Date: August 18, 2020

Re: Technical Memorandum Describing Potential Methods for Determining the Weighting Factor (F-Factor) for Testing E85 Flexible Fuel Vehicles (FFV) Light-duty Vehicles

From: EPA Office of Transportation and Air Quality, Assessment and Standards Division

To: F-Factor Determination Docket EPA-HQ-OAR-2020-0104

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1. Introduction

This technical memo details a draft methodology and rationale for calculating a revised E85[1] weighting factor, commonly referred to as the "F-Factor". The F-Factor is used in EPA's light-duty vehicle greenhouse gas (GHG) program to weight the CO2 emissions from an E85 flexible fuel vehicle (FFV) when tested with both gasoline and E85. EPA previously released a draft determination in March 2013 which proposed an F-Factor of 0.20 for 2016. In October of 2014, EPA finalized a weighting factor of 0.14 for MY's 2016-2018[2]. The 0.14 F-Factor was then carried over for MY 2019 [3].

Due to uncertainty associated with the projection of E85 fuel consumption required to determine an appropriate F-Factor for MY 2020 and beyond, EPA is finalizing to carry-over the MY 2016-2019 F-Factor of 0.14 into MY 2020[4]and beyond. The agency recognizes that this is an opportunity to seek public comment on the available data sources and methodologies that could be used for a future F-Factor determination, and the purpose of this technical memorandum is to describe an approach, including the data sources and methodology, which EPA is considering using for Model Years 2021 and later.

2. What is the F-Factor?

Dual fuel vehicles/model types are required to be tested on both fuels on which they can operate as part of the GHG emissions certification process. FFVs can be operated on both E85 and regular gasoline and must be tested on both fuels to determine their emissions compliance values. The F-Factor represents the E85 expected to be consumed by a model type over its life as a percentage of its total fuel consumption. 1 minus the F-Factor is the percentage of gasoline the model type will consume over its life.

The equation using the F factor is described in 40 CFR 600.510-12(j)(2)(vi) as follows where CREE is the "Carbon Rated Exhaust Emissions":

$$CREE = (F \times CREE_{alt}) + \left((1 - F) \times CREE_{gas}\right),$$

[1] E85 is a blend of gasoline and denatured ethanol containing up to 85 percent ethanol and is the highest ethanol fuel blend available in the market. E85 can only be used in flex fuel vehicles (FFVs) which are specifically designed to run on this fuel or any gasoline or ethanol blend ranging from E0 to E85. Much like diesel fuel, E85 is available at specially marked fueling pumps.

[2] See FFV F-Factor Guidance CD-14-18

[3] See FFV F-Factor Guidance CD-19-07

[4] EPA is determining this F-Factor for E85 in response to manufacturer requests and the Alliance submission. Note: 1) If no requests are made for an F-Factor for a model year it defaults to zero. 2) A manufacturer may always request an F-Factor of zero.

where $CREE_{alt}$ is the final CREE value calculated for the model type using the alternative fuel (in this case E85) and $CREE_{gas}$ is the CREE value calculated for the model type while operating on gasoline. For example, for an FFV emitting 330 g/mi CREE when tested on E85 and 350 g/mile CREE when tested on conventional gasoline, the CREE value for the FFV model type that would be used in the fleet average calculations under 600.510-12 would be calculated as follows:

Example Calculation:

$$CREE = (0.14 \times 330) + (0.86 \times 350) = 347.2\ g/mi$$

The F-Factor is also used for CAFE in model year 2020 and beyond[5]. As described in 40 CFR 600.510-12(c)(2)(v), the equation for CAFE is as follows:

$$MPG = \left(\frac{F}{MPGA} + \frac{(1-F)}{MPGG}\right)^{-1}$$

Where:

MPGA is the mile per gallon on E85 divided by 0.15

MPGG is the miles per gallon on Gasoline

So, if F=0.14,

MPG on E85 is 26.9, MPGA $=\left(\frac{26.9}{0.15}\right)$=244

MPGG is 36.6

MPG= $\left(\frac{.143}{244} + \frac{(1-.14)}{36.6}\right)^{-1}$=41.2 mpg

[5] CAFE regulations specify that starting with MY 2020, an F-Factor, once established by EPA under 40 CFR 600.510-12(k), will also be used in CAFE to weight FFV fuel economy on conventional gasoline test fuel and E85 in determining the FFV's model type fuel economy.

3. Methodology for Calculating an F-Factor

The F-Factor is on based on the EPA's assessment of the expected real-world use of the alternative fuel (E85) by FFV's. EPA's proposed F-Factor calculation methodology has three key data inputs:

1. The projected amount of E85 and Gasoline consumption by FFVs in future calendar years
2. Population of FFV's in a given model year
3. Number of Vehicle Miles Traveled (VMT) for a given year of a model year's life

For EPA's initial F-Factor determination we based the F-Factor primarily on projections from the Energy Information Administration's (EIA) 2014 Annual Energy Outlook (AEO2014) and EPA's MOtor Vehicle Emission Simulator (MOVES) model. EPA found a small math error in the initial F-Factor analysis which is discussed in Appendix A. The methodology presented below is similar to the methodology that EPA used for the 2014 determination. This methodology includes values based on the most recent data available to EPA such as projected E85 consumption, gasoline consumption, and FFV population based on AEO2020 and vehicle survival rates and relative mileage accumulation derived VMT from MOVES.

3.1. Yearly Percentage vs. Model Year F-Factor

E85 use can be analyzed two different ways. The first way is a Yearly Percentage[6] (calendar year percentage of E85 use) and the second way is a model year F-Factor

To calculate the model year F-Factor it is necessary to define the proportion of E85 and EALL (EALL=E0+E10+E15+E85) used each year of the vehicle model year's life. EPA defines this proportion by weighting the yearly E85 and EALL by percentage of vehicle miles traveled (VMT) times the population for each year of model's life. Note that EPA assumes that all E85 vehicles in a given calendar year refuel using E85 the same proportion of the time, independent of the vehicles age, and knows of no reason or data to develop an alternative assumption. The equation for the model year F-Factor is as follows:

$$F\_Factor = \frac{\sum_{i=0}^{N}(E85_i) * \frac{(VMT_i) * (Population_i)}{(\sum(VMT) * (Population))}}{\sum_{i=0}^{N}(EALL_i) * \frac{(VMT_i) * (Population_i)}{(\sum(VMT) * (Population))}}$$

Where

- $E85_i$ is the amount of E85 consumed in year i of the vehicle's life.
- $EALL_i$ is the amount of EALL (as described above) consumed in year i of the vehicle's life.
- VMT_i is VMT for a vehicle in year i of the vehicle's life.

[6] The "Yearly Percentage" is the Fleet annual FFV E85 usage percentage.

- $Population_i$ is the number of E85 capable vehicles in year i of the vehicle's life.
- Population is the original E85 capable production volume.
- $\sum(VMT)$ is the sum of the VMT over the vehicles life.
- N is the number of years of vehicle life for the model year.

To calculate the F-Factor for multiple model years it is necessary to add the sum as shown in the equation below.

$$F_{Factor} Model\ Years\ X\ through\ Y = \frac{\sum_X^Y (\sum_{i=0}^N (E85_i) * \frac{(VMT_i) * (Population_i)}{(\sum(VMT) * (Population))})}{\sum_X^Y \left((\sum_{i=0}^N (EALL_i) * \frac{(VMT_i) * (Population_i)}{(\sum(VMT) * (Population))} \right)}$$

4. F-Factor Analysis Using AEO2020

While EPA is finalizing the F-Factor of 0.14 for model year 2020 and beyond, EPA also is soliciting comment on an alternative approach for future years using updated data that would be based on EIA's Annual Energy Outlook (AEO) 2020 and the latest available MOVES model, MOVES 2014.

