Review of EPA's Anti-backsliding Analysis

AIR, Inc.

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Introduction

EPA released its Anti-backsliding Study for Renewable Fuels in May 2020.[1] Along with the study, EPA released other supporting materials, including a Proposed Determination document.[2] Upon performing an air quality analysis of the impact of the increase in renewable fuels associated with the RFS, and comparing these emission and air quality changes to the effects of the on-road Tier 3 final rule, EPA concluded that fuel regulations to mitigate any emission increases as a result of the Renewable Fuel Standard (RFS) are not necessary.

We agree with EPA that fuel regulations to mitigate such impacts are not necessary. In fact, due to various methodological issues with the fuel properties EPA used, the study overstates any potential negative air quality effects of the RFS. Specifically, the study overstates ozone and PM impacts, and undercounts the reductions of toxics. When using appropriate fuel properties, hydrocarbon and NOx increases are significantly smaller (leading to lower ozone impacts), PM emissions decline instead of increasing (leading to possible PM air quality benefit for the RFS), and toxics benefits of the RFS are higher.

This document is a review of EPA's emission inventory and air quality analysis performed for the Anti-backsliding Study, which appropriately focused on vehicle emissions pursuant to the Clean Air Act's statutory mandate in section 211(v). The document is organized as follows:

- Brief Summary of EPA's Analysis
- AIR's Comments on EPA's Analysis
- Implications

1. Brief Summary of EPA's Analysis

EPA evaluated two emissions and air quality scenarios, a "with RFS" scenario and a "no RFS" scenario. EPA evaluated both scenarios for calendar year 2016. The "with RFS" scenario used actual biofuel volumes used in vehicles in 2016. The "no RFS" scenario approximated biofuel volumes from calendar year 2005. Emission inventories were evaluated for calendar year 2016 only in conventional gasoline (CG) areas of the U.S., since all RFG areas already had E10 (10% ethanol by volume) in 2005.

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[1] *Clean Air Act Section 211(v)(1) Anti-backsliding Study*, EPA-420-R-20-008, May 2020.

[2] *Proposed Determination for Renewable Fuels and Air Quality Pursuant to Clean Air Act Section 211(v),* EPA-420-D-20-003, May 2020.

Onroad and nonroad emission inventories for the two scenarios were estimated with EPA's MOVES2014 model. EPA did not evaluate potential changes in upstream emissions (transportation and distribution, and refinery and ethanol plant emissions). All conventional gasoline counties have E10 fuel properties for 2016 in MOVES. To evaluate E0 in 2016 (the "No RFS" scenario), EPA made assumptions regarding the properties of a hypothetical E0 used in 2016 based on information from its report on MOVES fuel supply characteristics.[3] In other words, because all areas of the country had E10 in 2016, there was little or no real-world fuel data to evaluate E0 fuel properties on in 2016; thus, E0 fuel parameters in 2016 must be estimated. In particular, EPA used a table from the Fuel Supply Defaults report that illustrates the changes in fuel properties with a change in ethanol. This table is shown as Table 1 below.

Table 1. MOVES Fuel Adjustment Factors for E0 to E10

Fuel	Description	RVP (psi)	Aromatics (vol %)	Olefins (vol %)	E200 (%)	E300 (%)	T50 (F)	T90 (F)
E10 S	Summer E10	1.00	-2.02	-0.46	3.11	0.39	-6.34	-1.77
E10 W	Winter E10	1.00	-3.65	-2.07	4.88	0.54	-9.96	-2.45
E15 S	Summer E15		-3.36	-1.64	9.24	0.91	-18.86	-4.14
E15 W	Winter E15		-5.69	-3.27	11.11	1.01	-22.67	-4.59

The table shows that when moving from E0 to E10, RVP increases by 1 psi, aromatics are 2.02% lower, olefins are 0.46% lower, E200 increases by 3.11%, and E300 increases by 0.39%. T50 and T90 are closely related to E200 and E300. These relationships were developed by EPA from analysis of refinery batch data for the nation (not just conventional gasoline areas) reported from the fuel producers for calendar years 2007, 2009 and 2011. The data contain confidential business information from the refiners, and EPA has never described in detail how this analysis was performed. The fuel parameter relationships, particularly the relationship between ethanol increase, and the change in aromatics and T50, are a critical input to EPA's emission inventory analysis for onroad vehicles, and therefore are a critical input to the Anti-backsliding air quality analysis.

