MEETING U.S. PASSENGER VEHICLE EMISSIONS STANDARDS:

GREENHOUSE GAS CREDITS BALANCE

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Introduction

The automotive industry is charged with reducing greenhouse gas (GHG) emissions of its fleet to an estimated average of 163 gCO_2 per mile (equivalent to 54.5 MPG) by the year 2025.[1] From now through the year 2025, the standards for GHG emissions in the United States will become more stringent at a rate of approximately 4 to 5 percent. As U.S. standards become more stringent, the automakers must continue to reduce their fleet's GHG emissions to meet or exceed the standard, or utilize credits they have accrued in previous years. These credits may be earned by over-complying with the Environmental Protection Agency (EPA) GHG target for a given Model Year, implementing air conditioning and off-cycle technologies that improve fuel efficiency, selling of advanced powertrain vehicles such as electric vehicles (EVs), using alternative fuels, or any combination of these examples.[2] Manufacturers may also purchase credits from other vehicle manufacturers if they believe additional credits are necessary for the future or if they carry a deficit. Manufacturers are under no obligation to buy or sell credits from others and the value of these is primarily determined by the market. However, if a vehicle manufacturer is in a deficit after utilizing all accrued credits it will have to offset those deficits within three years or face monetary penalties and regulators may require the automaker to cease sales of non-complying vehicles in the United States. There is a key question related to these regulations: Can the vehicle manufacturers keep pace with the regulations, or will they burn through the credits they currently have?

This report reviews the GHG credit progress made thus far in the U.S. industry and how long those credits would last if no additional technology advancements were made to the fleet. Without significant advances in fleet fuel efficiency, none of the leading automotive manufacturers in the U.S. market will meet the future standards. After including all credits earned from MY 2009 through MY 2013 and carrying over the performance of the MY 2014 fleet against the standards from MY 2015 through MY 2025, all manufacturers would run out of credits by the year MY 2021 and some would run out of credits as early as MY 2017. The industry as a whole would have a cumulative deficit of credits by MY 2018 at which point there would not be enough credits to cover all deficiencies within the industry.

In reality, all manufacturers are taking measures to reduce GHG emissions. There are many strategies that may be implemented to reduce GHG emissions. The net effect of these strategies improves the compliance of the industry to various degrees. Going forward, each manufacturer must decide its own best strategy based on its position in the market.

[1] For the purpose of this study GHG and CO_2 are used interchangeably; however, it is understood that GHG could reference other emissions that are considered greenhouse gases. This distinction is not expected to have a significant impact on the analysis

[2] A more detailed description of available credits will be addressed in a separate document.

Method

This analysis is based on the credit program established under the EPA GHG regulations. Due to differences in credit trading, how the agencies offer credits for technologies, and the technologies that qualify for credits, the analysis conducted in this report does not directly represent the credit trading program offered under the NHTSA CAFE regulation. As a result, this report does not represent an analysis of the industry's compliance with the CAFE regulations. It does indicate how much advancement will be required to meet the corresponding EPA GHG regulation.

To conduct the analysis of credit accumulation for each manufacturer, the Center for Automotive Research (CAR) utilized information available in the following documents:

- U.S. EPA Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 – 2014 report[3]
- U.S. EPA GHG Emission Standards for Light-Duty Vehicles: Manufacturer Performance Report for the 2013 Model Year[4]
- U.S. EPA, NHTSA 2012 – 2016 and 2017 – 2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule[5,6]

The U.S. EPA Manufacturer Performance Report (MPR) includes the accumulated credits earned by each manufacturer through 2013 and includes whether those credits were earned through tailpipe emissions, air conditioning credits, off-cycle credits, and flex-fuel credits. The U.S. EPA Trends report provides the latest official data on fleet emissions performance and fleet footprint by manufacturer which is needed to compare the standard required for each year against the achieved performance.