For this AEO2020-based analysis EPA decided to use a 25-year window for calculating the F-Factor. In the previous analysis EPA performed in 2014, EPA created its own projections and used a 15-year window EPA decided on the 25-year window for this analysis because it was the maximum size it could choose for the model years being considered given EIA 2020 AEO data which goes out to 2050. Discussions of these sources follow.

4.1. Use of Data from EIA's AEO 2020

EPA relies on projections from EIA for many different analyses related to the transportation market, as EIA has been given the charge and has developed the expertise to make such projections. In relation to the F-Factor, these projections can be found in EIA's Annual Energy Outlook (AEO). EPA typically uses the most recent version of the AEO since it is based on the most up-to-date data, analytical tools, and methodology. The most recent version is AEO2020 which was released on January 29, 2020.

Two different types of data from EIA's AEO 2020 forecast would be relevant for the F-Factor. The first is the projected E85 volumes used by FFVs. The second is EIA's projected sales volumes for FFVs. Both projections differ between AEO2019 and AEO2020, and these differences would have a significant impact on the F-Factor. We therefore address these differences below before describing how we could use the projections from AEO2020 to calculate the F-Factor.

4.1.1. E85 Projections

Figure 1 below shows reference case projections of E85 consumed in FFVs from AEO2019 and AEO2020, along with EPA's estimates of actual E85 consumption from 2015-2019.[7,8] Actual E85 consumption has remained very low in recent years despite the opportunity for higher E85 volumes, reaching the highest level of 306 mill gal in 2018. AEO2020's E85 projections are a fraction of AEO2019's projections and track much closer to the estimated actual consumption of E85 over the past five years. The actual values shown in the graph show that AEO2020 is more in line with the historical use, and that the future projected consumption of E85 AEO 2020 is following the historic trend in E85 consumption.

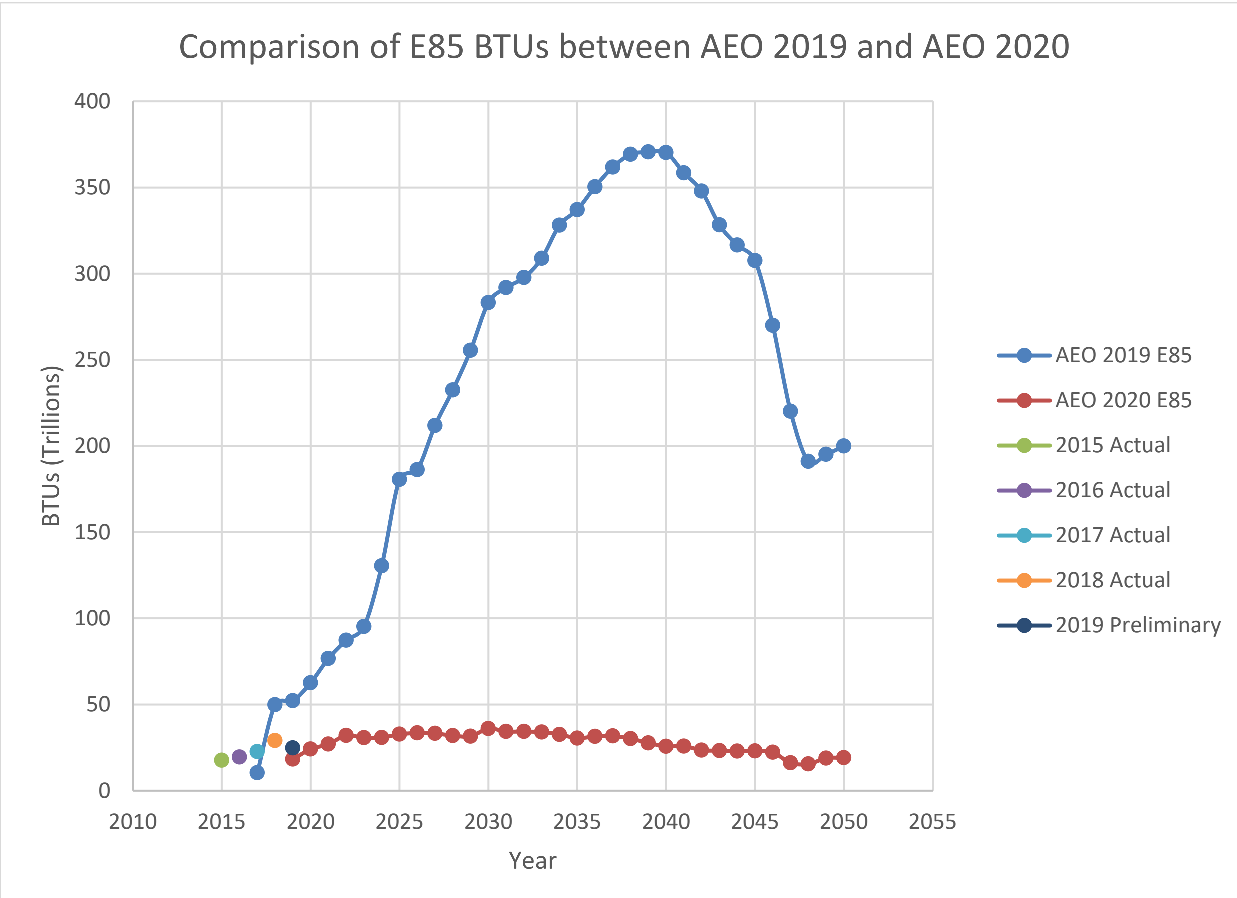

Figure 1: AEO 2019 vs AEO 2020 and Historic E85 Consumption

The projections of E85 consumption in AEO2020 are also consistent with EPA's understanding of the current and expected future near-term market factors that limit E85 use. Although the price of E85 relative to E10 has some impact on the total sales volumes of E85, the primary driver of increases in E85 volumes is currently the number of retail stations capable of offering

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[7] Projections of E85 in AEO are given in units of million barrels per day and were converted to trillion Btu per year using a conversion factor of 3.9972 million Btu per barrel (Table 73).

[8] For EPA estimates of E85 use, see for example "Final estimate of E85 consumption in 2018," memorandum from David Korotney to EPA Docket EPA-HQ-OAR-2019-0136, December 18, 2019.

E85 and choosing to do so.[9,10] Growth in the number of retail stations offering E85 has been aided in recent years by USDA's Biofuels Infrastructure Partnership (BIP) program and the ethanol industry's Prime the Pump program but has remained relatively slow.[11,12] While these grant programs have increased E85 offerings at retail, the growth was not substantially different during this period compared to previous years as shown below.

