Greenhouse Gas Emission Standards for Light-Duty Vehicles

Aston Martin
Lotus
McLaren
Tesla
Kia
BYD Motors
Toyota
Honda
Mazda
Ford
Subaru
General Motors
Mitsubishi
Nissan
Volkswagen
BMW
Fiat Chrysler
Volvo
Mercedes-Benz
Suzuki
Jaguar
Land Rover
Ferrari
Hyundai
Coda
Fisker
Porsche
Aston Martin
Lotus
McLaren
Tesla
Kia
BYD Motors
Toyota
Honda
Mazda
Ford
Subaru
General Motors
Mitsubishi
Nissan
Volkswagen
BMW
Fiat Chrysler
Volvo
Mercedes-Benz

Manufacturer Performance Report for the 2016 Model Year

United States Environmental Protection Agency

EPA-420-R-18-002 January 2018

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NOTICE:

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.

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Background

On May 7, 2010, the Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) issued a joint Final Rule to establish the first phase of a National Program with new standards for 2012 to 2016 model year light-duty vehicles that reduce greenhouse gas (GHG) emissions and improve fuel economy. These standards apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles. Subsequently, on October 15, 2012, EPA and NHTSA issued standards for GHG emissions and fuel economy of light-duty vehicles for model years 2017–2025, building on the first phase of the joint National Program.

EPA is releasing this report as part of our continuing commitment to provide the public with transparent and timely information about manufacturers' compliance with the GHG program.[1] This report supersedes previous reports and details manufacturers' performance towards meeting GHG standards in the 2016 model year, the fifth and final year of the first phase of the EPA GHG standards. This report includes data through the end of the 2016 model year. Some values from previous model years may have changed based on changes or corrections to the historical data.[2]

The following figure illustrates the process and the inputs that determine a manufacturer's compliance with the light-duty vehicle GHG emission standards. Every manufacturer starts at the same place: by measuring the CO_2 tailpipe emissions performance of their vehicles using EPA's City and Highway test procedures (referred to as the "2-cycle" tests). Then they may choose to apply a variety of optional technology-based credits to further reduce their fleet GHG emissions compliance value. The 2-cycle tailpipe CO_2 value, when reduced by the net grams per mile equivalent of the optional credits, determines a manufacturer's model year performance and whether credits or deficits are generated by a manufacturer's model year fleet.

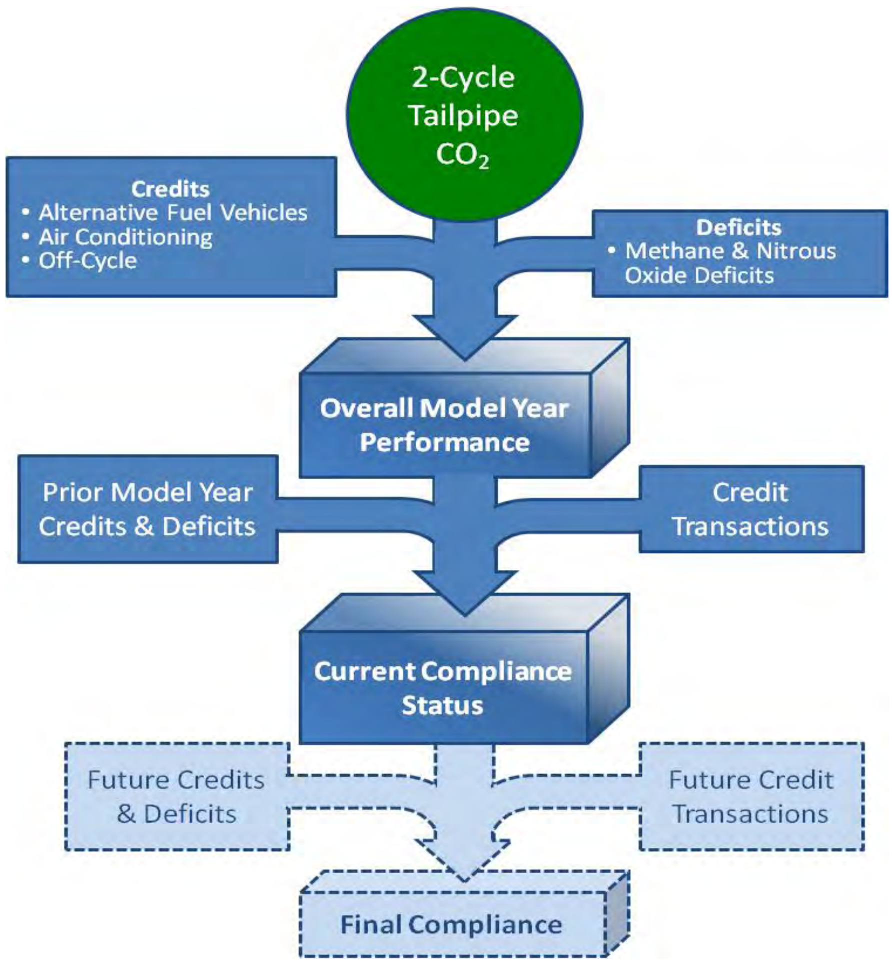
It is important to note that the Department of Justice, on behalf of EPA, alleged violations of the Clean Air Act by Fiat Chrysler Automobiles based on the sale of certain 2014 through 2016 model year vehicles equipped with devices that defeat the vehicles' emission control systems. In addition, the Department of Justice and EPA have reached a settlement with Volkswagen over the use of defeat devices for certain 2009 through 2016 model year vehicles. In this report, EPA uses the CO_2 emissions and fuel economy data from the initial certification of these vehicles. Should the investigation and corrective actions yield different CO_2 and fuel economy data, any relevant changes will be used in future reports. For more

[1] Relevant information on the CAFE program can be found on the NHTSA website at NHTSA's CAFE Public Information Center: http://www.nhtsa.gov/CAFE_PIC/CAFE_PIC_Home.htm.

[2] This report summarizes data as it was reported to EPA by the manufacturers and does not necessarily represent final EPA decisions or positions regarding the data or the compliance status of manufacturers.

information on actions to resolve these alleged violations, see www.epa.gov/vw and www.epa.gov/fca.

Process for Determining a Manufacturer's Compliance Status

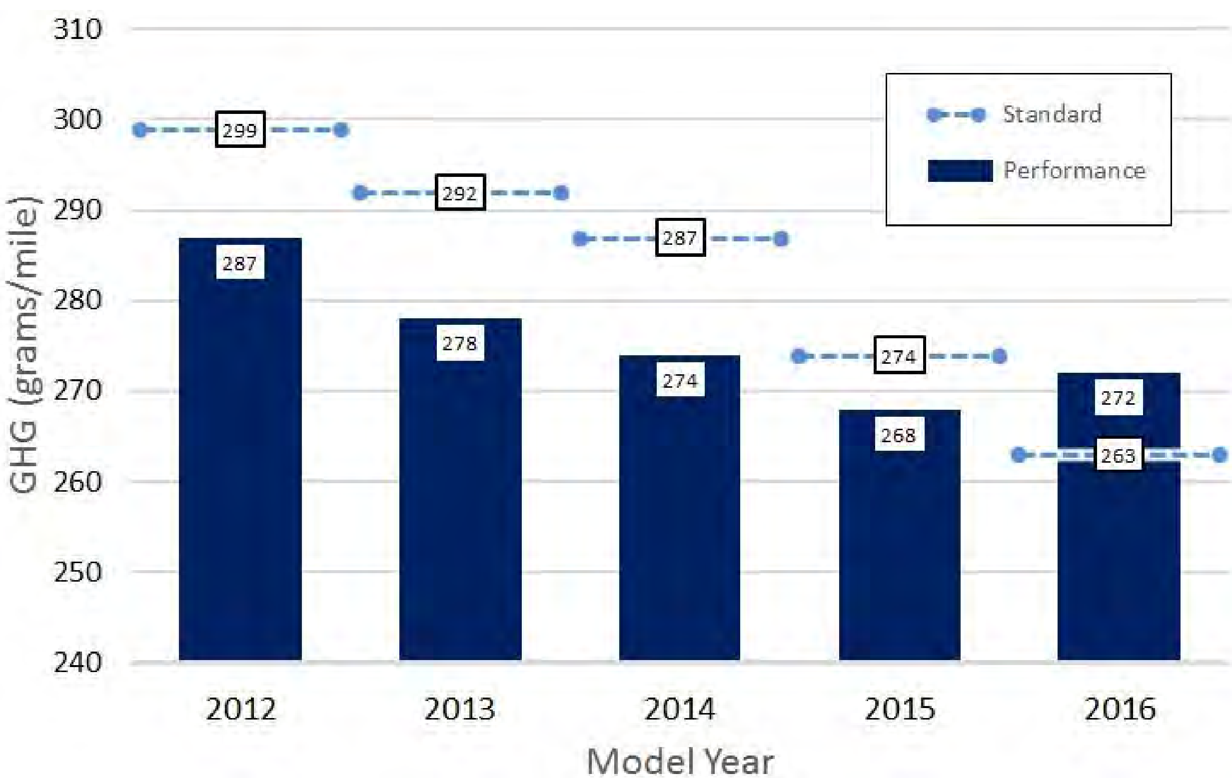


Individual model year performance, however, does not directly determine model year compliance or non-compliance. Manufacturers with deficits in a model year may use credits carried over from a previous model year to offset a deficit. They may also purchase credits from another manufacturer. Manufacturers with a deficit at the conclusion of a model year may also carry that deficit forward into the next model year. Manufacturers must, however, offset any deficit within three years after the model year in which it was generated to avoid enforcement action. After considering these additional credits and deficits, EPA determines a manufacturer's current compliance status. For example, a manufacturer with a deficit remaining from model year 2013 after the 2016 model year would be considered out of compliance with the 2013 model year standards. As this report will show, there are no manufacturers that ended 2016 in this position. No manufacturer is yet out of compliance with the GHG program in any of these first five model years; their performance in subsequent years, and whether deficits can be successfully offset using future credits (either generated or acquired) will ultimately determine final compliance.

1 ***The auto industry generated a GHG deficit in the 2016 model year, but all major manufacturers comply with the 2016 standards, with some companies using credits from prior years.***

Overall industry performance in model year 2016 was 9 grams/mile higher than required by the 2016 GHG emissions standard. This makes 2016 the first model year in which the industry generated a GHG emissions deficit, after generating credits in each of the first four years of EPA's program. The increases in stringency in the standards in the 2015 and 2016 model years were the largest increases in the first phase of EPA's GHG program; since the 2014 model year the standards have decreased by 24 grams/mile. The standards were intentionally structured with this progression of increasing stringency, as explained in the rulemaking. A contributing factor to the 9 gram/mile industry-wide gap between performance and the standard in the 2016 model year was the expiration of flexible fuel vehicle credits. Due to the credits accumulated in the previous four years and early credits generated by some manufacturers in the 2009-2011 model years, some of which were used to offset the 2016 deficit, the industry as a whole does not face any non-compliance issues in the 2016 model year. See Section 3 for more detail on these values.