In addition to the EPA reports, CAR estimated the effect of removing petroleum consumption reduction credits. Petroleum consumption reduction credits are an important part of compliance for several manufacturers. These credits are given for vehicles that displace petroleum through the use of an alternative fuel such as ethanol or CNG. This credit is part of the NHTSA CAFE program and was temporarily included in the EPA GHG program. Petroleum reduction will no longer be a part of the GHG program starting in MY 2016 as it is not considered a GHG reduction technology. To estimate the credits that would no longer be available from petroleum reduction, CAR assessed the proportion of flex-fuel credits generated through real GHG improvements of flex-fuel vehicles and subtracted the credits due to GHG improvements from the total flex-fuel credits. A full description of the petroleum reduction credit calculations is available in Appendix A: Petroleum Reduction Credit Calculations.

The estimation of vehicle manufacturer credit balances was based on the following information:

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[3] U.S.EPA, Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 – 2014, http://www3.epa.gov/otaq/fetrends-complete.htm

[4] U.S. EPA, GHG Emission Standards for Light-Duty Vehicles: Manufacturer Performance Report for the 2013 Model Year, http://www3.epa.gov/otaq/climate/ghg-report.htm

[5] U.S. EPA and NHTSA, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, http://www.gpo.gov/fdsys/pkg/FR-2010-05-07/pdf/2010-8159.pdf

[6] U.S. EPA and NHTSA, 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, http://www.gpo.gov/fdsys/pkg/FR-2012-10-15/pdf/2012-21972.pdf

1. GHG credits earned by manufacturer from MY 2009 to MY 2011 (through an early credit program)
2. MY 2012 and MY 2013 GHG credits through compliance with the GHG standard
3. MY 2014 performance of the fleet vs. the MY 2014 footprint-based standard (reported in the EPA Trends report)
4. For the MY 2015 through MY 2025, CAR carried forward MY 2014 fleet performance and footprint and compared it to the GHG standard for the MY 2015 through MY 2025
5. Carry forward the same amount of non-GHG credits (A/C, off-cycle, flex-fuel) that had been earned during MY 2013 to future model years
6. Credits for petroleum reduction were no longer available in new vehicles starting with MY2016 and not carried forward beyond MY 2016
7. Credits earned from MY 2009 expire in MY 2015 and are eliminated from the credit balance in MY2015

A summary of data used by year is included in the Appendix B: Summary of Data Sources and Uses.

Results

Using data that was publicly accessible through the EPA, CAR projected the balance of GHG credits/deficits for the industry. A baseline analysis was conducted of the industry with no changes in technology beyond 2014. The detailed results of this analysis are included in this section.

Projected industry compliance with no technology changes

Comparing current GHG emissions to those required between MY 2012 and MY 2021, the industry at large would effectively have a deficit of GHG credits by MY 2018 (Figure 1). An industry-wide deficit implies that there are not enough GHG credits across the entire U.S. fleet to comply with GHG standards.

This baseline analysis for the industry assumes there will be no improvements in GHG reduction and no inclusion of additional technologies for regulatory credits. In reality, the industry is advancing technologies to reduce GHG emissions and will fare better than the results presented in this analysis because of these advances. However, this baseline exercise demonstrates the severity of the current regulatory trend line and the need for further improvements to achieve the regulatory requirements over the long term.

