Benefits of an Enhanced RFS2 in the Midwestern States

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List of Acronyms

bgy: Billion Gallons per Year
CAFE: Corporate Average Fuel Economy
CARB: California Air Resources Board
CI: Carbon Intensity
DG: Distillers Grains
Enn: Ethanol Percentage (nn) in Fuel (eg, E10 is 10% Ethanol)
EPA: Environmental Protection Agency
FCM: Fuel Consumption Model
FFV: Flex-Fueled Vehicle
GHG: Greenhouse Gas
GM: General Motors
ILUC: Indirect Land Use Change
LCFS: Low Carbon Fuel Standard
LDT: Light Duty Truck
MGA: Midwestern Governors Association
MSW: Municipal Solid Waste
MY: Model Year
NGO: Non-Governmental Organization
PADD: Petroleum Administration for Defense Districts
RFS: Renewable Fuel Standard
RFS2: Updated Renewable Fuel Standard
RSM: RFS2 Spreadsheet Model

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1.0 Executive Summary

In November 2007, the Midwestern Governors Association (MGA) adopted the *Energy Security and Climate Stewardship Platform for the Midwest*, which calls for the creation of "a uniform, regional low-carbon fuels policy—implemented at the state or provincial level as a standard, objective or incentive—and report annually on progress."

In 2008, the MGA established an advisory group to develop a model LCFS framework for the region. Following a series of facilitated meetings, the advisory group produced a set of recommendations for a regional LCFS. One of the key recommendations was that, "The overall [GHG] intensity reduction [associated with the LCFS] should be at least 10 percent within 10 years after implementation by Midwestern jurisdictions." This set of recommendations was developed without knowing the benefits of the expanded Federal Renewable Fuel Standard (RFS2).

In March 2010, EPA finalized changes to the RFS2. The RFS2 requires fuel marketers to use increasing amounts of several classes of biofuels and requires that the each class of fuel reduce GHG emissions relative to a petroleum baseline – conventional biofuel (20% reduction in lifecycle emissions), advanced biofuel (achieving 50% reduction in lifecycle emissions), and cellulosic biofuel (achieving 60% reduction in lifecycle emissions). The total mandate is for 36 bgy of biofuel by 2022, which would include 15 bgy of conventional biofuel, 16 bgy of cellulosic biofuel, 1 bgy of biodiesel, and 4 bgy of advanced biofuel.

The purpose of this study is to assess the potential GHG reductions occurring in the Midwest as the result of full implementation of the RFS2. The study also discusses corresponding efforts that would be required of individual states (or the collective region) to promote increased adoption of vehicles capable of running on higher biofuel blends and proliferation of the infrastructure necessary to achieve greater GHG reductions and deliver higher volumes of biofuels to the consumer. This latter program we refer to as an "Enhanced RFS2" program.

AIR first developed a model to estimate the benefits of the RFS2 in the Midwest (we used the PADD 2 [Petroleum Administration Defense District] states as a proxy for the Midwest). The model utilizes fuel volumes predicted by the EPA and the lifecycle emissions benefits of these fuels, also estimated by the EPA. Indirect land use emissions were included in EPA's lifecycle emissions, and were also included in this assessment. The model showed that the RFS2 will reduce GHG emissions from 2005 levels by 7.7% in the Midwest. The GHG emission reductions in the Midwest for the RFS2 are 39 million metric tons per year.

Next we estimated the increase in cellulosic biofuel use in the Midwest that would need to take place to achieve a 10% benefit in GHG emissions from transportation sources (Enhanced RFS2 Program). EPA expects that a significant amount of cellulosic biofuel will be produced from corn residue, of which there are plentiful supplies in the Midwest. This analysis showed that if cellulosic biofuel from corn residue increased by 1.7 bgy in the Midwest above the level anticipated by EPA, the total GHG emission reductions from RFS2 implementation would be 10% from 2005 levels. GHG emission reductions in the Midwest increase from 39 million metric tons per year in the normal RFS2 case to 50 million metric tons per year in the "Enhanced RFS" case. However, if only the mandated amounts of cellulosic biofuel were available nationally, this could involve some reduction in cellulosic biofuel used elsewhere in the U.S.

Next, we determined whether there would be sufficient Flexible Fuel Vehicles (FFVs) in the Midwest to consume the ethanol production in the Midwest under the RFS2 and the Enhanced RFS2. Ford, GM, and Chrysler each have committed to increase FFV production to half of their sales by 2012. Our projections showed that one out of five vehicles in the Midwest would be FFVs by 2022. Under the RFS2, with E10 in the non-FFV fleet, the average ethanol level used in the Flexible Fueled Vehicles fleet needs to be 65% (E65) in order to utilize the ethanol and obtain the emission reductions. This implies that the available FFVs must be refueled with E85 about 75% of the time. The number of blender pumps and/or E85 pumps would have to be greatly expanded in the Midwest to deliver this amount of ethanol.

We performed this same evaluation for the Enhanced RFS2. Assuming E10 in the non-FFV fleet, the average ethanol volume level of the FFVs would need to be E79 (79% ethanol by volume) in 2022 for the necessary ethanol to be consumed in the Midwest. At an average level of E79, this would mean that the available FFVs would have to be refueled with E85 virtually all the time. This scenario would also require the availability of many more blender pumps and/or E85 pumps in the Midwest than are currently available. If the ethanol level in non-FFVs increases to E15, the average ethanol level in FFVs in the Midwest would need to be E67.

If all manufacturers were to convert all of their vehicle production to FFVs by 2015 (similar to recent legislative proposals), the maximum average ethanol level in FFVs would need to be in the mid-E30s (i.e., E33) by 2022.

Clearly, with either the RFS2 or the enhanced RFS2, where the enhanced RFS2 achieves a 10% reduction in GHGs, there is a need for greatly increased availability of FFVs and blender pumps in the Midwest.

2.0 Introduction

In April 2009, the state of California adopted the Low Carbon Fuel Standard (LCFS). The goal of the California LCFS is to reduce greenhouse gas (GHG) emissions from the state's transportation sector by 10% (relative to 2010 levels) in 10 years. Similar LCFS policies are being considered by several other states and regions of the United States, including the Midwest.

In November 2007, the Midwestern Governors Association (MGA) adopted the *Energy Security and Climate Stewardship Platform for the Midwest*, which calls for the creation of "a uniform, regional low-carbon fuels policy—implemented at the state or provincial level as a standard, objective or incentive—and report annually on progress."

In 2008, the MGA established an advisory group to develop a model LCFS framework for the region. Following a series of facilitated meetings, the advisory group produced a set of recommendations for a regional LCFS.[1] One of the key recommendations was that, "The overall [GHG] intensity reduction [associated with the LCFS] should be at least 10 percent within 10 years after implementation by Midwestern jurisdictions." According to the recommendations, the 10 percent GHG reduction would be relative to a 2005 baseline.

Following adoption of the LCFS recommendations by the MGA Steering Committee in March 2009, the MGA established a new, expanded stakeholder effort that began in the summer of 2009. The expanded advisory stakeholder effort involves petroleum fuel producers and refiners, biofuel producers, agricultural businesses and producer organizations, environmental NGOs, automakers, academics, and other interested parties.[2]

Throughout the second phase of the expanded stakeholder advisory group effort, numerous questions were raised about the efficacy of an LCFS policy at the state or regional level. Many stakeholder participants raised concerns about the effectiveness, mechanics, and economic impacts of existing LCFS models, such as the California policy. The key LCFS concerns and issues identified by stakeholders apparently will be discussed in more detail in a forthcoming report from the advisory group focused on "LCFS Design Considerations."

The expanded stakeholder group also discussed the need to explore other policy and regulatory mechanisms that may achieve the goals of the MGA as articulated in the March 2009 recommendations document. A number of stakeholders suggested that the goal of reducing GHG emissions from the Midwest's transportation sector by 10% relative to 2005 levels in 10 years may be more readily achieved through policies other

[1]The recommendations document and more background information on the MGA stakeholder process is available at the MGA web site: http://www.midwesterngovernors.org/lcfs.htm#November_17-19,_2009;_Calgary_and_Fort_McMurray,_Alberta_

[2] An advisory group roster is available at http://www.midwesterngovernors.org/LCFS/LCFS_Advisory_Group_Roster.pdf

than a regional LCFS. It was argued by some stakeholders that one newly promulgated policy in particular, the RFS2, could very likely result in GHG reductions approaching 10% in 10 years in the region, provided that Midwest states embrace the policy and undertake initiatives to ensure the increased biofuel volumes mandated under the RFS2 can indeed be produced and consumed.

Several stakeholders expressed interest in an effort to quantify the GHG reductions in the Midwest that would occur from full implementation of the RFS2 under various assumptions regarding technology adoption, infrastructure, fuel carbon intensity, and other critical factors. The purpose of this study is to assess the potential GHG reductions occurring in the Midwest as the result of full implementation of the RFS2. The study also discusses the corresponding efforts that would be required of individual states (or the collective region) to promote increased adoption of vehicles capable of running on higher biofuel blends and proliferation of the infrastructure necessary to deliver higher volumes of biofuels to the consumer.

This research was funded by a broad coalition of organizations and businesses who share a common interest in reducing the GHG intensity of transportation fuels in the Midwest, while at the same time harnessing the region's industrial and agricultural strengths and fostering regional economic growth. This work was supported by advisory group members (i.e., Renewable Fuels Association, Growth Energy, Monsanto Corporation, Minnesota Corn Growers), as well as other businesses and organizations that share in these interests (i.e., National Corn Growers Association, Iowa Corn Growers Association, Illinois Corn Growers Association, Missouri Corn Growers Association, Nebraska Corn Board, and Ohio Corn Growers Association).