EPA's Modeled Results of the "with RFS" Scenario compared to "No RFS":

- Ozone: a modest ozone (8-hour maximum average ozone) increase across the eastern U.S. and some areas of the western U.S., with some decreases in localized areas[4]
- PM: Relatively unchanged in most areas, with increases in some areas, and decreases in some localized areas.[5]

[3] *Fuel Supply Defaults: Regional Fuels and the Fuel Wizard in MOVES2014b,* EPA-420-R-18-008 July 2018.

[4] *Anti-backsliding Study*, Page 6.

[5] *Anti-backsliding Study,* Page 6.

- CO: Decreased concentrations across the U.S., and in some areas of the west, with larger decreases in some areas.[6]
- NO_2: Increases across the eastern U.S., and in some areas of the eastern U.S., with larger increases in some urban areas. [7]
- Toxics: Increased concentrations of acetaldehyde and formaldehyde, decreased concentrations of benzene and 1,3 butadiene, and mixed results for acrolein and napthalene.

2. AIR's Comments on EPA's Analysis

As an initial matter, EPA's modeled air quality results must be placed in context. The U.S. county average results for 2016 are shown in Table 2.

Table 2. EPA Estimated County Average Air Quality Impacts of E10 vs E0

Pollutant	Average % Change
Acetaldehyde	0.4
Acrolein	-0.37
Benzene	-2.64
1,3 Butadiene	-3.07
CO	-1.29
Formaldehyde	0.26
Naphthalene	-0.20
NO_2[8]	1.28
Ozone	0.36
PM2.5	-0.01

EPA's modeling shows an estimated ozone increase is 0.36%. This is very small and could be considered negligible. Of the toxics, acetaldehyde and formaldehyde very slightly increase, but benzene, 1,3 butadiene, and acrolein, and naphthalene are lower. According to the California Air Resources Board's Predictive Model, 1,3 butadiene and benzene are more potent air toxics than formaldehyde and acetaldehyde, thus, their reductions are more significant than the small increases in formaldehyde and acetaldehyde. [9]

Overall, we have two major concerns with EPA's analysis:

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[6] *Anti-backsliding Study,* Page 6.

[7] *Anti-backsliding Study,* Page 6.

[8] There are no nonattainment areas in the U.S. for NO2. See https://www3.epa.gov/airquality/greenbook/ancl.html

[9] California Procedures for Evaluating Alternative Specifications for Phase 3 Reformulated Gasoline Using the California Predictive Model, Last Amended: August 24, 2012, https://ww2.arb.ca.gov/resources/documents/gasoline-predictive-models-and-procedures. The potency weighting factors for toxics from this source are 1,3 butadiene: 1.0, benzene: 0.17, formaldehyde: 0.035, and acetaldehyde: 0.016. The source does not list potency weighting factors for acrolein or naphthalene.

- Fuel properties used in the MOVES model for the "no RFS" (E0) scenario in 2016
- Fuel correction factors used in MOVES model

These concerns are described below.

a. Effects of Ethanol on Fuel Properties in Conventional Gasoline Areas

EPA's Anti-backsliding analysis used modeled fuel properties, rather than its real-world fuels data. The modeled properties have a tendency to exaggerate ozone and PM impacts and underestimate toxic reductions. As indicated in Table 1, EPA's analysis of fuel properties from refiners for the U.S. indicates that a 10% increase in ethanol reduces aromatics by only 2% and T50 by 6.3F. This is not consistent with data over the 2006-2016 period in EPA's Fuel Trends Report.

As noted above, to perform the Anti-backsliding analysis, one must have fuel properties for E10 and E0 in 2016. EPA attempted to predict from a fuel modeling analysis what the E0 properties would be in 2016 for E0. An alternative method to discerning the fuel properties of a hypothetical E0 in 2016 is to examine how fuel properties changed between 2006 (when there was plenty of E0) and 2016. As described below, this method reveals that certain fuel properties in EPA's method are unrealistic, and thus distort the air quality results of transitioning from E0 to E10 in the "with RFS" scenario.

Specifically, Table 3 shows fuel properties from EPA's Fuel Trends report for conventional gasoline areas for calendar years 2006 and 2016 – the same areas modeled in the Anti-backsliding Study.[10] Ethanol increased from 0.5% to 9.9% between 2006 and 2016. Aromatics declined by 6.5%. T50 declined by 16.3F and T90 by 13.6F.