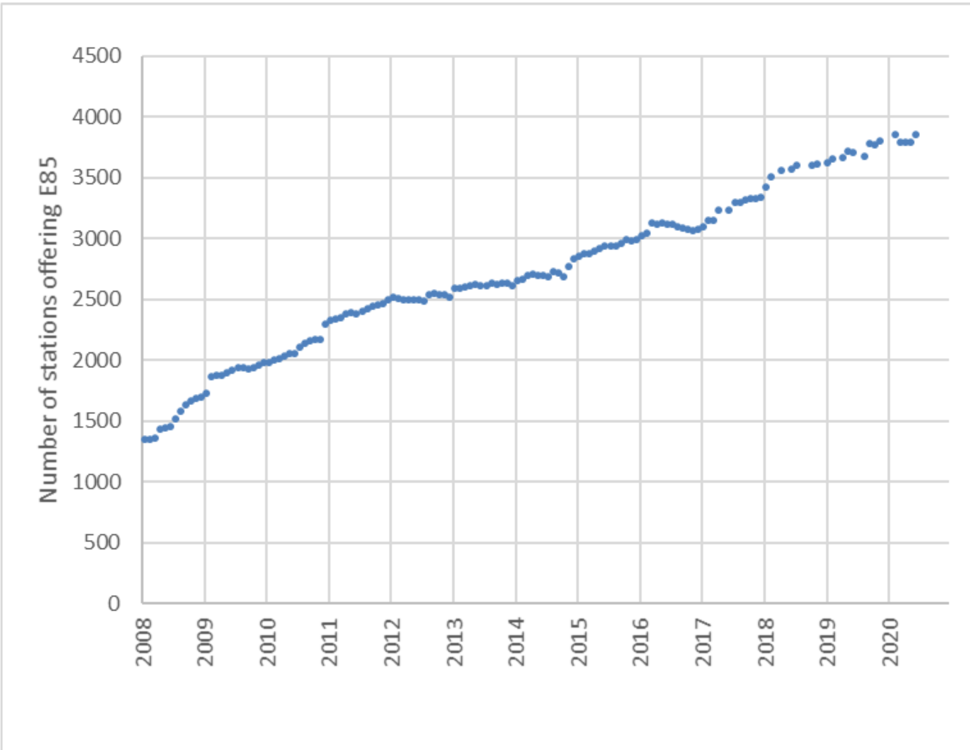

Figure 2: Number of Public and Private Fueling Stations Offering E85 per DOE's Alternative Fuels Data Center (AFDC) (https://afdc.energy.gov/stations/states)

The number of retail stations whose equipment conversions and upgrades to supply E85 have been completed and are now fully functional is still relatively low: as of June, 2020 there were 3,858 stations offering E85, representing about 2.6% of the approximately 142,000 total retail stations nationwide.[13] While USDA has recently developed a follow-up grant program called the "Higher Blends Infrastructure Incentive Program" that is likewise intended to increase E85 offerings at retail, the total grants available are the same as for the previous BIP program ($100 million). It is likely, therefore, that the number of additional E85 stations resulting from this

[9] "Updated correlation of E85 sales volumes with E85 price discount," memorandum from David Korotney to EPA docket EPA-HQ-OAR-2016-0004. November 18, 2016.
[10] See, for instance, discussion in "Updated market impacts of biofuels in 2020," memorandum from David Korotney to EPA Docket EPA-HQ-OAR-2019-0136.
[11] https://www.fsa.usda.gov/programs-and-services/energy-programs/bip/index
[12] https://growthenergy.org/2018/06/20/growth-energy-prime-the-pump-success-driving-ethanol-demand/
[13] DOE's Transportation Energy Data Book, Edition 38.1, 2020, Table 4.24.

program will follow the pattern in the figure above, that is a growth rate not dissimilar to longer-term historical growth. If so, then there is little reason to expect E85 volumes to increase dramatically in the near future in comparison to the actual E85 consumption levels seen in 2015 - 2019.

4.1.2. AEO2020 versus AEO2019

The differences in E85 consumption projections between AEO2020 and the previous edition AEO2019 are the result of several changes and improvements that EIA applied to their tools and methodology. The net result of these changes is that total projected biofuel consumption (including ethanol, biodiesel, and renewable diesel) is higher in AEO2020 despite the fact that ethanol consumption, and by extension E85, is lower in most years. It should be noted that the reduced RFS volumes in AEO2020 for 2018 - 2029 in comparison to AEO2019 did not result in lower total biofuel volumes being consumed in those same years. As stated above, total biofuel volumes in AEO2020 are higher than those in AEO2019 for all years after 2019 as a result of other factors such as increased transportation fuel demand. Although by themselves the lower required volumes would indeed tend to reduce the renewable fuel volumes, the other factors described above appear to have offset this reduction to the point where it is not evident in the final projected volumes by AEO2020.

The methodology behind AEO2019 assumed that the implied conventional renewable fuel volume requirement of 15 billion gallons would be met with ethanol. As a result, AEO2019 included unrealistically high projections for ethanol that was projected to be consumed as E85. For AEO2020, EIA modified their assumptions around biofuel production capacity and feedstock availability that allowed for more competition between biofuels to determine the amount of each fuel that would be consumed.[14] This allows their model to more accurately reflect the in-use experience over recent years wherein biodiesel and renewable diesel are used in greater quantities in lieu of higher volumes of E85. EIA also substantially increased their estimate of renewable diesel production capacity which provided greater opportunities for the model to choose it insofar as doing so was the more economical path than E85. EIA also made several other changes in AEO2020 as compared to AEO2019 which likely impact E85 projections. Projected sales of FFVs were reduced consistent with recent vehicle manufacturer actions, which reduced the number of FFVs in the in-use fleet and thus opportunities for E85 to be consumed. Projected demand for gasoline increased in AEO2020 which increased the volume of ethanol that could be consumed as E10 and reduced the need to consume ethanol as E85. The national agriculture sector simulation model POLYSIS (Policy Analysis System) was directly connected to the National Energy Modeling System (NEMS) that is the basis for AEO fuel projections, allowing biofuel feedstock prices to automatically adjust in concert with the other endogenous factors. Finally, EIA reduced the total renewable fuel volumes required to be met in keeping with recent implementation of the RFS program and projected declining reductions in the volume requirements out through 2030. EIA based these lower required RFS volumes on the actual small refinery exemptions granted by EPA for years up to and including 2018. For years

[14] https://www.eia.gov/todayinenergy/detail.php?id=43096 or See Docket EPA-HQ-OAR-2020-0104 "EIA projects U.S. biofuel production to slowly increase through 2050"

after 2018, EIA linearly ramped down the reduced volumes, targeting 2030 as the first subsequent year in which the full RFS volumes would apply. The particular form of this approach to basing future volumes on small refinery exemptions and phasing down that volume over time is based on analyst judgement and attempts to address the challenges inherent with achieving the full implied conventional renewable fuel volume requirement of 15 billion gallons in light of the projected decline in the E10 blendwall which is driven by declining gasoline demand.

The combined impacts of these changes is that the projection of E85 usage in future years was substantially reduced in AEO2020 in comparison to the projections made in AEO2019. Since AEO2020 aligns much more closely with the historical data, EPA believes that this new projection likely better represents the current and future reality of E85 production and consumption, as well as the mechanisms that the market uses to determine which biofuels are used to meet the applicable standards under the RFS program. However, it is unclear how each of the changes in AEO2020 individually contributed to the lower E85 volumes as their effects are inherently interactive. Since AEO2020 represents a significant change in both methodology and results from their past EIA modeling, we are continuing to evaluate it further for the purpose of using EIA modeling results in the determination of the F-factor.

