Flexible-Fuel Vehicle and Refueling Infrastructure Requirements Associated with Renewable Fuel Standard (RFS2) Implementation

Conducted for
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Table of Contents

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1.0 Summary

The Energy Independence and Security Act of 2007 (EISA) established an expanded Renewable Fuels Standard (RFS2) that requires the increasing consumption of renewable fuels in the United States, culminating with 36 billion gallons (bg) in 2022. Of the 36 bg required in 2022, 15 bg will be conventional "renewable biofuel" (assumed to be mostly grain ethanol), while the remaining 21 bg will be "advanced biofuel." Of the 21 bg of required advanced biofuels, 16 bg must come from cellulosic biofuels. It is expected that the remaining 5 bg of advanced biofuels will be comprised mostly of biodiesel and imported sugarcane ethanol.

The U.S. EPA published its final rules for the RFS2 in March 2010. In its examination of possible ethanol volumes resulting from RFS2 implementation, EPA developed three future ethanol volume scenarios– a Low Volume Case (17.5 bg in 2022), a Mid Volume Case (22.2 bg in 2022), and a High Volume Case (33.2 bg in 2022). EPA estimated the three cases because it believes non-ethanol biofuels could potentially contribute significant volumes toward meeting the RFS2. Still, it is possible that most of the 36 bg RFS could be satisfied through the consumption of ethanol made from grain, cellulosic feedstocks and sugarcane.

However, the amount of ethanol that can be used in the United States is essentially limited to 10% of the gasoline pool. This is because the Clean Air Act generally limits the amount of ethanol that can be consumed by conventional light-duty cars and trucks to 10% by volume (E10). Thus, a maximum of roughly only 14-15 bg of ethanol can be consumed by the conventional automobile fleet at the E10 level, based on expected gasoline demand. Only flexible-fuel vehicles (FFVs), which make up just 4% of the current fleet, may currently consume ethanol blends greater than E10. Further, "mid-level" ethanol blends (i.e., those blends above E10 but lower than E85) currently may only be dispensed by blender pumps, of which only approximately 300 exist today (out of roughly 160,000 service stations, each with an average of six to eight pumps).

EPA approved a waiver request allowing the use of E15 (15% ethanol by volume) for conventional light duty vehicles with a model year (MY) of 2007 or newer in October 2010. In January 2011, EPA extended the E15 waiver to vehicles dating back to MY2001. However, several additional infrastructure and regulatory obstacles exist before significant volumes of E15 can realistically penetrate the marketplace. Further, even if it is assumed that exclusively E15 is used in all MY2001 and newer vehicles in the near term, maximum ethanol use in conventional automobiles would grow to approximately 18-19 bg. This means that the likely volumes of ethanol produced under the RFS2 still could not be readily consumed by the U.S. light duty vehicle fleet.

Thus, it appears likely that rapid growth of FFVs and blender pumps will be necessary to consume the increasing ethanol volumes expected under the RFS2. The "Detroit Three"

(General Motors, Ford and Chrysler) have stated their commitment to provide one-half of their MY2012 and later model year sales as FFVs. Other manufacturers have started to offer FFVs as well.

This study examines a matrix of 27 future scenarios regarding ethanol volumes, FFV availability, ethanol use in non-FFVs, and the availability and location of blender pumps and/or E85 pumps. For this analysis, we utilized our Fuel Consumption Model, which was developed for a previous study conducted for the Renewable Fuels Association and others.

The results of our analysis led us to the following conclusions:

- Without the commitment of the Detroit Three to provide 50% of their sales as FFVs starting in 2012, it would not be possible to consume the ethanol in EPA's Mid and High Volume cases. However, even with this commitment, consuming the ethanol in the High Volume case would require every FFV to refuel with E85 essentially 100% of the time.

- Similarly, without significantly increased availability of either E85 or blender pumps at retail outlets, it will not be possible to consume the ethanol in EPA's Mid and High Volume cases.

- Under EPA's High Volume case (33.2 bg by 2022), and assuming E15 is used in all non-FFVs built in 2001 or later, the average fuel blend consumed in FFVs will need to contain 56% ethanol (E56). This means FFVs would need to fill up with E85 approximately 72% of the time (or E56 all of the time). This assumes the current trajectory of FFV penetration (i.e., 50% of the vehicles produced by the Detroit Three are FFV-capable in 2012 and subsequent years). AIR sees this as the most likely scenario in the absence of an FFV requirement.

- Under the High Volume case, if *all* vehicles sold in 2015 and subsequent years are FFV-capable, and E15 is used in all non-FFVs built in 2001 or later, the average fuel blend consumed in FFVs will need to contain 29% ethanol by volume (E29). This means FFVs would need to fill up with E85 only 37% of the time (or E30 all of the time). Coincidentally, E30 is one of the most common blends dispensed from blender pumps today.

- Under EPA's Mid Volume case (22.2 bg by 2022), and assuming E15 is used in all non-FFVs built in 2001 or later, the average fuel blend consumed in FFVs will need to contain just 21% ethanol by volume (E21). This means FFVs would need to fill up with E85 just 28% of the time (or E20 all of the time). This assumes the current trajectory of FFV penetration. The minimum ethanol blend drops to E17 and E85 refueling frequency drops to 22% of the time, if it is assumed all vehicles sold in 2015 and subsequently are FFVs.

- Under EPA's Low Volume case (17.5 bg by 2022) no FFVs or blender pumps are needed if it is assumed that E15 is used in all conventional vehicles.

- The number of blender pumps required to dispense the volumes of ethanol from EPA's three cases depends on a number of factors. However, to serve the areas that account for 80% of national vehicle miles traveled (VMT), we estimate a minimum of approximately 53,000 service stations would need to install blender pumps. This represents roughly 33% of service stations in the country.

2.0 Introduction

Air Improvement Resource (AIR) completed a study for the Renewable Fuels Association and others in June 2010 entitled "Benefits of an Enhanced RFS2 in the Midwestern States." [1] The "Enhanced RFS2" referenced in that study is a program that would utilize greater than the RFS2-required volumes of ethanol in the Midwest to achieve a 10% reduction in GHGs in the Midwestern states. The study examined the average ethanol levels and E85 refueling frequencies that Flexible Fuel Vehicles (FFVs) would need to experience in order to achieve this 10% GHG reduction benefit.

The previous study showed that with full implementation of the RFS2 and a limitation of 10% ethanol (E10) in non-FFVs, the available FFVs in the Midwest would have to consume an average of E65, or 65% ethanol by volume, in order to utilize just the proportional share of ethanol in the Midwest market as for a result of the RFS2. This means that FFVs would have to refuel with E85 about 75% of the time that they fill up. Under the "Enhanced RFS2," FFVs would have to consume E79, meaning that all FFVs would have to be continuously refilled with E85[1]. If the ethanol level allowed in the non-FFV fleet were raised to E12 or E15, these levels (i.e., E65 and E79) in FFVs would drop somewhat, reducing the need for FFVs to refuel almost continuously with E85. Also, if FFVs comprised a greater fraction of overall vehicle sales than is indicated by the current trajectory, then the required frequency of E85 refills in the FFV fleet would be reduced. If the E15+ and E85 required refueling frequency is high, then most gas stations will need to be equipped with blender pumps (pumps capable of blending E85 and gasoline).

This study is examining RFS2 implementation issues in more detail on a national level. This analysis starts with the volumes of ethanol projected by EPA in the RFS2 rule under the "Low", "Mid" and "High" volume scenarios, and evaluates the average ethanol level and FFV refueling frequency required to utilize these ethanol volumes. The study also examines the impacts of different mid-level blends on refueling frequencies, and the impacts of different FFV penetration rates on E85 refueling frequencies. Finally, the study examines the fraction of service stations that would need to be equipped with blender pumps in order to deliver these ethanol volumes.

The report is divided into the following sections:

- Background
- Scenarios and Modeling Method
- FFV Refueling Frequencies
- Blender Pumps Needed

[1] This would likely be unachievable because E85 is often limited to 70% ethanol in many locations during winter months, meaning E85 may actually be closer to E76 on an annual average basis.

3.0 Background

EPA's Regulatory Impact Analysis (RIA) for the RFS2 included some discussion of RFS2 implementation issues. [2] This section summarizes EPA's analysis of these issues.

If ethanol were completely fungible with gasoline, and permitted to be blended with gasoline at any level, there would be few, if any, RFS2 implementation issues. Oil companies would simply blend the required amount of ethanol with gasoline to meet the RFS2, or allow consumers a choice of how much ethanol to blend at the pump, with no restrictions on what kind of vehicles the fuel is dispensed into. This, however, is not the case. Ethanol can be blended as E10 throughout the country and sold into any light-duty vehicle, or sold as E85 in FFVs. In certain areas, blender pumps are being installed allowing consumers with FFVs to select "mid-level blends," based on mixes of E10 and E85.

EPA projects that E10 will be blended nationwide sometime between 2013 and 2015 (depending on the projected volumes), with close to 15 bg of ethanol (see Figure 1.7-3 in the RIA). Currently, a small amount of ethanol is blended as E85. The RFS, however, requires total renewable fuel use of 36 bg by 2022. While biodiesel and renewable diesel will account for some of the 36 bg, it is our belief that ethanol will be used to account for most of the required volume. If ethanol use is to fully expand beyond the amount projected to be used for E10, it must do so in FFVs, unless EPA waives the maximum limit of ethanol to E15 for *all* light duty vehicles. EPA has waived the maximum limit to E15 just for MY2001 and later model year light duty vehicles and trucks. [3] If MY2001 and newer vehicles consume E15 all of the time, the maximum amount of ethanol that could be used in non-FFVs would be around 19 bg, which is still far short of the amounts required under the RFS2 by 2022. If the E15 waiver was extended to all light duty cars and trucks, maximum ethanol use in non-FFVs would be approximately 21 bg. Thus, *with or without an E15 waiver*, FFV refueling with blends significantly above E10 must increase dramatically in the future.

EPA defines a term it calls "reasonable access" to E85. EPA assumes that for FFVs to have reasonable access to E85, one out of every four service stations, or 25%, would need to have E85 available. EPA's one-in-four assumption is based on the number of service stations offering diesel fuel in the U.S. market. Table 1 summarizes EPA's estimate of the number of service stations with E85 by 2022 in order for FFVs to have reasonable access. In 2008, there were 161,768 total service stations in the U.S.

Table 1. EPA Projected Number of Stations Offering E85 to Provide Reasonable Access				
EPA Volume	Reasonable Access Assumption	% of FFVs in Nation Needing Reasonable Access	Number of Stations Offering E85 for Reasonable Access	Number of pumps per station
High (33.2 bgy)	25%	70%	28,309	3
Mid (22.2 bgy)	25%	60%	24,265	50% - 1 50% - 2
Low (17.5 bgy)	25%	40%	16,177	All - 1

EPA estimates that for the High Volume case, 70% of FFVs need reasonable access to E85, and this would require 28,000+ stations to be equipped with E85 refueling capacity or blender pumps, and that three pumps would be required at each service station.

For the Mid Volume case, EPA estimates 60% of FFVs need reasonable access to E85, and this would require 24,000+ stations to have E85. For the Low Volume scenario, EPA estimates that 40% of FFVs need reasonable access to E85, and this would require 16,000+ stations to have E85 offered at one pump.

There are currently about 2,200 E85 retail refueling service stations in the U.S., which is less than 1.5% of the total service stations.[2] Thus, assuming FFVs are evenly distributed in the U.S. and not concentrated in areas with E85 refueling facilities, less than 1.5% of the current FFVs on the road have reasonable access to E85. There are approximately 8 million FFVs on the road today, which comprise about 4% of the total gasoline vehicle fleet. The "Detroit Three" (Ford, General Motors, and Daimler-Chrysler) still plan to offer 50% of their vehicle sales as FFVs in 2012, and other manufacturers are starting to offer some FFVs, so the percentage of the light duty fleet that is comprised by FFVs will grow rapidly after 2012. But there is little to no reasonable access to E85 for the current FFVs on the road, and there is no indication that even 40% reasonable access to E85 for the EPA Low Volume scenario will ever occur without specific action to ensure that it does.

3.1 Concerns with EPA's Analysis

There are several concerns with EPA's analysis of RFS2 implementation issues. EPA derived its E85 reasonable access percentage of 25% from the availability of diesel service stations to the total service stations. EPA referenced sources estimating that 36.6% of service stations offer diesel fuel. However, EPA states the following:

[2] Department of Energy. "Alternative Fueling Station Total Counts by State and Fuel Type." http://www.afdc.energy.gov/afdc/fuels/stations_counts.html

> Unlike diesel fuel vehicles that can refuel only in diesel fuel or alternative fuel vehicles that can only be fueled on the alternative fuel, flex fuel vehicles can refuel on gasoline as well as E85. Thus, we believe that fewer E85 stations should be necessary than were provided for diesel fuel.

EPA's rationale for lowering the reasonable access from 36.6% to 25% for FFVs is that they can also "refuel on gasoline." However, refueling a FFV on gasoline because E85 is unavailable defeats the purpose of using ethanol; and it does not help in meeting the RFS2 volume requirements.

The second concern is the inconsistency between the need for FFVs and the need for E85 service stations. EPA states:

> Based on reduced vehicle sales and gasoline demand, we believe an FFV mandate would be the only viable means for consuming the 33.2 bgy of ethanol in 2022 required under the high ethanol case.

Currently there are 8 million FFVs on the road with little access to E85. EPA appears to be contemplating the possibility of an FFV mandate for the High Volume case, but there is no corresponding infrastructure consideration to ensure E85 is available to the mandated FFVs in this scenario. These and other issues will be discussed in the remaining sections of the report.

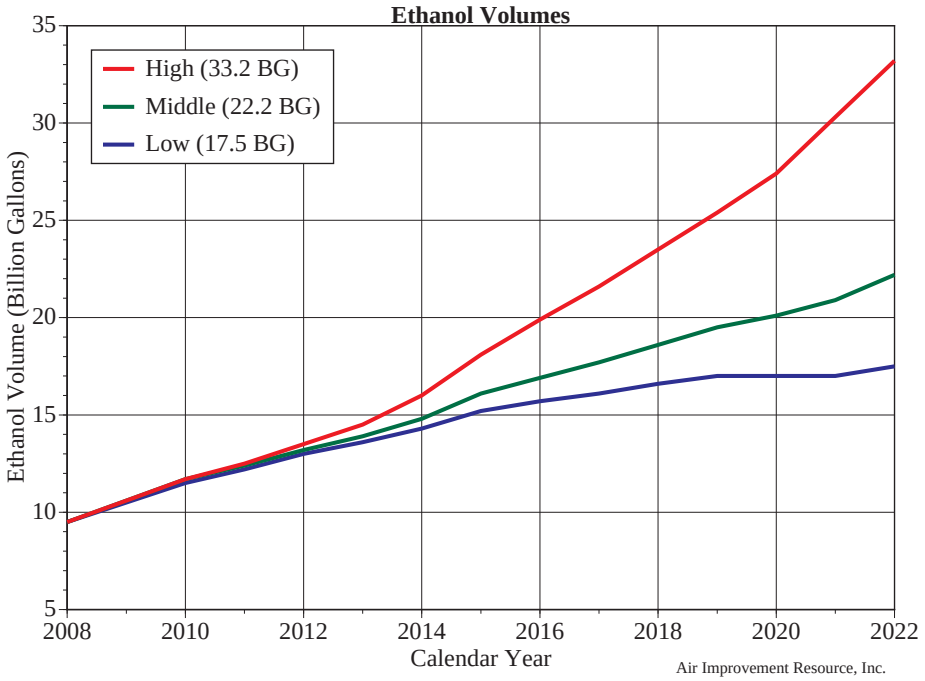
4.0 Study Scenarios and Modeling Method

The study scenarios examined in this report are summarized in Table 2. There are three different ethanol volume scenarios which correspond to EPA's Low (17.5 bgy), Mid (22.2 bgy) and High cases (33.2 bgy). These volumes are assumed to be achieved in calendar year 2022. This study assumes that the ethanol volume in 2008 is 9.5 bgy, and that ethanol use increases in accordance with EPA's volume predictions for each case. Figure 1 shows the ethanol increases for these three scenarios.

