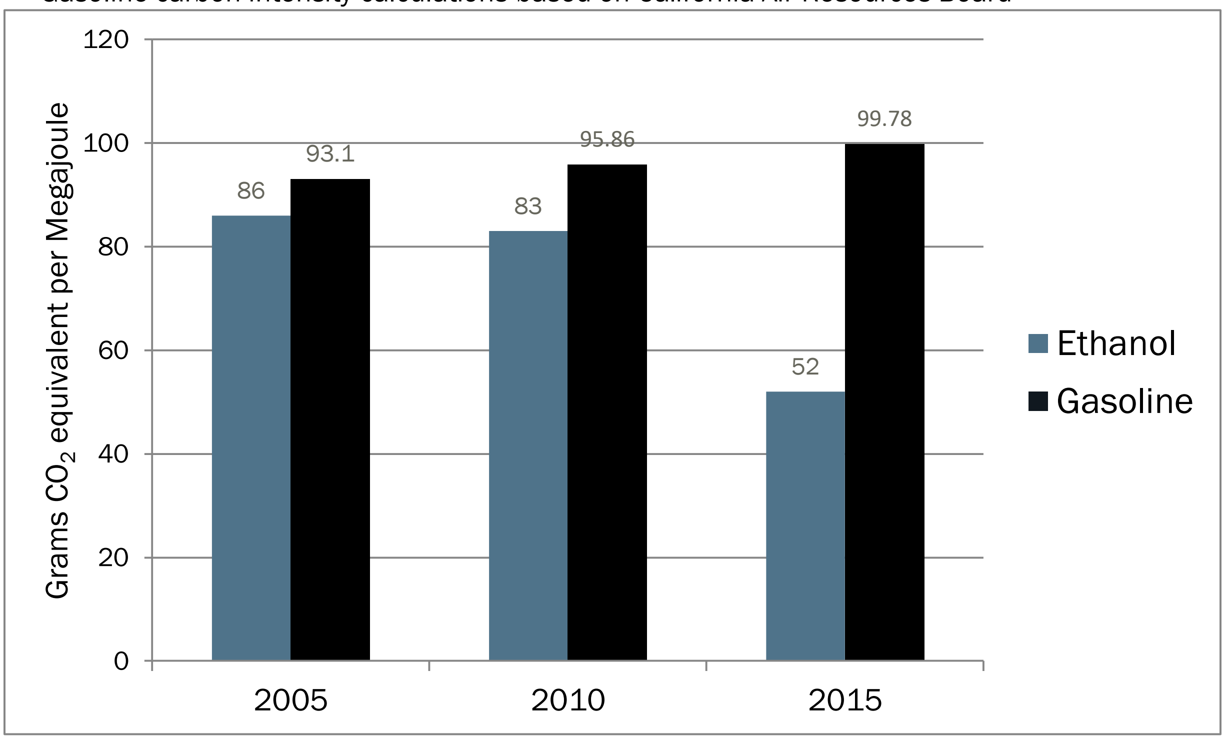
[9] "Octane Numbers of Ethanol-Gasoline Blends: Measurements and Novel Estimation Method from Molar Composition." Anderson, J., Leone, T., Shelby, M., Wallington, T. et al., "Octane Numbers of Ethanol-Gasoline Blends: Measurements and Novel Estimation Method from Molar Composition," SAE Technical Paper 2012-01-1274, 2012, doi:10.4271/2012-01-1274.

[10] "EPA dives head first into the ethanol/high octane debate." August 24, 2016. Gas2. Steve Hanley.

Renewable fuels like ethanol and fossil fuels such as gasoline are moving in opposite directions with respect to lifecycle GHG emissions. Since the original Renewable Fuel Standard (RFS) was enacted by Congress in 2005, the lifecycle carbon intensity of average Midwest corn ethanol has shrunk by nearly 40 percent. In that same time, the carbon intensity of gasoline has increased by nearly 7 percent and will continue to get worse because it is energy-intensive to extract unconventional fossil fuels. The lifecycle GHG benefits of ethanol have been well-established by respected independent and government scientists.[11][12] The trend highlighted in the chart below shows ethanol will be a reliable low carbon fuel for years to come.