On April 29, 2020, a collection of industry stakeholders which included the Fuel Freedom Foundation, the Alliance for Automotive Innovation, and ethanol industry stakeholders provided EPA with their own assessment of the E85 projections in AEO2020, including the impacts of several adjustments to NEMS which were implemented by OnLocation, Inc.[15,16] These model adjustments were intended to address assumptions made by EIA that OnLocation deemed to be in error or to underrepresent future market opportunities for E85. For instance, OnLocation increased the future effective renewable fuel mandates in comparison to AEO2020 to the implied statutory volume for conventional biofuel and non-cellulosic advanced biofuel by eliminating the volumes that EIA has assumed would be exempted in the future. Other changes made by OnLocation include: higher estimates of retail stations offering E85 from E85prices.com rather than the lower estimates provided by AFDC, an increased price of E85 relative to E10 at which consumers deem the two fuels to have equivalent value, and adjustments impacting biodiesel volumes.

4.1.3. EIA FFV Volume Projection Data

EPA used EIA's projected sales volumes by model year for FFVs. Figure 3 has AEO 2019 and AEO 2020 projected sales volumes for FFVs. Using these volumes is appropriate since BTUs of E85 used in AEO's projection are based on these model years FFV volumes along with other model years FFV volumes within AEO 2019 and AEO 2020. These volumes are applied to MOVES 2014 survival rates to create model year volumes by ages. The application of MOVES

[15] "F factor projections - Review of multiple data sets 4-29-20," available in docket EPA-HQ-OAR-2020-0104.

[16] "Update to Understanding E85 in the Annual Energy Outlook 2020 6-9-20," available in docket EPA-HQ-OAR-2020-0104.

2014 survival rates to AEO volumes will be discussed in section 4.2.1. Figure 3 shows that AEO 2020 car sales are significantly lower than AEO 2019 car sales.

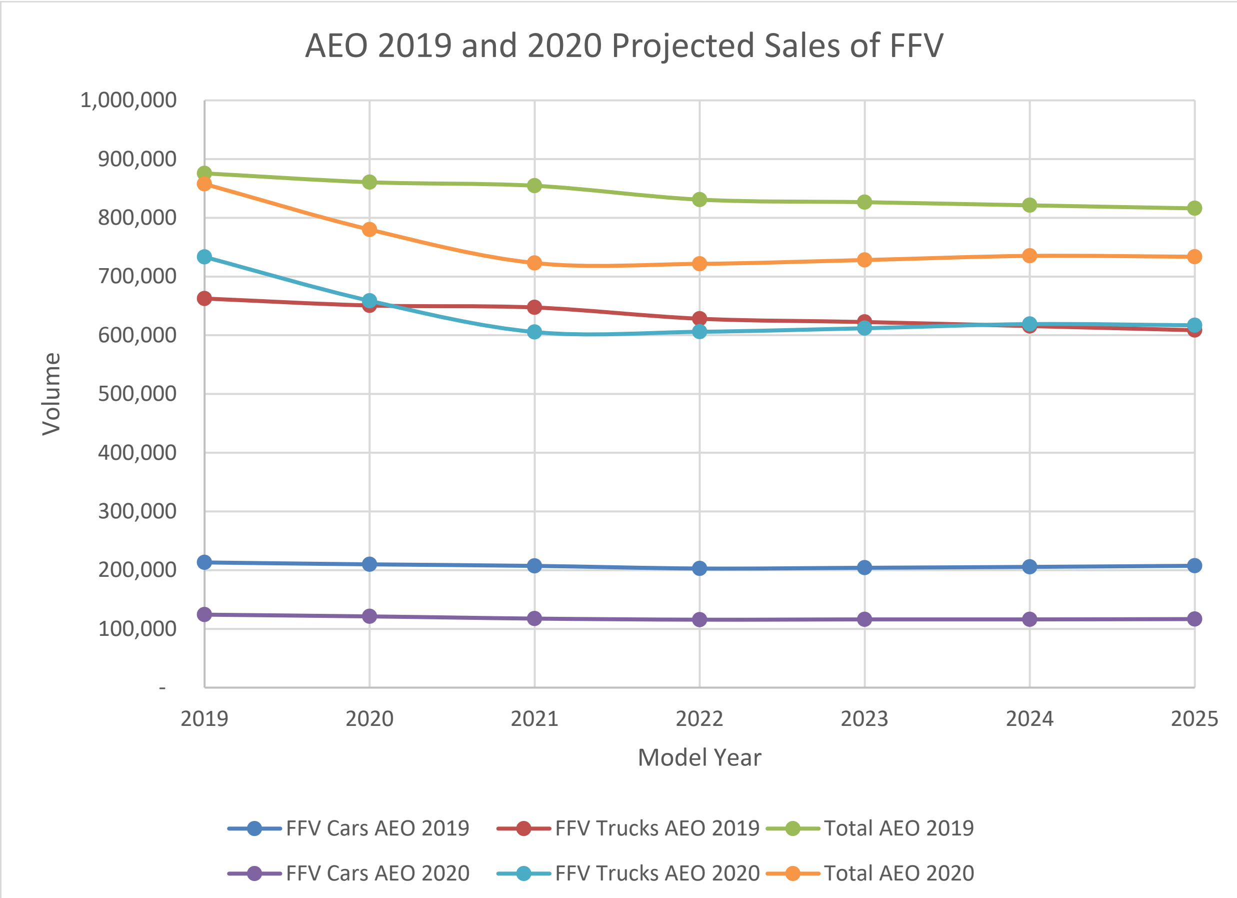

Figure 3: **Projected Sales Volume by Model Year for FFVs from AEO 2019 and AEO2020**

4.2. Use of Data from EPA's MOVES 2014 Model

As described above, vehicle population and VMT are primary inputs for the calculation of the F-Factor. For the purpose of this analysis EPA has used data from its MOVES 2014 Model. The data EPA used from MOVES are the survival rates table and Relative Mileage Accumulation Rate (RMAR) table, as shown below. EPA believes these data are the most appropriate source to create both population and VMT since it is the most recent release data from EPA and the data are foundational in all other mobile source emissions modeling analyses.

4.2.1. Use of Survival Rate Data from EPA's MOVES 2014 Model

EPA used the survival rates from MOVES 2014 along with the model year volumes projection from AEO 2019 and AEO 2020. The survival rates are for all vehicle types, not just FFVs. The survival rates are used by multiplying an original model volume to an age rate to get the volume for that age. This is done separately for each type of vehicle volume (car or truck). Table 1 shows the survival rates for cars and trucks. Figure 4 and Figure 5 shows the volumes by age for the model years considered in this analysis. There is a large separation shown below between the two curves. The upper curve represents trucks and the low curve cars. The separation is the result of the difference volumes between cars and trucks.