This report is organized into the following sections:

- Background
- RFS2 Benefits in the Midwest
- Enhanced RFS2
- Conclusions

3.0 Background

California implemented a Low Carbon Fuel Standard (LCFS) at a Board Hearing on April 23, 2009. [3] The regulation became final on April 15, 2010. [4] The LCFS requires gasoline marketers to reduce the carbon intensity (CI) of both gasoline and diesel by 10% by calendar year 2020.[5] The CI of gasoline and diesel can be reduced in two ways: (1) by reducing the carbon intensity of the gasoline and/or diesel itself, or (2) by blending alternative fuels with low carbon intensity with the gasoline or diesel. Because it is relatively difficult to reduce the CI of gasoline and diesel directly, the primary method of reducing the CI of these fuels is through blending with low CI substitutes. California has published carbon intensity estimates for fuels created from a number of different feedstocks. Gasoline marketers must decide the mix of base fuels and alternative fuels needed to meet the LCFS.

The Federal RFS2 was adopted by EPA on March 26, 2010.[6] Instead of reducing the carbon intensity of fuels provided by fuel marketers, the RFS2 requires marketers to use increasing amounts of several classes of biofuels – conventional biofuel (20% reduction in lifecycle emissions), advanced biofuel (achieving 50% reduction in lifecycle emissions), and cellulosic biofuel (achieving 60% reduction in lifecycle emissions). The total mandate is for 36 bgy of biofuel by 2022, which would include 15 bgy of conventional biofuel, 16 bgy of cellulosic biofuel, 1 bgy of biodiesel, and 4 bgy of advanced biofuel. The RFS2 does not credit gasoline and diesel marketers who reduce the carbon intensity of gasoline and diesel fuel, because it is recognized that generally, not much can be done to reduce the carbon intensity of these fuels.

Both programs require the development of increasing amounts of low carbon intensity biofuels, and if these are not developed, then the performance of both programs will decline. [7] Neither program guarantees that these low carbon intensity fuels will be available. But there is an important distinction between the two programs. If transportation fuel use in the U.S. continues to increase as it has over the past 20 years, the LCFS will require increased amounts of low carbon intensity fuels to be available, when little of this fuel is available now. In contrast to this, the RFS2 requires specified volumes of biofuels to be used, but these volumes are not adjusted as fuel consumption increases over the next 20 years. The EPA recently implemented higher CAFE standards for cars and light duty trucks (LDTs), so these higher fuel economy standards should slow the growth in U.S. gasoline consumption over the next 20 years.

A second important distinction between the two programs is focused on how the two governmental authorities estimate lifecycle emissions from various feedstocks. Both authorities included indirect land use changes (ILUC) in their estimates of lifecycle

[3] California Air Resources Board Resolution 09-31, April 23, 2009.
[4] Final Regulation Order, April 15, 2010
[5] Carbon intensity in the California rule is measured in terms of g GHG/MJ
[6] Federal Register: March 26, 2010, Volume 75, Number 58, pages 14669-14904.
[7] Sugarcane ethanol producers point out that their ethanol meets the advanced requirement currently. However, many sugarcane plants do not currently meet this requirement, because they do not generate enough surplus electricity to meet the requirement.

emissions, and the inclusion of these land use estimates was controversial for three reasons: (1) the lack of consistent and developed science of ILUC has lead to widely differing estimates, (2) indirect emissions have not been estimated for non crop-based fuels, leading to a lack of consistency, and (3) the indirect effects of a policy are so difficult to validate that many think they should not be included at all as a first principle. In addition, the two authorities have estimated different carbon intensities for corn ethanol, which is the primary biofuel currently used in the U.S. California estimates that the carbon intensity of corn ethanol is about the same as for gasoline, and EPA currently estimates that corn ethanol has about a 20% benefit relative to gasoline.

AIR has produced a report that compares the lifecycle emissions of corn ethanol between EPA and CARB. The report, commissioned by the Renewable Fuels Association and Nebraska Corn Board, was released June 16, 2010.

The Midwest region produces an extraordinary amount of food and biofuel for the nation and for export – biofuel production in the PADD 2 region exceeds Brazil's total ethanol production. Because of the abundance of cellulose in the region in the form of corn residue (or "stover"), this could also be the region that produces a significant amount of advanced or cellulosic biofuel. It makes economic sense to consume a large share of this fuel in the Midwest, because the GHG benefit is marginally reduced when it is shipped long distances. And, it does not matter where it is consumed, because GHGs have a long residence time in the atmosphere and thus are global in nature, so it makes more sense to not incur the transportation emissions in shipping it long distances (to both coasts).

4.0 Benefits of RFS2 in Midwest

This section estimates the benefits of the RFS2 in the Midwest. The section is divided into two subsections:

- EPA's Estimate of Benefits
- AIR's Estimate of Benefits

4.1 EPA's Estimate of Benefits

The RFS2 provides GHG benefits by substituting fuels with lower lifecycle GHG emissions for both gasoline and diesel fuel. As a part of the final rule, EPA estimated the annual national benefits of the rule at 138.1 million metric tons of GHG emissions per year by calendar year 2022.[8] This estimate was made for a scenario that used EPA's prediction of the availability of biofuels as required by RFS2, as compared to a Reference Case of the volumes of various fuels that would be available without RFS2. The estimate also included land use effects for different types of ethanol.

EPA did not estimate the percent reduction in GHGs due to RFS2. To make this estimate, we need the total GHG emissions from transportation sources. This estimate comes from EPA's Greenhouse Gas and Sinks Report, which is prepared annually by the EPA for GHG emissions from all sources in the U.S. [9] The Greenhouse Gas and Sinks Report estimates GHG emissions from transportation sources in calendar year 2008 of 1813 teragrams (a teragram is one million metric tons). Unfortunately, the GHG Emissions and Sinks Report does not provide projections beyond year 2008. This work requires GHG estimates for the transportation section in 2022. GHG emissions are expected to grow between 2008 and 2022 due to the general increase in vehicle miles traveled in the U.S. However, light duty CAFE standards are significantly increased between 2012 and 2016, which should largely mitigate this effect. Energy Information Administration long-term projections for fuel U.S. consumption corroborate this assumption. The 2008 estimate, therefore, is the best method available. Dividing the EPA estimated reduction from the RFS2 of 138.1 million metric tons by the total emissions of 1,813 million metric tons, we obtain 7.6%. Thus, the RFS2 is estimated to reduce GHG emissions from transportation sources nationally by about 7.6%. Absent any efforts to use disproportionate amounts of biofuels, the reductions in the Midwest would probably be similar.

The 7.6% benefit for the Federal RFS2 is close to the 10% reduction goal of California's Low Carbon Fuel Standard. This raises the possibility that if the RFS2 were "enhanced" in the Midwest, additional regional GHG reductions could be achieved. Enhancing the RFS2 in the Midwest would involve retaining more of the cellulosic ethanol produced in

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[8] "Renewable Fuel Standard Regulatory Impact Analysis", EPA-420-R-10-006, February 2010, see Table 5.51 and Section 5.5 of the RFS2 RIA for the complete explanation of this methodology and estimate.

[9] "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008", April 2010, U.S. EPA, 430-R-10-006.

the Midwest region, and using this ethanol in the non-FFV fleet via blend levels higher than E10, in FFVs, or both.

4.2 AIR's Estimate of the RFS2 Benefit

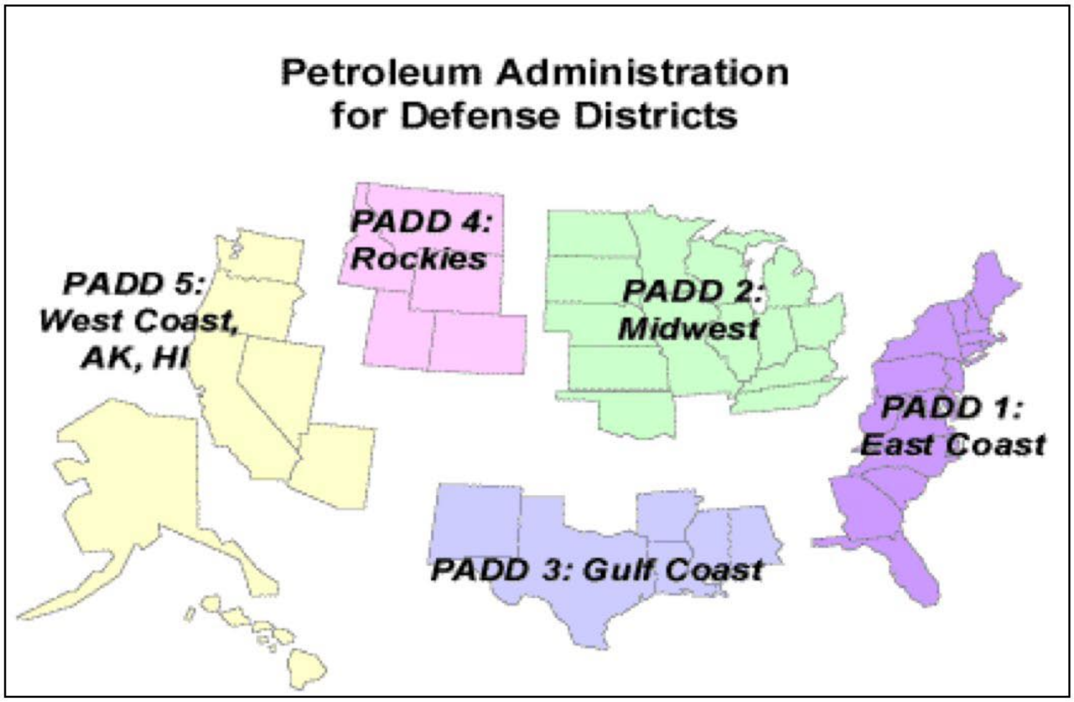
As noted earlier, EPA did not estimate the GHG percent reduction benefit of RFS2; this was achieved by using EPA's estimate of the RFS2 aggregate GHG reduction benefit divided by the GHG inventory from transportation from a different EPA report. The modeling systems used to estimate the reduction and the base inventory are not the same. Thus, it is necessary to make a second estimate of the percent benefit utilizing a common modeling system. This common modeling system can then be used to determine the benefits of an enhanced RFS2.