Table 2. Scenarios for Examining Implementation Issues

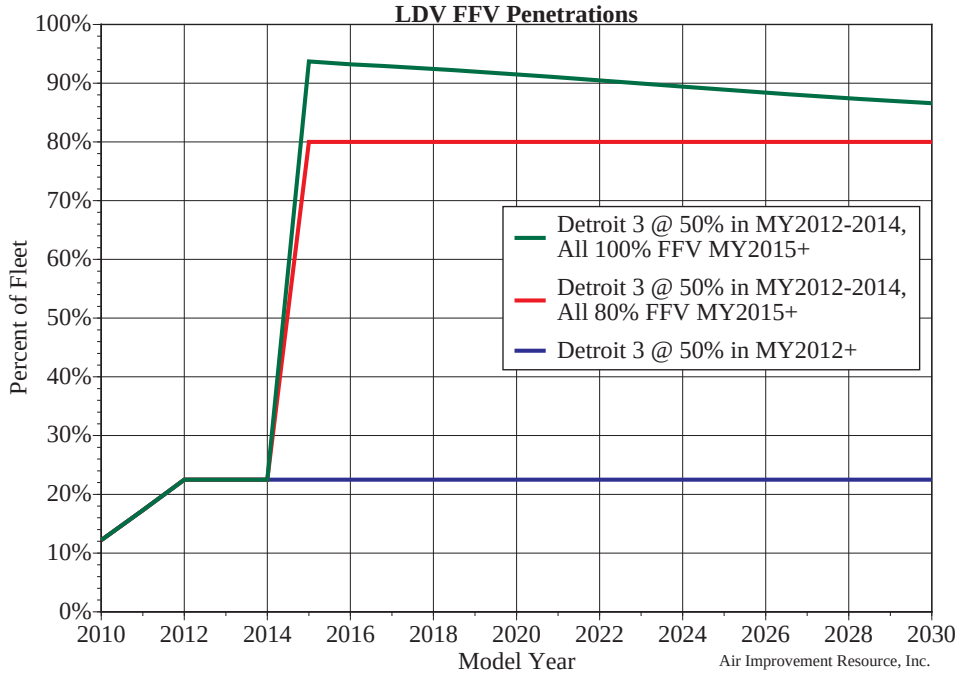
Factor	Case
2022 Ethanol Volume Scenarios (all scenarios ramp-up from 9.5 bgy in 2008)	17.5 bgy (EPA low)
	22.2 bgy (EPA mid)
	33.2 bgy (EPA high)
FFV Penetration Scenarios	Detroit 3 @ 50% FFV in 2012+ model years
	Detroit 3 @ 50% FFV in 2012-2014 model years, all automakers 80% FFV in 2015+ model years
	Detroit 3 @ 50% FFV in 2012-2014 model years, all automakers 100% FFV in 2015+ model years
Non FFV Ethanol Level Scenarios	E10
	E10 until 2012, E10 in 2012 in 2000- model years, E15 in 2012 in 2001+ model years
	E10 until 2012, E15 in all model years in 2012

Figure 1



There are three cases for FFV penetration in our matrix. The first case assumes that the Detroit Three (GM, Ford, Chrysler) provide 50% of their gas and diesel automobile sales across the entire light duty product line as FFV starting in 2012, and continuing thereafter. The second case assumes the Detroit Three provide 50% of their light duty car and light duty truck sales as FFV in 2012-2014, and that all manufacturers provide 80% of their light duty sales as FFVs starting in 2015. The last case is the same as the second case, but assumes that 100% of gasoline only sales are FFVs for all manufacturers starting in model year 2015. These three cases are shown in Figure 2 (the last case shows the percent at less than 100% due to the fraction of diesel sales assumed, which grows slightly with time).

Figure 2



Finally, there are three cases for the ethanol blend that will be used in non-FFVs. The first case assumes all light duty vehicles utilize only a maximum of 10% ethanol. The second case assumes E10 will be used in all non-FFVs until 2012; but in 2012, MY2000 and earlier model year vehicles will continue to be fueled with E10, while MY2001+ are fueled with E15. The third case assumes E10 in all non-FFVs until 2012; but in 2012 and later calendar years, *all* non-FFV vehicles are fueled with E15. These cases are shown in Figure 3. The figures appear to be identical, but they are not because the lines represent different scenarios.

Figure 3

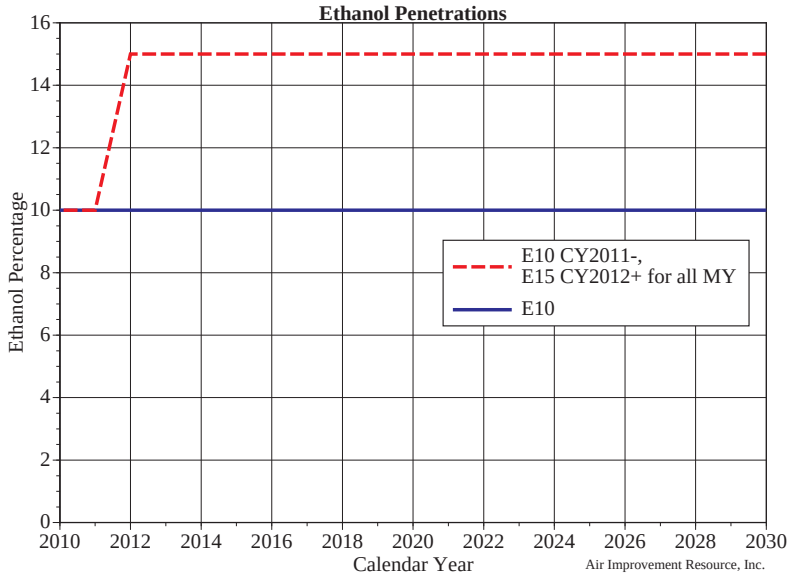
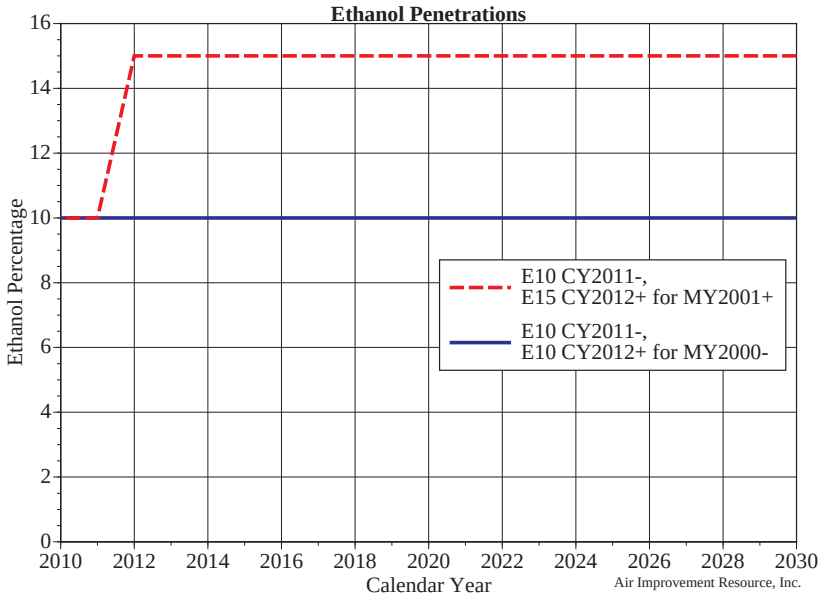


Figure 4



In all, this study is examining 27 scenarios that are summarized in Table 3.

Table 3. Summary of Scenarios			
Scenario	2022 Ethanol Volume	FFV Penetration	Non FFV Ethanol Level
1	17.5 bgy (EPA low)	Detroit 3 @ 50% in 2012+ myrs	E10
2			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
3			E10 until 2012, E15 in all myrs in 2012
4		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10
5			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
6			E10 until 2012, E15 in all myrs in 2012
7		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10
8			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
9			E10 until 2012, E15 in all myrs in 2012
10	22.2 bgy (EPA mid)	Detroit 3 @ 50% in 2012+ myrs	E10
11			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
12			E10 until 2012, E15 in all myrs in 2012
13		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10
14			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
15			E10 until 2012, E15 in all myrs in 2012
16		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10
17			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
18			E10 until 2012, E15 in all myrs in 2012
19	33.2 bgy (EPA high)	Detroit 3 @ 50% in 2012+ myrs	E10
20			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
21			E10 until 2012, E15 in all myrs in 2012
22		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10
23			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
24			E10 until 2012, E15 in all myrs in 2012
25		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10
26			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs
27			E10 until 2012, E15 in all myrs in 2012

As a part of our study to determine the benefits of an Enhanced RFS2 program in the Midwest (discussed earlier), 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. [1] The FCM was developed for on-road gasoline and diesel vehicles. The model also allows these projections by the Department of Energy's Petroleum Area Defense Districts, or PADDs.

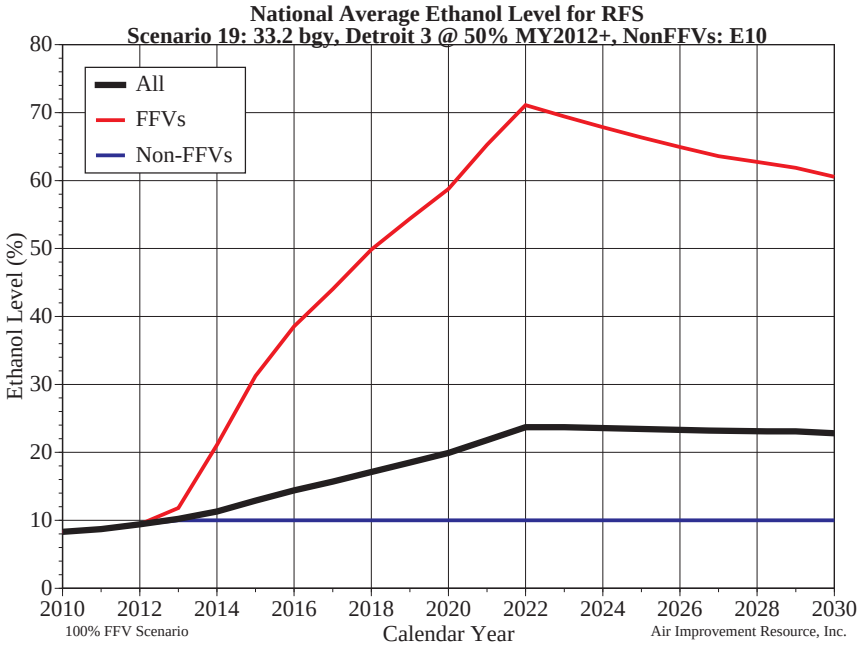
The FCM utilizes sales of vehicles by general weight class and fuel type by model year, scrappage rates by vehicle class and age, annual mileage accumulation rates by age, fuel consumption by model year, and other information to produce estimates of total fuel consumed by calendar year. The primary purpose of this model is to estimate the average ethanol level in FFVs needed to utilize the ethanol volumes expected under the RFS2. A level of ethanol is first specified for the non-FFVs (E10, for example). 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.

An example of the output from the FCM is a chart such as Figure 5. Figure 5 shows the national average ethanol level in three groups of vehicles (All, FFVs, and non-FFVs) for the RFS2 assuming 33.2 bgy of ethanol consumption in 2022, and 50% of 2012 and later model year sales being FFVs. In Figure 5, all non-FFVs are assumed to use only E10.

The chart shows that average FFV ethanol use peaks at about E70 in 2022, the average ethanol level in all vehicles is E23, and in non-FFVs it is E10. An average level of E70 in 2022 for FFVs indicates that FFVs must refuel with E85 nearly all the time in order for the entire fleet to utilize 33.2 bgy of ethanol. This implies that blender pumps must be widely available in order for the available FFVs to refuel this often. Figure 5 is just one example, and Attachment 1 to this report contains similar charts for all 27 scenarios.

Figure 5



5.0 FFV Refueling Frequencies

This section first discusses the average ethanol volume percentages in both FFVs and non-FFVs needed to use all of the ethanol for the various ethanol projections. Next, we develop the required FFV refueling frequencies.

5.1 Average ethanol levels in FFVs and non-FFVs

Figure 6 shows the national average ethanol level for Scenario 1 from Table 3. This type of figure was created for all 27 scenarios, and the figures for all scenarios are shown in Attachment 1. The figure shows the average ethanol levels by calendar year (2010-2030) for all vehicles, for just FFVs, and for non-FFVs. The total ethanol in this figure is the EPA low case at 17.5 bgy, with the Detroit 3 providing 50% of sales as FFVs in 2012+, and all non-FFVs fueled only with E10.

The figure shows that the average ethanol level for FFVs increases from E10 in 2013 to about E25 in 2022 for Scenario 1. There is a maximum value of 24.79% that occurs in calendar year 2022. This is both a maximum and a minimum. It is a maximum average ethanol level over the years in which ethanol volumes continue to increase. It is a minimum level in the sense that it is the minimum ethanol level that may be consumed in any year to utilize all of the ethanol in this particular RFS2 scenario. In this report, when we refer to maximum average ethanol values, it is in the first sense.

Figure 6

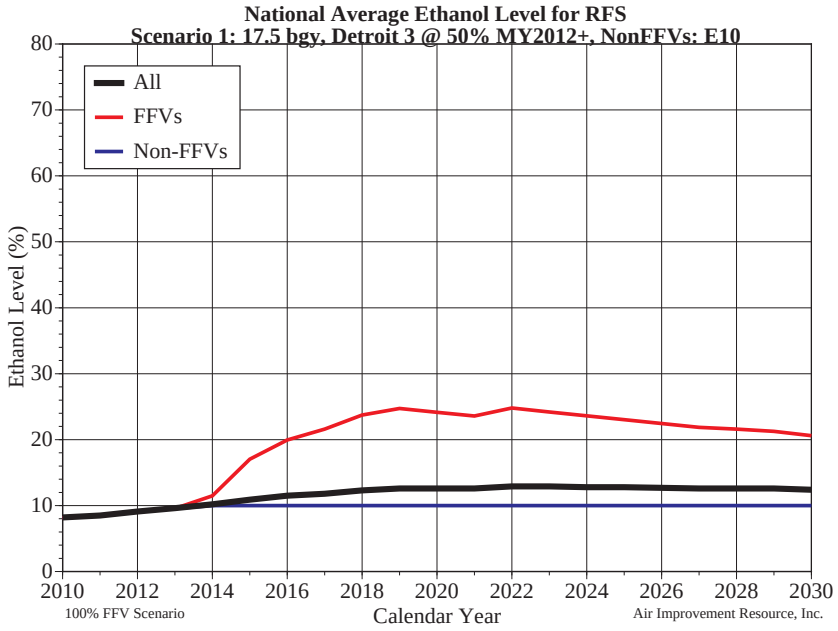


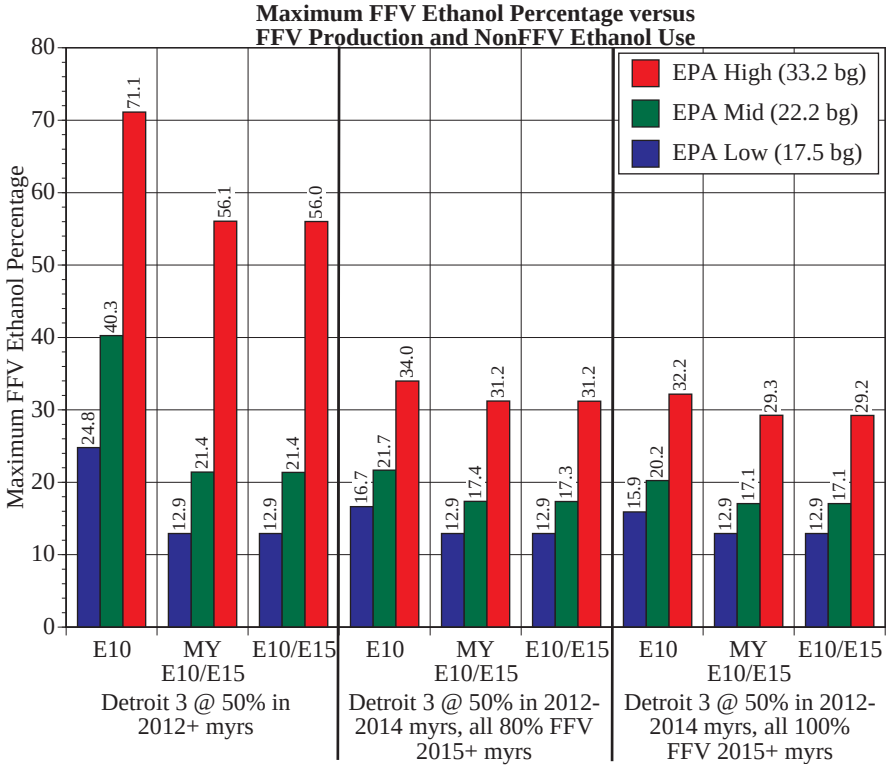
Figure 7 shows the maximum average ethanol level for FFVs for all 27 scenarios. The figure has three sections, which are differentiated by the FFV penetration scenario. In each section, there are three ethanol scenarios for non-FFVs. The E10 scenario means

that all non-FFVs are fueled only on E10. The "MY E10/E15" scenario refers to E10 being used in MY2000 and earlier vehicles, and E15 being used only in 2001+ vehicles, starting in 2013. The "E10/E15" scenario means that all non-FFVs vehicles are fueled on E15 after 2012. There are also three EPA ethanol volume scenarios for each of these individual cases.