Table 1: Survival Rate Table from MOVES 2014

Vehicle Age	Proportion of Original Sales Surviving to Age:	
	Car	Truck
1	100.0%	100.0%
2	98.8%	97.8%
3	97.7%	96.3%
4	96.1%	94.3%
5	94.5%	93.1%
6	93.0%	91.5%
7	91.1%	89.3%
8	89.1%	87.0%
9	86.9%	84.1%
10	84.0%	79.6%
11	80.0%	74.2%
12	75.6%	69.2%
13	70.6%	64.1%
14	65.3%	58.3%
15	59.5%	53.5%
16	53.1%	48.6%
17	45.8%	44.2%
18	38.3%	39.8%
19	30.8%	35.2%
20	24.1%	30.9%
21	18.3%	26.7%
22	13.9%	22.8%
23	10.7%	20.2%
24	8.2%	17.5%
25	6.3%	15.8%

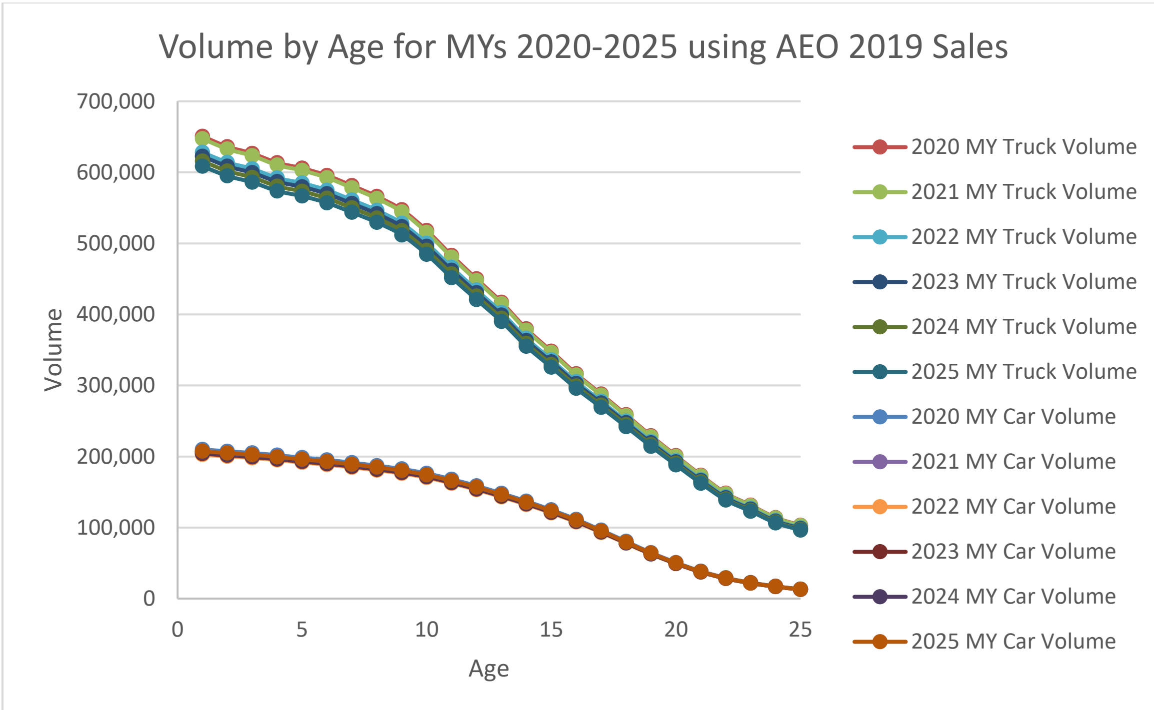

Figure 4: **Volume by Age for Model Years 2020-2025 using AEO 2019 Sales**

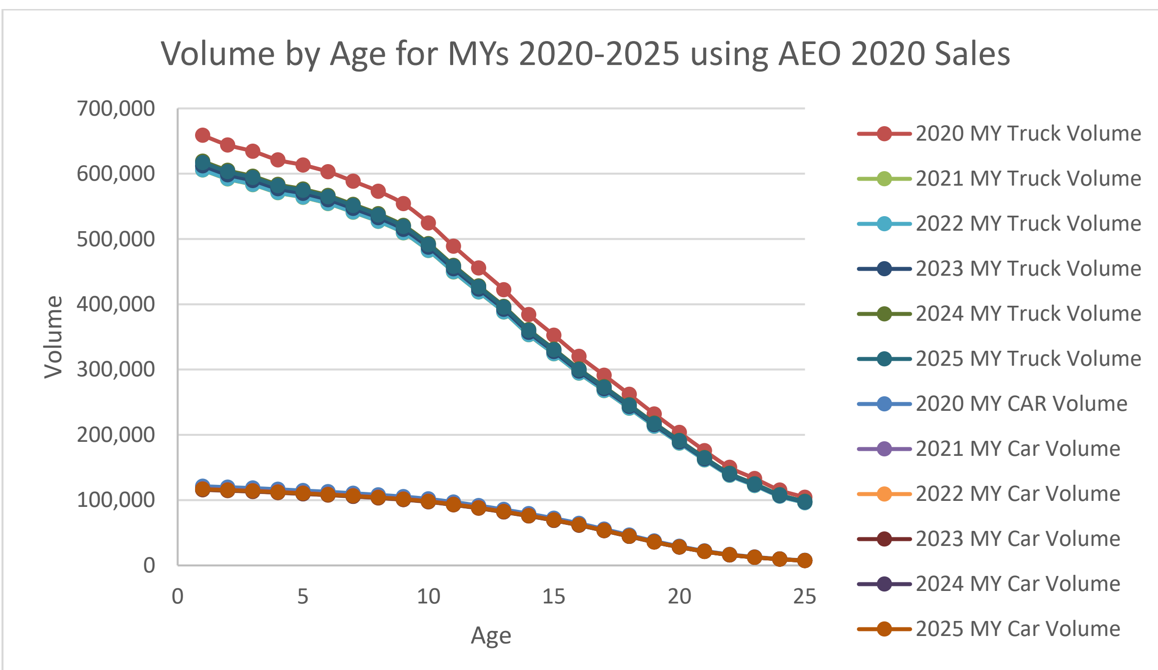

Figure 5: **Volume by Age for Model Years 2020-2025 using AEO 2020 Sales**

4.2.2. Use of Relative Mileage Accumulation Rate (RMAR)

EPA used the Relative Mileage Accumulation Rate (RMAR) values from MOVES 2014 to determine the mileage at each age for FFV cars and FFV trucks. The application of RMAR is done by multiplying RMAR values for car and trucks to the base mileage for trucks. Car mileage is a function of truck mileage using the RMAR. Table 2 shows the RMAR values and the results for applying those values to a base mileage of 18,000 miles for trucks.

Table 2: RMAR Table with Base Mileage for Trucks Set to 18,000

Age	RMAR Cars	RMAR Trucks	Base Mileage for Trucks	Car Mileage	Truck Mileage
1	0.885	1.000	18,000	15,925	18,000
2	0.868	0.981	18,000	15,623	17,662
3	0.850	0.960	18,000	15,296	17,280
4	0.830	0.937	18,000	14,947	16,862
5	0.810	0.912	18,000	14,579	16,412
6	0.788	0.885	18,000	14,193	15,934
7	0.766	0.857	18,000	13,792	15,431
8	0.743	0.828	18,000	13,379	14,909
9	0.720	0.799	18,000	12,956	14,373
10	0.696	0.768	18,000	12,526	13,828
11	0.672	0.738	18,000	12,090	13,275
12	0.647	0.707	18,000	11,653	12,722
13	0.623	0.676	18,000	11,215	12,173
14	0.599	0.646	18,000	10,780	11,633
15	0.575	0.617	18,000	10,350	11,106
16	0.552	0.589	18,000	9,927	10,595
17	0.529	0.562	18,000	9,514	10,107
18	0.506	0.536	18,000	9,114	9,644
19	0.485	0.512	18,000	8,728	9,214
20	0.464	0.490	18,000	8,358	8,820
21	0.445	0.470	18,000	8,009	8,465
22	0.427	0.453	18,000	7,683	8,156
23	0.410	0.439	18,000	7,381	7,895
24	0.395	0.427	18,000	7,106	7,690
25	0.381	0.419	18,000	6,861	7,542

4.3. The Yearly Percentage

The Yearly Percentage, though just a concept (not a regulatory measure or mathematically useful[17] in calculating the model year F-Factor), is a good way to discuss E85 use in future years because it provides a relative magnitude of the potential F-Factor for any given calendar year and a simple rationality check on the final model year F-Factor. The Yearly Percentage, again, is simply the total amount of E85 used in a year divided by the total amount of all fuels used by FFV's. The graph below in Figure 6 shows the expected Yearly Percentage from 2019 to 2050 calculated from EIA's AEO 2020 reference case data. It shows that the Yearly Percentage ranges between approximately 1 and 3 percent and is never greater than 3.15 percent. This means that the model year F-Factor will be less than 3.15 when calculated, as it is never more than 3.15 in any given calendar year.