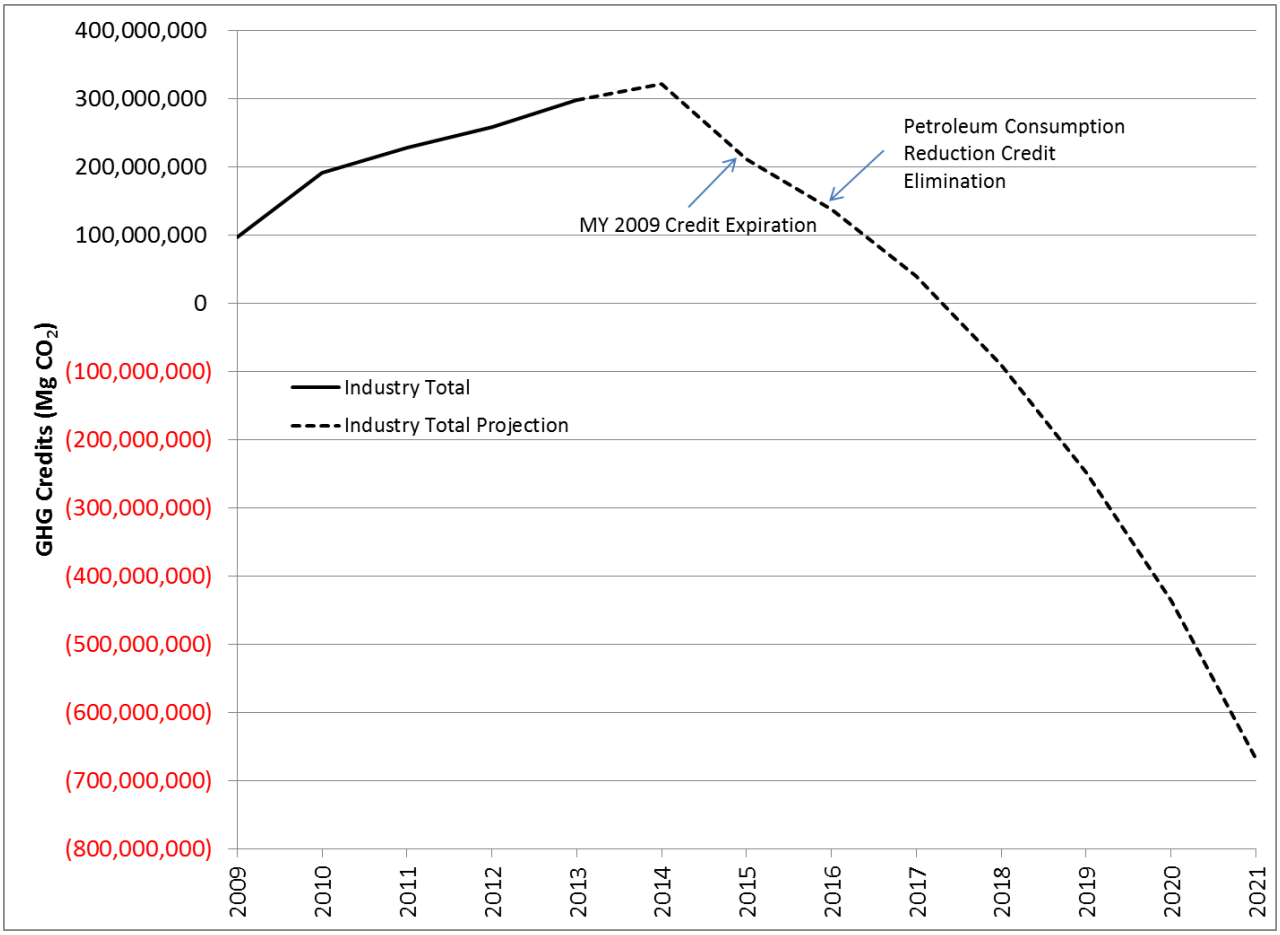

Figure 1 Cumulative GHG Credits for the Industry Assuming No Technology Improvements beyond MY 2014, MY 2009 – 2021
Source: EPA 2015, CAR 2015

The steep decline of GHG credits between MY 2014 and MY 2015 is the result of the credits from MY 2009 expiring. The credits from MY 2009 are no longer transferable to another manufacturer and are unlikely to be used by the time of their expiration. An additional decline of credits occurs in MY 2016 when credits for petroleum reduction are eliminated as a GHG regulation flexibility.

Looking more specifically by manufacturer, there are some manufacturers that will sustain a surplus of credits for a longer period of time compared to the rest of the industry (Figure 2). However, even manufacturers with the most banked credits would eventually run out of credits by MY 2021 without further significant reductions in GHG emissions.