AIR believes the left section of Figure 7 (showing ethanol percentages for the scenario in which the Detroit Three produce 50% FFVs in 2012 and subsequent years) is the most likely scenario for FFVs if an FFV mandate is not implemented. Logically, the figure shows that the required ethanol levels in FFVs are the highest for the EPA High Volume case. The average maximum ethanol in FFVs for these cases is 56% to 71%, which implies a need for FFVs to refuel with E85 nearly all the time. For the EPA Mid Volume case, the average ethanol in FFVs is 21% to 40%. For the EPA Low Volume case, the maximum ethanol concentration required in FFVs is between 12% and 25%.

For the middle and right sections of Figure 7, where the penetration of FFVs is much higher, the maximum ethanol level in FFVs is smaller. For the High Volume case, the maximum average ethanol values are between 30 and 34%. The Low Volume case, for all cases involving E10 and E15, shows an average ethanol content of 12.9%. The Mid and Low Volume cases have smaller maximum average ethanol values. All of the values in Figure 7, including the year of the maximum average ethanol content, are shown in Table 4.

Figure 7



There are at least two important implications from Figure 7. One is that if E15 is used in MY2001 and newer vehicle in the Low Volume case, there would be no particular need for FFVs, blender pumps, or E85. The second implication is that for both the Mid and High Volume cases, FFVs being voluntarily offered by the Detroit Three in one-half of their fleets starting with model year 2012 are critical to utilizing these ethanol volumes. Without these FFVs, utilizing these ethanol volumes would not be possible.

5.2 FFV Refueling Frequency

There are two types of pumps that provide fuel containing more than 10% ethanol to FFVs – pumps that provide E85 only (E85 pumps), and blender pumps, which allow the vehicle owner to select the volume fraction of ethanol (most blender pumps are set to dispense E10, E20, E30, E40 and E85). Most pumps being installed today are blender pumps, because of the better consumer choice and flexibility. The FFV refueling frequency is a function of what type of pump is used, and the fraction of ethanol selected by the vehicle owner during refueling. The refueling fraction range can be estimated by assuming 100% use of E85 pumps or 100% use of blender pumps.

For example, Scenario 21 (High Volume Ethanol, MYE10/E15, Detroit Three at 50% FFV in 2012) indicates an average maximum ethanol content of 56.02%. If 100% blender pumps are used to refuel FFVs, then all FFVs would have to be refueled 100% of the time with a minimum ethanol content of 56%. If 100% E85 pumps were used to refuel FFVs, then FFVs would need to refuel with E85 65.9% of the time (56.06%/0.85). Actually, the refueling frequency would be higher than this because in the winter, E85 is typically blended at E70 to allow for enhanced start-ability. So the annual refueling frequency becomes 72.34% (56.02% divided by E77.5, which is the average of E85 and E70). Thus, the minimum refueling frequency for E85 in Scenario 21 is 72.34% of the time, and for blender pumps is 100% of the time at a minimum ethanol level of E56.

Table 5 shows the refueling frequency ranges for E85 and blender pumps for each of the scenarios. In Table 5, we have highlighted Scenario 20, which is based on the High Volume ethanol case, with the Detroit Three providing 50% of their sales as FFVs starting in 2012, with E10 until 2012, E10 in 2012 for model year 2000 and earlier vehicles, and E15 for 2001+ model year vehicles. We consider this to be the “most likely” scenario, in the absence of an FFV mandate. In this scenario, if all FFVs utilize E85 pumps, they would have to refuel with E85 66% of the time. If they were to utilize only blender pumps, they would have to have an average ethanol content of 73%.

There are two important implications to these results. One is that for any average maximum ethanol level below E15, very few blender pumps or E85 pumps are required. This includes most scenarios based on the EPA Low Volume case. However, for the EPA Mid and High Volume scenarios, there is maximum average ethanol level above E15, therefore, significant numbers of E85 pumps or blender pumps will be needed. The second implication is that the greater the number of FFVs, the less mid-level blend from blender pumps or E85 needs to be used by each FFV.

Table 4. Scenarios, Descriptions, and Maximum FFV Ethanol Levels and Years					
Scenario	2022 Ethanol Volume	FFV Penetration	Non FFV Ethanol Level	Max FFV Ethanol %	Year
1	17.5 bgy (EPA low)	Detroit 3 @ 50% in 2012+ myrs	E10	24.79	2022
2			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	12.93	2022
3			E10 until 2012, E15 in all myrs in 2012	12.93	2022
4		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10	16.65	2018
5			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	12.93	2022
6			E10 until 2012, E15 in all myrs in 2012	12.93	2022
7		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10	15.90	2018
8			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	12.93	2022
9			E10 until 2012, E15 in all myrs in 2012	12.93	2022
10	22.2 bgy (EPA mid)	Detroit 3 @ 50% in 2012+ myrs	E10	40.25	2022
11			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	21.42	2022
12			E10 until 2012, E15 in all myrs in 2012	21.37	2022
13		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10	21.67	2022
14			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	17.36	2022
15			E10 until 2012, E15 in all myrs in 2012	17.34	2022
16		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10	20.23	2022
17			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	17.06	2022
18			E10 until 2012, E15 in all myrs in 2012	17.05	2022
19	33.2 bgy (EPA high)	Detroit 3 @ 50% in 2012+ myrs	E10	71.12	2022
20			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	56.06	2022
21			E10 until 2012, E15 in all myrs in 2012	56.02	2022
22		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10	33.99	2022
23			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	31.22	2022
24			E10 until 2012, E15 in all myrs in 2012	31.20	2022
25		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10	32.18	2022
26			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	29.25	2022
27			E10 until 2012, E15 in all myrs in 2012	29.23	2022

Table 5. Scenarios, Descriptions, E85 Refueling Frequencies and Blender Pump Ethanol Levels					
Scenario	2022 Ethanol Volume	FFV Penetration	Non FFV Ethanol Level	E85 Refueling Frequency	Blender Pump Ethanol Level
1	17.5 bgy (EPA low)	Detroit 3 @ 50% in 2012+ myrs	E10	31.99	24.79
2			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	16.68	12.93
3			E10 until 2012, E15 in all myrs in 2012	16.68	12.93
4		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10	21.48	16.65
5			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	16.68	12.93
6			E10 until 2012, E15 in all myrs in 2012	16.68	12.93
7		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10	20.52	15.90
8			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	16.68	12.93
9			E10 until 2012, E15 in all myrs in 2012	16.68	12.93
10	22.2 bgy (EPA mid)	Detroit 3 @ 50% in 2012+ myrs	E10	51.94	40.25
11			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	27.64	21.42
12			E10 until 2012, E15 in all myrs in 2012	27.57	21.37
13		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10	27.96	21.67
14			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	22.40	17.36
15			E10 until 2012, E15 in all myrs in 2012	22.37	17.34
16		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10	26.10	20.23
17			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	22.01	17.06
18			E10 until 2012, E15 in all myrs in 2012	22.00	17.05
19	33.2 bgy (EPA high)	Detroit 3 @ 50% in 2012+ myrs	E10	91.77	71.12
20			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	72.34	56.06
21			E10 until 2012, E15 in all myrs in 2012	72.28	56.02
22		Detroit 3 @ 50% in 2012-2014 myrs, all 80% FFV 2015+ myrs	E10	43.86	33.99
23			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	40.28	31.22
24			E10 until 2012, E15 in all myrs in 2012	40.26	31.20
25		Detroit 3 @ 50% in 2012-2014 myrs, all 100% FFV 2015+ myrs	E10	41.52	32.18
26			E10 until 2012, E10 in 2012 in 2000- myrs, E15 in 2012 in 2001+ myrs	37.74	29.25
27			E10 until 2012, E15 in all myrs in 2012	37.72	29.23

6.0 Blender Pumps Needed

This section discusses the number of service stations that need to be equipped with blender pumps in order to consume the ethanol volumes under each of scenarios examined in this study. It also estimates a required E85 volume for the scenario with E10 for model year 2000 and earlier vehicles and E15 for 2001 and later vehicles. Finally, it estimates the E85 volume per service station with blender pumps.

6.1 Number of Service Stations with Blender Pumps

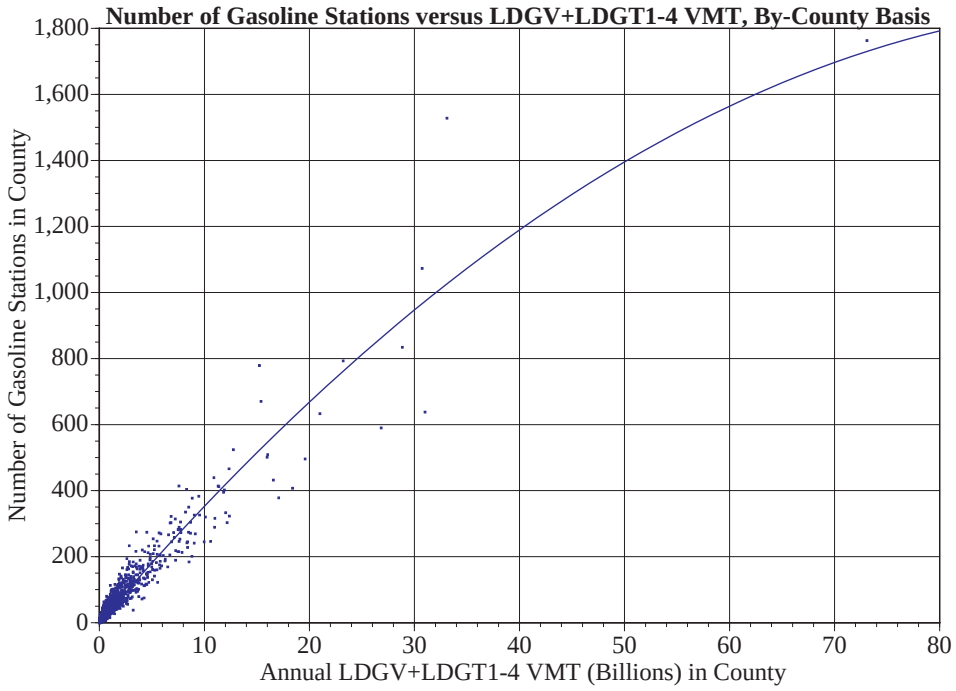
As indicated in the Background section, EPA estimates that in 2008, there were 161,768 service stations in the U.S. In addition, EPA further estimates that for FFVs to have reasonable access to E85, one in four stations, or about 40,000 stations, would need to be equipped to offer E85. EPA also indicates that the fraction of stations could be less than this, because E85 vehicles can fill with gasoline. However, as we have pointed out, if FFVs fill predominantly with gasoline it defeats the purpose of the RFS2.

We have taken a somewhat different approach from EPA in estimating the number of stations that need to be equipped with either E85 or at least one blender pump. First, it makes sense to evaluate E85 and mid-level blend use in the areas of the U.S. with the highest vehicle miles traveled (VMT).

Figure 8 shows the relationship between light duty vehicle annual VMT and number of service stations by counties in the US. The VMT in this figure comes from EPA's NMIM model, and the number of stations by county comes from the U.S. Census Bureau. Each point is a county with an associated number of vehicle miles traveled and number of service stations. The relationship is generally linear, except for the county with the highest VMT, which is Los Angeles County. This county has somewhat less service stations per million VMT then the other counties.

It makes sense for blender pumps to be installed in counties with the most VMT, because that is where the highest density of cars and light trucks are, and where also the FFVs will be. For example, this analysis makes the assumption that E85 should be targeted in counties with 80% of the national VMT.

Figure 8



Next, we assume that to cover 100% of VMT in a county, 100% of the service stations in that county need to have at least one blender pump. In a similar manner, to cover 50% of the VMT in a county, 50% of the service stations would need blender pumps. This assumption is further based on the assumption of equal volume sales at all the service stations in a county, and also that vehicle owners will not change their refueling locations just to find E85. While it is possible that 50% of the VMT in a county could be covered with less than 50% of the service stations in the county, if (1) the higher volume stations are equipped with blender pumps, and (2) vehicle owners are willing to find stations with E85 and change their refueling locations, we think the assumption we are making is a conservative assumption.

Figure 9 shows the relationship between national light duty vehicle miles traveled and national service stations. The “All” line assumes that as each county is added, all of its VMT is added, and all of the service stations are equipped with blender pumps. The highest VMT counties are added first. The “Half” line assumes that as each county is added, half of the service stations in that county are equipped with blender pumps.

It is very difficult to determine the minimum fraction of service stations that is required to effectively cover all or most of the VMT in a county. Most vehicle owners have 1-2 service stations that they visit when doing errands near their home, and 1-2 service stations near their work. Therefore, it seems very likely that if half of the service stations in a county were equipped with blender pumps, then this would cover most of the VMT in that county.

Looking at the “Half” line in Figure 9, at 80% coverage of vehicle miles traveled (top 80% of counties), 33% of the service stations in the country or approximately 53,000

stations, would need to have blender pumps. If all of the stations in counties that have 80% of the VMT are targeted for installation of blender pumps, then 66% of the service stations in the country, or approximately 106,000 service stations would have blender pumps. The number of service stations for the "Half" and "All" scenarios are shown in Figure 10.