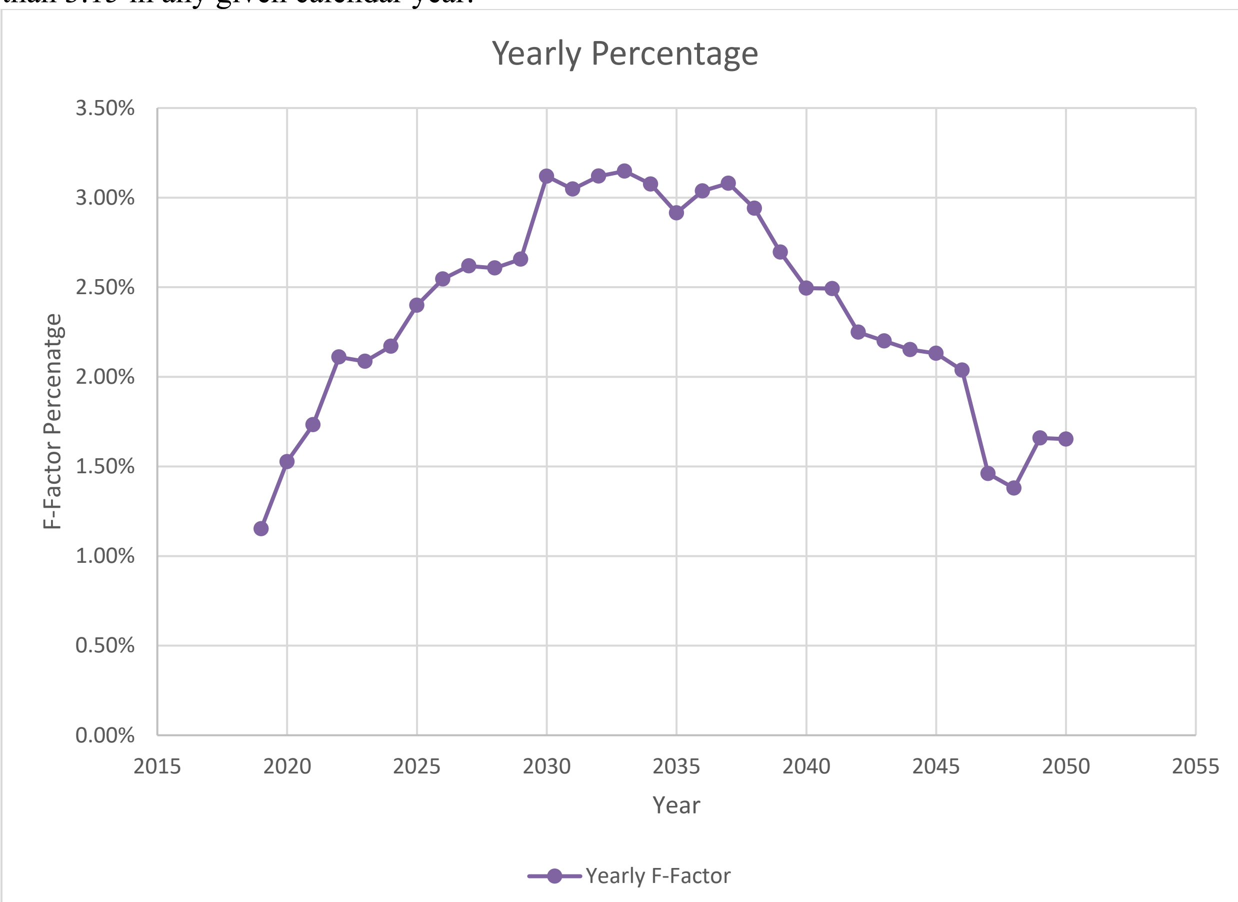

Figure 6: Yearly Percentage Calculated from AEO 2020

4.4. Historical E85 Consumption and Associated Yearly Percentages

[17] Note that the Yearly Percentage has been averaged to calculate the F-Factor which is mathematically incorrect since Yearly Percentages may not have a common denominator.

EIA also provides estimates of E85 production for past years separate and apart from their AEO forecasts.[18] We believe that these estimates are likely to be lower than actual E85 production. They are based on data collected from two sources: refiners and blenders, and ethanol production facilities. EIA's Bulk Terminal and Blender Report is administered only to entities with at least 50,000 barrels of product storage capacity, so production at terminals, ethanol production facilities, or blenders that do not meet this threshold is not reported to EIA.[19] EIA also does not collect information on E85 produced using reformulated gasoline or natural gasoline as the petroleum based component. We believe that E85 produced using these petroleum blendstocks represents a significant portion of the total E85 produced and consumed.

EPA has estimated the volume of E85 consumed in 2015 through 2019 using a variety of data sources. These sources and the associated calculation methodology can be found in two memoranda to the docket.[20] The estimated volumes are shown below.

Table 3 EPA Estimates of E85 Consumption (million gallons)

	Low[a]		High[b]	
	mill gal	trill Btu[c]	mill gal	trill Btu[c]
2015	166	16	186	18
2016	192	18	205	20
2017	204	19	239	23
2018	225	21	306	29
2019	224	21	261	25

[a] Based on Method #2 which extrapolates actual E85 consumption from six states to the entire nation.
[b] Based on Method #1 which uses nationwide average E85 prices discounts and a correlation previously developed by EPA to estimate E85 consumption for the entire nation.
[c] Conversion factor is 3.9972 mill Btu per barrel and is taken from Table 73 of AEO2019. The 2017 value is used as a best estimate for the years 2015 - 2019 in this table. While Table 72 of AEO2020 provides more recent conversion factors, they only apply to 2019+ and would have no material impact on the Yearly Percentages in Table 6 below.

We can use these annual E85 consumption estimates to calculate the fraction of fuel used by FFVs, in those same years, that was E85. This Yearly Percentage represents E85 actually used by the fleet of FFVs, in operation, in a given calendar year. This is not exactly the same as the F-Factor which represents the average projected use of E85 over a particular model year's lifetime.

[18] See "U.S. Refinery and Blender Production of Motor Gasoline, Finished, Conventional, Greater Than Ed55," https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=M_EPM0CAG55_YPR_NUS_MBBL&f=M
[19] Form EIA-815, https://www.eia.gov/survey/
[20] For Method #1 approach, see "Final estimate of E85 consumption in 2018," memorandum from David Korotney to EPA Docket EPA-HQ-OAR-2019-0136, December 18, 2019. For Method #2 approach, see "Preliminary estimate of E85 consumption in 2018," memorandum from David Korotney to EPA Docket EPA-HQ-OAR-2019-0136, June 26, 2019.