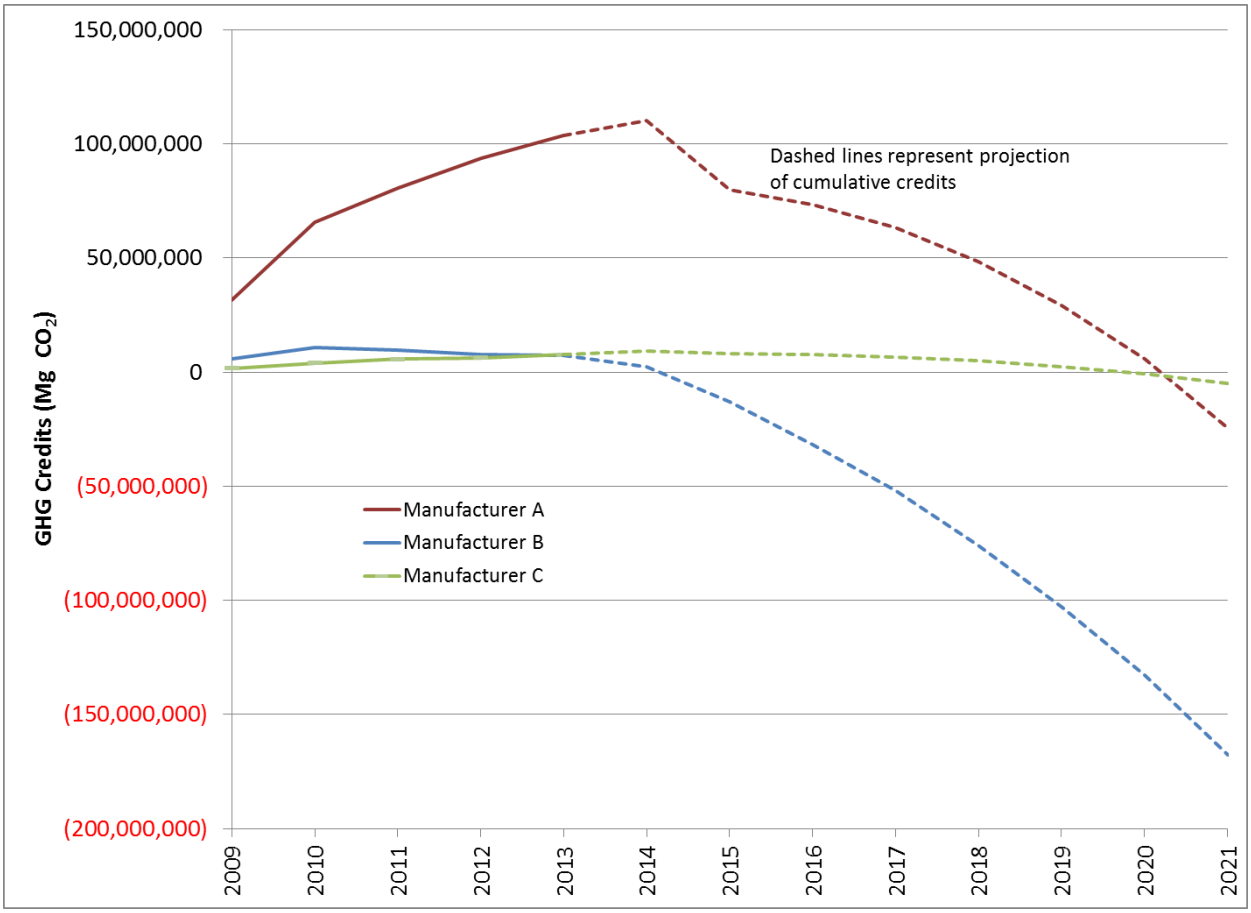

Figure 2 Cumulative GHG Credits Accrued by Three Automotive Manufacturers through Tailpipe Emissions and Flexibilities, MY 2009 – 2021
Source: EPA 2015, CAR 2015

While Figure 2 demonstrates the cumulative credits of three vehicle manufacturers, none of the manufacturers selling vehicles in the United States meets the GHG standards under their current fleet configurations. All manufacturers will require some strategy to meet the increasingly stringent GHG standards. Manufacturers are aggressively implementing strategies to reduce GHG emissions, and where appropriate, leveraging credits. Each manufacturer will carry out its own strategy to meet the regulations based on its capabilities and position in the market.

Projected industry compliance assuming GHG reductions

Additional improvements to fleet GHG emissions are expected over the course of the regulations. To demonstrate the impact GHG reductions would have on the credit balance of the industry, CAR conducted the same analysis as the previous section with the inclusion of a fleet-wide GHG emissions reduction. All other aspects of the fleet such as sales, credits, and footprint were kept as they were in the previous analysis.