Table 3. Fuel Property Trends Between 2006 and 2016 in Conventional Gasoline Areas

	Ethanol (vol %)	Aromatics (vol %)	Olefins (vol %)	E200 (%)	E300 (%)	T50 (F)	T90 (F)	RVP (psi)
2006	0.5	28.5	11	45	82	210.0	334.0	8.4
2016	9.9	22	9	53	85	193.7	320.3	9.3
Difference (2016-2006)	9.4	-6.5	-2	8	3	-16.3	-13.6	0.9

Regarding the aromatics decline, EPA's Fuel Trends report made the following two statements:

[10] *Fuel Trends Report: Gasoline 2006-2016,* U.S. EPA, EPA-420-R-17-005., 2017. The earliest years in the Fuel Trends Report is 2006, so in evaluating fuel properties between 2006 and 2016, we are ignoring potential changes between 2005 and 2006, which we understand to be inconsequential.

- "Ethanol's high octane value has also allowed refiners to significantly reduce the aromatic content of the gasoline, a trend borne out by the data."[11]
- "Aromatics levels in the CG gasoline continued to track lower as ethanol has entered the gasoline pool."[12]

Thus, the Fuels Trends report indicates that ethanol was the major contributor to lower aromatics and T50 levels in conventional gasoline areas. Yet EPA's Anti-backsliding Study used its modeled analysis of refinery batch data on all fuels – conventional and RFG – to determine the impact of ethanol on aromatics. This resulted in aromatics and other fuel parameter changes for its hypothetical E0 in 2016 that were much too low for conventional gasoline areas.

If the refinery batch data were publicly available, we would perform an analysis similar to EPA's just for the conventional areas that are being modeled in the Anti-backsliding Study. Since it is not available, we must infer from the fuel property trends between 2006 and 2016 the effects of ethanol for conventional areas.

First, we must attempt to isolate fuel changes that result from changes other than ethanol volumes. To do this, we evaluate other fuel regulations that can also have an influence on fuel properties. Other than the RFS, three fuel regulations were promulgated by EPA in the approximate 2006-2016 timeframe. The three fuel regulations are the Tier 2/Sulfur regulation[13], the Mobile Source Air Toxics (MSAT) rule[14], and the Tier 3/Sulfur regulation.[15] The Tier 2 sulfur regulation, however, was fully implemented by calendar year 2006, so changes in fuel properties for that rule should not affect fuel properties between 2006 and 2016.[16] The MSAT rule required benzene levels to be reduced starting in 2011.[17] The MSAT rule required the reduction in benzene levels from a baseline of around 0.97% to 0.62%.[18] EPA expected an equivalent reduction in aromatics levels since benzene is an aromatic (a reduction of 0.35% in aromatics).[19] Therefore, we could infer that 0.35% of the 6.5% reduction in aromatics between 2006 and 2016 was due to the MSAT rule. The third regulation was the Tier 3/Sulfur rule, which further reduced sulfur levels to 10 ppm in 2017. Some refiners would have implemented this requirement early to

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[11] *Fuel Trends Report*, Page 8.

[12] *Fuel Trends Report*, Page 61.

[13] *Control of Air Pollution From New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements; Final Rule*, 40CFR Parts 80, 85, 86, February 10, 2000.

[14] *Control of Hazardous Air Pollutants From Mobile Sources; Final Rule,* 40CFR Parts 59, 80, 85, 86, February 26, 2000.

[15] *Control of Air Pollution From Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards; Final Rule,* 40CFR Parts 79, 80, 85, et.al., April 28, 2014.

[16] *Tier 2/Sulfur*, Page 6698.

[17] *MSAT Rule*, Page 8428.

[18] *Control of Hazardous Air Pollutants from Mobile Sources, Regulatory Impact Analysis,* EPA420-R-07-002 February 2007, Page 6-6.

[19] *MSAT RIA*, Page 6-82.

generate credits, however, examination of the Reference and Control fuel properties in the Regulatory Impact Analysis shows little change in fuel properties other than sulfur.[20] Therefore, it is reasonable to attribute most of the fuel property changes between 2006 and 2016 to the expansion of ethanol in conventional areas.