Figure 9

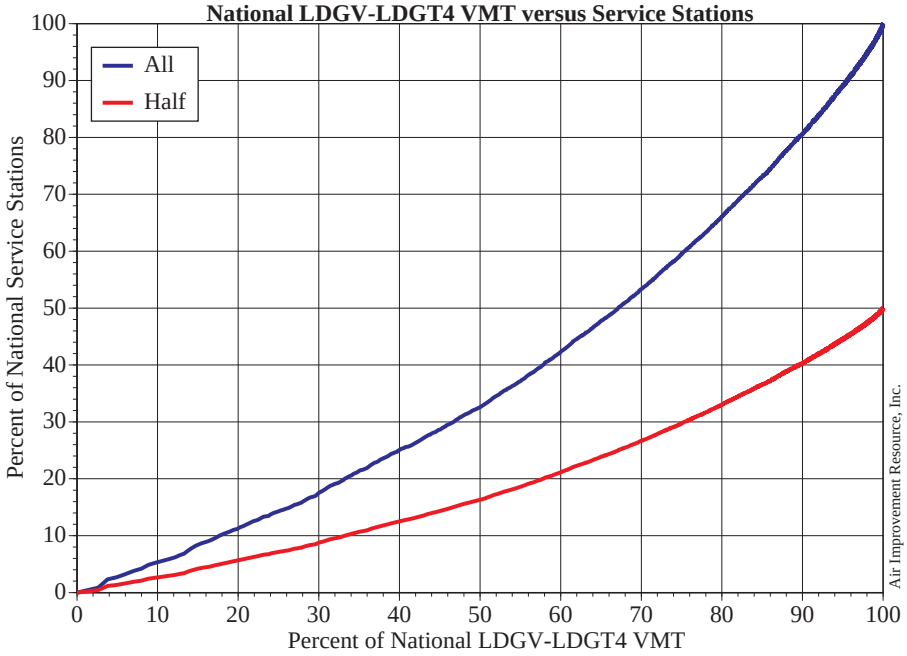
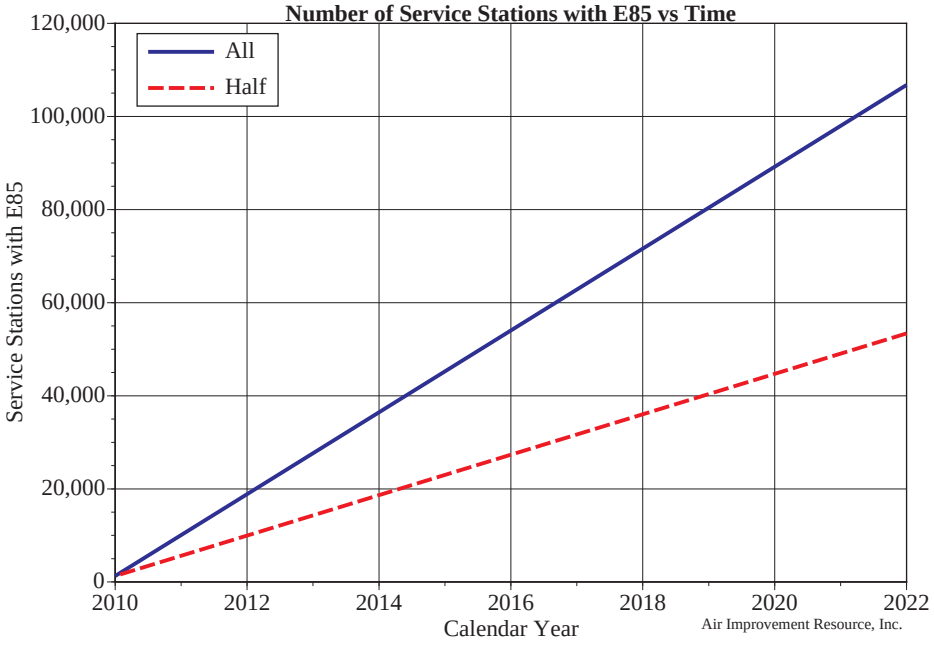


Figure 10



6.2 National and By-Service Station E85 Volumes

In order to estimate E85 volumes, we have selected two of the scenarios that we think are most likely for further examination. The two scenarios selected are the EPA Mid and EPA High Volume ethanol scenarios, with E10 for 2000 and earlier vehicles, and E15 for 2001 and later vehicles, starting in calendar year 2012. For these scenarios we have for simply assumed the FFV scenario with the Detroit Three offering 50% FFVs starting in 2012.

Several assumptions are made in this analysis:

1. That ethanol used nationally follows the Mid and High Volume trajectories shown in Figure 1.
2. That ethanol is used in conventional and FFV vehicles to satisfy E10 for MY2000 and earlier passenger cars and light trucks and E15 for all MY2001 and later passenger cars and light trucks.
3. That any remaining volume of ethanol that exceeds (2) is used to fuel FFVs at higher levels.
4. There are two bounding assumptions for the higher volumes of ethanol in (3): one is that it is all sold through blender pumps, at the minimum ethanol volume fraction needed to use all the excess ethanol, and (2) it is all sold as E85 in FFVs. The second assumption results in lower gasoline volume because of the much higher ethanol volume, so that the national volumes of E85 and per station volumes are much lower than the blender volumes of gasoline plus ethanol.

It is important to note that between assumptions 2 and 3 above, when the level of ethanol in FFVs just exceeds E15 (for example, to E16), it is assumed that every FFV ceases fueling from normal pumps with E15, and is fueled with fuel from a blender pump at E16. Of course, at the average level of E16, most could continue to be fueled with E15 and some could be fueled with E50, for example; they would not all need to be at E16. However, there are an infinite number of possible combinations. Therefore, to provide boundaries for this analysis, we have assumed that every FFV would start using blender pumps. This no doubt overstates the volume of fuel that is sold through blender pumps, so this is certainly an upper limit. At the lower end of the range, we assume that all ethanol in excess of E15 is marketed as E85.

These are simplifying volumes that are not completely accurate. For example, some E85 is sold now, even as the nation is just now approaching E10 saturation. However, our goal here is to estimate the minimum and maximum amount of fuel delivered through either blender pumps or E85 pumps.

6.2.1 EPA Mid Volume Scenario

Figures 11-14 show blender pump volumes and E85 volumes. Figures 11 and 12 are national volumes, and Figures 13 and 14 are per service station volumes. Figure 10 shows the FFV ethanol percentage (in volume %). The line represents the required

ethanol volume percentage for FFVs to use the necessary ethanol. This starts at E8 in 2010, and crosses the E10 line between 2013 and 2014, and crosses the E15 line in 2020, increasing to E21 in 2022. When the line crosses E15, we assume either blender pumps or E85 pumps are needed to dispense the extra ethanol. The volume increase in fuel from 2020 to 2022 is about 2.8 bg. This line indicates that there is not much need for blender pumps or E85 pumps until 2020 for this ethanol volume under this scenario, since E10 and E15 are available from non-blender pumps (E10 for MY2000-, E15 for MY2001+).

Figure 11

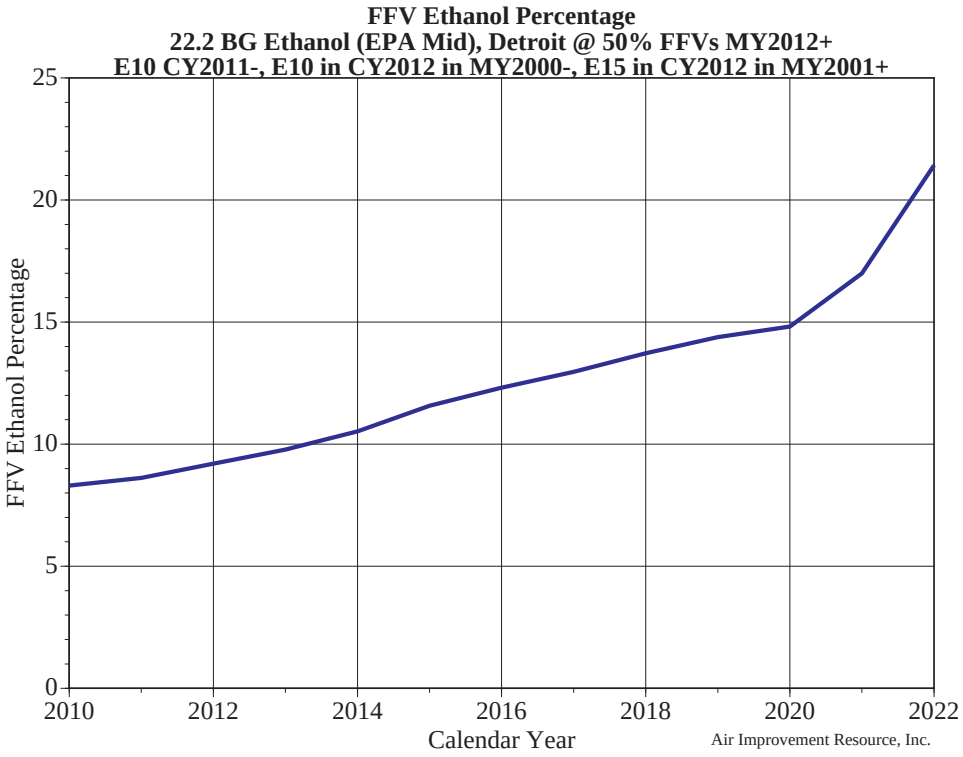


Figure 12 shows the national volumes of either blender pump fuel or E85 that is needed in 2021 and 2022 to use the ethanol that is not consumed primarily as E10 and E15. The amount of fuel marketed through blender pumps is much higher than E85, due to the assumption that all FFVs switch to blender pumps utilizing the minimum ethanol required to use-up the ethanol in excess of that needed for E10 and E15. The actual amount of fuel used in either blender pumps or E85 pumps would like somewhere between these two levels.

Figure 12

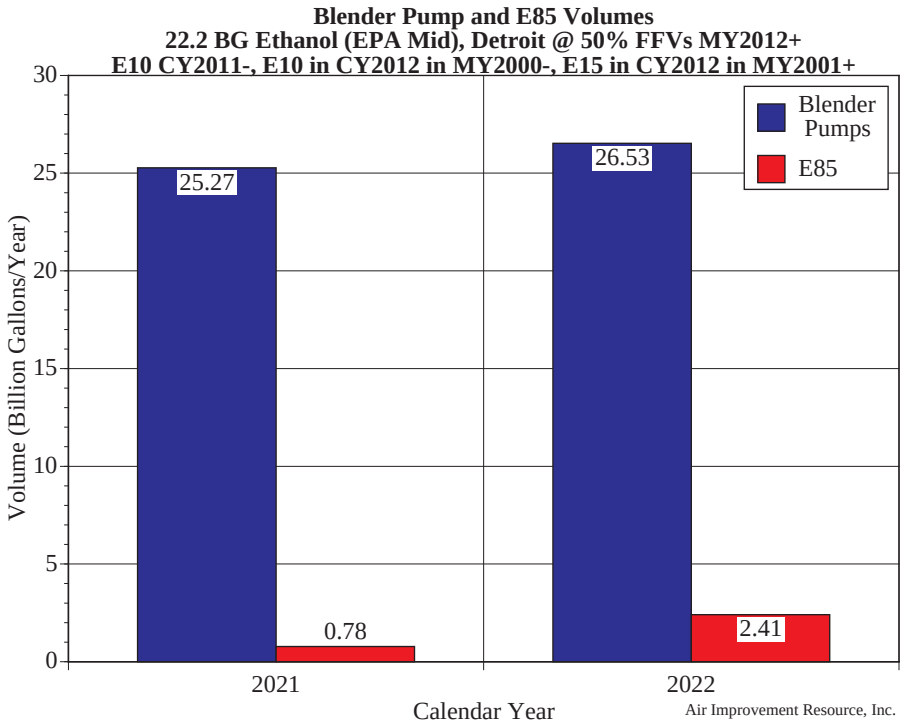


Figure 13 shows the blender pump volumes on a per station basis for 2021 and 2022. Two service station scenarios ("All" and the "Half") are shown. In 2021, service stations would deliver between 258,000 and 515,000 gallons of ethanol, and in 2022, between 248,000 and 497,000 gallons of ethanol.

Figure 13

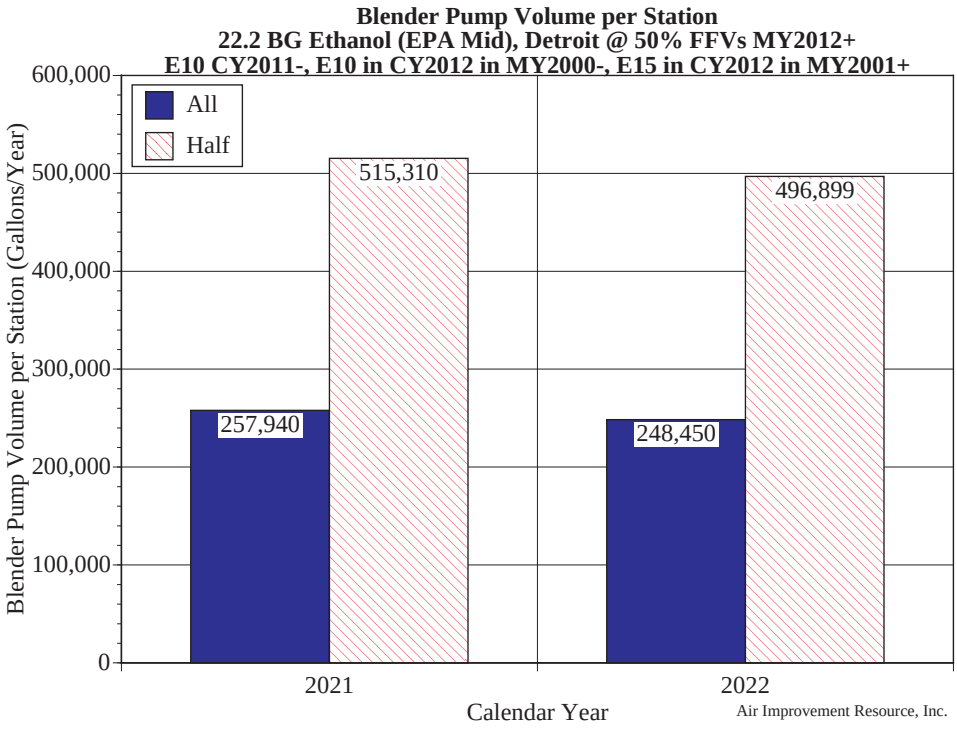
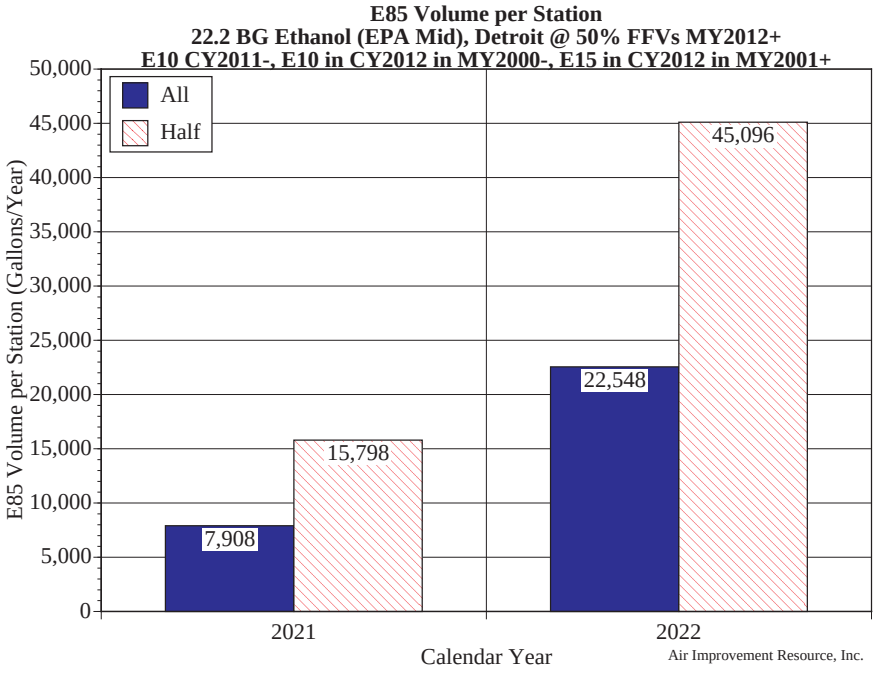


Figure 14 shows E85 volumes per service station for 2021 and 2022. In 2021, service stations would deliver between 7,908 and 15,798 gallons, and in 2022, between 22,548 and 45,096 gallons.

Figure 14



6.2.2 EPA High Volume Scenario

Figures 15-18 show the impacts of the EPA High Volume case (33.2 bg of ethanol in 2022). Figure 15 shows that the E15 level for FFVs is surpassed in 2016, and reaches E55 by 2022. Blender pump volumes expand by 7 bgy between 2018 and 2022.