Figure ES-1. Industry Performance versus Standards, 2012-2016 Model Years

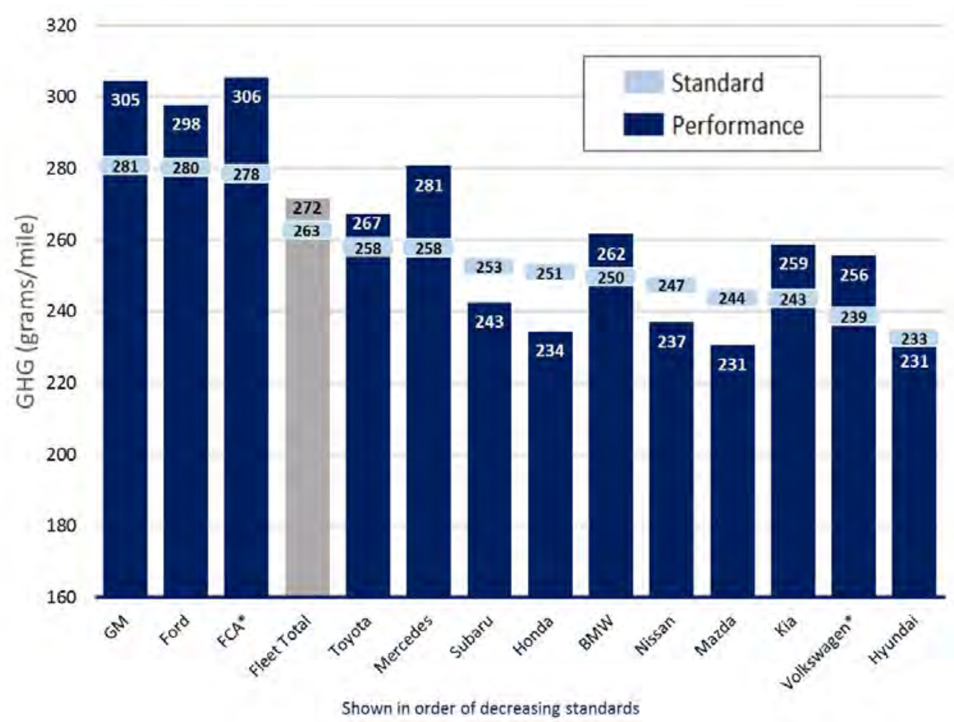


2

Eight out of the thirteen largest manufacturers generated deficits relative to their 2016 model year standards, but used credits from previous model years to comply.

Unlike the previous four years, in which generating credits was the norm, most large manufacturers (with sales greater than 150,000 vehicles) generated deficits in the 2016 model year. Five of the thirteen manufacturers reported beating their standard, with compliance margins ranging from 16 grams/mile (Honda) to 1 gram/mile (Hyundai). The remaining eight generated deficits against their standard due to fleet GHG emissions that were higher than the standard by amounts ranging from 10 grams/mile (Toyota) to 28 grams/mile (FCA). Note that the figure below does not include the impact of credit transfers reported from prior model years (within a company) or reported credit trades (transactions between companies), and thus does not portray whether or not a manufacturer has complied with the 2016 model year standards. In fact, the manufacturers that generated a 2016 model year GHG deficit have reported sufficient credits available from prior model years to be able to offset that deficit and thus achieve compliance with their respective 2016 model year standards. More detail about model year 2016 performance is provided in Section 3.

Figure ES-2. Manufacturer Performance and Standards in the 2016 Model Year



* FCA and Volkswagen are subjects of an ongoing investigation and/or corrective actions. These data are based on initial certification data provided to EPA, and are included in industry-wide, "Fleet Total", or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Note: Rounding may result in differences between charts and tables and the values reported in the text.

3 All large manufacturers concluded Phase 1 of EPA's GHG standards meeting the standards and with substantial credits available to use through 2021.

The majority of manufacturers, representing 99 percent of 2016 model year U.S. sales, have reported compliance with the standards for the 2012-2016 model years. In fact, 19 of 21 manufacturers are reporting a non-negative credit balance going into the 2017 model year, meaning that these manufacturers have met the standards in all of the 2012-2016 model years (credits cannot be carried forward if a deficit exists in a prior model year). Manufacturers are allowed to carry deficits forward for three model years. Thus, a manufacturer with a deficit from the 2016 model year (such as Volvo) must offset that deficit by the end of the 2019 model year, or be subject to possible enforcement action. All manufacturers that initially reported a deficit in the 2012-2013 model years have successfully offset that deficit, thus no manufacturer is in a position of non-compliance for any model year at the end of the 2016 model year. The makeup of these credit and deficit balances is tracked by model year "vintage" as explained in Section 5.

Table ES-1. Credit Balances After the 2016 Model Year (Mg)[3]
(including credit transfers & trades)[4]

Manufacturer	Credits Carried to 2017	Manufacturer	Credits Carried to 2017
Toyota	78,078,963	Mercedes	2,991,505
Honda	36,024,476	Mitsubishi	1,755,470
Nissan	26,682,834	Suzuki*	428,242
Ford	22,084,139	Karma Automotive*	58,852
Hyundai	20,583,544	BYD Motors*	4,824
GM	19,666,700	Tesla	576
Subaru	14,498,843	Volvo	(9,218)
Mazda	9,424,551	Jaguar Land Rover	(1,387,781)
Kia	6,011,615	*FCA†*	*19,217,792*
BMW	3,202,342	*Volkswagen†*	*2,438,608*
All Manufacturers			**261,759,183**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.
*Although these companies produced no vehicles for the U.S. market in the most recent model year, the credits generated in previous model years continue to be available.

[3] The Megagram (Mg) is a unit of mass equal to 1000 kilograms. It is also referred to as the metric ton or tonne.
[4] This table does not include unused credits from the 2009 model year, which expired at the end of the 2014 model year. See Section 2 for more information.

1. INTRODUCTION

A. Why Are We Releasing This Information?

We are releasing this report as part of our continuing commitment to provide the public with transparent and timely information about manufacturers' performance under EPA's GHG program. In the two regulatory actions that established new GHG emissions and fuel economy standards for light-duty vehicles, EPA and NHTSA committed to making certain information public regarding the compliance of automobile manufacturers with the CO_2 and fuel economy standards.[5,6] This report is the fifth such report released regarding EPA's GHG program. Because of changes that propagate back to prior model years, such as the buying and selling of credits by manufacturers, prior reports should be considered obsolete and are superseded by this report.

When EPA and NHTSA issued the proposed rule for the 2012-2016 model year CO_2 and fuel economy standards, the proposal received considerable comment about the need for transparency regarding implementation of the program, and specifically, regarding compliance determinations.[7] Many comments emphasized the importance of making GHG compliance information publicly available to ensure such transparency. This was also the case with the proposal for 2017-2025 model year GHG standards, in which we reiterated our commitment to the principle of transparency and to disseminating as much information as we are reasonably, practically, and legally able to provide.[8] In response to the comments on the proposed rule for 2012-2016 model year standards we noted that our public release of data could include "…GHG performance and compliance trends information, such as annual status of credit balances or debits, use of various credit programs, attained fleet average emission levels compared with standards, and final compliance status for a model year after credit reconciliation occurs" and that we would "…reassess data release needs and opportunities once the program is underway."[9]

In the final rule for model years 2017-2025, we also committed to expanding the information we release regarding GHG program compliance, noting in the preamble that "…EPA intends to publish the applicable fleet average standards (for cars and for trucks) and the actual fleet performance for each manufacturer, and the resulting credits or debits." Further, we stated that we anticipate publishing "…the amount of credits generated by each

[5] A comprehensive description of the EPA GHG program is beyond the scope of this document, thus readers should consult the regulatory announcements and associated technical documents for a detailed description of the program.
6 NHTSA now provides information to the public regarding fuel economy compliance through a web-accessible public information center. See https://one.nhtsa.gov/cafe_pic/CAFE_PIC_Home.htm.
[7] Proposed Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Proposed Rule, Federal Register 74 (28 September 2009): 49454-49789.
[8] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Final Rule, Federal Register 77 (15 October 2012): 62889.
[9] Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Final Rule, Federal Register 75 (7 May 2010): 25469.

manufacturer (separately for each of the car and truck fleets) under the optional credit programs, and the associated volumes of vehicles to which those credits apply." We also suggested that we would likely publish credit transactions, as well as the overall credit or debit balance for each manufacturer after taking into account the credit and debit carry-forward provisions and any credit transactions.

In addition to this and prior reports, we continue to release a considerable amount of information regarding fuel economy, emissions, and vehicle characteristics for each vehicle model. For example, starting with the 2013 model year, the downloadable data available at fueleconomy.gov includes CO_2 emission values for each vehicle model. In addition, we release actual vehicle emission test results on the Office of Transportation and Air Quality website, as well as detailed information on long-term industry-wide CO_2, fuel economy, and technology trends since model year 1975.[10] This latter report does not contain formal compliance data, but rather focuses on EPA's best estimates of real world CO_2 emissions and fuel economy.

B. What Data Are We Publishing?

The EPA GHG program requires compliance with progressively more stringent GHG standards for the 2012 through 2025 model years. The program includes certain flexibilities, several of which were designed to provide sufficient lead time for manufacturers to make technological improvements and to reduce the overall cost of the program, without compromising overall environmental objectives. The 2016 model year is the fifth year manufacturers have been subject to the standards. This report makes comparisons across the five complete model years of the GHG program where appropriate. This report contains updated data for previous model years and supersedes previous reports regarding manufacturer compliance with EPA's GHG program.

The manufacturer-reported 2016 model year data which form the basis for this report was required to be submitted to EPA by May 1 of 2017.[11] The data reported by each manufacturer includes the calculated manufacturer-specific footprint-based CO_2 standard for each vehicle category (car and truck), the actual fleet-average tailpipe performance for each vehicle category, the quantity of optional credits (e.g., based on air conditioning or off-cycle technology improvements), credit transfers within a manufacturer between car and truck fleets, credit trades between manufacturers, if applicable, and all the data necessary to calculate these reported values. The data being reported is subject to change due to future EPA approvals of "off-cycle" technology credits, credit transactions, correction of errors discovered by manufacturers or by EPA, or the results of other EPA investigations or actions. This report does not represent a final approval or validation of credits reported to EPA by manufacturers.

[10] See https://www.epa.gov/compliance-and-fuel-economy-data/data-cars-used-testing-fuel-economy and https://www.epa.gov/fuel-economy-trends.

[11] See 40 CFR 600.512-12.

This report first updates and summarizes the credits reported by manufacturers under the early credit provisions, and then summarizes the data reported by manufacturers for the 2012-2016 model years in a variety of ways. This includes separately detailing manufacturers' reported use of the flexibilities included in the program (e.g., credits for air conditioning improvements or reduced "off-cycle" emissions), as well as the credit transactions between manufacturers.

Vehicle and fleet average compliance for EPA's GHG program is based on a combination of CO_2, hydrocarbons, and carbon-monoxide emissions (i.e., the carbon-containing exhaust constituents). This is consistent with the carbon balance methodology used to determine fuel consumption for the vehicle labeling and CAFE programs. The regulations account for these total carbon emissions appropriately and refer to the sum of these emissions as the "carbon-related exhaust emissions," or "CREE." The carbon-containing emissions are combined on a CO_2-equivalent basis to determine the CREE value, i.e., adjusting for the relative carbon weight fraction of each specific emission constituent. Although the regulatory text uses the more accurate term "CREE" to represent the CO_2-equivalent sum of carbon emissions, the term CO_2 is used as shorthand throughout this report as a more familiar term for most readers.