In addition to fuel property regulation, changes in the ratio of gasoline and diesel production can also affect properties such as the E300 level. Specifically, if refiners increase diesel output, they shift some of the higher molecular weight components that are used in gasoline to diesel fuel. This shift can result in a gasoline with higher E300, or lower T90. With regard to E300 trends, EPA's Fuels Trends Report indicated:

- "E200 and E300 are also affected by the addition of ethanol. Ethanol boils below 200 Fahrenheit, and also causes some of the hydrocarbons in gasoline which boil above 200 Fahrenheit to boil below 200 Fahrenheit. Ethanol likely contributed to increased E300 values between 2000 and 2016 as well. However, as discussed above, the modest dieselization trend here in the United States also may have contributed to increased E300 over this time period. "

The MOVES model utilizes the following inputs in estimating fuel correction factors:

- Ethanol
- Aromatics
- RVP
- T50
- T90

Table 4 compares the EPA Anti-backsliding fuel changes to the EPA Fuels Trend Report average levels for 2016 for the five properties used in MOVES.[21]

Table 4. Change in Fuel Properties Due to Expansion from E0 to E10 Fuel in Conventional Areas

Fuel Parameter	EPA Anti-backsliding Study (Summer)	EPA Fuels Trends Report – Conventional Gasoline (Summer)[22]
Ethanol (%)	+10	+9.5
Aromatics (%)	-2.02	-6.5
RVP (psi)	+1.0	+0.9
T50 (F)	-6.34	-16.3
T90 (F)	-1.77	-13.6

[20] *Control of Air Pollution from Motor Vehicles: Tier 3 Motor Vehicle Emission and Fuel Standards Final Rule, Regulatory Impact Analysis,* EPA-420-R-14-005, March 2014. See Tables 7-9 and 7-10.

[21] For purposes of this analysis, we ignored the small effect of the MSAT rule on aromatics.

[22] These were determined by visual observations of the plots in the Trends Report, since the raw data were not available in the report.

While the increase in ethanol and RVP are very close in both cases, the changes in the other fuel properties are very different. Specifically, the changes for the Anti-backsliding Study are much smaller than the actual data of fuel properties in conventional areas.[23] Assuming that most if not all of the fuel parameter changes are due to the expansion of ethanol in conventional areas, the actual values from conventional areas are preferable for modeling the impacts of the RFS than modeled values from all conventional and RFG areas.[24]

Using the more appropriate Fuels Trend data from conventional gasoline areas for E0 in 2006 (with three adjustments – benzene, sulfur, and T90) and E10 in calendar year 2016, AIR estimated the change in annual emissions inventories in conventional gasoline areas using the MOVES model. Fuel property adjustments used in this analysis as compared to the EPA analysis are shown in Table 5 (i.e., the rows called "Data"). For sulfur and benzene for E10, we used MOVES values by county for 2016. For sulfur and benzene for E0, we assumed the same sulfur and benzene levels as for E10.[25] For T90, we assumed that one-half of the change in T90 is due to ethanol blending, and the other half is due to the dieselization trend mentioned by EPA. For example, Table 5 shows that increasing from E0 to E10 reduced aromatics by 6.5%. Therefore, to predict hypothetical E0 aromatics levels in conventional areas in 2016, aromatics is increased by 6.5%.

Table 5. EPA and AIR, Inc. Evaluation of Fuel Properties of E10 relative to E0 in Conventional Gasoline Areas

Season	Source	RVP	Aromatics	Olefins	T50	T90
Summer	EPA	1.0	-2.02	-0.46	-6.34	-1.77
	Data	0.9	-6.5	-2.0	-16.3	-6.8
Winter	EPA	1.0	-3.65	-2.07	-9.96	-2.45
	Data	0.2	-6.0	-2.8	-12.2	-6.8

We compare the percent changes in annual emissions with EPA's Anti-backsliding Study in Table 6. In our emissions analysis, similar to EPA's, we also did not include California.

[23] If the changes in fuel parameters are not mostly related to the expansion in ethanol, it is critical to explain what factors besides ethanol are influencing these changes. We know it is not the fuel sulfur or MSAT regulations.

[24] EPA based its ethanol impacts on fuel parameters on refinery batch data from 2007, 2009, and 2011 for both RFG and conventional areas. No one outside of EPA has been able to review this analysis in detail. EPA could, at a minimum use, have used a wider range of data (for example, from 2007-2016), and also analyzed conventional areas separately from RFG areas.

[25] Benzene was reduced in the 2012-2016 timeframe, and although Tier 3 sulfur was not reduced until 2017, some reductions could have occurred prior to 2016. Neither regulation had a significant effect on aromatics, T50, or T90 levels, so we assumed the same levels for both fuel properties for E0 and E10.