Figure 15

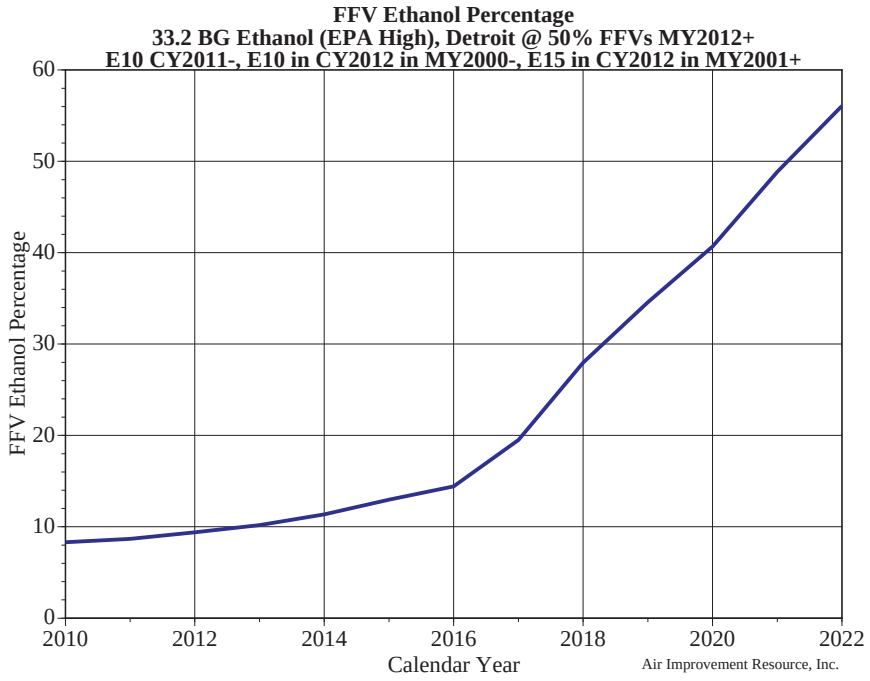


Figure 16 shows national blender pump and E85 volumes for this scenario. The blender pump volumes start at 21.22 bg in 2017 and expands to 29.76 bg in 2022. E85 volumes start at 1.35 bg in 2017 and expand to 16.11 bg in 2022. It is important to note the volumes shown in Figure 16 indicate the volume required if ethanol is consumed *either as E85 or as a mid-level blend*; that is, volumes of both would not be needed simultaneously to consume required amounts of ethanol under the High Volume case.

Figure 16

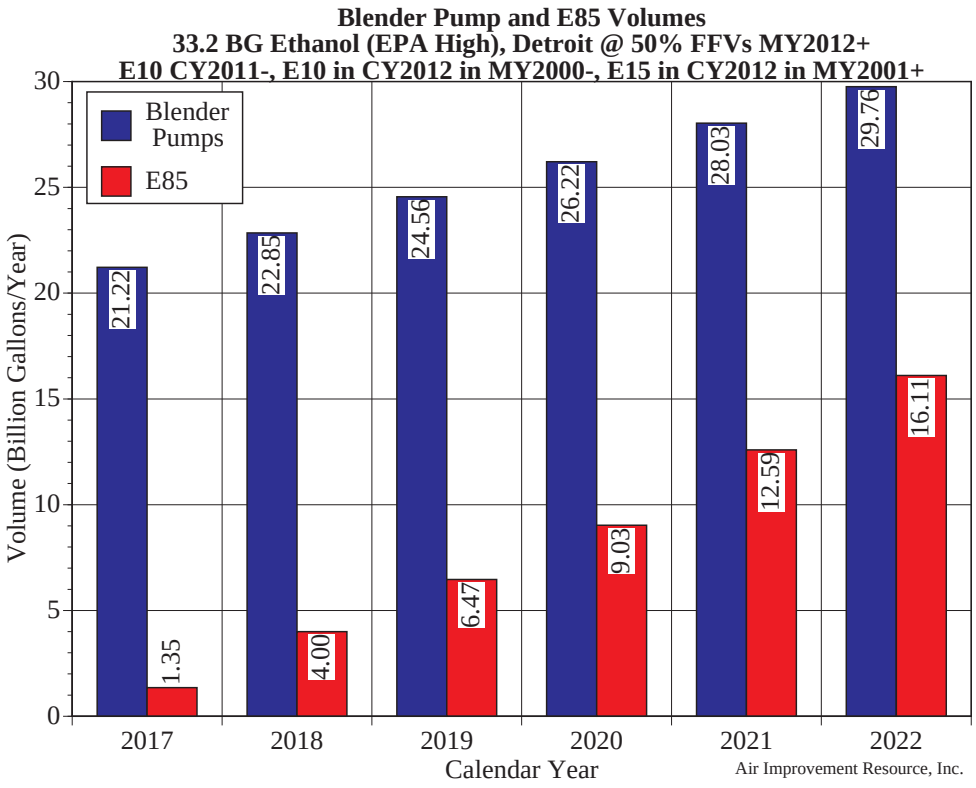


Figure 17 shows the annual blender pump volumes per service station for 2017-2022. In 2022, blender pumps volumes range between 278,000 and 557,000 gallons per year. The reduction in volume per station between 2017 and 2022 is due to increased numbers of stations with blender pumps with time (see Figure 9).

Figure 17

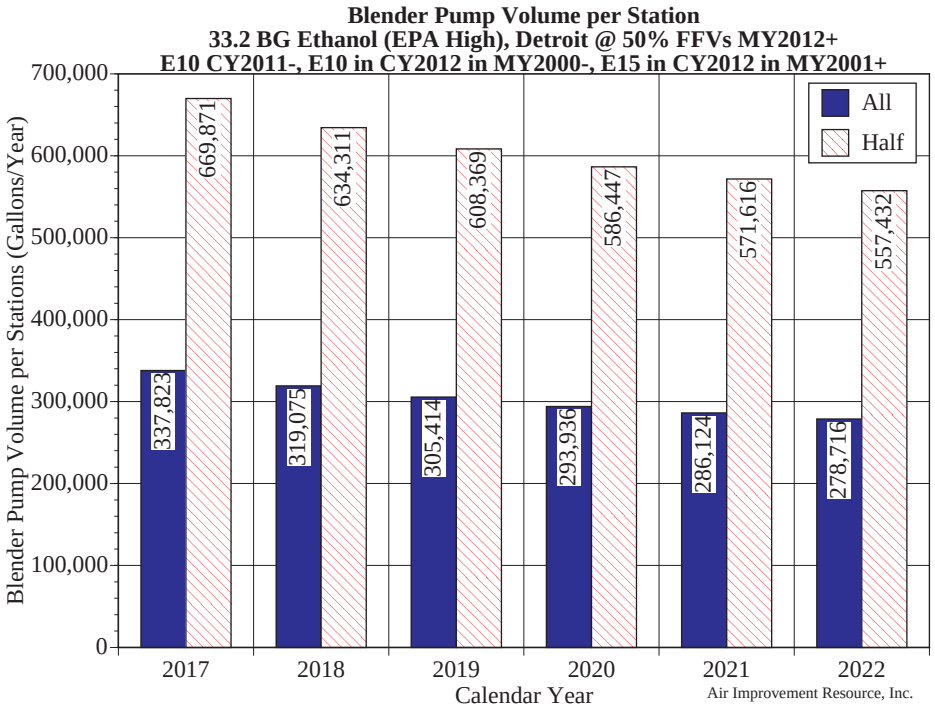
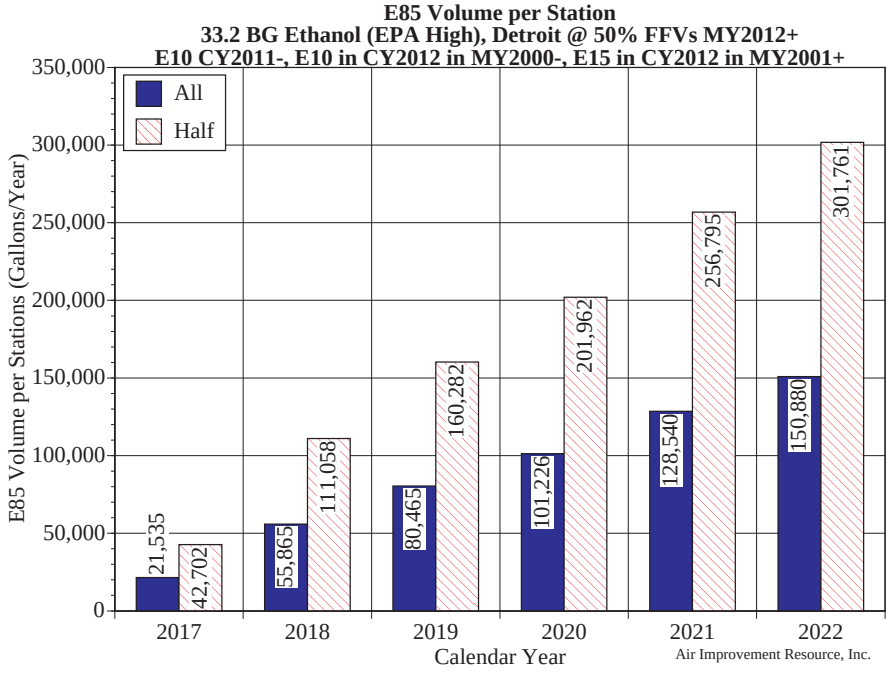


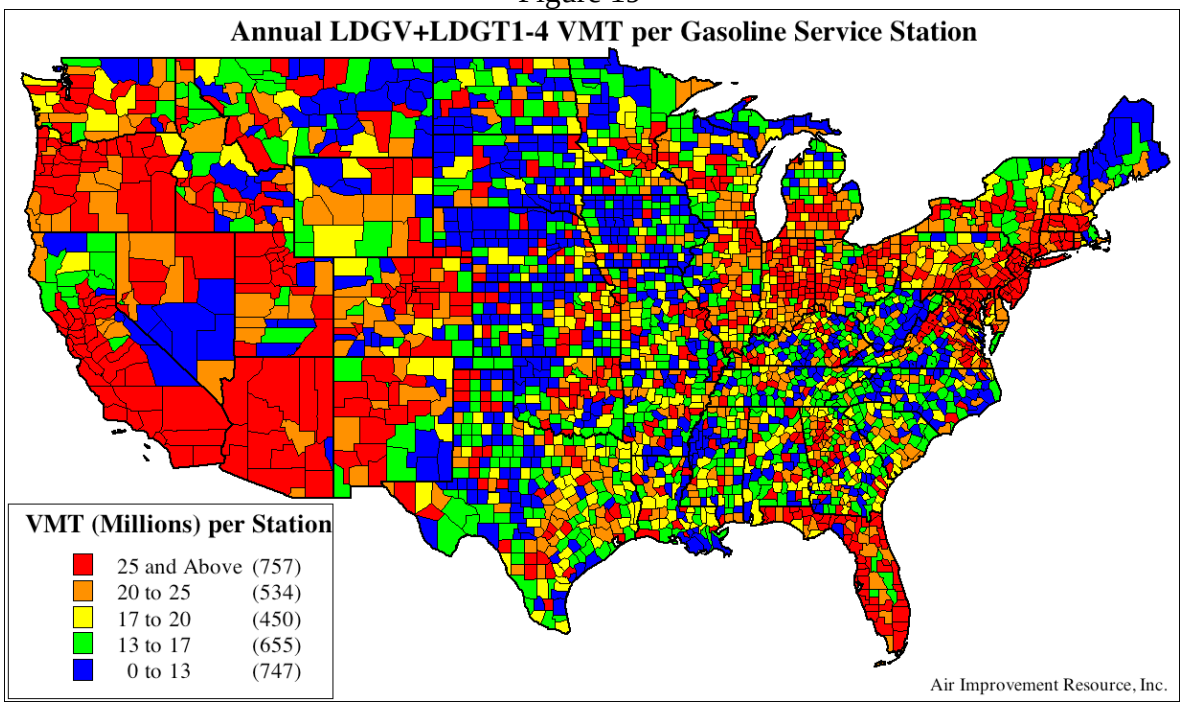
Figure 18 shows the E85 volumes per station for 2018-2022. In 2022, E85 volumes are between 151,000 and 302,000 gallons per year. The E85 volumes increase with time even though the stations are increasing with time because of the greater percentage growth in E85 as compared to the percent growth in blender fuel.

Figure 18



Finally, Figure 19 shows vehicle miles traveled allocated over all the gas stations in the U.S., by county. It should be a priority to target blender pumps or E85 pumps to those areas with the highest VMT per station. These are likely to be the same stations with the highest gasoline sales volumes.

Figure 19



References

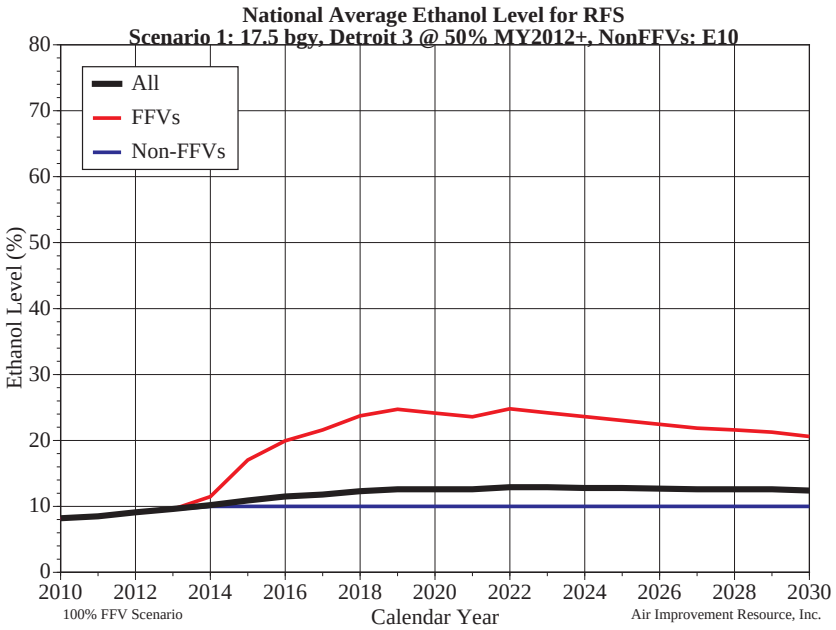
1. "Benefits of an Enhanced RFS2 in the Midwestern States", Air Improvement Resource, Inc., June 14, 2010.

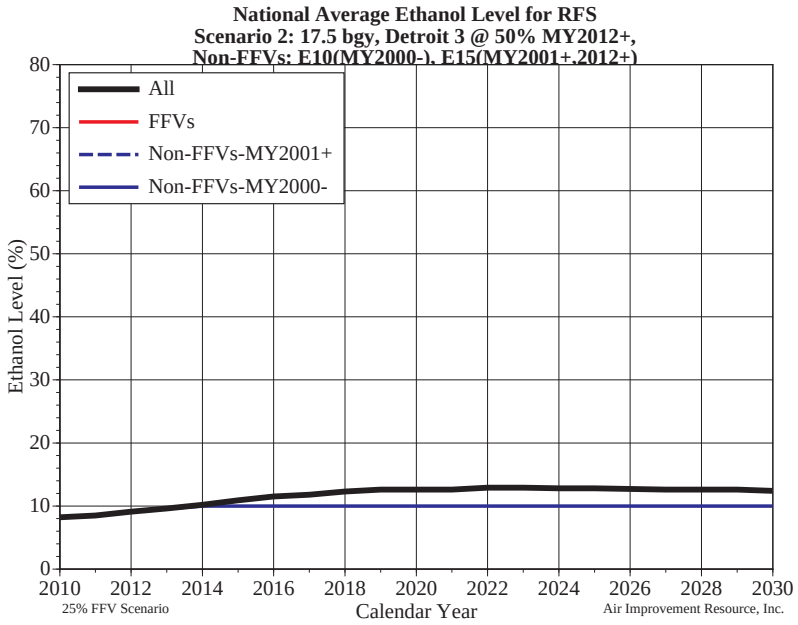
2. "Renewable Fuel Standard Regulatory Impact Analysis", EPA-420-R-10-006, February 2010.

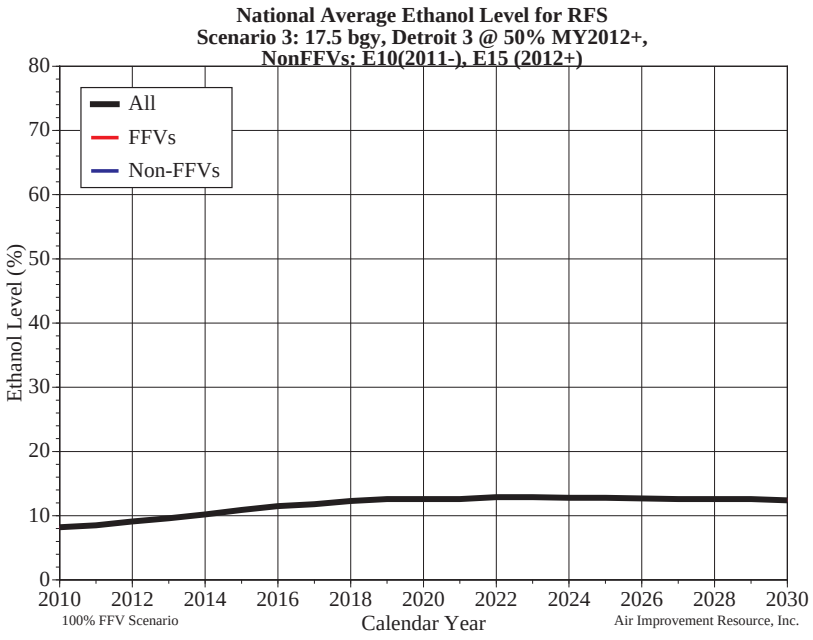
3. "EPA Announces E15 Partial Waiver Decision and Fuel Pump Labeling Proposal", EPA-420-F-10-054, October 2010.