The CO_2 standards in EPA's GHG program and the related compliance values in this report differ from the CO_2 values reported in EPA's "Trends" report or on new vehicle fuel economy labels.[12] The Trends report presents CO_2 and fuel economy values that are based on EPA's label methodology, which is designed to provide EPA's best estimate of the fuel economy and GHG emissions that an average driver will achieve in actual real-world driving. EPA's CO_2 standards, like the CAFE standards, are not adjusted to reflect real world driving. Instead, the GHG standards and compliance values are based on the results achieved on EPA's city and highway tests, weighted 55 and 45 percent, respectively. These tests are conducted under ideal driving conditions and do not reflect a number of driver and environmental conditions that impact real world fuel economy. Results from these two tests are commonly referred to as the "2-cycle" test procedures, in that they are based on weighted results from two unique driving cycles. The CO_2 values that appear in the Trends report and on the EPA fuel economy window stickers will be about 25 percent higher than those in this report, and are based on what is frequently referred to as the "5-cycle" methodology, because the results are based on five different test procedures. The 5-cycle methodology includes tests that capture the impacts of aggressive driving, cold temperatures, and hot temperatures with air conditioning operating, among other factors. None of these factors are reflected in the 2-cycle tests used to determine compliance with CAFE and GHG standards.

Credits are expressed throughout this report in units of Megagrams (Mg), which is how credits are reported to EPA by the manufacturers.[13] Further, compliance is ultimately

[12] "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2016. U.S. EPA-420-R-16-010, Office of Transportation and Air Quality, November 2016. See https://www.epa.gov/fuel-economy-trends.

[13] The Megagram (Mg) is a unit of mass equal to 1000 kilograms. It is also referred to as the metric ton or tonne.

determined based on the balance of Megagrams of credits and/or deficits for a given model year, after accounting for credit transfers and trades. In order to present the impact of these credits in terms that might be more understandable and are comparable equitably across manufacturers, we calculate and present a grams per mile equivalent value where possible (see inset on this page for the methodology used to convert Megagrams to grams per mile).[14] Where such a value in a table applies to a specific manufacturer, the grams per mile value represents the impact of credits on the fleet of that specific manufacturer, whereas the final Fleet Total row displays the grams per mile impact of the total credits across the entire model year fleet of cars, trucks, or combined fleet, whichever may be applicable. Finally, this report does not attempt to summarize or explain all of the elements or details of EPA's GHG program. Readers should consult EPA's final regulations and supporting documents for additional information.

How We Determine a Grams per Mile Equivalent from Megagrams (Metric Tons) of Credits and Deficits

The Megagrams (Mg) of credits or deficits reported to EPA are determined from values expressed in grams per mile. For example, fleet average credits/deficits are based on the difference between the fleet standard and the fleet average performance, each of which is expressed in grams per mile. The general form of the equation is:

Credits [Mg] = (CO_2 x VMT x Production) / 1,000,000

"CO_2" represents the credit in grams per mile. "VMT" represents the total lifetime miles, which we specified in the regulations as 195,264 miles for cars and 225,865 for trucks. "Production" represents the production volume to which the CO_2 credit applies.

The CO_2-equivalent of a credit value expressed in Mg is derived by reversing the equation as follows:

CO_2 [g/mi] = (Credits[Mg] x 1,000,000) / (VMT x Production)

When using this equation to calculate CO_2 grams per mile for aggregate car and truck credits, we use a weighted average of the car and truck VMT values. For example, for the entire 2016 model year fleet covered by this report, the weighted VMT is 208,946 miles. The weighting is by the proportion of cars or trucks relative to the total fleet. The weighting may be applied on a manufacturer-specific basis or across the entire fleet, depending on the data presented in each table. Unless specifically stated, this is always the source of combined car/truck fleet values in this report.

Two manufacturers in this report, FCA and Volkswagen, are affected by on-going investigations and/or corrective actions related to alleged violations of the Clean Air Act resulting in excess emissions of oxides of nitrogen (NOx). Oxides of nitrogen emissions are not directly related to tailpipe CO_2 emissions or fuel economy. In this report, EPA uses the CO_2 emissions data from the initial certification of these vehicles. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

In 2016 and 2017, the Department of Justice, on behalf of EPA, has resolved a civil enforcement case, through a series of three partial settlements, against Volkswagen AG, Audi AG, Dr. Ing. h.c. F. Porsche AG, Volkswagen Group of America, Inc., Volkswagen

[14] The quantity of Megagrams generated by a manufacturer is based on production volume, thus, larger manufacturers will produce larger balances of credits or deficits. Because of the connection to production volume, comparing Megagrams across manufacturers isn't meaningful, e.g., a higher volume of credits in Megagrams does not necessarily indicate better performance relative to the standard relative to other manufacturers with fewer credits.

Group of America Chattanooga Operations, LLC, and Porsche Cars North America, Inc. (collectively referred to as Volkswagen). Subject to their reservations, these settlements resolve allegations that Volkswagen violated the Clean Air Act with the sale of certain model year 2009-2016 diesel vehicles equipped with defeat devices in the form of computer software designed to cheat on federal emissions tests. The complaint alleged that during normal vehicle operation and use, the cars emit levels of oxides of nitrogen (NOx) significantly in excess of the EPA compliant levels. For more information, see www.epa.gov/vw. New fuel economy and CO_2 data is available for some vehicles that have been modified under the VW consent decree; however, this report does not reflect these revisions. Any relevant changes will be addressed in future reports.

In 2017, the Department of Justice, on behalf of EPA, filed a civil complaint against FCA US LLC, Fiat Chrysler Automobiles N.V., V.M. Motori S.p.A., and V.M. North America, Inc. (collectively referred to as FCA). The complaint alleges that certain diesel vehicles are equipped with software functions that were not disclosed to regulators during the certification application process, and that the vehicles contain defeat devices. The complaint alleges that the undisclosed software functions cause the vehicles' emission control systems to perform differently, and less effectively, during certain normal driving conditions than on federal emission tests, resulting in increased oxides of nitrogen (NOx) emissions. For more information on actions to resolve these violations, see www.epa.gov/fca.

Because the FCA and Volkswagen diesels account for less than 1% of industry production, updates to the emissions rates, whether they are higher or lower, will not change the broader trends characterized in this report. Should the investigations and corrective actions yield different CO_2 data, any relevant changes will be addressed in future reports.

C. How Can CO_2 Emissions Credits Be Used?

The ability to earn and bank credits, including early credits, is a fundamental aspect of the program's design, intended to give manufacturers flexibility in meeting the 2012-2016 model year standards, as well as to aid in the transition to the progressively more stringent standards in the 2017-2025 model years. Credits represent excess emission reductions that manufacturers achieve beyond those required by regulation under EPA's program. Credit banking, as well as emissions averaging and credit trading (collectively termed "Averaging, Banking, and Trading", or "ABT") have been an important part of many mobile source programs under the Clean Air Act. These programs help manufacturers in planning and implementing the orderly phase-in of emissions control technology in their production, consistent with their unique redesign schedules. These provisions are an integral part of the standard-setting itself, and not just an add-on to help reduce costs. In many cases, ABT programs address issues of cost or technical feasibility which might otherwise arise, allowing EPA to set a standard that is more stringent than could be achieved without the flexibility provided by ABT programs. EPA believes that the net effect of the ABT provisions allows additional flexibility, encourages earlier introduction of emission reduction technologies than might otherwise occur, and does so without reducing the overall effectiveness of the program.

Credits (or deficits) are calculated separately for cars and trucks. If a manufacturer reports a net deficit in either the car or truck category, existing credits must be applied towards that deficit. Although a deficit may be carried forward up to three years, under no circumstances is a manufacturer allowed to carry forward a deficit if they have credits available with which to offset the deficit. If credits remain after addressing any deficits, those credits may be "banked" for use in a future year, or sold or otherwise traded to another manufacturer. Credits earned in the 2010 through 2015 model years may be carried forward and used through the 2021 model year. Credits from the 2009 model year and 2016 and later model years may only be carried forward for five years. Thus, any early credits from the 2009 model year still held by a manufacturer after the 2014 model year have expired and have been removed from the manufacturer's credit bank.

D. Which Manufacturers and Vehicles Are Included in This Report?

The vast majority of manufacturers producing cars and light trucks for U.S. sale are currently covered by EPA's GHG program and are included in this report. Small businesses are exempted from the GHG program (but not from the CAFE program), and there are other manufacturers included in this report with unique circumstances, as explained below. The report generally uses the common and recognizable names for manufacturers, rather than their formal corporate names; "GM" instead of "General Motors Corporation," "FCA" instead of "Fiat Chrysler Automobiles," "Ford" instead of "Ford Motor Company," Mercedes" instead of "Mercedes-Benz," and so on. Finally, the company formally known as Fisker has changed ownership and has reemerged as Karma Automotive. Karma did not produce any vehicles in the 2016 model year, but the new ownership retains the credits from Fisker vehicles sold in the 2012 model year.

1. Small Businesses

Small businesses are exempt from EPA's GHG standards given that these businesses would face unique challenges in meeting the standards. However, the program allows small businesses to waive their exemption and voluntarily comply with the GHG standards. For example, a small manufacturer of electric vehicles could choose to comply if they were interested in generating GHG credits and potentially participating in the credit market. For the purpose of this exemption, a small business is defined using the criteria of the Small Business Administration (SBA). For vehicle manufacturers, SBA's definition of a small business is any firm with less than 1,500 employees. These businesses account for less than 0.1 percent of the total car and light truck sales in the U.S., thus this exemption has a negligible impact on overall GHG reductions.

2. Small Volume Manufacturers

Similar to small businesses, some very small volume manufacturers (i.e., manufacturers with limited product lines and production volumes that do not meet the SBA definition of a small business) would likely find the GHG standards to be extremely challenging and potentially infeasible. Given the unique feasibility issues faced by these manufacturers, EPA deferred establishing CO_2 standards for model years 2012-2016 for manufacturers with annual U.S. sales of less than 5,000 vehicles.[15]

To be eligible for deferment in each model year, a manufacturer must demonstrate a good faith effort to attempt to secure GHG credits to the extent credits are reasonably available from other manufacturers. Credits, if available, would be used to offset the difference between a company's baseline emissions and what their obligations would be under the GHG footprint-based standards. Three manufacturers – Aston Martin, Lotus, and McLaren – requested and received a conditional exemption for the 2012 model year. Because the 2012 model year was the first model year of the program, and because companies seeking conditional exemptions were required to submit their requests to EPA prior to the start of the 2012 model year, it is not surprising that a credit market had not yet developed, despite inquiries made by these three companies of manufacturers that were holding credits. The only manufacturers with any credits at the time were those with optional early credits, and most were likely awaiting the conclusion of the 2012 model year to better evaluate their ability to sell credits. Because of their conditionally exempt status for the 2012 model year, these three manufacturers were not included in EPA's report that covered that model year.[16] Since then, however, we have seen a number of credit transactions take place, as described in Section 4 of this report. As a consequence, EPA expects small volume manufacturers may be able to purchase credits and use them to comply with the standards in the 2013 and later model years. No conditional exemptions were approved for the 2016 model year. Small volume manufacturers may continue to make use of certain flexibilities the program provides for this category of manufacturers, including temporary relaxed standards and the ability to petition EPA for alternative standards.