Nevertheless, the Yearly Percentage provides a conceptually similar value from which to judge whether historical and future F-Factors are reasonable.

In order to estimate the Yearly Percentages, we must know the total amount of fuel used by FFVs in each of the calendar years shown in **Table 4**. Estimates of these values are available in EIA's Annual Energy Outlook (AEO). Each edition of the AEO typically provides these estimates only for one or two years prior to that edition year (e.g., the oldest estimates in AEO2020 are for 2019). Therefore, we used several editions of the AEO to obtain the necessary values. The specific AEO editions that we used are shown below.

Table 4 AEO Editions for Data on Total Fuel Consumption in FFVs

AEO edition	Earliest calendar year addressed
2017	2015
2018	2016
2019	2017[a]
2020	2019

[a] Since AEO2020 does not include values for calendar year 2018, AEO2019 was used as the source for calendar year 2018 values.

The necessary values are provided separately for light-duty cars/trucks and commercial light trucks in AEO. All FFV fuel consumption for light duty cars and trucks was taken from the table entitled "Light-Duty Vehicle Energy Consumption by Technology Type and Fuel Type," which is Table 38 for AEO2017 through AEO2019 and is Table 37 for AEO2020. The relevant values were labeled as "Ethanol-Flex Fuel ICE" under the category "Alternative-Fuel Vehicles." All FFV fuel consumption for commercial light trucks was taken from the table entitled "Transportation Fleet Car and Truck Fuel Consumption by Type and Technology," which is Table 44 for AEO2017 through AEO2019 and is Table 43 for AEO2020. The relevant values were labeled as "Ethanol-Flex Fuel" under the category "Commercial Light Trucks." The values from these tables are summarized below.

Table 5 Total Fuel (gasoline + E85) Consumption in FFVs from AEO

	Light-duty cars/trucks (trill Btu)	Commercial light trucks (trill Btu)	Total (trill Btu)	Total[a] (mill gal)
2015	1,436	109	1,546	12,838
2016	1,503	133	1,636	13,589
2017	1,350	187	1,537	12,767
2018	1,347	213	1,560	12,959
2019	1,358	225	1,583	13,151

[a] Conversion from Btu to gallons assumes that all fuel used in FFVs is E10. This is a reasonable assumption as the volume of E85 used in FFVs is much lower than the volume of E10. Conversion factor is 5.0566 mill Btu per barrel and is taken from Table 73 of AEO2019. The 2017 value is used as a best estimate for the years 2015 - 2019 in this table. While Table 72 of AEO2020 provides more recent conversion factors, they only apply to 2019+ and would have no material impact on the Yearly Percentages in Table 6 below.

The Yearly Percentages are simply the result of dividing the values in **Table 3** by the values in **Table 5**. The results are shown in **Table 6**.

Table 6 Yearly Percentage of Fuel used in FFVs which is E85

	Based on energy		Based on volume	
	Low	High	Low	High
2015	0.010	0.011	0.013	0.014
2016	0.011	0.012	0.014	0.015
2017	0.013	0.015	0.016	0.019
2018	0.014	0.019	0.017	0.024
2019	0.013	0.016	0.017	0.020

The Yearly Percentages which are based on the energy values of fuel used in FFVs are most directly comparable to F-Factors. Based on EPA's estimates of actual E85 used between 2015 and 2019, the Yearly Percentages are far lower than the F-Factors that have been issued for Model Years 2016 to 2019 vehicles, and far lower than the 0.14 that is proposed for use for 2020 model year FFVs.

4.5. Estimating the F-Factor Using Historical Fleet Data

Now that we have a number of years of experience with the use of E85 in FFVs, and given the challenges associated with projecting all the data inputs needed to calculate the F-Factor as described above in the previous sections, one possibility for establishing an F-Factor would be to simply use historical data on annual E85 consumption by the existing FFV fleet and assume that new FFVs will continue to consume E85 in a similar manner over their lifetime to the existing fleet today. The F-factor would then be set based entirely on the historical data. Alternatively, one could use historical data with a projection to help account for future infrastructure changes. This is different from the methodology described above in that it would rely on the historical E85 the consumption trend to establish future E85 consumption. EPA requests comment on analytical methods using historical data with and without projections to determine the F-Factor. EPA also requests comment on data sources and analytical methods that would enable projections of E85 use that account for future changes in E85 infrastructure.

4.6. Illustration of Potential F-Factor Values for Model Years 2020-2025

During 2019 one of the trade associations that represents light-duty vehicle manufacturers, the Alliance of Automobile Manufacturers, presented EPA with their assessment of the F-Factor[21]. The Alliance analysis was based on AEO2019. EPA has reviewed the Alliance analysis and concluded that the results the F-Factor values produced are largely a function of the input data, including data from EIA's AEO, and the assumed vehicle life. We present the Alliance 2019 report results below, alongside our own analysis, to compare the calculated values.

Table 7 below shows EPA and the Alliance potential F-Factor values using AEO 2019 and AEO 2020. The Alliance values are somewhat larger due to the math error which is explained in appendixes A and B. As a result, every year of the Alliance AEO 2019 values are higher than the EPA values. (A complete discussion of the Alliance method of calculating the F-Factor is available in appendix B.) The Alliance used 20 year life and 15 year life with the 20 year life values larger than the 15 year life values. AEO 2019 has a significant increase in projected ethanol use farther out in time (see Figure 1) which makes longer vehicle life increase the F-Factor. EPA used a 25 year life and the values are lower when the math is done correctly.

Table 7: Potential F-Factor Values Using AEO 2019 and AEO 2020

	Using AEO 2019 Data			Using AEO 2020 Data		
Model Year	**EPA 25 Year Life**	**Alliance 20 Year Life**	**Alliance 15 Year Life**	**EPA 25 Year Life**	**Alliance[a] 20 Year Life**	**Alliance[a] 15 Year Life**
2019		16.53%	13.80%		2.55%	2.40%
2020	15.01%	17.91%	15.40%	2.39%	2.63%	2.53%
2021	16.56%	19.26%	17.05%	2.49%	2.68%	2.62%
2022	18.13%	20.56%	18.71%	2.58%	2.72%	2.71%
2023	19.70%	21.79%	20.38%	2.63%	2.72%	2.77%
2024	21.27%	22.98%	22.03%	2.68%	2.73%	2.83%
2025	22.64%	23.99%	23.50%	2.73%	2.73%	2.87%
2020-2025[b]	18.84%	20.43%	18.70%	2.58%	2.68%	2.68%

Notes:

a. These columns were calculated using the Alliance methodology.
b. The Alliance numbers are for 2019-2025 in this row, and the EPA numbers are for 2020-2025. The Alliance numbers would be larger if they were averaging 2020-2025.

Table 7 also has F-Factors for MYs 2020-2025 using AEO 2020 for both EPA's method and the methodology submitted by the Alliance. The values presented here are a direct application of AEO 2020 into the Alliance methodology as calculated by EPA. The Alliance methodology

[21] See "F" Factor Developed from Energy Information Agency (EIA) Docket EPA-HQ-OAR-2020-0104

provides similar values to EPA's since the Yearly Percentages for the model year's lives are between 1 and 3 percent. If AEO2020 values were used the F-Factor would be 3 percent for 2020-2025.