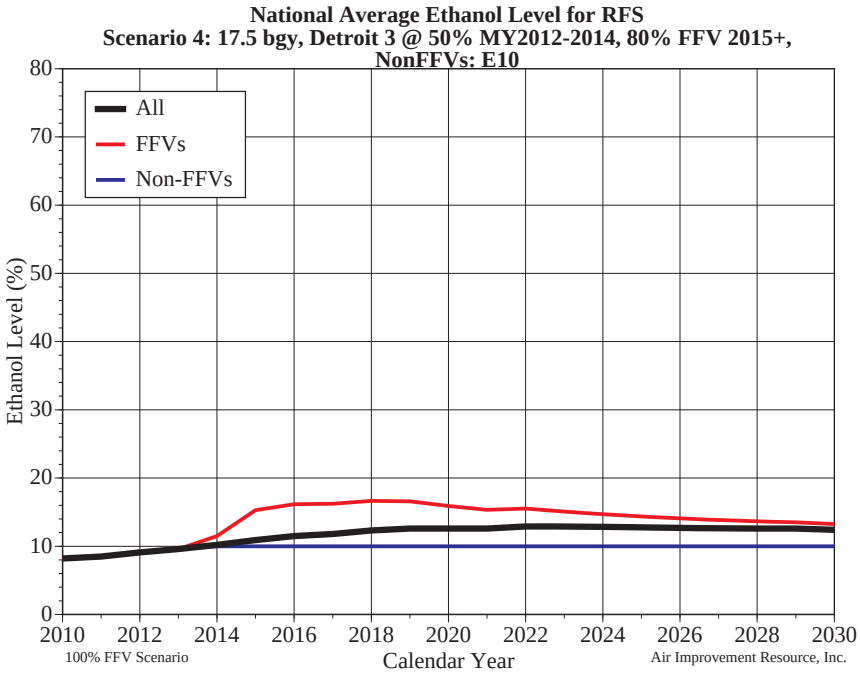
Attachment 1
Average Ethanol Levels for the 27 Scenarios

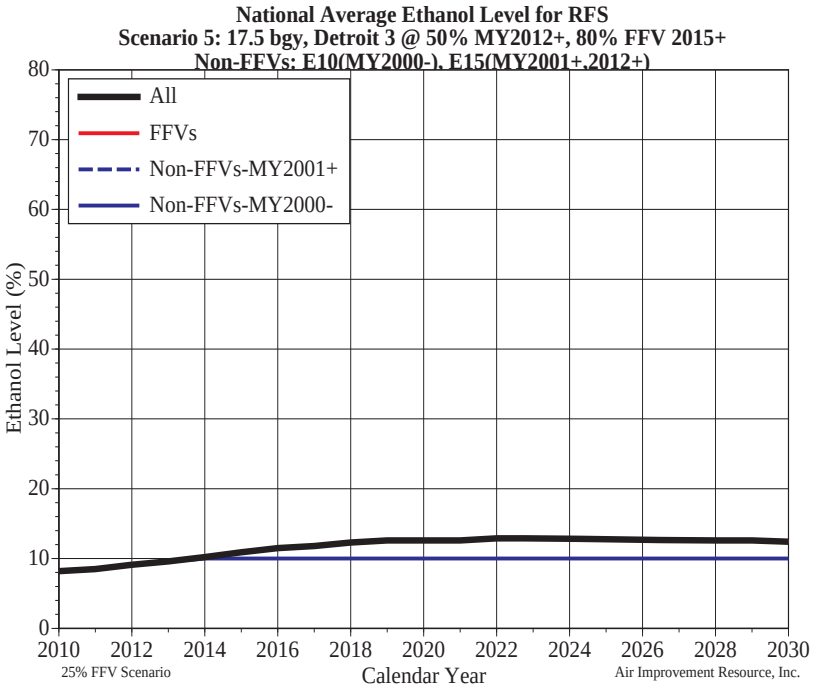
Group 1

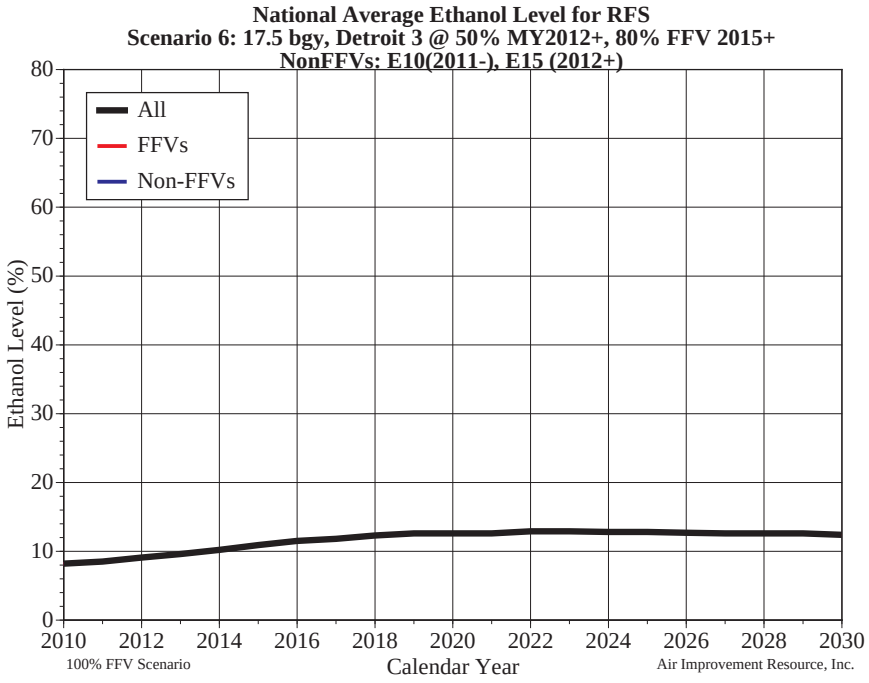


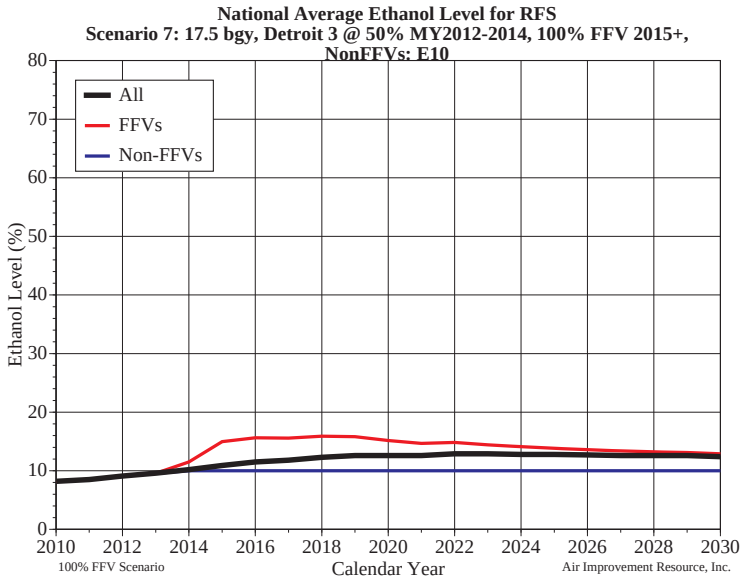


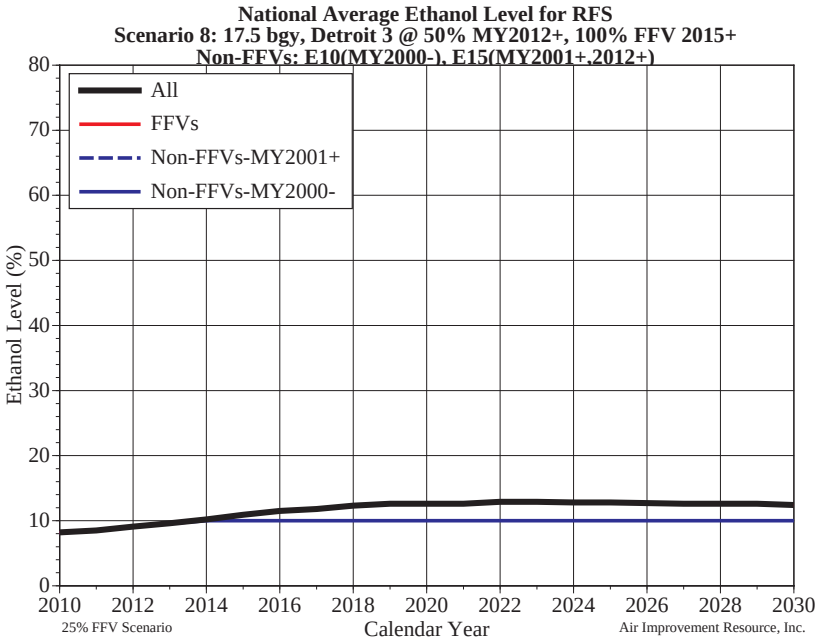

National Average Ethanol Level for RFS
Scenario 3: 17.5 bgy, Detroit 3 @ 50% MY2012+,
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

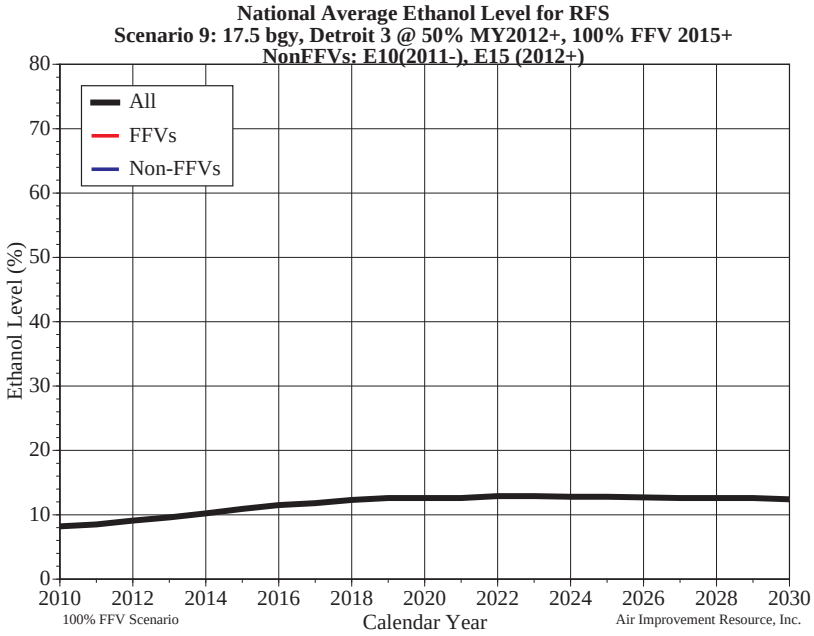

National Average Ethanol Level for RFS
Scenario 4: 17.5 bgy, Detroit 3 @ 50% MY2012-2014, 80% FFV 2015+,
NonFFVs: E10
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 5: 17.5 bgy, Detroit 3 @ 50% MY2012+, 80% FFV 2015+
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.

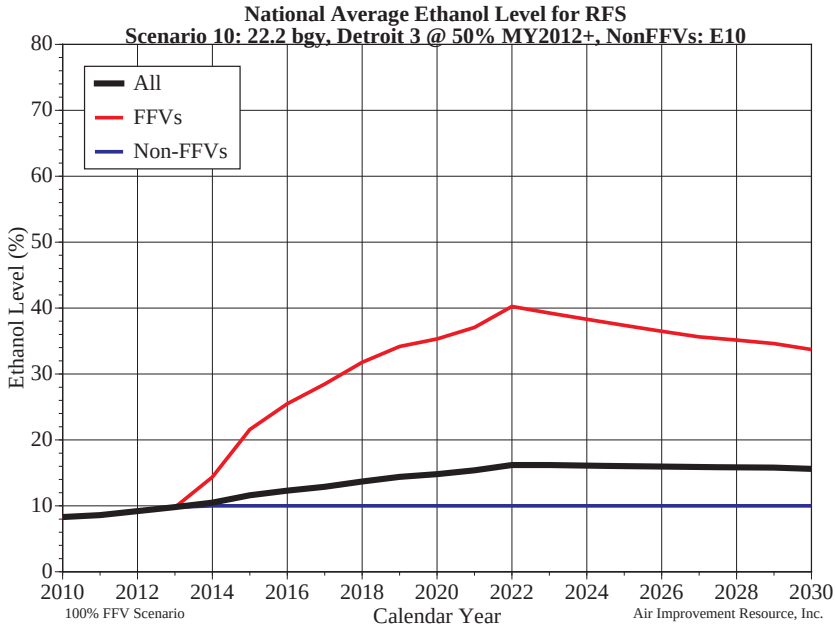

National Average Ethanol Level for RFS
Scenario 6: 17.5 bgy, Detroit 3 @ 50% MY2012+, 80% FFV 2015+
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

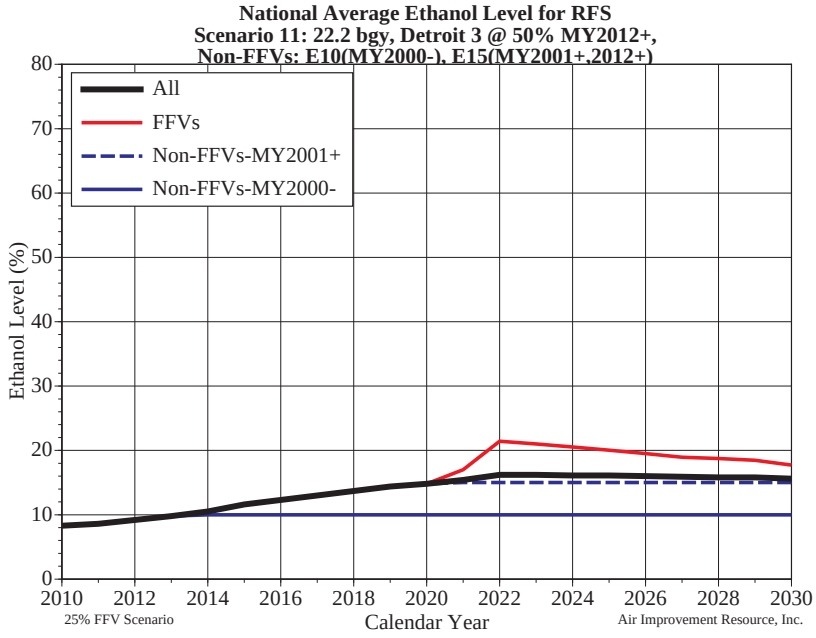

National Average Ethanol Level for RFS
Scenario 7: 17.5 bgy, Detroit 3 @ 50% MY2012-2014, 100% FFV 2015+,
NonFFVs: E10
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

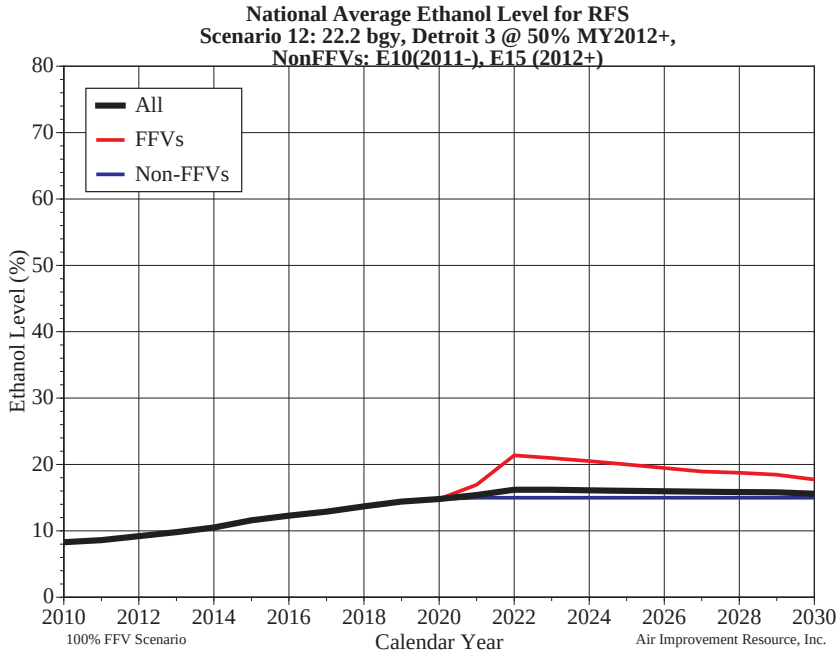

National Average Ethanol Level for RFS
Scenario 8: 17.5 bgy, Detroit 3 @ 50% MY2012+, 100% FFV 2015+
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.