Between MY 2004 and MY 2013 the automotive industry had reduced GHG emission of the fleet by approximately two percent per year (Figure 3). Based on the prior reductions in GHG emissions, CAR analyzed the effect a two percent reduction would have on the industry credit balance through MY

2025. In addition, analysis of three and four percent reductions was added to show the influence additional improvements would have on the fleet.

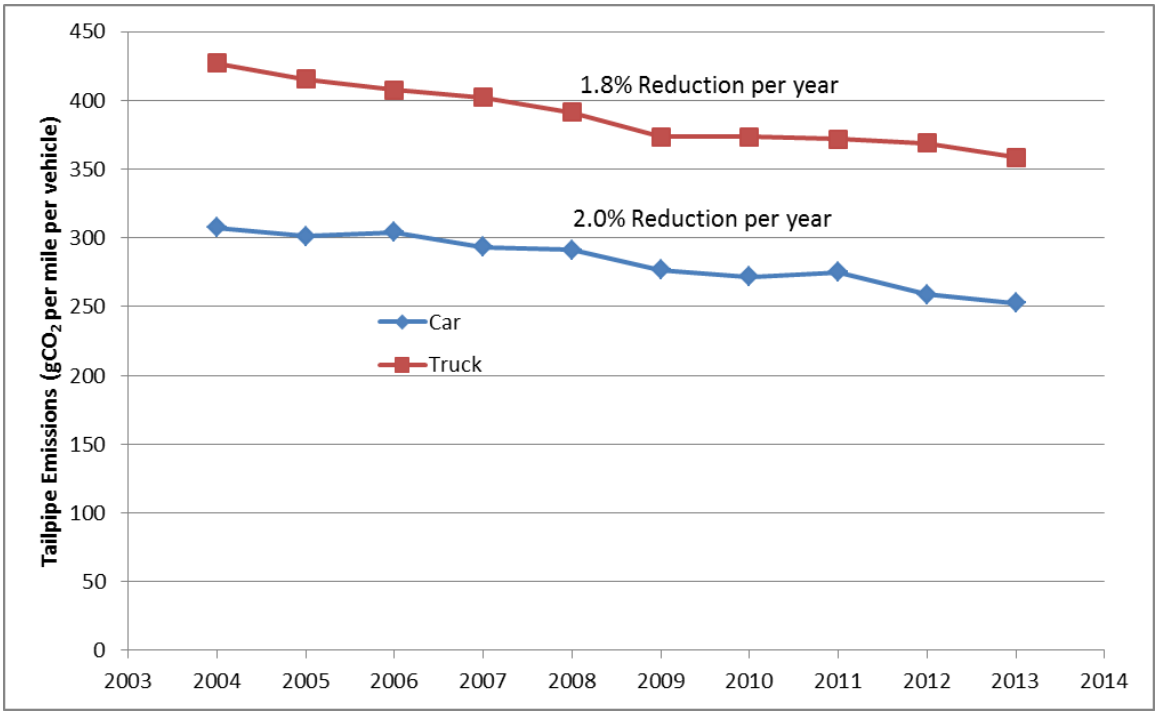

Figure 3 Industry-wide tailpipe emissions for 2004 - 2013
Source: EPA 2015

The results from additional reductions in GHG emissions without any other changes to the fleet for MY 2015 through MY 2025 are shown in Figure 4. With the additional GHG emissions reductions to the fleet, a positive credit balance through MY 2019, MY 2021, and beyond MY 2025 would occur with a fleet GHG emission reduction of two, three, and four percent respectively. While the credit balance for a four percent improvement per year the industry would extend beyond MY 2025, starting with MY 2021, the credit balance would once again begin to decline.