Acknowledging the greater challenge that small volume manufacturers might face in meeting CO_2 standards compared to large manufacturers because they only produce a few vehicle models, EPA proposed and finalized a pathway allowing them to apply for alternative GHG emissions standards applicable to the 2017 and later model years.[17] Small volume manufacturers with annual U.S. sales of less than 5,000 vehicles may apply for alternative standards for up to five model years at a time, and the standards that EPA establishes for model year 2017 may optionally be met by the manufacturers in the 2015 and 2016 model years. Four manufacturers have applied for alternative standards: Aston Martin, Ferrari, Lotus, and McLaren. Because of the likelihood that these manufacturers will choose to meet the alternative standards in the 2015 and 2016 model years, and because a final determination of those standards has not been made by EPA, the data from these

[15] The deferment applies only to the fleet average CO_2 standards; these manufacturers are required to meet the applicable nitrous oxide (N_2O) and methane (CH_4) emission standards.
[16] Conditional exemptions are available only through the 2016 model year, after which manufacturers must comply with the GHG program standards or petition EPA for alternative manufacturer-specific GHG standards. The three manufacturers noted here have already submitted applications requesting alternative standards, and EPA is in the process of reviewing those applications.
[17] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Final Rule, Federal Register 77 (15 October 2012): 62889.

manufacturers have been excluded from this report. A future edition of this report will present the data from these four companies once the applicable standards are established and a valid credit balance can be reported.[18]

3. Operationally Independent Manufacturers

Some manufacturers, even though they may be wholly or largely owned by another manufacturer, may consider themselves to be "operationally independent" from the company that owns them. EPA's GHG program contains provisions that allow these manufacturers to seek separate and independent treatment under the GHG standards, rather than be considered as part of their parent company. Manufacturers wishing to obtain operationally independent status are required to submit very detailed information to EPA regarding their business structure, financial operations, manufacturing operations, and management structure. The information in an application for operationally independent status must also be verified by an independent third party qualified to make such evaluations. Ferrari, which was owned by FCA during the 2015 model year, petitioned EPA for operationally independent status, and EPA granted this status to Ferrari starting with the 2012 model year.[19] As an operationally independent manufacturer in model year 2016 with a low U.S. sales volume (1852 cars in the 2016 model year), Ferrari has the same options as the three small volume manufacturers discussed above. However, Ferrari is not included in this report for reasons described above.

4. Aggregation of Manufacturers

We refer throughout this report to the names of manufacturers at the highest aggregated level, and it may not necessarily be readily apparent who owns whom and which brands, divisions, subsidiaries, or nameplates are included in the results of a given manufacturer. Table 1-1 shows how manufacturers are aggregated based on the ownership relationships and vehicle partnerships in the 2016 model year. Many other manufacturers are covered in the report, but their names and brands are self-explanatory and thus are not shown in Table 1-1.

[18] The regulations specify the requirements for the supporting technical data and information that a manufacturer must submit to EPA as part of its application. The process for considering such applications includes a draft determination published by EPA followed by a public comment period of 30 days after which EPA will issue a final determination establishing alternative standards for the manufacturer.

[19] FCA announced in October 2014 the intention to spin off Ferrari into a separate, shareholder-owned company. At the time of writing this report, the spin-off has been complete for more than a year.

Table 1-1. Aggregation of Manufacturers

Manufacturer	Manufacturers and Brands Included in U.S. Market
BMW	BMW, Mini, Rolls-Royce
FCA	Alfa Romeo, Chrysler, Dodge, Fiat, Jeep, Maserati, Ram
Ford	Ford, Lincoln
GM	Buick, Cadillac, Chevrolet, GMC
Honda	Acura, Honda
Jaguar Land Rover	Jaguar, Land Rover
Mercedes	Maybach, Mercedes-Benz, Smart
Nissan	Infiniti, Nissan
Toyota	Lexus, Scion, Toyota
Volkswagen	Audi, Bentley, Bugatti, Lamborghini, Porsche, Volkswagen

In 2009, Volkswagen acquired 49.9 percent of Porsche, and in 2012 purchased the remaining 51.1 percent, resulting in Volkswagen's full ownership of Porsche. EPA regulations allow for a reasonable transition period in the case of mergers such as this, requiring that Volkswagen AG (including Porsche) meet the GHG standards as a single entity "beginning with the model year that is numerically two years greater than the calendar year in which the merger/acquisitions(s) took place." This means that Porsche was considered a separate entity under the GHG program for the 2012 and 2013 model years, but beginning with the 2014 model year has been considered part of Volkswagen AG and included in the Volkswagen fleet for compliance purposes.

Additionally, the company formerly known as Fisker has undergone some ownership changes and is now known as Karma Automotive. Karma did not produce any vehicles in the 2016 model year, but they appear in this report because the credits generated in the 2012 model year by then Fisker are now held by Karma and continue to be carried forward under the new ownership.

2. Optional GHG Credits From 2009-2011 Model Years

One of the flexibilities in the GHG program is an optional program that allowed manufacturers with superior greenhouse gas emission reduction performance to generate credits in the 2009-2011 model years. Because this was an optional program, without any compliance implications in these early model years, only those manufacturers that achieved emissions performance beyond that required by existing California or CAFE standards chose to provide data; thus the data does not include information for all manufacturers. Also included in the data in this section are off-cycle credits approved by EPA; see Section 3.E for more information regarding these credits.

Early credits were earned through tailpipe CO_2 reductions, improvements to air conditioning systems that reduce refrigerant leakage or improve system efficiency, off-cycle credits for the implementation of technologies that reduce CO_2 emissions over driving conditions not captured by the "2-cycle" test procedures, and introduction of advanced technology vehicles (i.e., electric, fuel cell, and plug-in hybrid electric vehicles). The optional early credits program allowed manufacturers to select from four pathways that provided opportunities for early credit generation through over-compliance with a fleet average CO_2 level specified by EPA in the regulations. Manufacturers wishing to earn early credits selected one of these four pathways, and the selected pathway was followed for the three model years of 2009-2011. Since EPA's GHG standards did not begin until model year 2012, EPA established tailpipe CO_2 thresholds below which manufacturers were able to generate early fleet average credits. For two of the pathways, the tailpipe emission levels below which credits were available were equivalent to the GHG standards established by California prior to the adoption of the EPA GHG program. Two additional pathways included tailpipe CO_2 credits based on over-compliance with CO_2 levels equivalent to the CAFE standards in states that did not adopt the California GHG standards. In March of 2013, EPA released a report documenting manufacturers' use of the early credit provisions allowed under the GHG program (the "early credits report").[20]

Table 2-1 summarizes the credits (or deficits) reported by manufacturers in each of the three model years for each participating manufacturer and shows the total net early credits for each manufacturer. The early credits program required that participating manufacturers determine credits for each of the three model years under their selected pathway, and that they carry forward their net credits from the three early years to apply to compliance with EPA's GHG standards in the 2012 and later model years. Thus, even manufacturers with a deficit in one or more of the early model years, (i.e., their tailpipe CO_2 performance was worse than the applicable emissions threshold under the selected pathway) could benefit from the early credits program if their net credits over the three years was a positive value. Manufacturers not listed in Table 2-1 chose not to participate in the early credits program.

[20] Greenhouse Gas Emission Standards for Light-Duty Automobiles: Status of Early Credit Program for Model Years 2009-2011, Compliance Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Report No. EPA-420-R-13-005, March 2013.

Additionally, this table is intended to show the credits reported by manufacturers in these years and does not include the impacts of any credit banking or trading on credit balances. In particular, the sale of some early credits by some manufacturers (see Section 4), while not shown in Table 2-1, impacts the available credit balances of the manufacturers involved in such transactions, as has the use of early credits to offset future model year deficits. Further, while credits from the 2009 model year may be used for compliance in 2014, any remaining unused 2009 model year credits expired after model year 2014 and were not carried forward into the 2015 or later model years. Table 2-2 shows the total early credits reported by each participating manufacturer, broken down by the type of credit reported. Note that the early credits program did not include credits for flexible fuel vehicles, whereas these credits are permitted in the 2012-2015 model years.

Table 2-1. Reported Early Credits, by Manufacturer and Model Year (Mg)

Manufacturer	2009	2010	2011	Total
BMW	512,973	359,131	379,418	1,251,522
Ford	8,358,440	7,438,264	319,749	16,116,453
GM	13,009,374	11,455,325	1,045,858	25,510,557
Honda	14,133,353	14,182,429	7,526,552	35,842,334
Hyundai	4,605,933	5,388,593	4,012,969	14,007,495
Kia	3,134,775	2,651,872	4,657,545	10,444,192
Mazda	1,405,721	3,201,708	875,213	5,482,642
Mercedes	96,467	124,120	157,685	378,272
Mitsubishi	625,166	521,776	302,394	1,449,336
Nissan	10,496,712	5,781,739	1,852,749	18,131,200
Subaru	1,620,769	2,225,296	1,909,106	5,755,171
Suzuki	448,408	329,382	98,860	876,650
Tesla	-	35,580	14,192	49,772
Toyota	31,325,738	34,457,797	14,651,963	80,435,498
Volvo	194,289	359,436	176,462	730,187
FCA†	*6,265,066*	*5,310,269*	*(1,164,014)*	*10,411,321*
Volkswagen†	*2,243,205*	*2,811,663*	*1,386,537*	*6,441,405*
All	**98,476,389**	**96,634,380**	**38,203,238**	**233,314,007**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 2-2. Total Reported Early Credits, By Credit Category

Credit Category	Credits (Mg)	Percent of Total (%)
Tailpipe CO_2*	198,792,034	85
A/C Leakage	23,429,772	10
A/C Efficiency	8,551,932	4
Off-Cycle	2,540,269	1
Total	**233,314,007**	**100**

*Tailpipe CO_2 credits in the early credits program do not include credits from flexible fuel vehicles.

Early credits from advanced technology vehicles (electric vehicles, plug-in hybrid electric vehicles, and fuel cell vehicles) may be included in Table 2-2, depending upon how the manufacturer chose to account for them. In these early credit years, manufacturers producing advanced technology vehicles had two options available to them. They could simply incorporate these vehicles into their fleet averaging in the relevant model year calculations using zero grams per mile to represent the operation using grid electricity (see the discussion of advanced technology vehicles in Section 3.C for more information regarding this incentive). Alternatively, the program allowed manufacturers to exclude them from their fleet average in the 2009-2011 model years and carry the vehicles forward into a future model year, where they must be used to offset a GHG deficit. Four manufacturers had qualifying vehicles in the 2009-2011 model years. GM and Mercedes chose the latter approach, while Nissan and Tesla chose the former approach. Advanced technology vehicle credits are discussed in more detail in Section 3.C which also reports the production volumes of advanced technology vehicles for the 2009-2016 model years.

Due to concerns expressed by stakeholders during the rulemaking process, EPA placed certain regulatory restrictions on credits from the 2009 model year.[21] Specifically, 2009 model year credits may not be traded to another company, and they retained a 5-year credit life. Thus, any unused 2009 model year credits expired at the end of the 2014 model year. Table 2-3 shows the credits left unused by each manufacturer at the end of the 2014 model year. These credits could not be carried forward to the 2015 model year, and were removed from each manufacturer's bank of credits. Note that of the nearly 100 million Mg of 2009 credits earned by manufacturers, almost 76 million Mg, or more than 75 percent, were never used and have now expired. The expired credits also amount to about one third of the total early credits accumulated by manufacturers in the 2009-2011 model years.

[21] Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Final Rule, Federal Register 75 (7 May 2010): 25324, 25328.

Table 2-3. Expired 2009 Model Year Credits

Manufacturer	Credits (Mg)
Toyota	29,732,098
Honda	14,133,353
Nissan	8,190,124
GM	6,894,611
Ford	5,882,011
Hyundai	4,482,649
Kia	2,362,882
Mazda	1,340,917
Mitsubishi	583,146
Subaru	491,789
Suzuki	265,311
BMW	134,791
Volkswagen†	*1,404,947*
All	**75,898,629**

†Volkswagen is listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Again, previous EPA reports regarding EPA's GHG program should serve only as historical references that are superseded by later reports. Each report is based on the best available data at the time of publication. This report regarding the 2016 model year should be used as the sole reference from which to determine credit balances and overall performance at the conclusion of the 2016 model year, and prior reports should generally be considered obsolete.