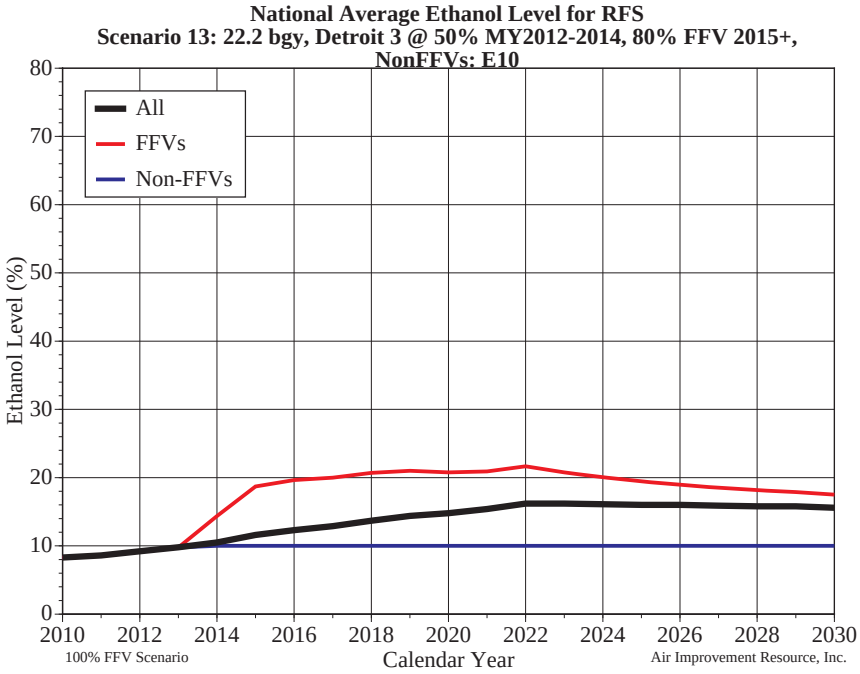

National Average Ethanol Level for RFS
Scenario 9: 17.5 bgy, Detroit 3 @ 50% MY2012+, 100% FFV 2015+
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

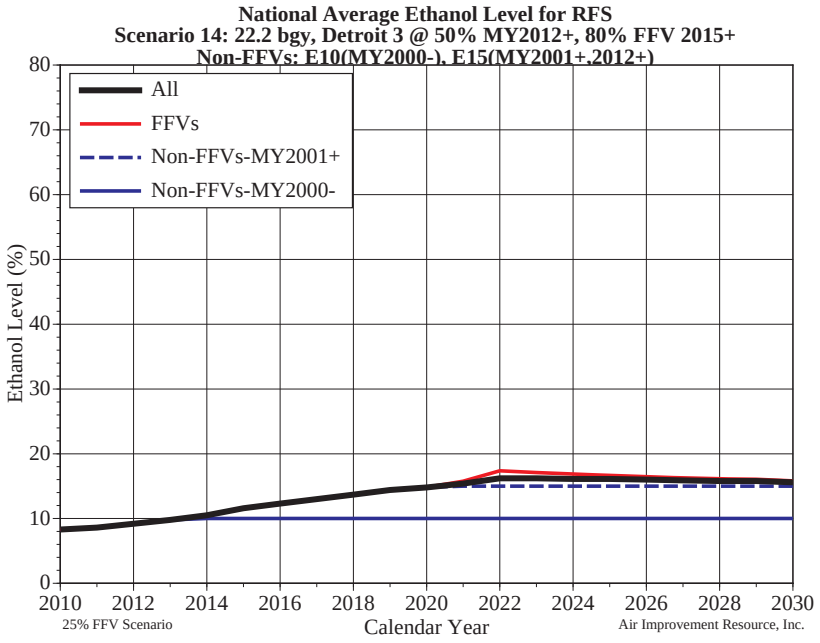
Group 2


National Average Ethanol Level for RFS
Scenario 10: 22.2 bgy, Detroit 3 @ 50% MY2012+, NonFFVs: E10
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

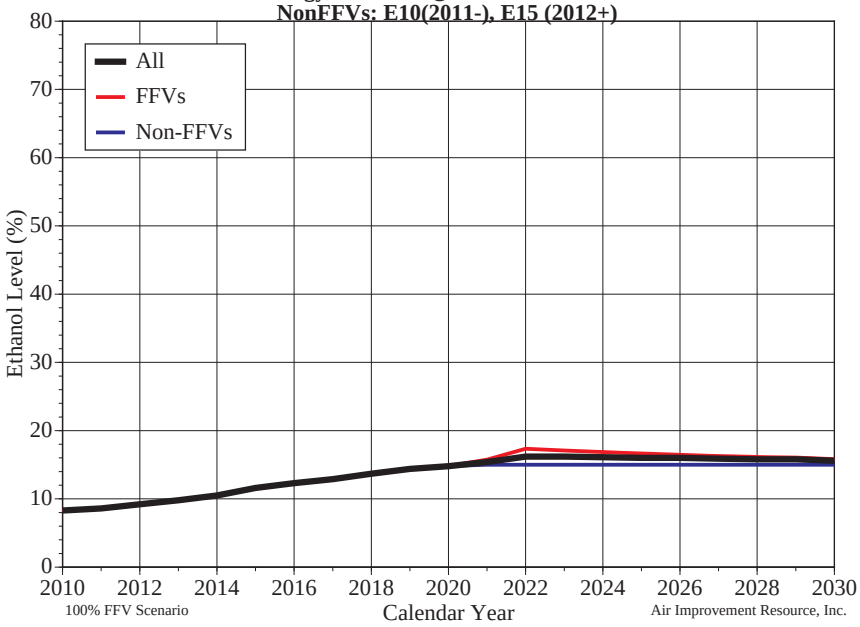

National Average Ethanol Level for RFS
Scenario 11: 22.2 bgy, Detroit 3 @ 50% MY2012+,
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 12: 22.2 bgy, Detroit 3 @ 50% MY2012+,
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

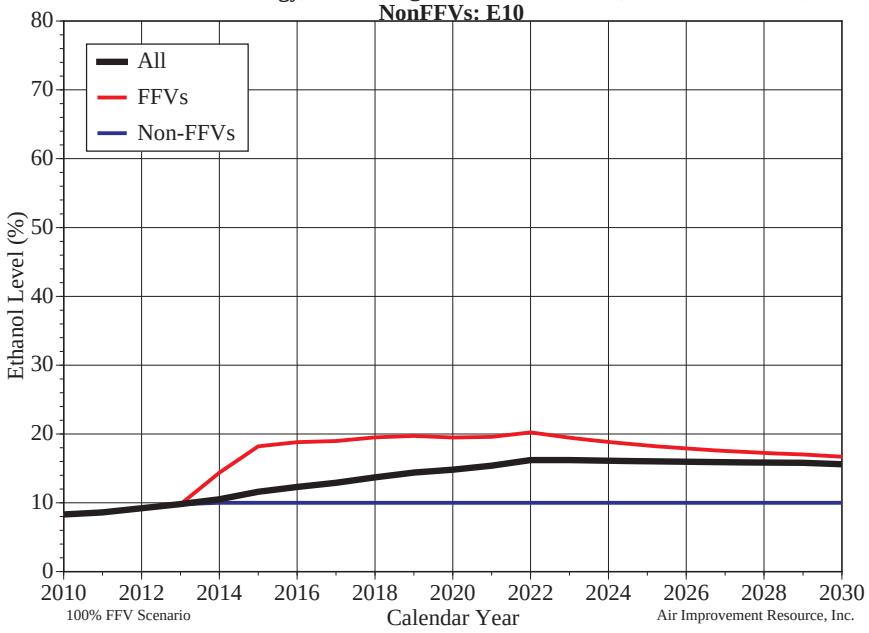

National Average Ethanol Level for RFS
Scenario 13: 22.2 bgy, Detroit 3 @ 50% MY2012-2014, 80% FFV 2015+,
NonFFVs: E10
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

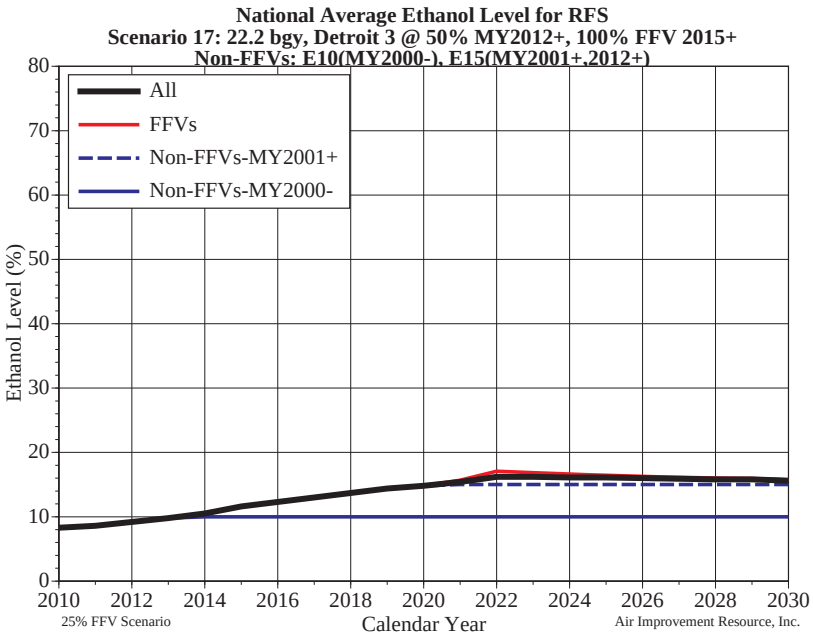

National Average Ethanol Level for RFS
Scenario 14: 22.2 bgy, Detroit 3 @ 50% MY2012+, 80% FFV 2015+
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.

National Average Ethanol Level for RFS
Scenario 15: 22.2 bgy, Detroit 3 @ 50% MY2012+, 80% FFV 2015+
NonFFVs: E10(2011-), E15 (2012+)



National Average Ethanol Level for RFS
Scenario 16: 22.2 bgy, Detroit 3 @ 50% MY2012-2014, 100% FFV 2015+,
NonFFVs: E10




National Average Ethanol Level for RFS
Scenario 17: 22.2 bgy, Detroit 3 @ 50% MY2012+, 100% FFV 2015+
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
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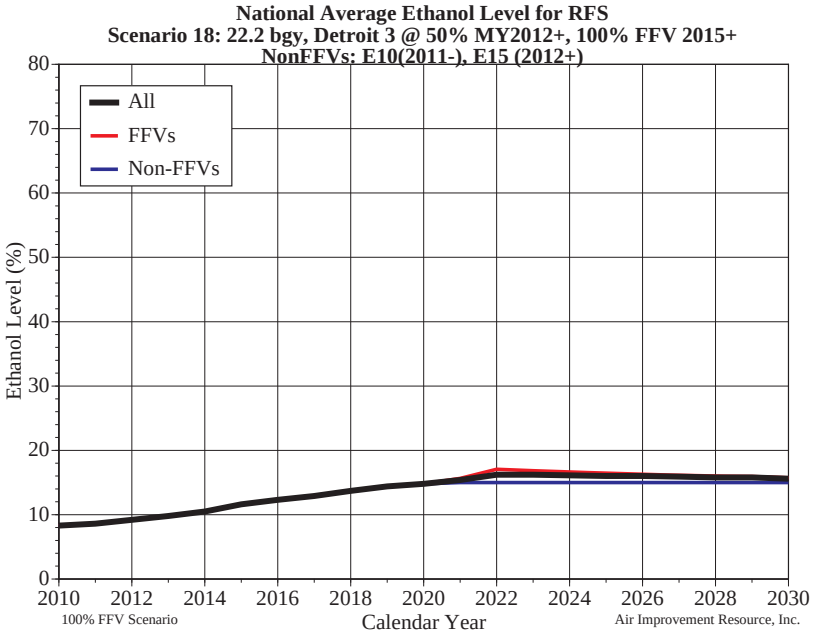
2030
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 18: 22.2 bgy, Detroit 3 @ 50% MY2012+, 100% FFV 2015+
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
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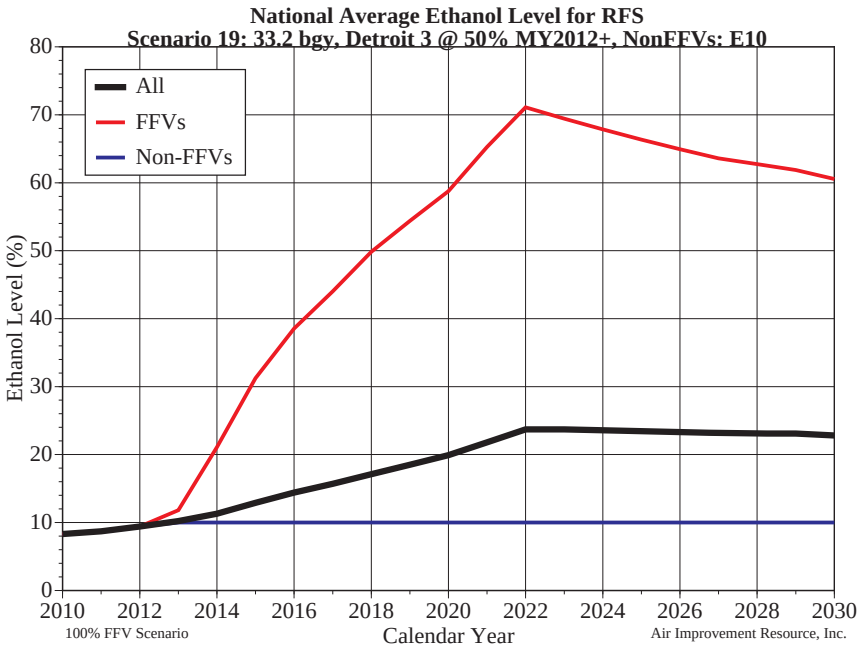
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.