As a part of the final rule, EPA provided its projection of the volumes of alternative fuels that would be available as part of the Reference Case and RFS2 (Control Case). EPA also provided the lifecycle GHG emission benefits of these fuels (including land use effects), relative to both gasoline and diesel fuel. We have utilized these volumes, along with the lifecycle GHG benefits and energy density of these various fuels, to estimate the percent benefit of the RFS2, and also to determine the increase in low-GHG fuel needed to achieve a 10% benefit in the Midwest. This is accomplished with a RFS2 Spreadsheet Model (RSM).

While the RSM can estimate the benefit of the current and enhanced program, it cannot show how alternative fuels are used, and whether there will be enough FFVs in the Midwest to utilize the ethanol produced. AIR developed a Fuel Consumption Model (FCM) that predicts fuel consumption for gasoline, diesel, ethanol, and biodiesel from the current year to 2030 for the nation. The FCM was developed for on-road gasoline and diesel vehicles. The model also allows these projections by Petroleum Area Defense District, or PADD. The Midwestern states are in PADD 2, as shown in Figure 1.

The FCM utilizes sales of vehicles by general weight class and fuel type by model year, scrappage rates by vehicle class and age, annual mileage accumulation rates by age, fuel consumption by model year, and other factors to produce estimates of total fuel consumed by calendar year. The primary purpose of this model is to estimate the average ethanol level in FFVs needed to utilize the ethanol volumes under the RFS2. A level of ethanol is first specified for the non-FFVs, for example, E10. Then the model allocates any remaining ethanol into FFVs, until all the ethanol is fully used. The FCM also allows the user to vary the ethanol blend in non-FFVs. For example, we can increase the ethanol blend in non-FFVs to E15 in a certain calendar year, and determine the impact of this change on the average ethanol level used in FFVs.

Figure 1



PADD 2 includes the following states: Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio, Oklahoma, Tennessee, and Wisconsin. Although this includes more states than are represented by the Midwestern Governors Association, many of the other states are major ethanol producing states, so we thought it was appropriate to include these states in this study as well. Throughout the remainder of this report, when we refer to the Midwest, we are referring specifically to all of the states in PADD 2.

The FCM is calibrated using AEO2010 data for the U.S.[10] Growth in vehicle miles traveled between 2010 and 2030 in AEO2010 model is shown in Attachment 1. To determine the number of FFVs, we assume that GM, Ford, and Chrysler follow through on their commitment to increase FFV sales to 50% of each manufacturer's sales volume by model year 2012, and that they continue at that rate through 2022. Currently, we are assuming that these three manufacturers account for 50% of the sales of cars and LDTs nationally. Therefore, in the long term, 25% of the fleet would be FFVs. If 50% is an appropriate fraction for the national sales fraction of these three manufacturers, then it is likely that their sales fractions would be slightly higher than that in the Midwest, and the percent of FFVs in the fleet could climb above 25%.

[10] Annual Energy Outlook 2010, Energy Information Agency, Department of Energy.

The light duty fuel consumption (or fuel economy in mpg) levels in the FCM are consistent with EPA's recently adopted fuel economy standards for cars and light duty trucks. [11]

The use of these two models to estimate the benefits of the RFS2 is described further in the next sections.

4.2.1 RFS2 Spreadsheet Model (RSM)

The RSM uses alternative fuel volumes from the RFS2 to estimate RFS2 benefits. [12] Those volumes are shown in Table 1.

Table 1. Biofuel Volumes Expected by EPA in RFS2

Fuel	Reference	RFS2	Change
Ethanol (billion gallons per year)			
Corn	12.3	15	2.7
Corn Residue Cellulosic	0	4.9	4.9
Sugarcane Bagasse Cellulosic	0.2	0.6	0.4
Switchgrass Cellulosic	0	7.9	7.9
Forestry Residue Cellulosic	0	0.1	0.1
Sugarcane Imports	0.6	2.2	1.6
Other Ethanol (includes municipal solid waste, or MSW)	0.1	2.6	2.5
Total Ethanol	13.2	33.3	20.1
Biodiesel (million gallons per year)			
Soybean Oil	119.9	659.4	539.5
Corn Oil	0.4	681.3	680.8
Animal Fats	93.9	126.9	33
Yellow Grease	170.9	253.1	82.3
Total	385.1	1720.7	1335.6
Total Ethanol + Biodiesel (billion gallons per year)			
Total	13.6	35.0	26.4

EPA produced lifecycle emission impacts for fuels produced from corn, corn residue, switchgrass, sugarcane imports, soybean oil, and yellow grease. Lifecycle impacts were not developed for fuels produced from sugarcane bagasse, forestry residue, animal fats, corn oil, or other sources of ethanol. The lifecycle GHG reductions developed for corn ethanol by EPA were for various processes used in production plants. For example, EPA individually assessed wet mills and dry mills, dry mills with dried DGs (distillers grains) and wet DGs, and other categories. Additionally, EPA developed different estimates for

[11] Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, FR Vol 75 No 88, May 7, 2010, 25324-25728.

[12] Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule, FR Vol 75 No 58, March 26, 2010, 14670-14904. See Table VII.A.1-1.

two different methods of producing cellulosic ethanol – enzymatic and thermal-chemical. The reductions were all given in terms of the percent reduction in lifecycle emissions relative to gasoline and diesel fuel.

The RSM combines EPA's disaggregated lifecycle emissions with the volumes shown in Table 1. In addition, these are corrected for the energy density of each fuel (ethanol versus biodiesel), so that the total energy demanded in the U.S. and in the Midwest remains constant between the Reference and RFS2 cases. We use two Reference Cases: one is EPA's Reference Case in 2022; the second is a 2005 Reference Case where we utilize the ethanol levels in 2005, but increase the gasoline demand to equal the same total energy content as required in 2022. This second 2005 Reference Case is included because generally, low carbon fuel standard goals are to reduce emissions by 10% within 10 years.

Total GHG emissions are estimated for the two reference cases, and the percent difference in these two cases is estimated for gasoline and diesel separately, and for the combined gasoline and diesel fuel pool.

The benefits of RFS2 are shown in Table 2.

Table 2. RFS2 Benefits in the Midwest

Relative to Fuel	% Benefit in 2022 versus 2022 Reference Case	% Benefit in 2022 versus 2005 Reference Case
Gasoline	9.2%	10.5%
Diesel	1.6%	2.1%
Combined	6.7%	7.7%

The results show that the GHG reduction benefits of RFS2 range between 6.7% (2022 Reference Case) and 7.7% (2005 Reference Case). These benefits are very similar to the GHG benefit of 7.6% estimated earlier using an alternative method.

The diesel benefits in Table 2 are low relative to gasoline, due to the lower biodiesel volumes in Table 1. EPA examines a case where significant amounts of cellulosic diesel are possibly provided, and in this case, the gasoline and diesel benefits are more balanced. But we would expect about the same total benefit for the overall program.

4.2.2 Application of Fuel Consumption Model (FCM) to the RFS2

Light duty fuel economy levels utilized in the FCM are shown in Figure 2 by model year. The combined car and light truck fuel economy level reflects the expected split of cars and light trucks in the Midwest. The car/light truck sales assumption is not critical to this study, because the same assumption is used for reference and RFS2 cases, and we are evaluating the relative difference in these cases.