GHG Carbon Intensity: Ethanol Is Improving, Oil Is Getting Worse*

*Ethanol carbon intensity calculations based on ANL GREET model
*Gasoline carbon intensity calculations based on California Air Resources Board



*Ethanol carbon intensity calculations based on ANL GREET model

Ron Alverson, the President of the ACE Board of Directors, has extensively documented work by DoE's Argonne National Laboratory (ANL) and others regarding corn ethanol carbon intensity reductions. He authored a paper titled "Re-thinking the Carbon Reduction Value of Corn Ethanol Fuel" in 2015 and reports the following: "ANL scientists recently determined (GREET version 2.0, 2013) that since 2008 average ethanol manufacturing energy use has decreased 25 percent, corn farming energy use decreased 24 percent, corn fertilizer and chemical use decreased by 3 percent,

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[11] "Updated Life Cycle Greenhouse Gas Data for Corn Ethanol Production." Mueller, S. UIC Energy Resources Center, November 2, 2015.

[12] "Energy and greenhouse gas emissions effects for corn and cellulosic ethanol with technology improvements and land use changes." Wang, M.Q., Han, J., et al. Science Direct. 2011.

and that ethanol manufactures are extracting 3 percent more ethanol from each bushel of corn. ANL affiliated scientists have also updated their land use change (LUC) calculations (Dunn et al. 2013) with recent data and now estimate that soil carbon emissions from LUC are 7.6 grams CI instead of the widely used and outdated estimate of 30 grams CI. A significant portion of this reduction resulted from CENTURY (Kwon H-Y et al. 2013) and CCLUB (Carbon Calculator for Land Use Change from Biofuels Production) soil carbon modeling that predicts significant soil carbon sequestration from corn."

Alverson goes on to write: "If GHG modeling of transportation fuels are to maintain integrity and achieve their desired outcome, it is essential that modeling is done consistently and that modeling assumptions are periodically reviewed and updated with the latest science. U.S. corn ethanol fuel production has experienced significant energy use and greenhouse gas emission reductions over the course of the last few years. Since 2008, innovation in energy use and conversion technology at ethanol production facilities, innovation in enhanced efficiency fertilizers and in corn production management,
and improved accuracy of GHG modeling assumptions have reduced current corn ethanol fuel CI by more than 50 percent. The future is bright for corn ethanol blends to provide significant reductions in U.S. transportation fuel CI."

There are at least two updates modelers such as DoE and regulators such as EPA should consider with respect to measuring the lifecycle GHG of renewable fuels such as ethanol. First, there is a growing body of evidence that continuous corn planted in no-till and low-tillage production systems build organic matter and soil carbon stocks.[13] It is appropriate to consider establishing a credit for corn ethanol production that results in building soil carbon. Second, current models presume low nitrogen (N) fertilizer prices, resulting in assumptions of "heavy" application of fertilizer use and high emissions of nitrous oxide (N2O) emissions from corn production. These models therefore assume about 30 percent of applied N fertilizer is "leached" to the air and water. These assumptions are not grounded in today's reality. Corn farmers respond to market signals and have rapidly adopted precision agriculture technology and employed enhanced efficiency fertilizers in order to reduce N application rates and efficiency, reducing N losses to the air and water. Updating models to reflect this reality would reduce the CI penalty from nitrous oxide emissions in half.

One of the most widely respected scientists in the world has commented on the value of ethanol in helping contribute to the realization of a low-carbon energy future. "The reality is that we need to go to a lower-carbon future. There's no technology miracle needed. We know how to do it. We know it's not very expensive. The question is: Is that the direction we want to go? Our laboratory analyses have indicated that something like a 30 percent mixture (of ethanol) is optimal," according to U.S. Secretary of Energy Ernest Moniz.[14]

Secretary Moniz is confident about the role ethanol can play in the future based on extensive research from DoE laboratories, which for several years have shown significant engine efficiency and emission reduction benefits can be derived from high-octane, low-carbon fuels, specifically blends of ethanol in the 25-40 percent range.

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[13] Impacts of Corn Yields and No-Till on Carbon Sequestration and Carbon Footprints. Clay et al., 2012.

[14] Energy Secretary: U.S. must be energy independent. May 6, 2016. Des Moines Register. Donnelle Eller.