3. Credits Reported From the 2012-2016 Model Years

The mandatory compliance calculations that manufacturers must perform are (1) to determine credits or deficits based on manufacturer-specific, vehicle footprint-based CO_2 standards for both car and truck fleets, and (2) to demonstrate compliance with N_2O (nitrous oxide) and CH_4 (methane) exhaust emission standards. Compliance with CO_2 standards is assessed separately for car and truck fleets at the end of each model year, using emission standards and fleet average values determined based on the sales-weighted actual production volumes of the model year. Compliance with N_2O and CH_4 standards is typically done in conjunction with emission tests for other pollutants, although there are additional options as described later in this report.

Although the minimum requirement is that manufacturers calculate credits (or deficits) based on fleet average tailpipe CO_2 emissions, manufacturers have several options to generate additional credits as part of their overall strategy to reduce GHG emissions and meet the standards. These options are described in detail in this report, and include credits for gasoline-ethanol flexible fuel vehicles, improvements to air conditioning systems that increase efficiency and reduce refrigerant leakage, reductions in emissions that aren't captured on EPA tests ("off-cycle" emissions), transitional alternative standards (for eligible low-volume manufacturers), and advanced technology vehicle incentives. The use of the optional credit provisions varies from manufacturer to manufacturer (some manufacturers have not availed themselves of the extra credit options, while others have used some combination of, or all, options available under the regulations). Although a manufacturer's use of the credit programs is optional, EPA projected that the standards would be met on a fleet-wide basis by using a combination of reductions in tailpipe CO_2 and use of the additional optional credit and incentive provisions in the regulations.

Compliance with the EPA GHG program is achieved with the use of many different building blocks, starting with tailpipe emissions levels and, depending on need, strategy, and technology development and availability, employing one or more credit or incentive programs as additional elements contributing to compliance. Depending on the manufacturer, some of these credit and incentive building blocks may or may not be used. However, all manufacturers start with the same two mandatory building blocks: (1) GHG emissions on a gram per mile basis as measured on EPA test procedures for each vehicle model, and (2) fleet-specific gram per mile CO_2 standards based on the footprint of models produced in each car and truck fleet in a given model year. If a manufacturer uses no credits, incentive programs, or alternative standards (if applicable), then we can assess compliance by comparing the production-weighted fleet average emissions from the emission tests with the fleet-specific footprint-based standards. However, most manufacturers are using some credits, incentives, or alternative standards (if applicable), thus for those manufacturers (and for the aggregated fleet as a whole) these building blocks must be accounted for before determining whether or not a standard is met. Indeed, EPA's rulemaking analysis projected that the use of credits and incentive programs would be an integral part of achieving compliance, especially in the early years of the program.

> **Important Note Regarding Tables**
> Many of tables in this section have a final row labeled "Fleet Total." This row indicates a value that is calculated based on the entire model year fleet and is not specific only to the manufacturers listed in the table. For example, not all manufacturers generated credits for air conditioning systems, but the final "Fleet Total" row in those tables indicates values that are calculated to show the impact of air conditioning credits on the entire model year fleet (i.e., across all manufacturers, whether or not they reported air conditioning credits).

We begin by discussing the "2-cycle" tailpipe GHG emissions value (Section 3.A), which is the starting point for compliance for every manufacturer. We then detail each of the different credit and incentive programs, distilling each to an overall gram per mile impact for each manufacturer. Section 3.B describes the temporary lead time allowance alternative standards (TLAAS); Section 3.C describes alternative fuel vehicle incentives, including the temporary flexible fuel vehicle incentives; Section 3.D describes credits based on air conditioning system improvements; Section 3.E describes off-cycle emission reductions; and Section 3.F discusses the impact of alternative methane and nitrous oxide standards. Once these values have been determined, the 2-cycle tailpipe value is reduced by the total of all the credit and incentive programs to determine a "compliance value," as described in Section 3.G. Section 3.H describes the derivation of manufacturer-specific CO_2 standards, which leads into Section 3.I, which concludes Section 3, by comparing the compliance values to the CO_2 standards to determine whether or not a given fleet generates credits or deficits in the model year. We also show results aggregated on an industry-wide car and light truck fleet basis and an industry-wide total combined fleet basis for informational purposes.

This report approaches the description of manufacturer compliance in the same manner as did the previous model year reports. Instead of focusing on Megagrams of credits and deficits (which is how credits are reported to EPA by the manufacturers), this report describes compliance (for each manufacturer's car, truck, and combined fleets, as well as for the aggregated industry) by describing each of the building blocks of compliance and the gram per mile contribution to a manufacturer's total compliance. However, note that the gram per mile values are calculated only for the purpose of this report, and are not specific compliance values defined in or required by the regulations.

A. "2-Cycle" Tailpipe CO_2 Emissions

The starting point for each manufacturer is to test their vehicles on two test procedures defined in EPA regulations: The Federal Test Procedure (known as the "City" test) and the Highway Fuel Economy Test (the "Highway" test). These tests produce the raw emissions data reported to EPA, which is then augmented by air conditioning credits, off-cycle credits, incentives for dual fuel vehicles, and other provisions, to produce the total compliance picture for a manufacturer's fleet. Results from these two tests are averaged together, weighting the City results by 55% and the Highway results by 45%, to achieve a single value for each vehicle model produced by a manufacturer. A sales-weighted average of all of the combined city/highway tailpipe values is calculated for each passenger car and light truck fleet and reported to EPA. This value represents the actual tailpipe CO_2 emissions of a fleet without the application of any additional credits or incentives, and as such, comparison with a fleet-specific CO_2 standard would be inappropriate.

Table 3-1 shows the 2-cycle tailpipe emissions for the car, truck and combined fleets reported by each manufacturer for the 2012-2016 model years.[22] Absent the use of credits and incentives, manufacturers demonstrated overall reductions in tailpipe GHG emissions in both the car and truck fleets in model year 2016 relative to model year 2015. Of the 17 manufacturers active in the program in the 2016 model year, excluding the small volume manufacturers, seven manufacturers increased aggregate fleet average tailpipe CO_2 emissions, while the remainder reported either no change or a decrease in the 2-cycle tailpipe emissions from their fleet. Across the industry, a small reduction in 2-cycle GHG emissions from both cars and trucks (3 g/mi for each fleet) led to a small net reduction of 1 g/mi in overall fleet-wide 2-cycle emissions. The overall reduction is lower than the individual fleet reductions because of a continuing shift of consumers to buying trucks, which reached 45 percent of the fleet in the 2016 model year.

On a percentage basis the most significant reductions from the 2015 to the 2016 model year were reported by Hyundai (-5%) and Mazda (-3.1%). Hyundai is interesting because their truck emissions increased by 15 g/mi and cars decreased by 10 g/mi, but an overall reduction was achieved because car sales made up 97 percent of Hyundai's fleet in model year 2016. Volvo's 9.9 percent reduction in CO_2 emissions (-33 g/mi) from their truck fleet led the industry, with Mazda not far behind at 9.1 percent. Kia led the way in the car fleet with a CO_2 reduction of 5.4 percent, with Hyundai following with a reduction of 4.1 percent, and then Ford, GM, and Honda showing reductions relative to model year 2015 between 1 and 3 percent. Jaguar Land Rover and Nissan have made the greatest percentage reductions in 2-cycle emissions since the first year of the program, demonstrating reductions of 16 and 17 percent, respectively. Mazda, Mercedes, and Subaru also showed double-digit reductions of 12, 14, and 13 percent, respectively. Every manufacturer except Toyota reduced 2-cycle emissions in the first phase of the program, from the 2012 to the 2016 model year (of course, Toyota entered the program in model year 2012 with CO_2 emissions among the lowest of all manufacturers).

[22] The values in Table 3-1 do not include the impacts of credits or incentives resulting from air conditioning improvements and off-cycle technologies. The impacts of these are detailed in subsequent sections. The values do reflect that direct tailpipe GHG emissions from electricity are zero, as well as the estimated real-world impact of the use of E85 in flexible fuel vehicles, as described in section 3.C.3. Because the values in this table do not include all credits and incentives, the table does not describe a manufacturer's actual model year performance or a manufacturer's compliance status.

Table 3-1. "2-cycle" Tailpipe CO_2 Production-Weighted Fleet Average Emissions (g/mi)

	Model Year 2012			Model Year 2013			Model Year 2014			Model Year 2015			Model Year 2016		
Manufacturer	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**
BMW	277	363	302	271	346	292	256	312	270	256	316	270	262	310	276
BYD Motors	0		0	0		0	0		0	No production volume					
Coda	0		0	0		0	No production volume								
Ford	261	385	315	256	375	321	256	375	315	258	353	311	254	354	311
GM	283	397	331	273	395	325	267	369	314	267	362	321	260	365	319
Honda	237	320	266	228	312	257	228	299	259	217	283	243	213	285	245
Hyundai	243	312	249	238	317	241	247	325	253	246	324	252	236	339	239
Jaguar Land Rover	376	439	426	347	414	399	330	377	369	324	343	339	322	361	356
Karma	102		102	No production volume											
Kia	258	324	266	252	301	254	265	330	269	260	327	266	246	330	267
Mazda	241	324	263	232	296	251	220	287	240	217	285	238	214	259	231
Mercedes	316	393	343	296	371	321	285	372	309	273	347	301	269	342	296
Mitsubishi	262	283	267	254	267	258	224	256	236	215	254	228	241	251	248
Nissan	258	382	295	232	340	266	229	335	263	217	307	245	221	297	246
Porsche	325	362	342	309	363	336	Included in Volkswagen								
Subaru	257	296	282	254	270	264	250	254	253	241	247	245	244	246	246
Suzuki	267	361	287	266	330	273	No production volume								
Tesla	0		0	0		0	0		0	0		0	0		0
Toyota	221	354	273	225	347	278	221	358	274	225	342	279	224	342	279
Volvo	297	343	311	292	348	318	288	348	319	254	333	285	249	300	283
FCA†	*300*	*384*	*357*	*289*	*380*	*344*	*298*	*364*	*346*	*275*	*354*	*329*	*288*	*348*	*331*
Volkswagen†	*274*	*332*	*282*	*272*	*327*	*279*	*266*	*336*	*280*	*251*	*336*	*269*	*247*	*320*	*264*
All	**259**	**369**	**302**	**251**	**360**	**294**	**250**	**349**	**294**	**243**	**336**	**286**	**240**	**332**	**285**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

B. TLAAS Program Standards

EPA established the Temporary Lead-time Allowance Alternative Standards (TLAAS) to assist manufacturers with limited product lines that may be especially challenged in the early years of EPA's GHG program. The TLAAS program was established to provide additional lead-time for manufacturers with narrow product offerings which may not be able to take full advantage of averaging or other program flexibilities due to the limited scope of the types of vehicles they sell. In the 2012 model year the program was used by Ferrari, Jaguar Land Rover, Mercedes, and Porsche. Aston Martin, Lotus, and McLaren – companies that were exempt from the 2012 standards under the program's small volume manufacturer provisions – joined the program in the 2013 model year and incorporated use of the TLAAS standards in their 2013-2015 model year compliance. Volvo placed a small fraction of their 2015 fleet, all trucks, under the TLAAS standards.

The TLAAS program was available only to manufacturers with 2009 model year U.S. sales of less than 400,000 vehicles, and, except as noted below, was available during the 2012-2015 model years. Under this program, a manufacturer was allowed to treat a portion of its fleet as a separate averaging fleet to which a less stringent CO_2 standard applied. Specifically, a qualifying manufacturer was allowed to place up to 100,000 vehicles (combined cars and trucks) under the less stringent standards over the four model years from 2012 through 2015 (i.e., this is a total allowance, not an annual allowance). The CO_2 standard applied to this limited fleet is 1.25 times – or 25 percent higher than – the standard that would otherwise be calculated for the fleet under the primary program. Providing that certain conditions are met, manufacturers with 2009 model year U.S. sales of less than 50,000 vehicles may be allowed an additional 150,000 vehicles (for a total of 250,000 vehicles at the 25 percent higher standard), and may be able to extend the program through the 2016 model year (for a total eligibility of five model years). No manufacturers used the TLAAS option in the 2016 model year.