Figure 2

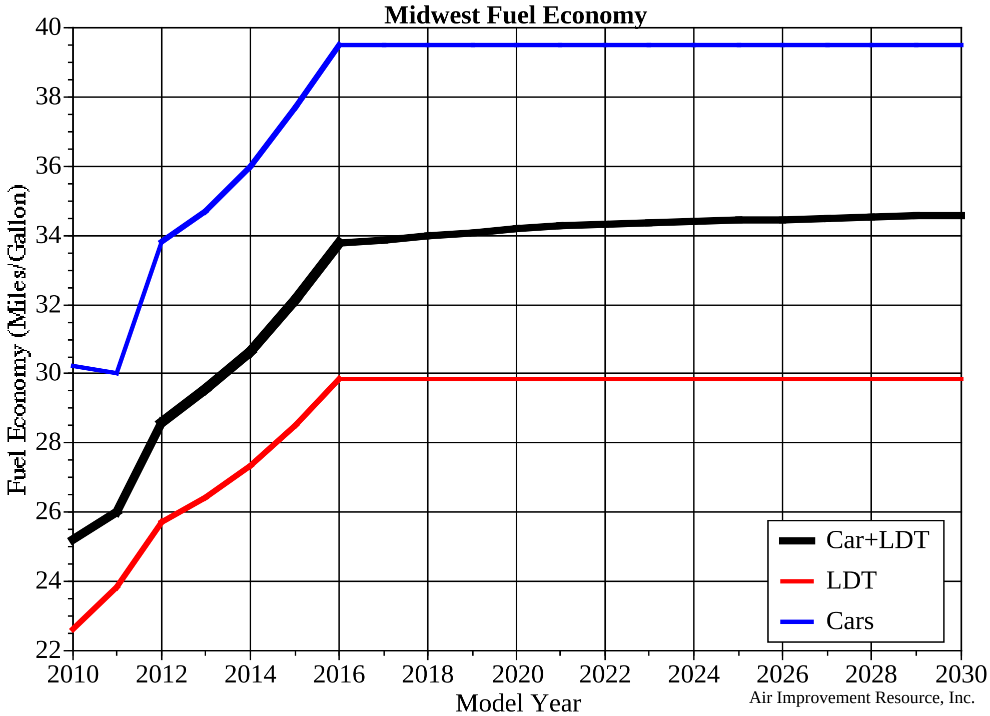
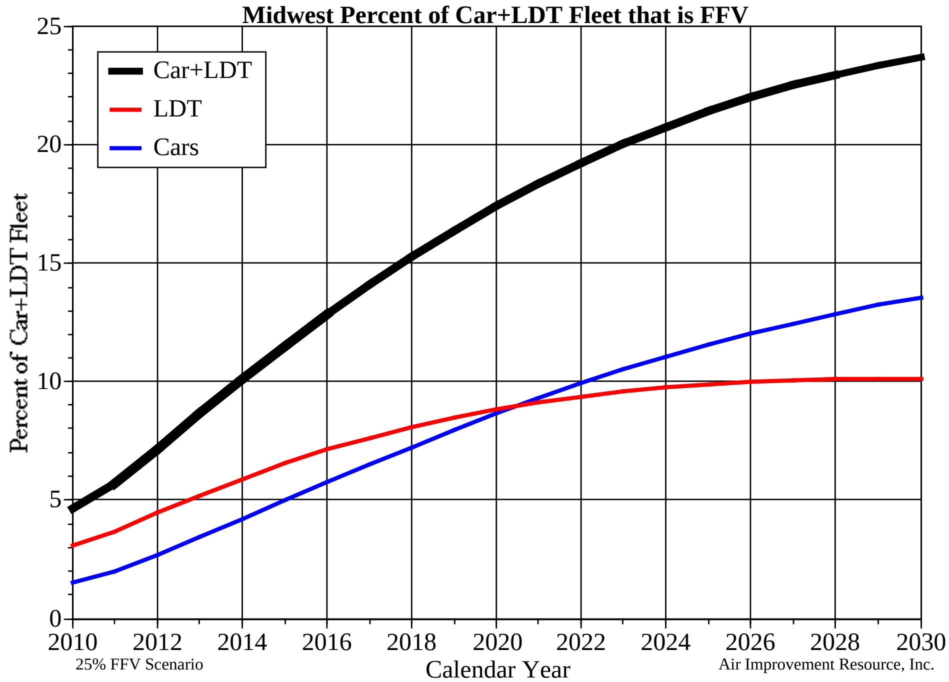


Figure 2 shows dramatic increases in fuel economy between 2010 and 2016, with a leveling off after 2016. The levels after 2016 will probably continue increasing, but for this analysis we have assumed they remain constant after 2016. There is a slight increase in the combined car and light truck fuel economy due to an expected shift from LDTs to cars.

The percent of the fleet that is FFVs in the Midwest is shown in Figure 3. Three lines are shown – Cars, LDTs, and Cars + LDTs. All 3 lines use the same denominator (sum of car and LDT sales). Thus, the car and LDT lines can be added directly to obtain the Car + LDT line.

Figure 3*



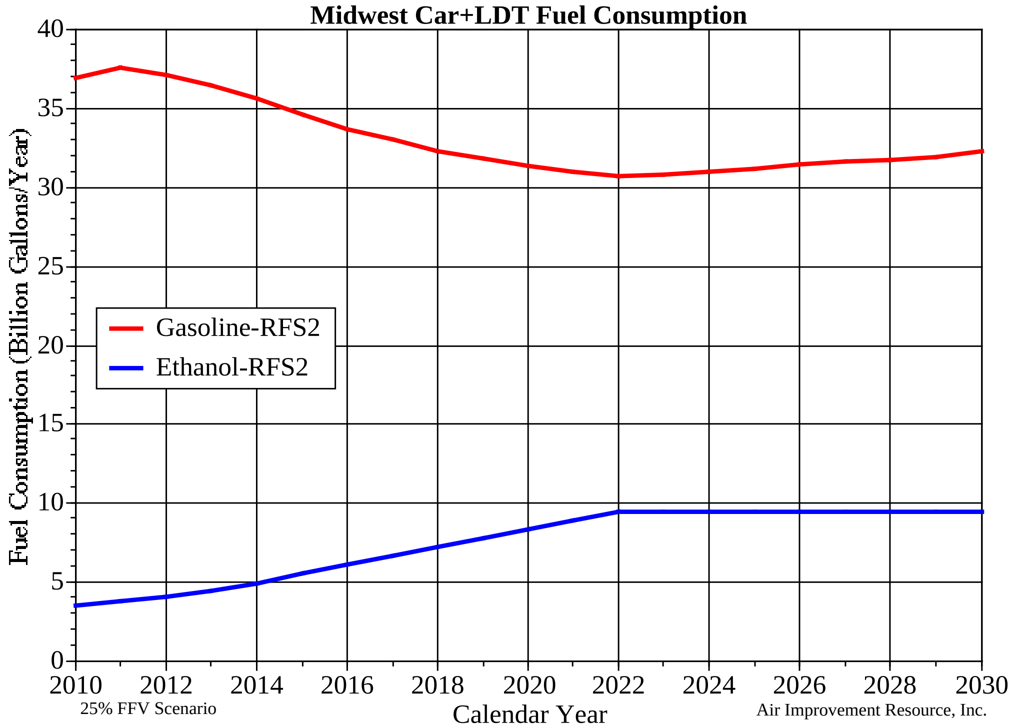
*Assumes Ford, GM, and Chrysler have 50% of car + LDT sales in Midwest, and that they sell 50% of their vehicles as FFVs in 2012+

Figure 3 shows a fleet level of almost 5% FFVs in 2010, but this rises to nearly 24% by 2030 due to the GM, Ford and Chrysler commitment to increased production of FFVs in 2012 and later model years.

The AIR FCM was used to determine gasoline and ethanol volumes in the PADD2, and to determine if there are available FFVs to utilize the available ethanol volumes.

Figure 4 shows gasoline and ethanol volume in the Midwest for the RFS2. Gasoline use declines from 37 bgy in 2010 to near 30 bgy in 2022, while ethanol use increases from 4 bgy to near 10 bgy, respectively. The overall trend in energy use is about an 8% reduction (again, the trend in vehicle miles traveled is shown in Attachment 1). The reduction in overall energy use is due to the implementation of improved light duty fuel economy standards.

Figure 4



Figures 5 through 8 show ethanol use in FFVs, non-FFVs, and the entire fleet of FFVs and non-FFVs, with the RFS2. Figure 5 assumes E10 in the non-FFV fleet. Figure 6 assumes E10 until 2012, and then E15 for 2001+ model year vehicles and E10 for 2000- model year vehicles. Figure 7 shows E10 assumed in the non-FFV fleet until 2012, and E15 assumed in the entire fleet in 2012 and later calendar years. These cases could bound the possibilities in the near-term. These assumptions are further summarized in Table 3. We also show the maximum average ethanol level over the period from 2010 to 2030 in FFVs for these 3 cases, and the frequency of time that FFVs must be refueled with E85. The maximum average level always occurs in 2022.

Figure 5

Midwest Average Ethanol Level for RFS
Non-FFVs: E10(2012+)

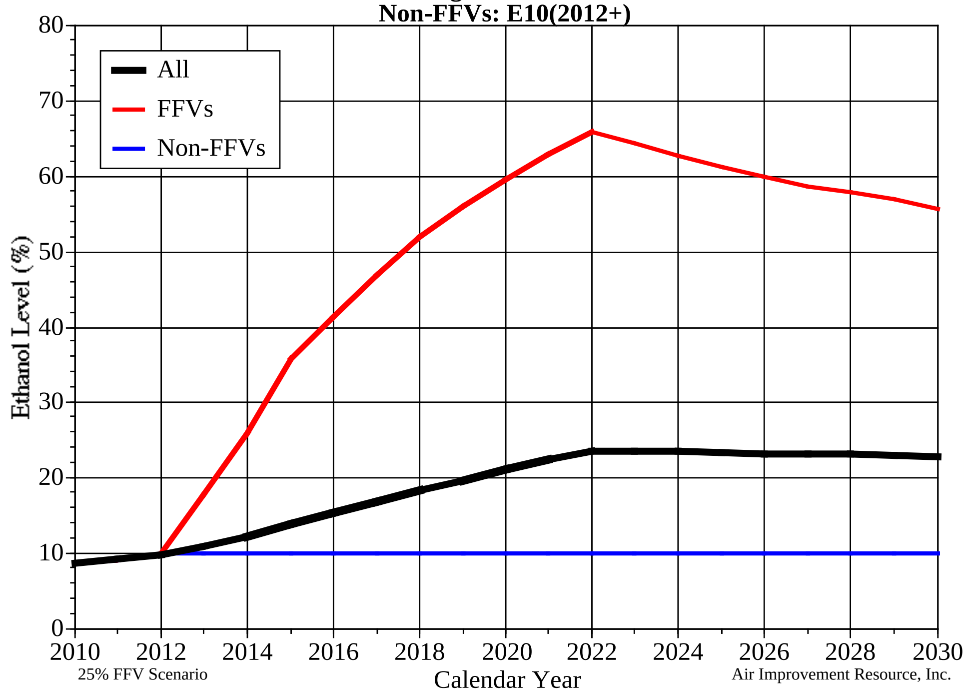


Figure 6

Midwest Average Ethanol Level for RFS
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)