In July 2016, ORNL, NREL, and ANL released the Summary of High-Octane, Mid-level Ethanol Blends Study.[15] This comprehensive paper examined the GHG emission benefits of high-octane mid-level ethanol blends, knock-resistance and ethanol blends, the economics of ethanol, and marketplace issues such as retail and terminal infrastructure. "The experimental and analytical results of this study considered together show that HOF, specifically mid-level ethanol blends (E25-E40), could offer significant benefits for the United States. These benefits include an improvement in vehicle fuel efficiency in vehicles designed and dedicated to use the increased octane. The improved efficiency of 5-10% could offset the lower energy density of the increased ethanol content, resulting in volumetric fuel economy parity of E25-E40 blends with E10. Most of the flex-fuel vehicles on the road today would be expected to have faster acceleration using HOF, which offers a marketing opportunity in the near term. Furthermore, dedicated HOF vehicles would provide lower well-to-wheel GHG emissions from a combination of improved vehicle efficiency and increased use of ethanol. If ethanol were produced using cellulosic sources, GHG emissions would be expected to be up 17 to 30% lower than those from E10 using conventional ethanol and gasoline. Refinery modeling suggests that refiners could use higher levels of ethanol to meet potentially high market shares of HOF. Analysis of the HOF market and the primary stakeholders reveals that the automotive OEMs, consumers, fuel retailers, and ethanol producers all stand to benefit to varying degrees as HOF increases its market share. The results depend on the underlying assumptions; but HOF offers an opportunity for improved fuel economy, and these dedicated vehicles are likely to be appealing to consumers."

Dan Nicholson, Vice President of Global Propulsion Systems at General Motors (GM), said in *Automotive News* that he could boost fuel economy in most engines by about 5 percent if America had the same high-octane fuel as Europe. According to Michael Wang, Senior Scientist at DoE's Argonne National Lab, "if you get a 5 percent gain in fuel economy, you will get about a 4.5 percent reduction in GHG emissions. In some cases, you could achieve up to a 10 percent gain in fuel economy for high-octane fuel, which would give you about a 9 percent reduction in GHG emissions."[16]

Leone et al conducted a literature review examining fuel and engine factors that impact knock resistance and their contribution to higher engine efficiency and lower tailpipe CO2 emissions.[17] The paper found that future vehicle regulations striving to improve fuel economy and reduce criteria emissions will require cleaner and higher-octane fuel. "New vehicle trends to improve efficiency include higher compression ratio, downsizing, turbocharging, downspeeding, and hybridization, each involving greater operation of spark-ignited engines under higher-load, knock-limited conditions. Higher octane ratings for regular-grade gasoline (with greater knock resistance) are an enabler for these technologies. Higher ethanol content is one available option for increasing the octane ratings of gasoline and would provide additional engine efficiency benefits for part and full load operation."

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[15] Summary of High-Octane, Mid-level Ethanol Blends Study. July 2016. ORNL, NREL, ANL. U.S. Department of Energy. http://info.ornl.gov/sites/publications/files/Pub61169.pdf

[16] "In Pursuit of High-Octane Fuels." Downstream Business. June 22, 2016. Bryan Sims.

[17] "The Effect of Compression Ratio, Fuel Octane Rating, and Ethanol Content on Spark-Ignition Engine Efficiency." *Environ. Sci. Technol.*, 2015, *49* (18), pp 10778–10789. DOI: 10.1021/acs.est.5b01420 Publication Date (Web): August 3, 2015. American Chemical Society. http://pubs.acs.org/doi/10.1021/acs.est.5b01420

Authors associated with AVL Powertrain Engineering, BP North America, Deere and Company, Ford, and ICM found similar evidence about ethanol and engine efficiency: "For a given gasoline blendstock, increasing ethanol content significantly increased knock-limited performance with combustion phasing near the thermodynamic optimum. However, due to ethanol's high sensitivity, knock-limited performance improved to a much greater extent with increased ethanol content as combustion phasing was retarded. This effect was further enhanced by a charge cooling with direct injection. Increasing ethanol content also significantly increased the knock-limited performance before enrichment was required to control exhaust gas temperature."[18]

Ricardo Energy & Environment concluded in July 2016 that the introduction of E20 high-octane fuel along with vehicles optimized to run more efficiently on the blend would reduce lifecycle GHG emissions by 14 percent. "Increasing the share of ethanol beyond 2020 levels further reduces GHG emissions. In particular, the highest GHG reductions in transport (14.1 percent) compared to 2005 are achieved when ethanol use is increased through the introduction of E20. This reduction is compared to a 9.3 percent reduction in a scenario with no biofuel at all."[19] Ricardo concludes that European policymakers should explore the deployment vehicles optimized to use high-octane E20 fuel to reduce transportation emissions in the future.

Ricardo's findings validate a meta-analysis by the University of Vienna's Institute for Powertrains and Automotive Technology that ethanol blends result in more clean and efficient combustion of fuel.[20]

It should be noted that Europe's use of 102 RON fuel helps deliver a ten percent fuel efficiency improvement in engines operating with a compression ratio of 11.5:1 or more compared to lower compression engines using the lower octane (95 RON) fuel that is normally marketed as mid-grade there.