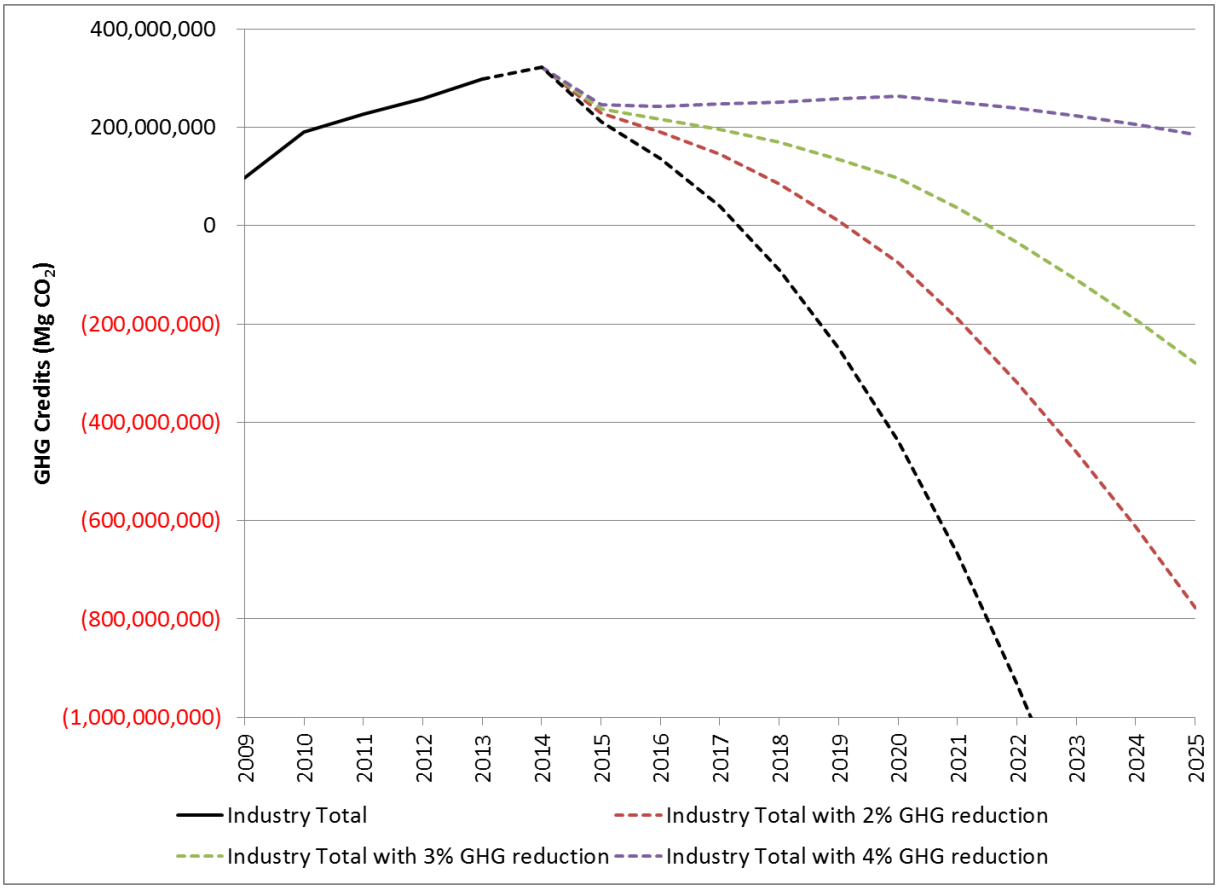

Figure 4 Cumulative GHG Credits for the Industry Assuming 2, 3, and 4 percent Tailpipe Emission Improvements, MY 2009 - 2025

Source: EPA 2015, CAR 2015

Implications for the Industry

The automotive industry faces a substantial challenge meeting fuel economy and GHG regulations. If the vehicle fleet were to remain static (i.e., sales, emissions, and credits) after MY 2014, the industry as a whole would incur a deficit of GHG credits and none of the manufacturers would have enough credits to carry forward past MY 2021. Improvements in GHG emissions beyond what has been experienced over the past 10 years will be needed to maintain a positive credit balance over the next 10 years. How each manufacturer will comply with the standards and what will happen if they do not remains in question.