Group 3


National Average Ethanol Level for RFS
Scenario 19: 33.2 bgy, Detroit 3 @ 50% MY2012+, NonFFVs: E10
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
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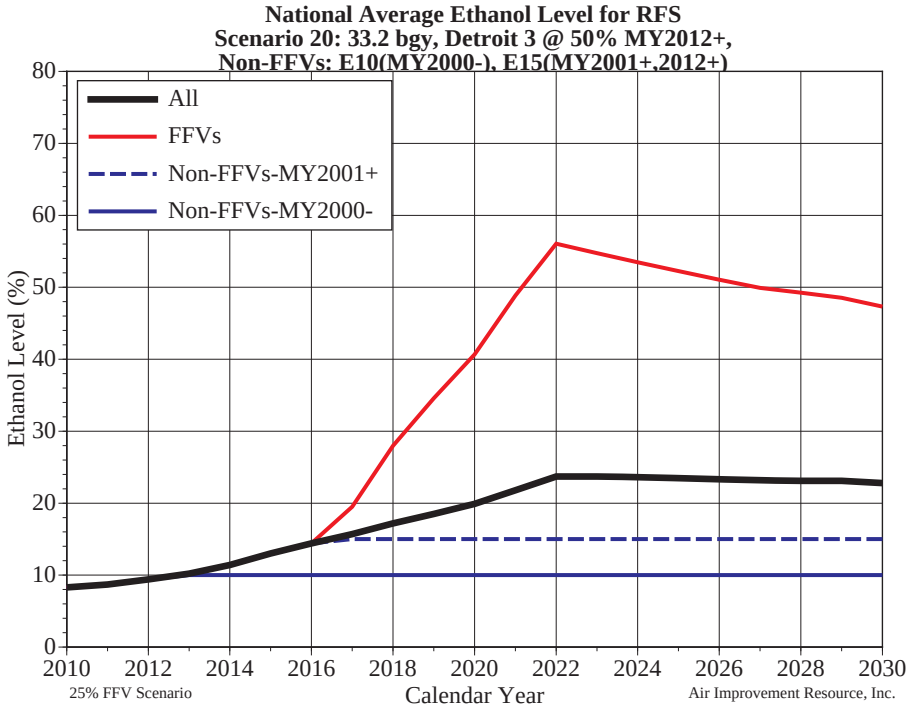
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 20: 33.2 bgy, Detroit 3 @ 50% MY2012+,
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
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2022
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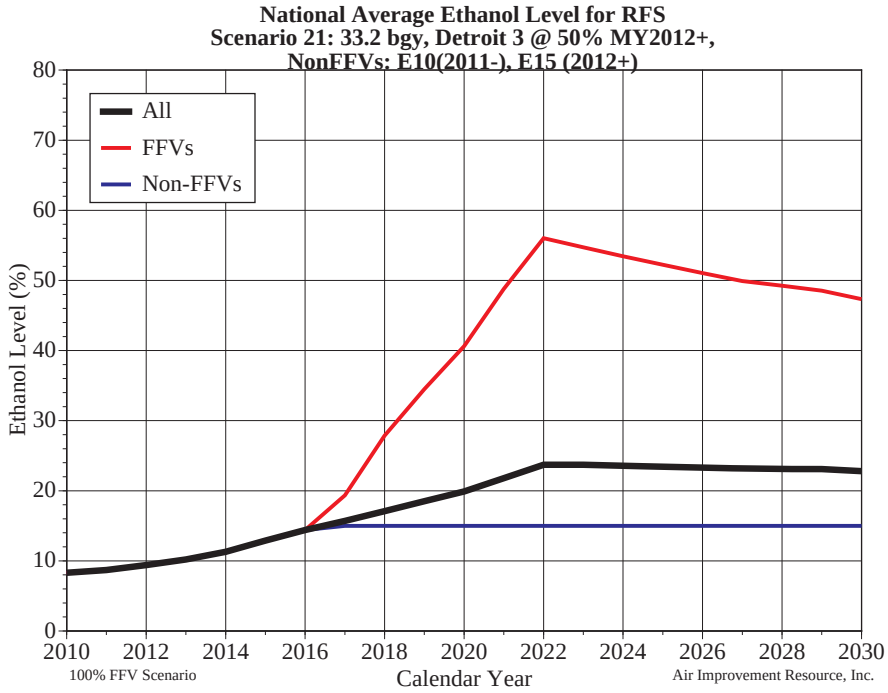
2028
2030
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 21: 33.2 bgy, Detroit 3 @ 50% MY2012+,
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
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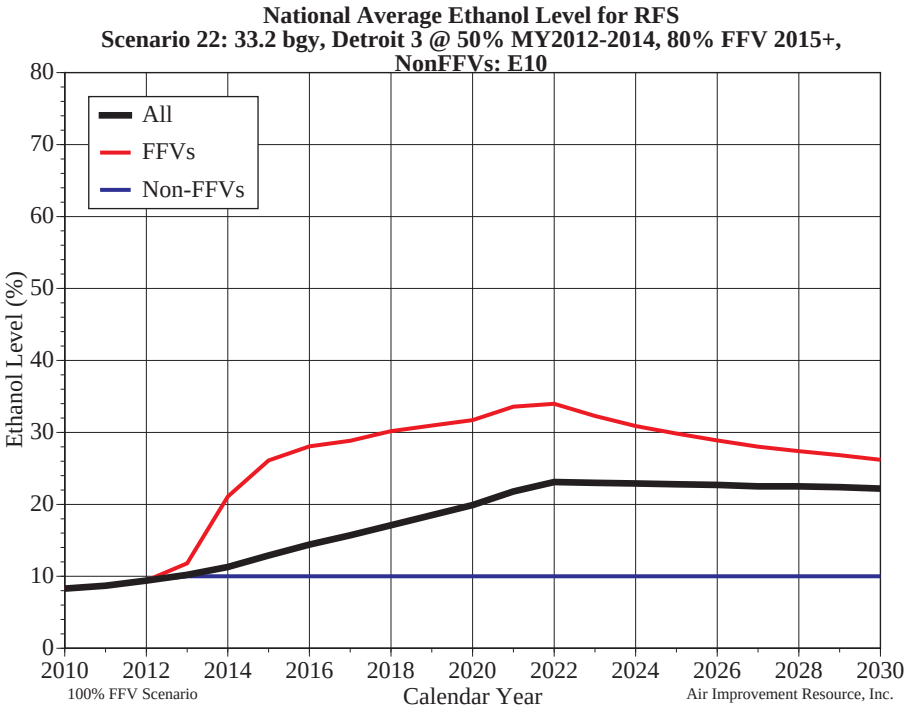
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 22: 33.2 bgy, Detroit 3 @ 50% MY2012-2014, 80% FFV 2015+,
NonFFVs: E10
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
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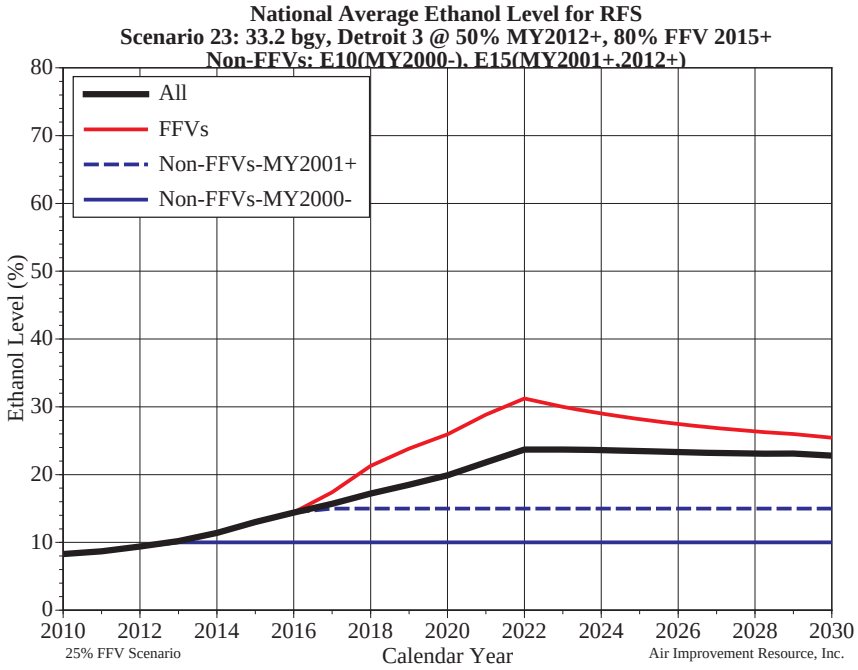
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 23: 33.2 bgy, Detroit 3 @ 50% MY2012+, 80% FFV 2015+
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
20
30
40
50
60
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2010
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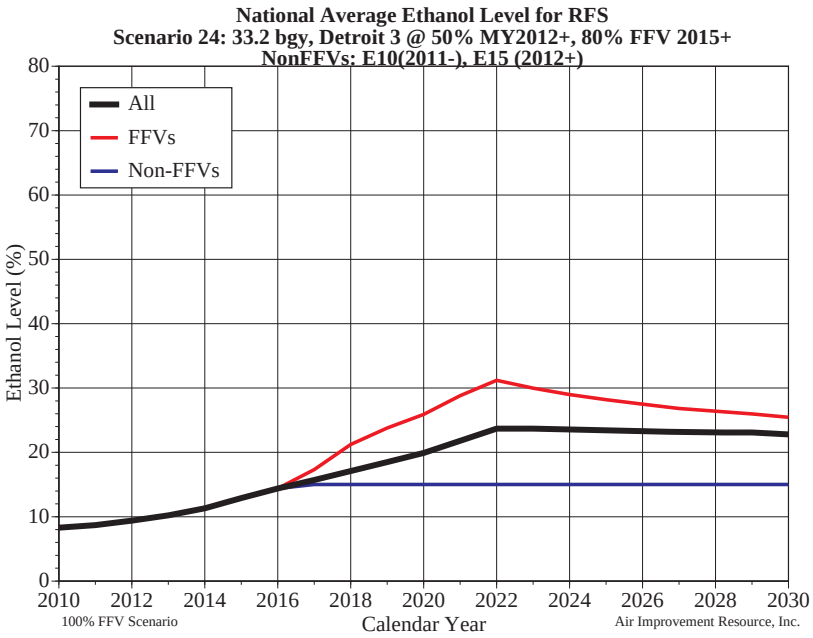
2030
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 24: 33.2 bgy, Detroit 3 @ 50% MY2012+, 80% FFV 2015+
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
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2010
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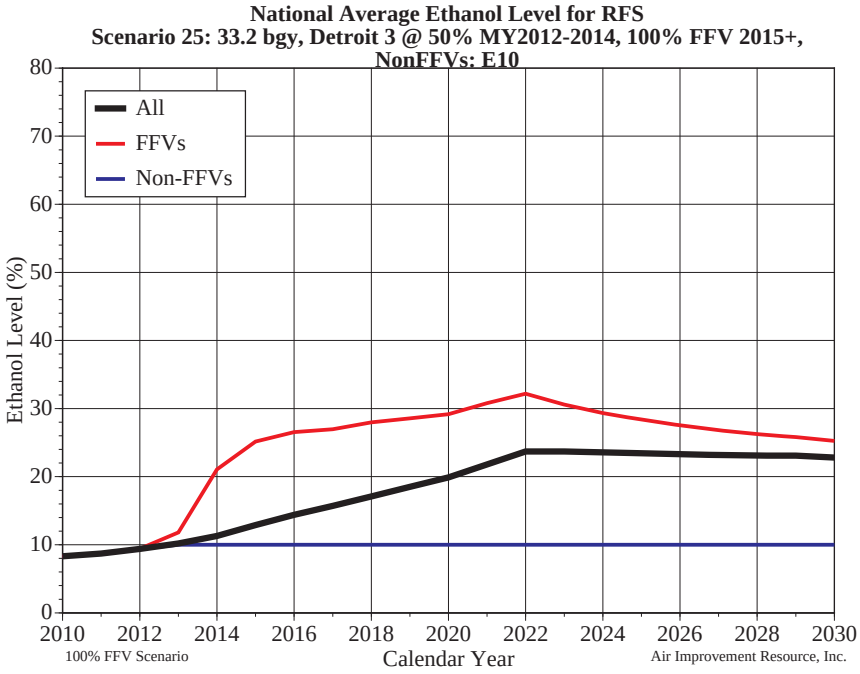
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 25: 33.2 bgy, Detroit 3 @ 50% MY2012-2014, 100% FFV 2015+,
NonFFVs: E10
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
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2016
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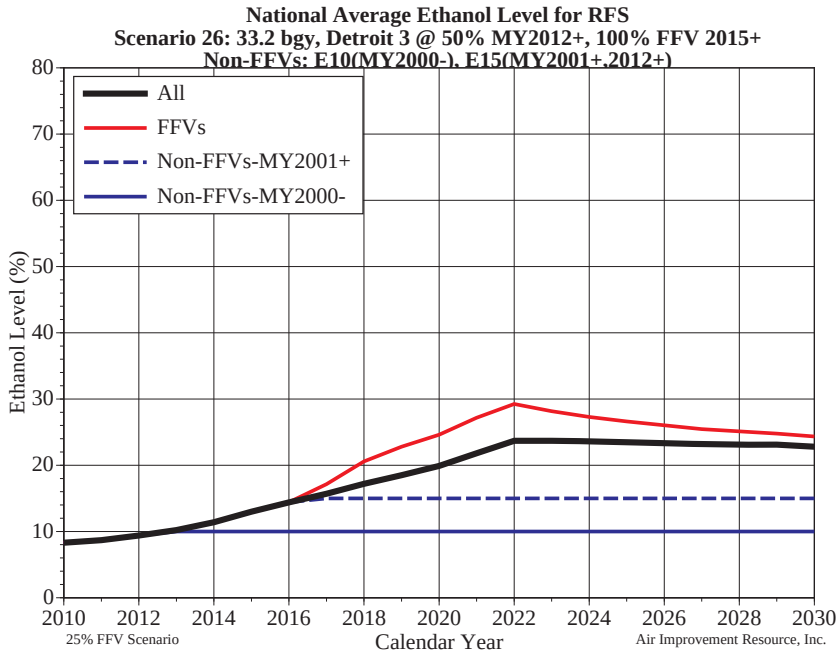
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 26: 33.2 bgy, Detroit 3 @ 50% MY2012+, 100% FFV 2015+
Non-FFVs: E10(MY2000-), E15(MY2001+,2012+)
All
FFVs
Non-FFVs-MY2001+
Non-FFVs-MY2000-
Ethanol Level (%)
0
10
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2010
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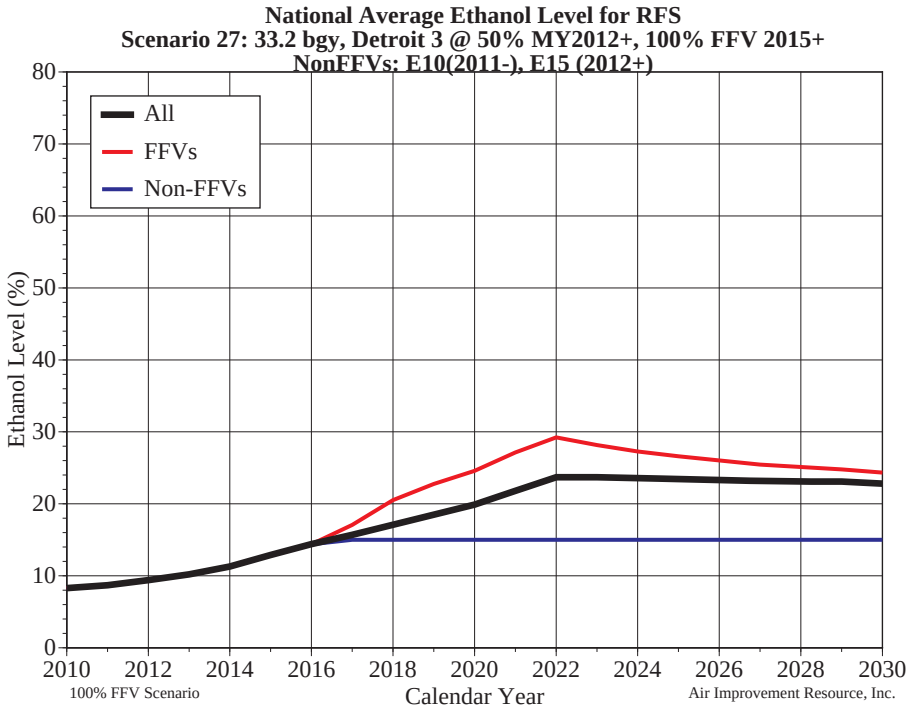
Calendar Year
25% FFV Scenario
Air Improvement Resource, Inc.


National Average Ethanol Level for RFS
Scenario 27: 33.2 bgy, Detroit 3 @ 50% MY2012+, 100% FFV 2015+
NonFFVs: E10(2011-), E15 (2012+)
All
FFVs
Non-FFVs
Ethanol Level (%)
0
10
20
30
40
50
60
70
80
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Calendar Year
100% FFV Scenario
Air Improvement Resource, Inc.