A paper by Eric W. Chow of MIT recommends raising the minimum octane of fuel for new vehicles, and changing the octane standard from AKI to RON, in order to meet increasingly stringent fuel economy regulations.[21] The primary goal of his paper was to quantify the reduction in fuel consumption and GHG emissions if new vehicles were designed to use higher-octane fuel. Among the findings, "For a compression ratio increase of 1.5:1, this results in a 4.7 percent efficiency gain for a downsized, naturally-aspirated, spark-ignition vehicle. If the vehicle is turbocharged, a 6.9 percent efficiency gain is possible due to additional boosting and further downsizing. Ultimately, by redesigning vehicles to take advantage of 100 RON fuel, fuel consumption and GHG emissions for

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[18] Stein, R., Polovina, D., Roth, K., Foster, M. et al., "Effect of Heat of Vaporization, Chemical Octane, and Sensitivity on Knock Limit for Ethanol - Gasoline Blends," *SAE Int. J. Fuels Lubr.* 5(2):823-843, 2012, doi:10.4271/2012-01-1277. http://papers.sae.org/2012-01-1277/

[19] Ricardo Energy & Environment. SULTAN modelling to explore the potential contribution of bioethanol to EU transport GHG reduction in 2030. http://epure.org/media/1410/contribution-of-ethanol-to-eu-transport-ghg-reduction.pdf

[20] Vienna University of Technology. Institute for Powertrains and Automotive Technology. Meta-analysis for an E20/25 technical development study - Task 2: Meta-analysis of E20/25 trial reports and associated data. Prof. Dr. Bernhard Geringer et al. https://ec.europa.eu/energy/sites/ener/files/documents/Meta-Analysis_ReportFinal.pdf

[21] "Exploring the Use of a Higher Octane Gasoline for the U.S. Light Duty Vehicle Fleet" Eric W. Chow. 2013 Massachusetts Institute of Technology. http://web.mit.edu/sloan-auto-lab/research/beforeh2/files/Eric_Chow_Thesis.pdf

the fleet can be reduced by about 6 percent over the baseline case." The paper goes on to note that RON is the predominant octane standard for much of the world, with only the U.S., Canada, Brazil, and a few other countries still using AKI.

Flexible Fuel Vehicles (FFVs) should be encouraged by credits and can play a role as a bridge to new engine technologies dedicated to run on higher-octane, higher-level ethanol blends

Generous multiplier incentives are available for most model year 2017-2025 alternative fuel vehicles with the exception of flexible fuel vehicles (FFVs). Electric vehicles, plug-in hybrids, fuel cell vehicles and CNG vehicles are allowed to count as more than one vehicle in the manufacturer's compliance calculation while FFV credits erode from 0.8 miles per gallon in model year 2017 to zero for model years 2020 and beyond. All alternative fuel vehicle technologies ought to receive fair and equal treatment by the agencies instead of the inherent bias of the current program which penalizes FFVs.

We encourage the agencies to reconstruct a meaningful credit or multiplier for the future FFV production and consider a new incentive for ICEs that are optimized for high-octane, low-carbon fuels such as ethanol.

There are more than 17 million FFVs on the roads today. One of the ways to transition from today's legacy fleet to new vehicles with advanced engine technologies dedicated to run optimally on a higher octane fuel is to look at FFVs as the bridge. U.S. DoE has investigated the potential performance advantage to use high-octane ethanol blends such as E25 and E30 in FFVs and legacy vehicles to serve as that bridge.[22] (It should be noted that Leone et al found that if the minimum octane rating of the fuel available to customers was increased, it may be technically feasible to update, or "reflash," the engine calibrations on existing legacy vehicles to extract the most benefit from the improved fuel properties. A lesser gain would be realized on most, if not all, vehicles without a calibration change). Key findings in the DoE report include: "Experiments were performed with four FFVs using an E10 (92.4 RON) and E30 (100.7 RON) fuel. The two GDI FFVs demonstrated performance improvements for E30 compared to E10 of 2.5 to 3 percent, based on the 15-80 WOT acceleration time. Three of the four FFVs showed performance improvement with high-octane E30 compared to regular E10. A non-flex fuel vehicle with a small turbocharged GDI was tested with ethanol-free gasoline (90.7 RON) and E15 (97.8 RON). Significant WOT performance improvement was measured for this vehicle. Marketing E25 or E30 to FFV owners as a performance fuel may enable greater utilization of ethanol in the near term, and could help establish the refueling infrastructure to enable manufacturers to build dedicated vehicles designed for a high-octane midlevel ethanol blend."