Finally, EPA also received an estimated F-Factor from the Fuel Freedom Foundation as part of their April 29, 2020 meeting with EPA. In their April 2020 materials the FFF and their co-presenters recommended an F-Factor of 0.20 or 20% based on their analysis. Unlike the Fall 2019 Alliance analysis, EPA does not have a full understanding of all the data inputs and the methodology used to calculate their recommended F-Factor and it may not be appropriate to draw a direct comparison between the FFF results and those based on a straight application of AEO2019 or AEO2020. We do, however, think it is important to present the resultant F-Factor based on the changes that FFF proposed (as described in 4.1.2 above).

Overall, the projected F-Factor values based on different sources of data and methodologies range from a low of 2.58% for an EPA analysis based on AEO 2020 and 25-year vehicle life to at high of 20.43% for the Alliance analysis based on AEO2019 and a 20-year vehicle life. The 20% F-Factor from the Fuel Freedom Foundation is slightly lower than that of the Alliance. Both the Yearly Percentage calculated from AEO2020 and the historical E85 percentages for calendar years 2015 through 2019 are below 3%. The historical percentages are also lower than the EPA 2014 F-Factor analysis[22] (where the F-Factor was determined to be 0.14).

Appendix A: Review of Methodology used in the Previous (2013) Analysis of the F-Factor

In preparing this revised F-Factor analysis, EPA reviewed the previous F-Factor analysis and in that process determined that a minor math error was present in the previous calculations. This error occurred when the Yearly Percentage (which is the percentage of E85 for a given year) was weighted by multiplying the percentage of the VMT*population. Percentages can only be multiplied if the original fractions have a common denominator. The Yearly Percentage does not have a common denominator since the total amount of fuel used varies from year to year. In order to properly weight the F-Factor each weight must be applied to each year's numerator and each year's denominator and the weighted yearly numerators and denominators must be added to give the proper fraction. The following examples illustrate the difference between correct math and incorrect math in applying percentages.

Example 1: Adding Fractions to find the F-Factor for two years.

In the first year 19 BTUs of E85 and 20 BTUs of EALL are used. In the second year 10 BTUs of E85 and 100 BTUs of EALL are used.
To find the F-Factor we add the numerators and denominators of each fraction:

[22] See https://www.eia.gov/outlooks/aeo/pdf/AEO2020%20Full%20Report.pdf for more information on the cases.

$$\frac{19}{20}, \frac{10}{100} \quad \frac{19+10}{20+100} = \frac{29}{120} = 24.2\%$$

If we just average the fractions, we get the wrong answer.
.95 +.1=1.05, 1.05/2=52.5%
This example shows that we can't just average yearly or model year-based F-Factors.

Example 2: Production and VMT weighted F-Factor

90% of the vehicles and VMT happens in the first year using 90 BTUs of E85 and 100 BTUs of total fuel and 10% of the vehicle and VMT happen the second year using 10 BTUs of E85 and 20 BTUs of total fuel.

$$\frac{.9*90+.1*10}{.9*100+.1*20} = \frac{81+1}{90+2} = \frac{82}{92} = 89.1\%$$

The math done in the original analysis does the weights like below.
.9*.9 +.5*.1=.81+.05=86%
Again, weighting using this method only works if the total number of BTUs is the same every year.
The equation for the original method is shown below followed by the corrected method.

Original Method Incorrect Math

$$F_{Factor} = \sum_{i=0}^{15} \%E85_i * \frac{(VMT_i)*(Population_i)}{(\sum(VMT)*(Population))}, \ \%E85_i = \frac{E85_i}{EALL_i}$$

Where

- $\%E85_i$ is the Yearly Percentage in year i of the vehicle's life.
- VMT_i is VMT for an E85 vehicle in year i of the vehicle's life.
- $Population_i$ is the number of E85 vehicles in year i of the vehicle's life.

Original Method Corrected Math

$$F\_Factor = \frac{\sum_{i=0}^{15}(E85_i) * \frac{(VMT_i)*(Population_i)}{(\sum(VMT)*(Population))}}{\sum_{i=0}^{15}(EALL_i) * \frac{(VMT_i)*(Population_i)}{(\sum(VMT)*(Population))}}$$

The difference in results between the original math and the corrected math in 2016 rounds to the same value (14%) which is what was released. Due to rounding the difference between the previous analysis and corrected math but as shown below the results would have been identical with both 14.2% and 13.6% rounding to 14%. The results of this type of math error can vary greatly in magnitude, so EPA was fortunate to have the issue not have an impact.

Appendix B: Review of the Methodology used in the 2019 Alliance Proposal for the F-Factor

The Alliance of Automobile Manufacturers presented an analysis[23] (created for them by Air Improvement Resource) for model years 2019-2025 using EIA's AEO 2019 reference case data and MOVES 2014 data for the F-Factor. The analysis used both 15 and 20 year life spans for vehicles. EPA reviewed their analysis and found the following items.

The equation for the method used in the Alliance submission is as follows:

$$F_{Factor} = \frac{\sum_{i=0}^{x} \%E85_i * \frac{(VMT_i)}{(\sum(VMT))}}{x}, \ \%E85_i = \frac{E85_i}{EALL_i}, x = 15 \ years \ or \ 20 \ years$$

This equation averages Yearly Percentages and weights them using truck VMT.

EPA has four technical concerns with the analysis presented by the Alliance, as described below. First, it contains the same math error as in EPA's original 2014 analysis where percentages are being multiplied by percentages without having a common denominator. This is being done in multiple places. Second, E85 is only being weighted by VMT. Weighting E85 by population and VMT gives a different distribution that weights the early years higher than using VMT alone. The VMT from the MOVES data is for one vehicle each year so to get the VMT for all vehicles in that year one must multiply it by the population. Third, the analysis is using only VMT from trucks also gives a different distribution than car and trucks. And fourth, similar to the first item, the equation used averages the Yearly Percentages which does not yield the correct F-Factor for the model year (see example 1 in Appendix A).

EPA observed one additional issue with the Alliance analysis regarding their multiyear (2019-2025) results. Instead of adding the different model years total weighted E85 and total weight EALL, the analysis simply average F-Factors for model years 2019-2025. As seen in the example 1 in Appendix A, this does not give the correct result.

The analysis uses data from MOVES 2014 which EPA agrees with. Shown below in Table 8 are the original Alliance projections using AEO 2019, and the results using their spread sheets with AEO 2020 used as an input are shown in Table 9. The Alliance method produces the same conclusion as EPA's analysis (rounded up to 3 percent for 2020-2025 using AEO 2020 regardless of the expected life of the vehicle).

Table 8: **Alliance Method using 2019 AEO**

Model Year	20-Year Life	15-Year Life
2019	16.53%	13.80%

[23] See "F" Factor Developed from Energy Information Agency (EIA), Fuel Consumption Projections Air Improvement Resource, Inc., February 1, 2019 in Docket EPA-HQ-OAR-2020-0104

2020	17.91%	15.40%
2021	19.26%	17.05%
2022	20.56%	18.71%
2023	21.79%	20.38%
2024	22.98%	22.03%
2025	23.99%	23.50%
2019-2025	**20.43%**	**18.70%**

Table 9: **Alliance Method using 2020 AEO**

Model Year	20-Year Life	15-Year Life
2019	2.55%	2.40%
2020	2.63%	2.53%
2021	2.68%	2.62%
2022	2.72%	2.71%
2023	2.72%	2.77%
2024	2.73%	2.83%
2025	2.73%	2.87%
2019-2025	**2.68%**	**2.68%**