All manufacturers that participated in the TLAAS program are subject to a number of restrictions designed to ensure its use only by those manufacturers that truly need it. Manufacturers using the TLAAS program were not allowed to sell credits, they may not bank credits that are accrued by their non-TLAAS fleets, they must use up any banked credits before utilizing a TLAAS fleet, and the movement of credits between a manufacturer's TLAAS and non-TLAAS fleets is restricted.

There are four possible fleets for emissions averaging and credit or deficit calculation under the TLAAS program: both cars and trucks in either the Primary or TLAAS program. Manufacturers employed a variety of strategies in the use of the TLAAS program in the 2012 through 2015 model years. The smallest-volume companies (Aston Martin, Ferrari, Lotus, and McLaren) placed all of their 2013-2015 production into a TLAAS fleet, because they can do so without any risk of exceeding the applicable limits. As noted in section 1.D.2, data from these companies is not included in this report. Porsche, which placed all of its 2012 and 2013 vehicles in the TLAAS program (totaling more than 70,000 vehicles), would have reached the 100,000 vehicle limit in the 2014 model year except for the fact that as of the 2014 model year they were aggregated with the Volkswagen fleet and no longer eligible to use the TLAAS program.

Table 3-2 shows each manufacturer's reported use of the TLAAS program for the 2012-2015 model years. Note that the total of 283,440 vehicles placed under the less stringent standards in the program to date represents less than 0.5 percent of the total number of vehicles produced in the 2012-2016 model years.

While required by the regulations, the complexity of reporting credits and deficits in Megagrams of CO_2 can sometimes obscure the progress that companies are actually making towards reducing their GHG emissions. The approach we have developed in this report provides the transparency needed to be able to make these evaluations. For example, Mercedes-Benz and Jaguar Land Rover, the largest of the manufacturers using these temporary and limited alternative standards, have both made substantial progress reducing tailpipe GHG emissions from 2012 to 2016. As shown in the previous section, Jaguar Land Rover and Mercedes reduced their overall 2-cycle tailpipe emissions by 70 and 47 g/mi, respectively, since the program started in the 2012 model year.

Table 3-2. Production Volumes Assigned to TLAAS Standards

Manufacturer	Model Year 2012			Model Year 2013			Model Year 2014			Model Year 2015			Cumulative Total
	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All	
Jaguar Land Rover	326	38,871	39,197	25	24,254	24,279	521	9,019	9,540	19	26,965	26,984	100,000
Mercedes	10,585	20,230	30,815	6	28,437	28,443	7,095	14,740	21,835	118	18,789	18,907	100,000
Porsche	16,946	12,927	29,873	22,021	19,461	41,482	Merged with Volkswagen, no longer eligible for TLAAS						71,355
Volvo	0	0	0	0	0	0	0	0	0	0	12,085	12,085	12,085
Fleet Total	**27,857**	**72,028**	**99,885**	**22,052**	**72,152**	**94,204**	**7,616**	**23,759**	**31,375**	**137**	**57,839**	**57,976**	**283,440**

To understand the impact of the TLAAS program on compliance with EPA's GHG program, we determined the gram per mile "benefit" achieved by each manufacturer and accrued for each fleet as a result of using the TLAAS program. For manufacturers placing all their vehicles in a TLAAS fleet the calculation is easy; it is simply the difference between the TLAAS program standard and the Primary Program standard that would have otherwise applied. For manufacturers with a mix of TLAAS and Primary Program vehicles in each fleet, we determined the difference in the total credits (in Megagrams) for each fleet with the use of TLAAS and without the use of TLAAS. This difference was then converted to grams per mile, and the resulting values are shown in Table 3-3. The final row in the table indicates the overall impact from the use of the TLAAS program on the entire model year fleet, not just the set of manufacturers enrolled in the TLAAS program. Thus, the overall net impact on the 2015 fleet of the TLAAS program is 0.3 g/mi. As noted above, no manufacturer used the TLAAS program in the 2016 model year. Unlike other credits, the impact of the TLAAS program is not an adjustment to 2-cycle emissions, but rather, an adjustment to the standard. For example, Volvo's 2015 model year fleet average standard against which they must demonstrate compliance was 14 g/mi greater than it would have been without use of the TLAAS program, as seen in Table 3-3.

Table 3-3. Net Impact from Use of the TLAAS Program (g/mi)

Manufacturer	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year		
	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All
Jaguar Land Rover	2	76	60	0	40	31	3	13	11	0	38	31
Mercedes	4	22	10	0	27	9	2	13	5	0	12	5
Porsche	66	84	75	63	82	73	Merged with Volkswagen, no longer eligible for TLAAS					
Volvo	0	0	0	0	0	0	0	0	0	0	36	14
Fleet Total	**0.2**	**1.3**	**0.6**	**0.2**	**1.1**	**0.5**	**0.1**	**0.3**	**0.2**	**0.0**	**0.6**	**0.3**

C. Credits Based on Alternative Fuel Vehicles

EPA's GHG program contains several credits and incentives for dedicated and dual fuel alternative fuel vehicles. Dedicated alternative fuel vehicles are vehicles that run exclusively on an alternative fuel (e.g., compressed natural gas, electricity). Dual fuel vehicles can run both on an alternative fuel and on a conventional fuel such as gasoline; the most common is the gasoline-ethanol flexible fuel vehicle, which is a dual fuel vehicle that can run on E85 (85 percent ethanol and 15 percent gasoline), or on conventional gasoline, or on a mixture of both E85 and gasoline in any proportion. Dual fuel vehicles also include vehicles that use compressed natural gas (CNG) and gasoline, or electricity and gasoline. This section separately describes three different and uniquely-treated categories of alternative fuel vehicles: advanced technology vehicles using electricity or hydrogen fuel cells; compressed natural gas vehicles; and gasoline-ethanol flexible fuel vehicles.

1. Advanced Technology Vehicles

EPA's GHG program contains incentives for advanced technology vehicles. For the 2012-2016 model years, the incentive program allows electric vehicles and fuel cell vehicles to use a zero grams per mile compliance value, and plug-in hybrid electric vehicles may use a zero grams per mile value for the portion of operation attributed to the use of grid electricity (i.e., only emissions from the portion of operation attributed to gasoline engine operation are "counted" for the compliance value). Use of the zero grams per mile option is limited to the first 200,000 qualified vehicles produced by a manufacturer in the 2012-2016 model years. Electric vehicles, fuel cell vehicles, and plug-in hybrid electric vehicles that were included in a manufacturer's calculations of early credits also count against the production limits. As noted in Section 2, both GM and Mercedes selected an option in the early credit provisions by which they could choose to set aside their relatively small 2011 model year advanced technology vehicle production for inclusion in a future model year yet to be determined.

All manufacturers of advanced technology vehicles in the 2012-2016 model years are well below the cumulative 200,000 vehicle limit for the 2012-2016 model years, thus all manufacturers remain eligible to continue to use zero grams per mile. If a manufacturer were to reach the cumulative production limit before the 2017 model year, then advanced technology vehicles produced beyond the limit must account for the net "upstream" emissions associated with their vehicles' use of grid electricity relative to vehicles powered by gasoline. Based on vehicle electricity consumption data (which includes vehicle charging losses) and assumptions regarding GHG emissions from today's national average electricity generation and grid transmission losses, a midsize electric vehicle might have upstream GHG emissions of about 180 g/mi, compared to the upstream GHG emissions of a typical midsize gasoline car of about 60 g/mi. Thus, the electric vehicle would have a net upstream emissions value of about 120 g/mi.[23] EPA regulations provide all the information necessary to calculate a unique net upstream value for each electric or plug-in hybrid electric vehicle.[24]

The nature of this incentive is such that it is reflected in the 2-cycle emissions values shown in Section 3.A. For example, the incentive allows Tesla to record zero grams per mile for their fleet (see Table 3-1) in the 2012-2016 model years. Without the incentive, however, the 2016 model year 2-cycle fleet average GHG emissions for Tesla would in fact be about 105 g/mi.[25] Use of the incentive in Tesla's case in the 2016 model year allowed them to generate almost 950,000 Mg of additional GHG credits relative to what they would generate by using the net upstream value of 105 g/mi. Nissan's passenger car fleet benefitted similarly from the ability of the electric Nissan Leaf to use zero grams per mile instead of the calculated net upstream value of 82 g/mi.[26] As a result, the overall impact on Nissan's passenger car fleet in the 2016 model year was an improvement of 1.1 g/mi, allowing them to generate about 210,000 Mg of credits more than if the incentive provisions were not in place. The net impact from Nissan and Tesla on the entire 2016 model year fleet of this incentive is thus about 1.1 million Mg of credits, or about 0.3 g/mi. While there are other electric vehicles and plug-in hybrid electric vehicles in the 2016 fleet, as shown in Table 3-4, Nissan and Tesla account for a substantial fraction of the 2016 model year volume of these vehicles. A few thousand of the remaining advanced technology vehicles are electric vehicles, but the majority of the remaining vehicles are plug-in hybrid electric vehicles, which will have a smaller overall impact than electric vehicles because of their use of gasoline in addition to electricity (the other companies with larger volumes of advanced technology vehicles – General Motors and Ford – produced far more plug-in hybrids than dedicated electric vehicles in the 2016 model year). Because it is unlikely that the total impact of this incentive exceeds 0.5 g/mi across the 2016 model year fleet, we have not carried out the analysis for all advanced technology vehicles. In the future, however, it may be more important, interesting, and useful to have a complete assessment of the impact of incentives for these vehicles. Table 3-4 shows the 2010-2016 production volumes of advanced technology vehicles that utilized the zero grams per mile incentive.

[23] Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Final Rule, Federal Register 75 (7 May 2010): 25435.
[24] See 40 CFR 600.113-12(n).
[25] Using the calculations prescribed in the regulations, the sales-weighted upstream emissions for Tesla's 2016 passenger cars is 180 grams/mile and the upstream emissions associated with a comparable gasoline vehicle is 75 grams/mile. The difference, or the net upstream emissions of Tesla's 2016 passenger car fleet, is 105 grams/mile.
[26] The upstream GHG emission value for the 2016 Nissan Leaf is 144 grams/mile and the upstream emissions associated with a comparable gasoline vehicle is 62 grams/mile. The difference, or the net upstream emissions of the 2016 Leaf, is 82 grams/mile.