With respect to refueling infrastructure, it should be noted that in 2009, Underwriters' Laboratory approved a new certification path for the 87A listed standard to include 87A-E25, which addresses gasoline and mid-level ethanol fuel blends up to E25 (including E15).[23] Furthermore, just this year, Wayne Fueling Systems became the first manufacturer to supply all North American retail fuel dispensers as compatible and UL-listed to E25 as a standard feature. The shift from the standard UL

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[22] "Effects of High Octane Ethanol Blends on Four Legacy FFVs and a Turbocharged GDI Vehicle." Thomas, J., West, and Huff, S., U.S. DoE-ORNL. March 2015.
https://www.fueleconomy.gov/feg/pdfs/ORNL_High_Octane_Legacy_Vehicles_Report%28final%29.pdf

[23] "UL Announces a New Certification Path for Ethanol Fuel Dispensers" August 10, 2009.
http://www.ul.com/newsroom/pressreleases/ul-announces-new-certification-path-for-ethanol-fuel-dispensers/

listing of E10 to E25 is effective immediately for Wayne Ovation fuel dispensers and by year-end for Wayne Helix dispensers.[24]

The MOVES model needs to be fixed

The Motor Vehicle Emissions Simulator (MOVES) model is EPA's tool for estimating emissions from motor vehicles, based on multiple variables, including fuel composition. It is used by state regulators to determine compliance with air quality standards. While adding ethanol to gasoline has been scientifically proven to lower emissions of particulate matter and nitrous oxides, EPA's MOVES2014 model predicts increased emissions from ethanol. We believe the MOVES2014 model is severely flawed and needs to be fixed.

MOVES2014 is based on an EPA-commissioned fuel study that purported to analyze the emissions effects of different fuel parameters, including ethanol content, while artificially and unnecessarily holding other fuel parameters constant. This so-called "match-blending" methodology unfairly blames ethanol for the emissions effects of including toxic aromatic hydrocarbons in the test fuel to maintain certain arbitrary distillation points that are naturally and harmlessly lowered by higher concentrations of ethanol. As EPA tested higher levels of ethanol, the agency also added more toxic aromatics to the gasoline. Furthermore, research used to help build the MOVES2014 model curiously examined T50 and T90, but not T70, which clearly shows how ethanol reduces emissions from gasoline. We encourage EPA to recognize the scientific flaws in the MOVES model and fix the inequities accordingly.

The R-factor needs to be updated

According to Bob McCormick, Principal Engineer for the Fuels Performance Group at NREL, "…current CAFE calculations penalize high-octane fuel through and outdated conversion factor that aims to put modern fuels on a comparable footing with 1975 test fuel. The R-factor is the ratio of the percent change in fuel economy to the percent change in volumetric energy content when comparing the two fuels. It is used to adjust fuel economy test results to a baseline fuel energy content corresponding to an outdated 1975 test fuel. In the 1980s, fuel economy tests indicated that R was 0.6, which a more recent testing shows that the value for modern cars is above 0.9. This makes midlevel ethanol high-octane fuel a less powerful tool to meek future CAFE standards."[25]

It is our understanding EPA continues to hold ethanol's R-factor at 0.6 despite testing by automakers and government scientists that the R-factor should be in a range from 0.93 to 0.96. We ask that the agencies appropriately update the R-factor.

Agencies should look to harmonize the goals of CAFE-GHG with the Renewable Fuel Standard (RFS)

The CAFE-GHG standards and RFS can and should be complementary programs which simultaneously focus on reducing GHG emissions from the transportation sector. If EPA is able to get implementation of the RFS back on track it would signal to renewable fuel producers and automakers to continue investing in technologies to make them most out of low-carbon biofuels.

We hope our comments can constructively help the agencies with the next step of the MTE process which is for EPA to make its Proposed Determination on whether the 2022-2025 model year CAFE-

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[24] "Wayne Standardizes Offering for All North American Retail Fuel Dispensers to E25" August 30, 2016. https://wayne.com/en/press-releases/2016-08-30-wayne-standardizes-offering-for-all-north-american-retail-fuel-dispensers-to-e25/

[25] "In Pursuit of High-Octane Fuels." Downstream Business. June 22, 2016. Bryan Sims.

GHG standards are appropriate. Whatever direction the standards take, we urge action now, instead of ten years from now, to establish a mechanism for high-octane, low-carbon fuels to serve as a compliance tool for meeting and exceeding the 2022-2025 standards.

Thank you for your time and consideration of these comments.

Sincerely,

Brian Jennings, Executive Vice President
American Coalition for Ethanol