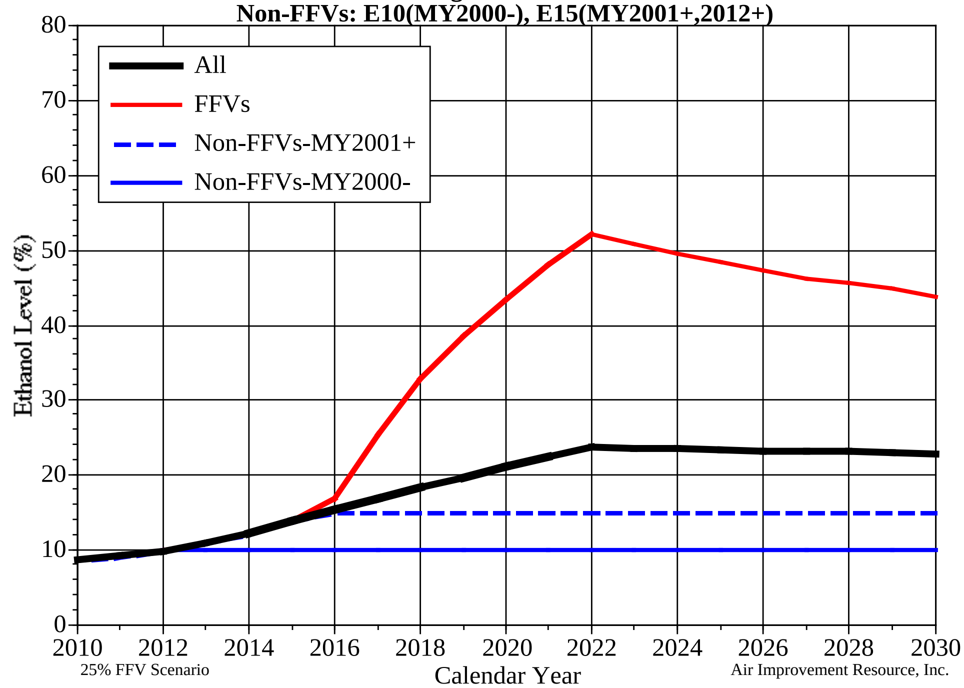


Figure 7

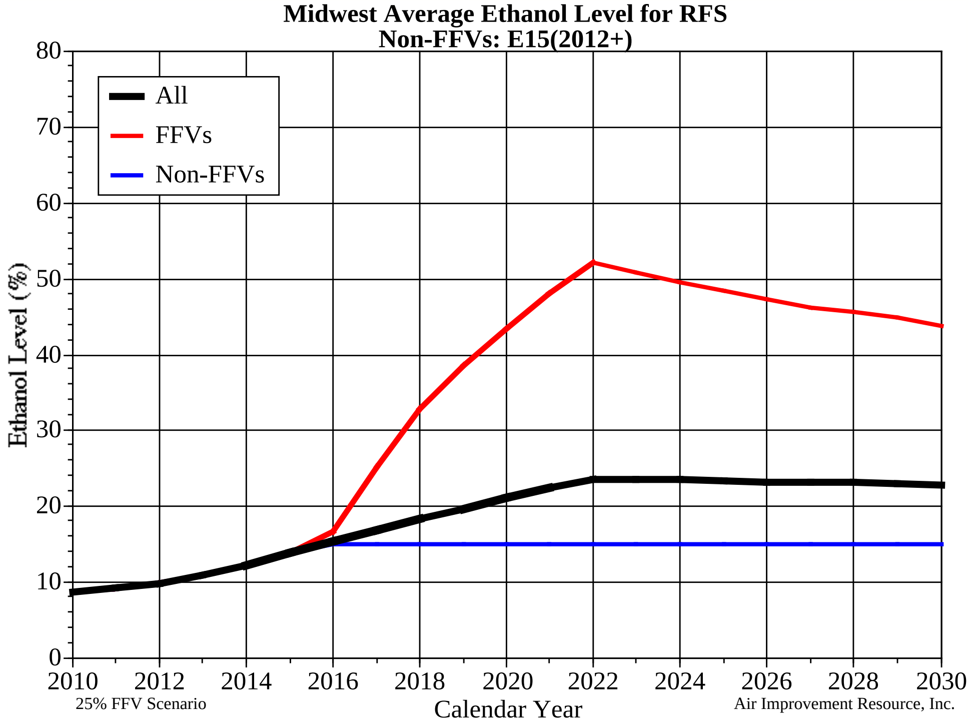


Table 3. Ethanol in non-FFV Sensitivity Cases				
Figure	Ethanol assumed in non-FFVs		Maximum Average Ethanol Level in FFVs	Frequency FFVs must be refueled with E85
	2000- model years	2001+ model years		
5	E10		66%	75%
6	E10	E15 in 2012	52%	56%
7	E15 in 2012		52%	56%

The data in Table 3 and in Figures 5-8 illustrate two primary results: (1) there appear to be enough FFVs in the Midwest to theoretically utilize the ethanol that will be produced, and (2) the maximum average ethanol percent in FFVs is reduced as more ethanol is used in the non-FFV fleet, and as more FFVs enter the fleet. Regardless of the scenario assumed for the non-FFVs, the maximum average level of ethanol in the FFV fleet, however, never gets reduced to the level in the non-FFV fleet. Thus, to meet the RFS2, gasoline marketers will need to market significant quantities of fuel to FFVs. This will most likely be accomplished through the increased use of mid-level blends (e.g. E20, E30, E40), E85 and blender pumps that allow the FFV driver to select a custom ethanol level.

4.3 Sensitivity Cases on the RFS2 Benefit

This section examines the impact of three sensitivity cases – the impact of higher volumes of FFVs, the impact of assuming no land use impacts for corn ethanol, and the impact of assuming a higher gasoline and diesel carbon intensity in the Midwest than the national average (i.e., a significant amount of gasoline and diesel in the Midwest comes from Alberta tar sands, which has a higher GHG intensity than national average).

If all manufacturers (instead of just GM, Ford, Chrysler) provided one-half their sales as FFVs starting in 2010, then the number of FFVs would double, and the maximum average ethanol volume in FFVs would be reduced significantly from the E52-E66 range (see Table 3). The relationship between FFV sales percentage for the entire fleet of cars and LDTs and maximum average ethanol content for the RFS2 is shown in Figure 8. The figure shows that increasing the FFV sales fraction from 25% to 50% (E10 case) reduces the maximum average ethanol content from 65% to 42%. The values are lower for both 25% and 50% sales for the E15 case.