Table 3-4. Production Volumes of Advanced Technology Vehicles Using Zero Grams/Mile Incentive, by Model Year

Manufacturer	Model Year 2010	2011	2012	2013	2014	2015	2016	Total
BMW	-	-	-	-	9,895	11,386	11,755	33,036
BYD Motors	-	-	11	32	50	-	-	93
Coda	-	-	-	37	-	-	-	37
Ford	-	-	653	18,654	18,826	17,384	22,343	77,860
GM	-	4,370	18,355	27,484	25,847	14,847	12,447	103,350
Honda	-	-	-	471	1,635	-	-	2,106
Hyundai	-	-	-	-	-	72	1,432	1,504
Karma	-	-	1,415	-	-	-	-	1,415
Kia	-	-	-	-	-	926	2,788	3,714
Mercedes	-	546	25	880	3,610	3,125	2,365	10,551
Mitsubishi	-	-	1,435	-	219	-	130	1,784
Nissan	-	8,495	11,460	26,167	10,339	33,242	13,128	102,831
Tesla	599	269	2,952	17,813	17,791	24,322	46,058	109,804
Toyota	-	-	452	829	1,218	5,838	-	8,337
Volvo	-	-	-	-	-	-	2,183	2,183
FCA†	*-*	*-*	*-*	*2,353*	*3,404*	*7,825*	*4,639*	*18,221*
Volkswagen†	*-*	*-*	*-*	*-*	*755*	*4,869*	*12,776*	*18,400*
Total	**599**	**13,680**	**36,758**	**94,720**	**93,589**	**123,836**	**132,044**	**495,226**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

2. Compressed Natural Gas Vehicles

There were no compressed natural gas vehicles (CNG) subject to the GHG standards in the 2016 model year. The Honda Civic CNG was the only CNG vehicle produced for general purchase by consumers during the first phase of EPA's GHG program, and it was only available in the 2012-2014 model years, and is a dedicated alternative fuel vehicle. In the 2015 and 2016 model years, Quantum Technologies offered a dual fuel (CNG and gasoline) version of GM's Chevrolet Impala through an agreement with GM. Quantum Technologies is exempt from GHG standards under the small business provisions (although they could opt in if they chose), and as a result these vehicles were not subject to 2015-2016 model year GHG standards and thus won't be accounted for in this report.

3. Gasoline-Ethanol Flexible Fuel Vehicles

For the 2012 to 2015 model years, EPA provided GHG credits for flexible fuel vehicles (FFVs) that corresponded to the statutory fuel economy credits under CAFE. As with the CAFE program, the GHG program based FFV credits in these years on the assumption that FFVs operate 50% of the time on the alternative fuel and 50% of the time on conventional fuel, resulting in CO_2 emissions that are based on an arithmetic average of alternative fuel and conventional fuel CO_2 emissions. Further, to fully align the credit with the CAFE program, the CO_2 emissions measurement on the alternative fuel was multiplied by a 0.15 factor. The 0.15 factor was used because, under the CAFE program's implementing statutes, a gallon of alternative fuel is deemed to contain 0.15 gallons of gasoline fuel. Again, this approach was only applicable for the 2012–2015 model years of the GHG program.

For example, for a flexible-fuel vehicle that emits 330 g/mi CO_2 while operating on E85 and 350 g/mi CO_2 while operating on gasoline, the resulting CO_2 compliance value used in the manufacturer's fleet average calculation prior to the 2016 model year would be:

$$\mathrm{CO_2} = \frac{[(330\times0.15) + 350]}{2} = 199.8 \text{ g/mi}$$

By temporarily using the CAFE-based approach—including the 0.15 factor—the CO_2 emissions value for an FFV was calculated to be significantly lower than it actually would be otherwise, even if the vehicle were assumed to operate on the alternative fuel at all times. For example, the FFV compliance value of 199.8 g/mi shown above is 150 g/mi, or 43 percent, less than the gasoline-only value of 350 g/mi. This was a short-term incentive being provided to FFVs, available in EPA's GHG program only through the 2015 model year. In fact, the standards in the early years of the GHG program were developed with an explicit understanding that some manufacturers would make use of this and other incentive and credit programs to meet the standards.

Starting in model year 2016, GHG compliance values for FFVs are based on the actual emissions performance of the FFV on conventional and alternative fuels, weighted by EPA's assessment of the actual use of these fuels in FFVs. A guidance letter released in 2014 defined a weighting factor (the "F factor") of 0.14 to use for E85 when weighting E85 and gasoline CO_2 emissions for FFVs in the 2016-2018 model years. EPA estimated that FFVs would be operating on E85 14 percent of the time in these years.[27] This approach could be thought of as comparable to the "utility factor" weighting method used to weight gasoline and electricity for plug-in hybrid electric vehicles (PHEV), which projects the percentage of miles that a PHEV will use electricity based on how many miles a fully-charged PHEV can drive using grid electricity. Thus, for the example FFV described above, the new equation for determining the CO_2 emissions compliance value for the 2016 model year, reflecting a 0.14 and 0.86 weighting of E85 and gasoline values, respectively, is the following:

$$\mathrm{CO_2} = (330\times0.14) + (350\times0.86) = 347.2 \text{ g/mi}$$

Depending on the relative FFV tailpipe emissions values on E85 and gasoline, FFVs can still represent a CO_2 emissions benefit, and can help to lower the emissions of a manufacturer's fleet, but the overall impact is significantly diminished relative to the magnitude of the

[27] EPA Guidance Letter "E85 Flexible Fuel Vehicle Weighting Factor for Model Year 2016-2018 Vehicles," CD-14-18, November 12, 2014.

incentives provided in previous model years. Under the 2016 model year methodology, the FFV compliance value of 347.2 g/mi in the example above is less than 3 g/mi, or less than one percent, lower than the gasoline-only value of 350 g/mi. This reduction is about 50 times less relative to the methodology for the 2012 to 2015 model years. This methodology that is based on the actual emissions performance of FFVs on the EPA test procedures weighted based on projected fuel use over the life of the vehicle results in a credit that is substantially less relative to the methodology for the 2012 to 2015 model years.

Six manufacturers produced FFVs in the 2016 model year, as shown below in Tables 3-5 and 3-6. Clearly, FCA, Ford, and GM produced the overwhelming majority of vehicles capable of operating on E85. FFVs started the GHG program in 2012 at about 15 percent of the fleet, then grew to almost 20 percent of the fleet in the 2014 model year, when production peaked, and then began to decline in subsequent model years. FFVs make up about eight percent of the 2016 model year fleet. Note that the number of models shown in Table 3-5 is based on EPA's "model type" designation (used for EPA Fuel Economy and Environment Labels), and is not equivalent to "nameplate." Generally speaking, a model type is a unique combination of a nameplate (e.g., Silverado), an engine (e.g., 6 cylinder), a drive system (e.g., 4-wheel drive), and a transmission (e.g., 6-speed automatic). Thus, a single nameplate that is offered with two engines, in both two- and four-wheel drive, and in manual and automatic transmissions, will result in eight different model types. For example, two of the Toyota truck models shown in Table 3-5 are made up of two- and four-wheel drive versions of the Toyota Tundra pickup truck.

Most of these manufacturers focused their FFV production in the truck segment, with trucks making up almost 70 percent of all FFV production in the 2016 model year. Ford, Toyota, and Mercedes slightly increased FFV production in the 2016 model year, while FCA and GM significantly reduced FFV production, and Nissan and Jaguar Land Rover ended FFV production. Overall, however, FFV production dropped by about 500,000 vehicles relative to 2015, a drop of about 27 percent.

Table 3-5. Number of FFV Models by Manufacturer, 2012-2016 Model Years

Model Year	Category	Ford	GM	Jaguar Land Rover	Mercedes	Nissan	Toyota	*FCA†*	*Volkswagen†*	Total
2012	Car	7	19	-	5	-	0	*10*	*4*	45
	Truck	23	60	-	1	4	2	*11*	*-*	101
	All	30	79	-	6	4	2	*21*	*4*	146
2013	Car	6	18	4	7	-	0	*10*	*10*	55
	Truck	23	58	-	1	4	2	*13*	*1*	102
	All	29	76	4	8	4	2	*23*	*11*	157
2014	Car	6	11	6	7	0	0	*10*	*8*	48
	Truck	21	44	6	1	4	2	*11*	*1*	90
	All	27	55	12	8	4	2	*21*	*9*	138
2015	Car	5	7	5	2	0	0	*11*	*7*	37
	Truck	7	22	3	1	4	2	*11*	*1*	51
	All	12	29	8	3	4	2	*22*	*8*	88
2016	Car	6	6	0	2	0	0	*8*	*4*	26
	Truck	11	17	0	2	0	3	*6*	*1*	40
	All	18	23	0	4	0	3	*14*	*5*	66

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-6. Production Volume of FFVs by Manufacturer, 2012-2016 Model Years

Model Year	Category	Ford	GM	Jaguar Land Rover	Mercedes	Nissan	Toyota	*FCA†*	*Volkswagen†*	Total
2012	Car	174,597	396,264	-	13,493	-	-	*105,174*	*2,060*	691,588
	Truck	323,563	511,183	-	8,289	24,154	31,670	*453,399*	*-*	1,352,258
	All	498,160	907,447	-	21,782	24,154	31,670	*558,573*	*2,060*	2,043,846
2013	Car	209,988	374,354	321	34,493	-	-	*142,158*	*30,346*	791,660
	Truck	546,695	637,576	-	22,082	13,650	33,203	*431,359*	*20,799*	1,705,364
	All	756,683	1,011,930	321	56,575	13,650	33,203	*573,517*	*51,145*	2,497,024
2014	Car	259,189	282,707	2,754	48,597	-	-	*76,570*	*39,375*	709,192
	Truck	498,245	801,740	32,013	12,079	14,809	56,516	*650,617*	*25,666*	2,091,685
	All	757,434	1,084,447	34,767	60,676	14,809	56,516	*727,187*	*65,041*	2,800,877
2015	Car	140,169	170,959	2,640	12,026	-	-	*183,860*	*28,994*	538,648
	Truck	296,039	313,961	10,795	5,208	13,565	43,060	*585,462*	*31,987*	1,300,077
	All	436,208	484,920	13,435	17,234	13,565	43,060	*769,322*	*60,981*	1,838,725
2016	Car	137,556	125,079	-	24,782	-	-	*115,995*	*21,237*	424,649
	Truck	338,099	139,667	-	9,894	-	69,596	*313,607*	*39,212*	910,075
	All	475,655	264,746	-	34,676	-	69,596	*429,602*	*60,449*	1,334,724

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide “Total” or “All” values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-7 shows the impact of the FFV credits on each manufacturer’s fleet for the 2012-2015 model years. Although FFVs, in conjunction with use of the 0.14 usage factor, can help lower a manufacturer’s fleet GHG emissions in the 2016 and later model years, EPA does not consider the GHG performance-based approach to be a credit or an incentive. The methodology for 2016 and later FFVs is, like the use of utility factors for PHEVs, considered to simply be the appropriate methodology by which to calculate emissions on the test procedures based on the fuels, or mixture of fuels, that FFVs are projected to consume. The data show that three manufacturers benefitted from FFVs in the 2016 model year. Compared to fleet performance based only on gasoline test results, FCA and GM used FFVs to lower their passenger car fleet 2-cycle CO_2 emissions by 1 g/mi, while Ford reduced truck fleet 2-cycle CO_2 emissions by 1 g/mi. The overall impact of FFVs on the fleet in 2016 was negligible, a small fraction of one g/mi. These much smaller impacts will not be reported separately as credits beginning with the 2016 model year; rather, the impact of FFVs for the 2016 and later model years is “built in” to the 2-cycle tailpipe emissions.