Manufacturers have the option of buying and selling credits as a method of compliance; however, with the potential that none of the automakers would be able to meet the standards long term, there is a strong possibility manufacturers will hold on to the credits they have. Also, the expense of buying credits may limit the potential of a manufacturer to invest in technology that would further reduce GHG emissions of its fleet. Theoretically, credit trading may allow some manufacturers to sell vehicles with non-conforming emissions while others sell vehicles based on other attributes preferred by some consumers. As a result, some manufacturers might be vulnerable if those credits were no longer available or if the regulations are lessened in stringency.

Continuing the current trend of two percent GHG emission reductions per year would extend the positive credit balance of the industry fleet by a mere two years. It should be noted that the two percent reduction between MY 2004 and MY 2013 occurred at a time of relatively unchanged fuel economy standards but increasingly expensive gas prices. This means manufacturers generally will need to reduce GHG emissions by approximately four percent per year through MY 2021 and increase the rate beyond four percent per year after MY 2021 to prevent an eventual reduction in credit surpluses. Further, with the increasingly stringent standards, all manufacturers may be greatly challenged to sell more fuel efficient vehicles at a faster rate than in previous years.

The strategies used to meet the regulations are becoming increasingly apparent. For example, Ford has gained notice for the recent conversion to aluminum for body panels on the F-150 pickup truck. This decision may have been driven in part by the company's long history of research in aluminum component processing. Similarly, Toyota has leveraged its hybrid technology capabilities to boost its fleet-wide GHG level. Each individual company will continue to pursue strategies to leverage its unique strengths; however, each company will also need to broaden its technology portfolio to meet future standards.

This report represents analysis to demonstrate how much advancement will be required by the industry to achieve the corresponding EPA GHG regulation. The key question is: ***Can the vehicle manufacturers keep pace with the regulations, or will they burn through the credits they currently have?***

While each OEM is taking a different and unique approach, and will decide its own best strategies, none of the leading automotive manufacturers in the U.S. market will meet the future standards without significant advances in fleet fuel efficiency. CAR will continue to monitor and consult on the progress of the industry, develop additional analysis and scenarios highlighting the continued performance of the industry, and update this report and our analysis as new data becomes available.

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EPA and NHTSA. (2008). *2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards.*

EPA and NHTSA. (2011). *Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule.*

Appendix A: Petroleum Reduction Credit Calculations

Credits due to petroleum reduction may be calculated using data provided in the EPA Manufacturer Performance Report and estimated the reduction in fuel efficiency due to compromises of flex fuel powertrains. The EPA report includes sales of flex-fuel vehicles and credits earned for flex fuel vehicles. The following calculations were used by CAR to estimate the credits to due petroleum reduction.

The GHG rating of a flex fuel vehicle with petroleum reduction credits is:

$$(eq1)\ GHG_{FFVcurrent} = 0.5 * GHG_{FFV\ only\ gasoline} + 0.15 * 0.5 * GHG_{E85}$$

The flex-fuel portion of the eq1 is multiplied by 0.15 to account for the petroleum reduction credit of 85 percent. Starting with the model year 2016, the EPA will no longer offer petroleum reduction credits. Based on this change, the GHG rating of a flex-fuel vehicle will be:

$$(eq2)\ GHG_{FFV\ MY2016} = 0.5 * GHG_{FFV\ only\ gasoline} + 0.5 * GHG_{E85}$$

The fuel economy penalty of operating a flex-fuel vehicle on E85 instead of gasoline is between 15 and 30 percent.[7] The fuel economy penalty of 15 percent is based on an E85 blend with only 51 percent ethanol content while the 30 percent estimate is based on EPA estimates of performance during testing. There are also estimates from the U.S. Department of Energy (DOE) of a 25 percent fuel economy penalty.[8] For the purpose of this study, a fuel economy penalty of 27.5 percent was used. This penalty is offset by a reduction in the amount of CO_2 generated per gallon of ethanol compared to gasoline. For every gallon, 6,295 gCO_2 are generated from ethanol and 8,887 gCO_2 for gasoline. Using these estimates the GHG rating while using E85 is estimated as:

$$(eq3)\ GHG_{E85} = \frac{6{,}295 * GHG_{FFV\ only\ gasoline}}{8{,}887 * 0.725} = 0.977\ GHG_{FFV\ only\ gasoline}$$