Figure 8

Maximum FFV Ethanol Percentage versus FFV Sales Percentage RFS

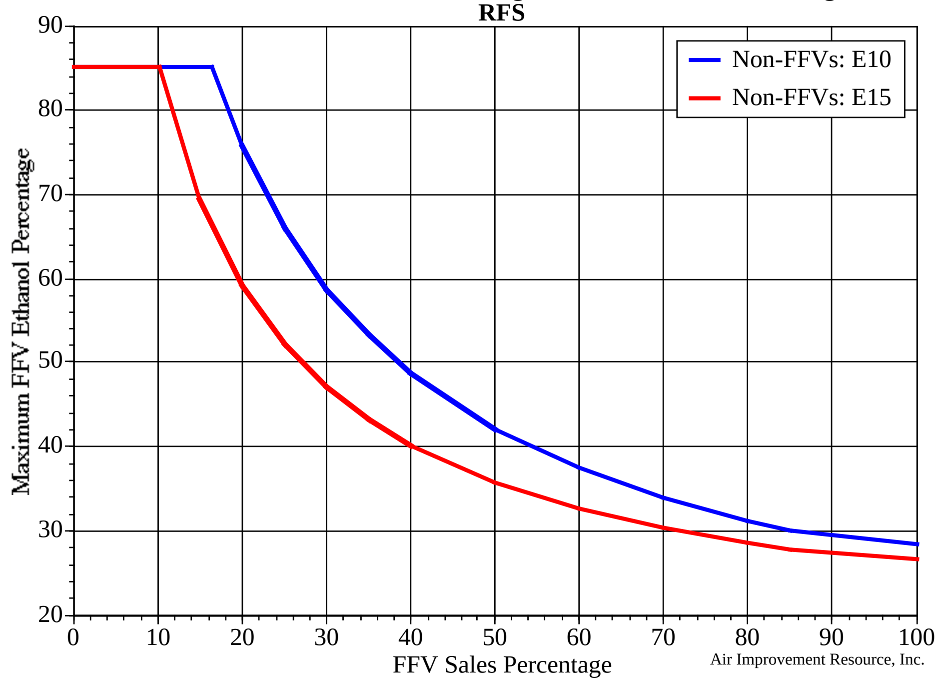
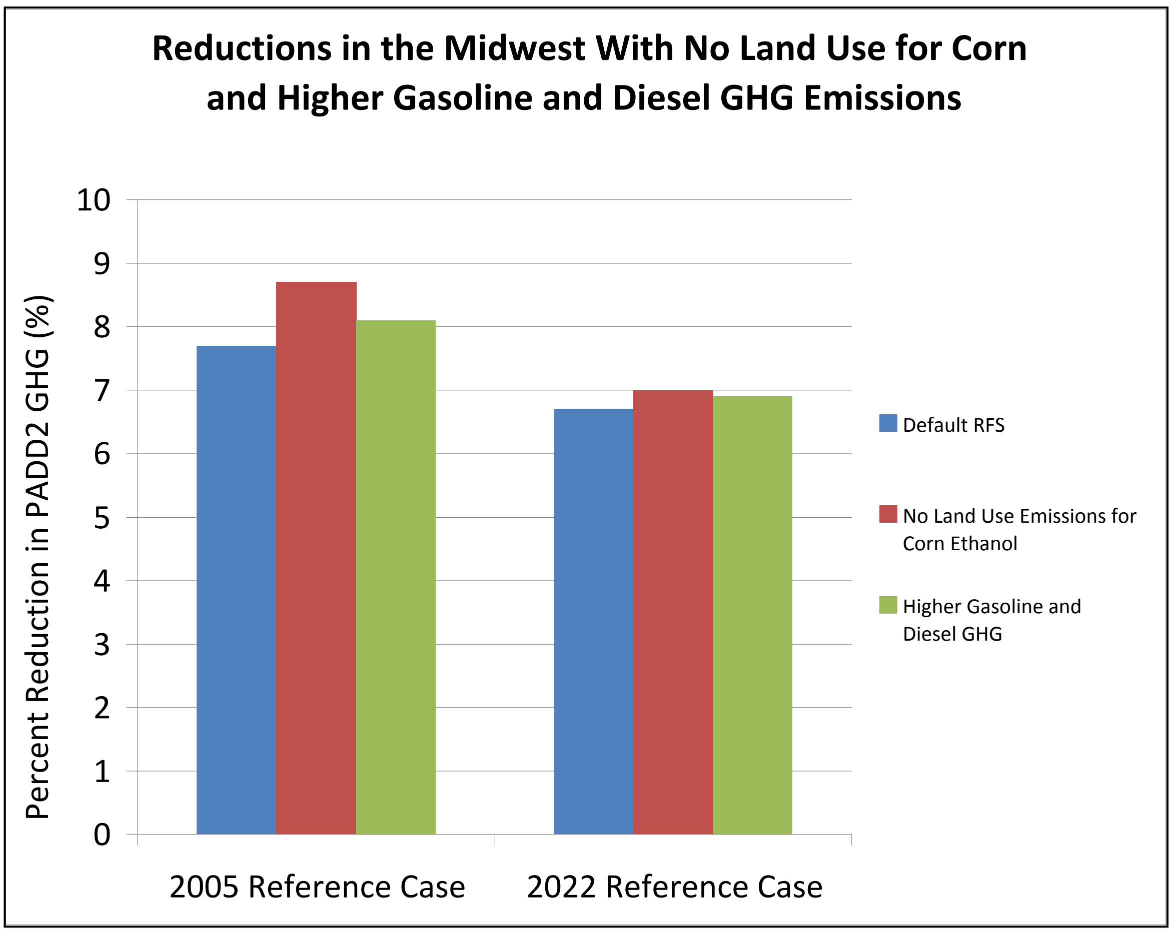


Table 4 shows the impact of the other two sensitivity cases on the percent benefit of the RFS2 in the Midwest. If land use emissions are not included for corn ethanol, the benefit of the RFS2 is increased by about 1% for the 2005 Reference Case and 0.3% for the 2022 Reference Case. The reason that removing the land use impact does not have a greater impact is that this change occurs for both the Reference and the Control Cases. Increasing the carbon intensity of gasoline and diesel by 10 g/MJ in also increases the benefit of the RFS2 by 0.2% (2022 Reference) to 0.4% (2005 Reference).

Table 4. Land Use and Gasoline Carbon Intensity Impacts on RFS2 % Reduction in Midwest		
Case	% Reduction, 2005 Reference	% Reduction, 2022 Reference
Default RFS2	7.7%	6.7%
No land use emissions for corn ethanol	8.7%	7.0%
Gasoline and diesel carbon intensity higher in Midwest (+10 g/MJ)	8.1%	6.9%

Figure 9 shows the information from Table 4 in graphical form.

Figure 9



5.0 Benefits of Enhanced RFS2 in Midwest

As mentioned earlier, an enhanced RFS2 program in the Midwest would retain more of the ultra low-GHG ethanol fuel in this region. This would be ethanol produced from corn residue or switchgrass, or both.

We used the RSM to increase the volume of corn residue ethanol in the Midwest until the total aggregated gas + diesel percent benefit (relative to the 2006 Reference Case) was 10% (corn residue is already plentiful in the Midwest). This causes an increase in corn residue ethanol use in the Midwest of 1.7 bgy. Since total production from corn residue is not increased in this scenario, areas outside of the Midwest would receive correspondingly less ethanol from this feedstock. The Midwest would be consuming 59% of the total U.S. supply of ethanol from this feedstock, rather than 28%. We also estimated the increase in corn residue ethanol in each of the PADD 2 states, and this is shown in Attachment 2. There are other feedstocks that could be increased as well, for example switchgrass, but this could involve a slight increase in ethanol volume needed to meet the 10% requirement, due to the slightly smaller GHG emission reductions relative to gasoline for switchgrass as compared to corn residue.

The impact of this enhanced RFS2 program in the Midwest is shown in Figures 10-13. Figure 10 shows the change in gasoline and ethanol volumes. Ethanol volume increases, and gasoline volume decreases.

Figure 10

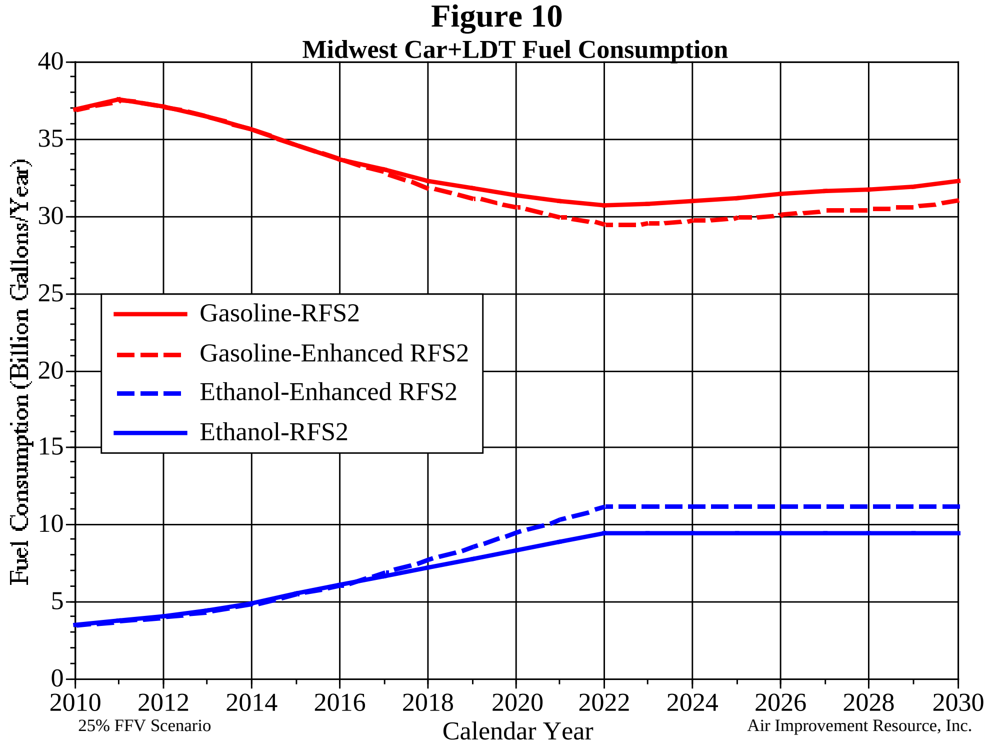


Figure 11
Midwest Average Ethanol Level for Enhanced RFS
Non-FFVs: E10(2012+)

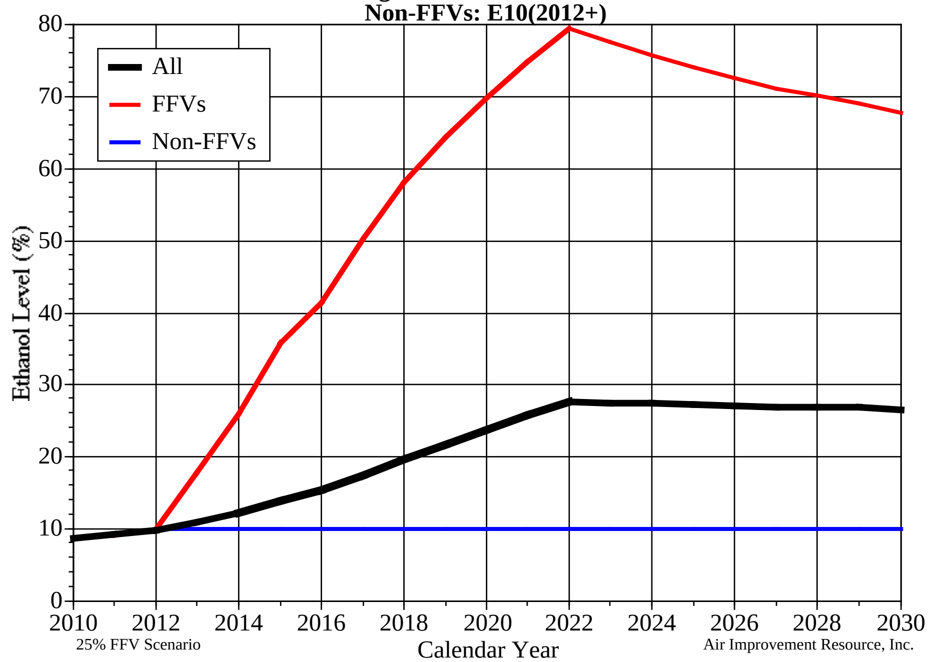


Figure 12
Midwest Average Ethanol Level for Enhanced RFS
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)