Table 6. Percent Changes in National On-Road Gasoline Emissions Due to E10 in Conventional Areas (Excludes California)		
	EPA Anti-backsliding	Using Actual Fuel Properties for Conventional Areas
NOx	+6%	+3.1%
VOC	+6.6%	+1.8%
PM2.5	+1.3%	-3.0%
CO	-5.6%	-7.3%
Benzene	-12.4%	-15.2%
1,3 Butadiene	-12.2%	-13.8%
Acetaldehyde	+110%	+79%
Acrolein	+8.5%	+2.1%
Formaldehyde	+7.4%	+7.6%

Table 6 shows that using ethanol effects based on actual fuel properties has a significant effect on the change in emission inventories. VOC, NOx, acetaldehyde, and acrolein increase much less than in the EPA analysis. Fine particulate flips from a 1.3% increase to a 3.0% decrease. Carbon monoxide shows a greater decline. The benzene decline is even more substantial –15.2%. 1,3 butadiene also shows a greater decrease.

These emission inventory changes would alter the EPA air quality analyses as well, although it is difficult to predict whether ozone would increase or decrease. At a minimum, the already very small increase in ozone in the EPA analysis would shrink further. Fine PM may show widespread air quality reductions due to E10.
In sum, as contrasted with real-world fuels data, EPA's Anti-backsliding Study overstates adverse emissions impacts associated with a transition from E0 to E10 and underestimates the benefits for air toxics, particulate matter, and carbon monoxide.

b. *EPA's Fuel Correction Factors in MOVES*

AIR previously outlined its concerns with the EPA MOVES fuel correction factors in an SAE paper. [26] For PM, EPA failed to take into account the influence of the T70 parameter on PM emissions. The EPAct testing program used by EPA to evaluate the MOVES fuel correction factors evaluated T50, T90, aromatics, and ethanol's effects on emissions. The fuels were match-blended in the testing program. Since ethanol affects all of these fuel properties, the test fuel blender adjusted T70 of some of the test fuels in an attempt to get the other distillation properties to match. The T70 values of some of the fuels were outside of the range of properties that would be seen in the U.S. Ignoring T70's effect on PM emissions attributed the T70 effect to

[26] *Analysis of EPAct Emission Data Using T70 as an Additional Predictor of PM Emissions from Tier 2 Gasoline Vehicles*, T. Darlington, D. Kahlbaum, S. Von Hulzen, and R. Furey, SAE2016-01-0996, April, 2016. Available for purchase from SAE at https://www.sa**e**.org.

other fuel properties in the modeling, including ethanol. AIR re-analyzed the EPAct data using T70, and ethanol dropped out of the equation used to predict Bag 1 (cold start) PM emissions. The paper concludes that if T70 were included in the model predicting PM emissions, that E10 would reduce PM emissions instead of increasing PM. AIR recommended including the T70 parameter for PM emissions in MOVES.

If T70 were included in the MOVES fuel correction factors, the modeled PM emissions would be reduced even further from the level shown in Table 5 (see Figure 9 of the T70 report).

Additional commentary on the fuel correction factors in MOVES is addressed in the attached "Review of U.S. EPA's Analysis of the Emissions Impacts of Providing Regulatory Flexibility for E15," Trinity Consultants, previously submitted by Growth Energy on the 2019 E15/RVP Proposed Rule.

3. Discussion

EPA's Anti-backsliding analysis shows that increasing ethanol from E0 to E10 in the U.S. had very little impact on ozone and PM, and reduced the most potent air toxics (benzene and 1,3 butadiene). The emission inventory analysis, which drives the air quality results, hinges on the quality of prediction of E0 properties in calendar year 2016 in conventional gasoline areas, and the MOVES fuel correction factors. EPA's analysis of E0 properties in 2016 is based on an analysis of refiner gasoline batch processing data (also used in MOVES) for conventional and RFG areas. Real data on fuel parameter changes in conventional gasoline areas do not confirm EPA's analysis. Instead, the real fuel trends data in conventional areas show a larger effect of ethanol on key fuel properties such as aromatics, T50, and T90 levels than EPA has estimated and used in the emission inventory analysis. Using real-world fuel properties, emissions associated with E10 vs. E0 are lower across the board, with even more dramatic decreases of potent air toxics and significant CO and PM decreases.

EPA's proposed determination is that it is not necessary to promulgate fuel regulations to mitigate the air quality impacts resulting from required renewable fuels volumes. Although EPA's analysis amply supports this proposed determination, improving the analysis with ethanol fuel effects data and improved MOVES correction factors would show that the modest adverse impacts EPA observed are lessened or entirely absent. An improved analysis based on real fuel data would show ethanol-blended fuels are associated with PM improvements, lower benzene and 1,3 butadiene, and lower carbon monoxide emissions.