Replacing GHG_{E85} from eq3 into eq1 and eq2 leaves:

$$(eq4)\ GHG_{FFVcurrent} = 0.5 * GHG_{FFV\ only\ gasoline} + 0.15 * 0.5 * 0.977 * GHG_{FFV\ only\ gasoline}$$

$$GHG_{FFVcurrent} = 0.57 * GHG_{FFV\ only\ gasoline}$$

$$(eq5)\ GHG_{FFV\ MY2016} = 0.5 * GHG_{FFV\ only\ gasoline} + 0.5 * 0.977 * GHG_{FFV\ only\ gasoline}$$

$$GHG_{FFV\ MY2016} = 0.9885 * GHG_{FFV\ only\ gasoline}$$

Finally, to calculate the portion of GHG reduction due to petroleum reduction a comparison must be made between the GHG performance of the fleet with and without E85. The GHG performance of the fleet without any benefit of E85 would be calculated as follows:

[7] http://www.fueleconomy.gov/feg/flextech.shtml
[8] http://www.afdc.energy.gov/uploads/publication/ethanol_basics.pdf

$$(eq6)\ GHG_{baseline} = \frac{Sales_{FFV} * GHG_{FFV\ only\ gasoline} + Sales_{non-FFV} * GHG_{non-FFV}}{Sales_{total}}$$

The GHG performance of the fleet utilizing credits available to flex-fuel vehicles for both petroleum reduction and GHG reductions is as follows:

$$(eq7)\ GHG_{with\ full\ FFV} = \frac{Sales_{FFV} * GHG_{FFV} + Sales_{non-FFV} * GHG_{non-FFV}}{Sales_{total}}$$

From these two equations, the GHG performance of the fleet without use of flex fuels may be calculated as:

$$(eq8)\ GHG_{FFV\ only\ gasoline} = \frac{Sales_{total}(GHG_{baseline} - GHG_{with\ full\ FFV})}{Sales_{FFV}}$$

The credits lost as a result of elimination of the petroleum reduction credit is calculated as follows:

$$\text{(eq9) Maximum Petroleum Reduction Credits} = \frac{Sales_{FFV}(GHG_{FFV\ MY2016} - GHG_{FFV\ current})}{Sales_{total}}$$

Using eq4 and eq5, the final tally for the elimination of petroleum reduction credits is:

$$\text{(eq10) Maximum Petroleum Reduction Credits} = 0.4185\frac{Sales_{FFV} * GHG_{FFV\ only\ gasoline}}{Sales_{total}}$$

- Actual FFV credits are capped - credits for 2016 must be compared to capped credits in MY 2012
- Vehicles experience about a 25 to 30 percent reduction in fuel economy when operating on E85

$$CO_{2_{E85}} = \frac{(1 - FE\ reduction_{gas\ to\ E85}) * CO_{2_{gas}} * \frac{CO_2}{Gallon\ E85}}{\frac{CO_2}{Gallon\ Gasoline}} = \frac{0.725 * CO_{2_{gas}} * 6297}{8887}$$
$$= 0.977 * CO_{2_{gas}}$$

Appendix B: Summary of Data Sources and Uses

Year	Tailpipe Performance	A/C and Off-cycle Credits	FFV Petroleum Reduction Credits	Credit Carryover
MY 2009 – 2013	EPA MY 2013 MPR	EPA MY 2013 MPR	EPA MY 2013 MPR	
MY 2014	2014 EPA tech trends report MY 2014 prelim data	EPA MY 2013 MPR MY 2013 data carryover	EPA MY 2013 MPR MY 2013 data carryover	
MY 2015	2014 EPA tech trends report MY 2014 prelim data	EPA MY 2013 MPR MY 2013 data carryover	EPA MY 2013 MPR MY 2013 data carryover	Elimination of MY 2009 credits
MY 2016 and Beyond	2014 EPA tech trends report MY 2014 prelim data	EPA MY 2013 MPR MY 2013 data carryover	Eliminated	

MPR = Manufacturer Performance Report