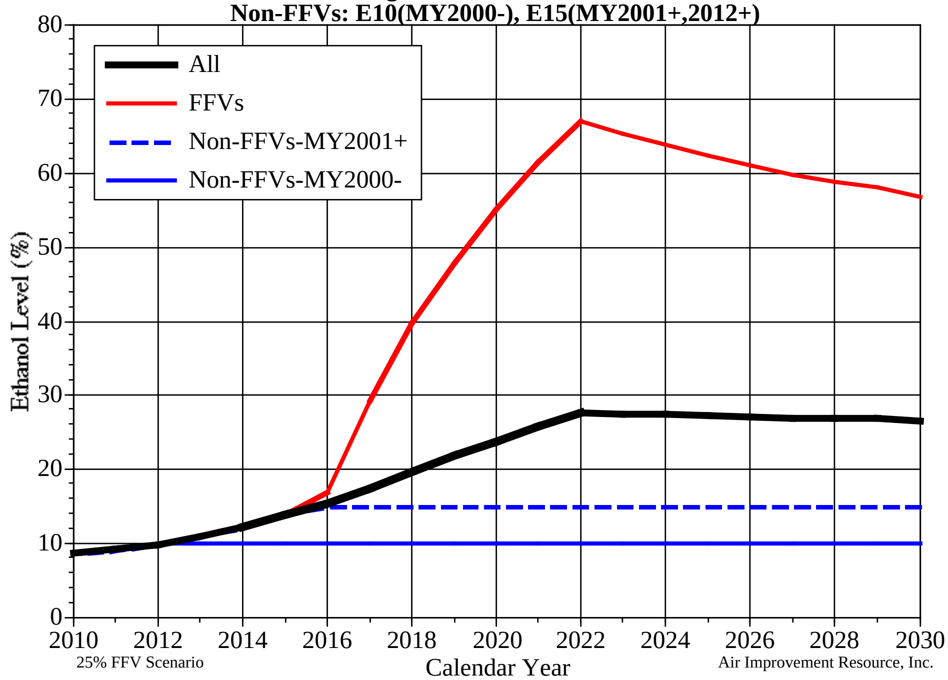
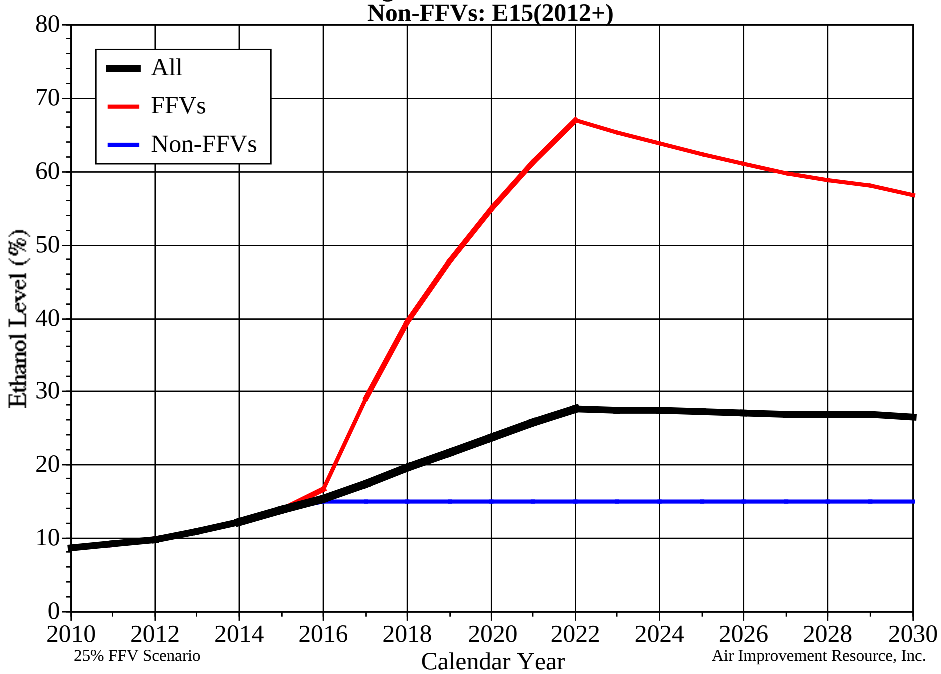


Figure 13
Midwest Average Ethanol Level for Enhanced RFS
Non-FFVs: E15(2012+)



Figures 10-13 and Table 5 show that with the Enhanced RFS2, the level of ethanol in FFVs is higher than with the RFS2, but the level of ethanol in FFVs does not reach E85, thus, there still appear to be enough FFVs physically in the Midwest for any of these scenarios. However, the level of refueling of FFVs with E85 would need to be quite high.

Table 5. Changes in Maximum Average Ethanol Volume for FFVs due to Enhanced RFS2 in Midwest

Ethanol Assumed in non-FFVs		Max Ethanol Volume – RFS2	Max Ethanol Volume – Enhanced RFS2	Frequency FFVs must be refueled with E85 in Enhanced RFS2
2000- model years	2001+ model years			
E10		66%	79%	92%
E10	E15 in 2012	52%	67%	76%
E15 in 2012		52%	67%	76%

5.1 Benefits of FFV Sales Increase

The previous section showed that with the enhanced RFS2, the maximum average ethanol volume in the Midwest increases to 75-79%. If there are not enough blender pumps and/or E85 pumps available, it may be difficult for FFV owners to refuel frequently with E85. In this section, we examine the impact on maximum average ethanol in FFVs of a FFV sales increase. The sales fraction starts at 25% in 2012 (this is accomplished voluntarily by GM, Ford and Chrysler). We increase this to 40% in 2013, 80% in 2014, and 100% in 2015. The impacts on maximum average ethanol content are shown in Figures 14-16 and Table 6.

Figure 14

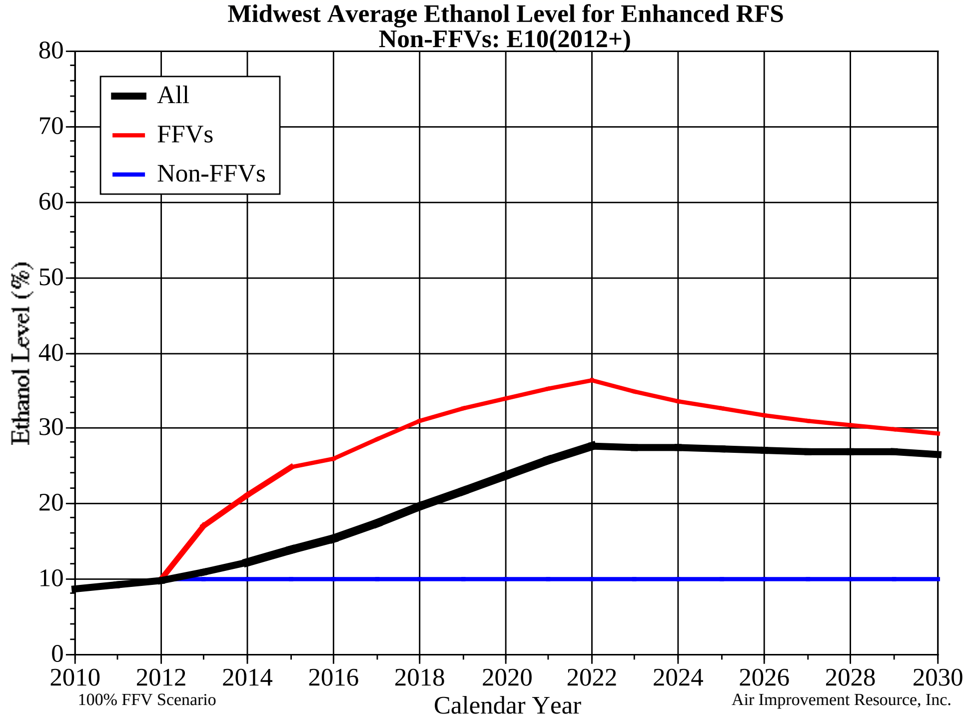


Figure 15

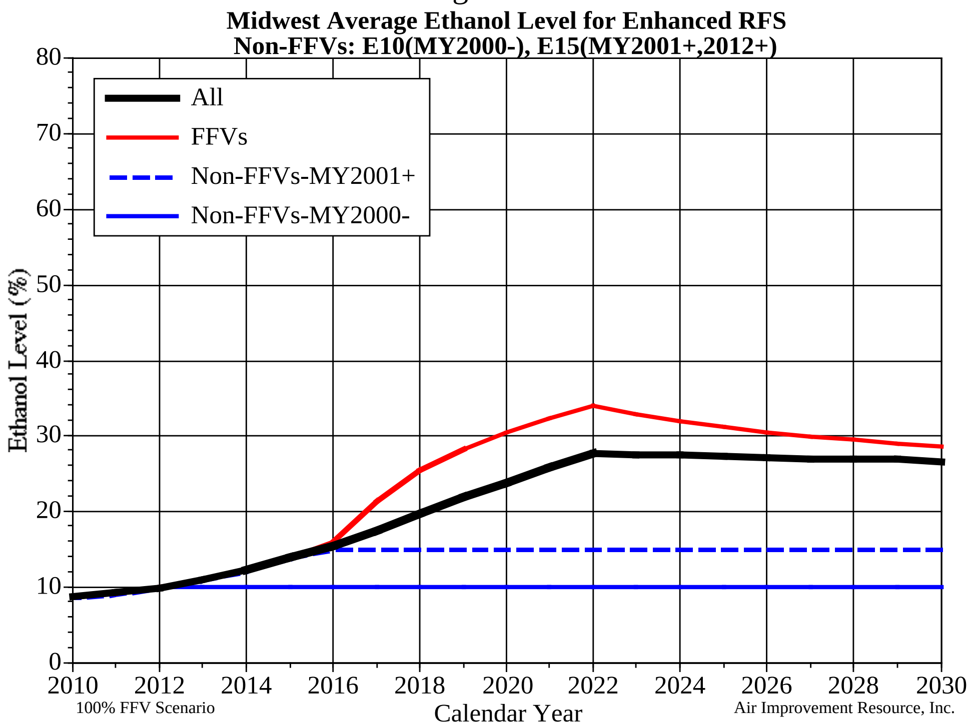


Figure 16

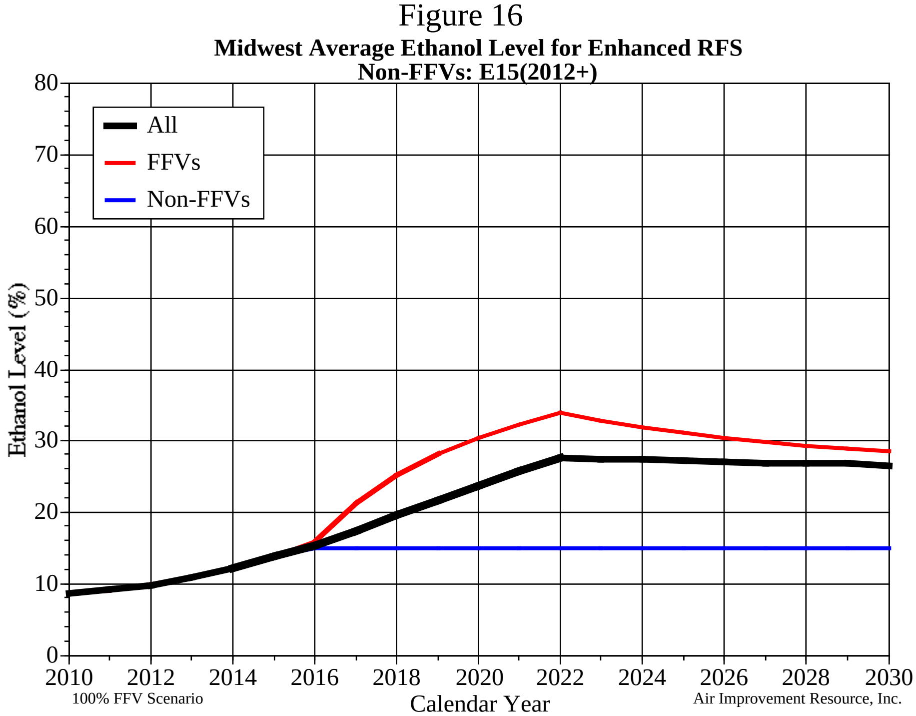


Table 6. Changes in Maximum Average Ethanol Volume for FFVs due to Enhanced RFS2 in Midwest			
Ethanol Assumed in non-FFVs		Enhanced RFS2 without FFV Sales Increase Beyond 25% in 2012	Enhanced RFS2 with FFV Sales Increasing to 100% by 2015
2000- model years	2001+ model years		
E10		79%	36%
E10	E15 in 2012	67%	34%
E15 in 2012		67%	34%

With an FFV sales increase, the maximum average ethanol volume is reduced by about one-half to the 34%-36% range.

5.2 Overall Benefits of Enhanced RFS2

We can also estimate the benefits of the enhanced RFS2 program in PADD2, using EPA's estimate of the benefit nationwide, and the increase in the benefit in the Midwest. The nationwide benefit of the RFS is 138 mmt per year. If we multiply by the vehicle miles traveled fraction in the Midwest, and the ratio of 10% divided by 7.6%, we obtain:

$$138 \text{ mmt} * 0.28 * 10\%/7.6\% = 50.2 \text{ mmt}$$

Thus, the GHG benefits in the Midwest for the RFS2 are 39 mmt, but the benefits of the Enhanced RFS2 in the Midwest are 50 mmt.

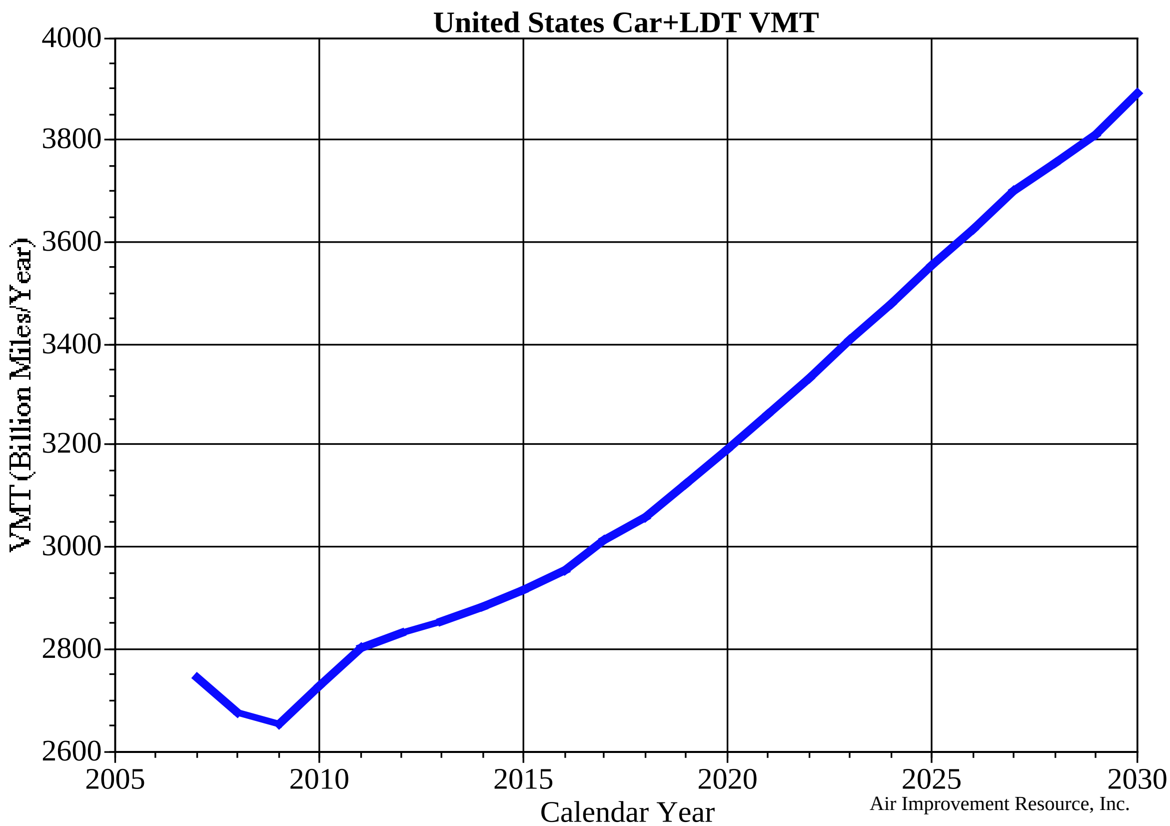
6.0 Conclusions

Through two different methods, we have determined that the Federal RFS2 reduces GHG emissions about 7.6 to 7.7%, nationally and in the Midwest. This benefit is achieved by dramatically increasing lower-GHG biofuels from today's levels.

The Midwest region consumes approximately 28% of the nation's fuels. The region also produces most of the nation's corn ethanol, and will probably produce much of the nation's cellulosic ethanol from corn residue, which is already readily available. Other fuel feedstocks such as switchgrass could be grown in the Midwest. With the Federal RFS2, consumption of cellulosic ethanol will increase to 1.5 bgy in the Midwest region. An enhanced RFS2 would increase the GHG benefit in the region from 7.7% to 10% by increasing cellulosic ethanol consumption in the region by 1.7 bgy to 3.2 bgy.

FFV sales in the nation and Midwest will increase significantly as GM, Ford and Chrysler increase the percent of their sales to 50% by 2012. This increase in FFVs is physically capable of absorbing the increase in ethanol in the Midwest, but E85 refueling frequency for FFVs would need to be about 75% for the RFS2 and 92% for the Enhanced RFS2, assuming the non-FFV fleet is fueled with E10. Both programs require greatly increased availability of blender pumps. Increased sales of FFVs would reduce the maximum average ethanol content needed for FFVs.

Attachment 1
Growth in Vehicle Miles Traveled between 2007 and 2030
In AEO2010 and in AIR Fuel Consumption Model (FCM)



Attachment 1
Increase in Corn Residue Ethanol in the PADD2 States Beyond the RFS2 Required to Achieve a 10% reduction in GHG Emissions

Ethanol Consumption byPADD2 State	
State	Consumption (Million Gallons/Year)
IA	65
IL	219
IN	152
KS	59
KY	99
MI	202
MN	110
MO	143
ND	15
NE	38
OH	226
OK	95
SD	17
TN	137
WI	123
Total	1,713