Table 3-7. Credits Accrued from Use of the FFV Incentives, 2012-2015 Model Years (g/mi)

Manufacturer	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year		
	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All
Ford	9	21	14	9	20	15	9	20	14	8	15	12
GM	11	23	16	10	22	15	10	19	14	8	15	12
Jaguar Land Rover	0	0	0	5	0	1	1	18	15	13	6	7
Mercedes	11	15	13	12	12	12	11	17	12	6	5	6
Nissan	0	15	4	0	8	3	0	8	3	0	6	2
Toyota	0	9	4	0	8	3	0	15	6	0	8	4
FCA†	*13*	*21*	*18*	*12*	*21*	*17*	*12*	*19*	*17*	*9*	*15*	*13*
Volkswagen†	*1*	*0*	*1*	*7*	*15*	*8*	*10*	*16*	*11*	*7*	*13*	*8*
Fleet Total	**4**	**14**	**8**	**4**	**14**	**8**	**5**	**14**	**9**	**3**	**10**	**6**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

D. Credits Based on Air Conditioning Systems

The vast majority of new cars and light trucks in the United States are equipped with air conditioning (A/C) systems. There are two mechanisms by which A/C systems contribute to the emissions of greenhouse gases: through leakage of hydrofluorocarbon refrigerants into the atmosphere (sometimes called "direct emissions") and through the consumption of fuel to provide mechanical power to the A/C system (sometimes called "indirect emissions"). The high global warming potential (GWP) of the current predominant automotive refrigerant, HFC-134a, means that leakage of a small amount of refrigerant will have a far greater impact on global warming than emissions of a similar amount of CO_2. The impacts of refrigerant leakage can be reduced significantly by systems that incorporate leak-tight components, or, ultimately, by using a refrigerant with a lower global warming potential. The A/C system also contributes to increased tailpipe CO_2 emissions through the additional work required by the engine to operate the compressor, fans, and blowers. This additional power demand is ultimately met by using additional fuel, which is converted into CO_2 by the engine during combustion and exhausted through the tailpipe. These emissions can be reduced by increasing the overall efficiency of an A/C system, thus reducing the additional load on the engine from A/C operation, which in turn means a reduction in fuel consumption and a commensurate reduction in GHG emissions. Manufacturers may generate and use credits for improved A/C systems in complying with the CO_2 fleet average standards in the 2012 and later model years (or otherwise to be able to bank or trade the credits). These provisions were also used in the 2009-2011 model years to generate early credits, prior to the 2012 model year. Sixteen manufacturers used the A/C credit provisions – either for leakage reductions, efficiency improvements, or both – as part of their compliance demonstration in the 2016 model year.

The A/C provisions are structured as additional and optional credits, unlike the CO_2 standards for which manufacturers must demonstrate compliance using the EPA exhaust emission test procedures. The EPA compliance tests do not measure either A/C refrigerant leakage or the increase in tailpipe CO_2 emissions attributable to the additional engine load of A/C systems. Because it is optional to include A/C-related GHG emission reductions as an input to a manufacturer's compliance demonstration, the A/C provisions are viewed as an additional program that credits manufacturers for implementing A/C technologies that result in real-world reductions in GHG emissions. A summary of the A/C credits reported by the industry for all model years, including the early credit program years, is shown in Table 3-8 (note that because not all manufacturers participated in the early credits program, credit volumes and percentages from 2009-2011 and 2012-2015 are not comparable). Table 3-9 shows the total air conditioning credits (combined leakage and efficiency credits, in Megagrams) reported by each manufacturer in the 2016 model year, and the grams per mile impact across their entire vehicle fleet. Like the TLAAS program and alternative fuel vehicle incentives, EPA's standards are predicated in part upon manufacturers earning credits for reducing GHG emissions from A/C systems. Table 3-10 shows the benefit of A/C credits, translated from Megagrams to grams per mile, for each manufacturer's fleet for the 2012-2016 model years.

Table 3-8. Reported A/C Credits by Credit Type and Model Year

Model Year	Leakage Credits		Efficiency Credits		Total (Mg)
	Mg	% of Annual A/C Total	Mg	% of Annual A/C Total	
2009	6,239,573	75%	2,113,939	25%	8,353,512
2010	8,323,159	75%	2,843,761	25%	11,166,920
2011	8,867,040	71%	3,594,232	29%	12,461,272
2012	11,121,450	65%	5,881,319	35%	17,002,769
2013	13,239,784	61%	8,517,721	39%	21,757,505
2014	16,588,243	61%	10,540,350	39%	27,128,593
2015	20,240,734	62%	12,383,461	38%	32,624,195
2016	21,422,607	63%	12,479,386	37%	33,901,993
Total	**106,042,590**	**65%**	**58,354,169**	**35%**	**164,396,759**

Table 3-9. Reported A/C Credits by Manufacturer, 2016 Model Year

Manufacturer	A/C Leakage Credits (Mg)	A/C Efficiency Credits (Mg)	Total A/C Credits (Mg)	Grams/Mile Equivalent of Total A/C Credits
BMW	418,678	338,605	757,283	10
Ford	3,154,215	1,411,163	4,565,378	10
GM	3,573,176	2,201,272	5,774,448	11
Honda	2,026,647	1,137,628	3,164,275	8
Hyundai	379,578	537,703	917,281	7
Jaguar Land Rover	425,008	144,567	569,575	22
Kia	380,830	502,748	883,578	6
Mercedes	412,257	365,340	777,597	11
Mitsubishi	86,597	-	86,597	5
Nissan	1,380,015	795,312	2,175,327	8
Subaru	-	335,224	335,224	3
Tesla	-	51,263	51,263	6
Toyota	2,426,563	2,260,189	4,686,752	9
Volvo	127,361	74,919	202,280	11
FCA†	*6,047,361*	*1,910,581*	*7,957,942*	*18*
Volkswagen†	*584,321*	*412,872*	*997,193*	*9*
Fleet Total	**21,422,607**	**12,479,386**	**33,901,993**	**10**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-10. Net Impact of A/C Credits, 2012-2016 Model Years (g/mi)

Manufacturer	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All
BMW	7	11	8	8	11	9	8	11	9	9	11	9	9	11	10
Ford	5	8	6	7	8	8	8	10	9	9	11	10	9	11	10
GM	8	8	8	9	9	9	9	11	10	10	11	10	10	11	11
Honda	3	5	4	4	6	4	4	6	5	4	7	5	9	8	8
Hyundai	4	7	4	5	7	5	6	7	6	6	7	6	7	5	7
Jaguar Land Rover	5	8	7	5	9	8	12	22	21	14	23	21	19	23	22
Kia	5	3	5	5	8	5	6	5	6	6	6	6	6	6	6
Mercedes	9	11	10	9	12	10	10	12	11	11	12	11	11	12	11
Mitsubishi	-	-	-	-	-	-	-	-	-	-	-	-	3	7	5
Nissan	2	4	3	4	4	4	5	6	6	7	8	7	7	9	8
Subaru	2	2	2	1	2	2	1	2	2	3	2	2	3	3	3
Tesla	6	-	6	6	-	6	6	-	6	6	-	6	6	-	6
Toyota	7	6	7	7	7	7	8	7	8	8	8	8	8	11	9
Volvo	11	12	11	10	11	10	8	8	8	8	9	8	8	12	11
FCA†	*9*	*10*	*10*	*10*	*11*	*10*	*13*	*14*	*14*	*17*	*19*	*19*	*17*	*19*	*18*
Volkswagen†	*6*	*9*	*7*	*6*	*10*	*7*	*8*	*12*	*9*	*9*	*12*	*9*	*8*	*12*	*9*
Fleet Total	**5**	**7**	**6**	**6**	**8**	**7**	**7**	**10**	**8**	**8**	**11**	**9**	**9**	**11**	**10**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

1. Air Conditioning Leakage Credits

A manufacturer choosing to generate A/C leakage credits with a specific A/C system is required to calculate a leakage "score" for the A/C system.[28] This score is based on the number, performance, and technology of the components, fittings, seals, and hoses of the A/C system.[29] This score, which is determined in grams per year, is calculated using the procedures specified by the SAE Surface Vehicle Standard J2727. The score is subsequently converted to a gram per mile credit value based on the global warming potential (GWP) of the refrigerant, for consistency with the units of GHG exhaust emissions. The grams per mile value is used to calculate the total tons of credits attributable to an A/C system by accounting for the VMT of the vehicle class (car or truck) and the production volume of the vehicles employing that A/C system.

In the 2012 model year, all leakage credits were based on improvements to the A/C system components, e.g., to O-rings, seals, valves, and fittings, as no manufacturer had yet introduced a new low-GWP refrigerant in the U.S. In the 2013 model year, General Motors and Honda introduced vehicles that further reduced the impacts of A/C system leakage by using HFO-1234yf, a relatively new low-GWP refrigerant. These two manufacturers were the first to introduce this refrigerant in U.S. vehicle models (the Cadillac XTS and the Honda Fit EV). HFO-1234yf has an extremely low GWP of 4, as compared to a GWP of 1430 for HFC-134a, the refrigerant currently used throughout most of the industry. The use of HFO-1234yf expanded considerably in the 2014 model year, from 42,384 vehicles in the 2013 model year to 628,347 vehicles in the 2014 model year. Although Honda dropped the Fit EV in model year 2015 and GM sales of models using HFO-1234yf declined, both FCA and Jaguar Land Rover increased their offerings of vehicles using HFO-1234yf, contributing to a tripling of the number of vehicles using this refrigerant in the 2015 model year. The 2016 model year continued to show growth in the use of the new refrigerant, but no new manufacturers took up the refrigerant in 2016. Although use of HFO-1234yf decreased by FCA, who continues to produce more vehicles with this refrigerant than any other manufacturer, GM, Honda, and Jaguar Land Rover all increased their production of vehicles using it. Honda, in fact, was the principle driver in an almost 25 percent increase in vehicles using HFO-1234yf in the 2016 model year. Industry-wide, 13 percent of 2016 model year vehicles are using HFO-1234yf, with FCA accounting for almost 70 percent of vehicles using the new refrigerant. Jaguar Land Rover continues to have the greatest penetration within their fleet, using HFO-1234yf in 100 percent of vehicles produced in the 2016 model year. The net impact on credits is that these manufacturers collectively generated 3.8 million more Megagrams of A/C leakage credits than they would have generated by using HFC-134a. FCA accounts for most of these credits, accumulating 2.6 million Megagrams more than they would have had they used HFC-134a. Table 3-11 shows the aggregated production volume of vehicles using HFO-1234yf for the 2012-2016 model years, by manufacturer.

[28] See 40 CFR 86.1867-12.

[29] The global warming potential (GWP) represents how much a given mass of a chemical contributes to global warming over a given time period compared to the same mass of carbon dioxide. Carbon dioxide's GWP is defined as 1.0.

Table 3-11. Production of Vehicles Using HFO-1234yf, 2013-2016 Model Years

Manufacturer	2013	2014	2015	2016	Total
GM	41,913	30,652	16,298	32,775	121,638
Honda	471	599		541,393	542,463
Jaguar Land Rover		56,604	62,316	114,580	233,500
FCA[†]		*540,098*	*1,683,956*	*1,504,046*	*3,728,100*
Total	**42,384**	**627,953**	**1,762,570**	**2,192,794**	**4,625,701**

[†]FCA is listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Fourteen manufacturers reported A/C leakage credits in the 2016 model year, as shown in Table 3-12. These manufacturers reported more than 20 million Mg of A/C leakage credits in 2016, accounting for GHG reductions of 6 g/mi across the 2016 vehicle fleet. Table 3-13 shows the leakage credits in grams per mile for the 2012-2016 model years.

Table 3-12. Reported A/C Leakage Credits by Manufacturer and Fleet, 2016 Model Year (Mg)

Manufacturer	Car	Truck	Total	Grams/mile Equivalent of Total Credits
BMW	261,750	156,928	418,678	5
Ford	1,202,274	1,951,941	3,154,215	7
GM	1,529,206	2,043,970	3,573,176	7
Honda	1,242,114	784,533	2,026,647	5
Hyundai	372,376	7,202	379,578	3
Jaguar Land Rover	45,546	379,462	425,008	17
Kia	283,543	97,287	380,830	3
Mercedes	236,227	176,030	412,257	6
Mitsubishi	14,092	72,505	86,597	5
Nissan	746,573	633,442	1,380,015	5
Toyota	897,532	1,529,031	2,426,563	5
Volvo	31,954	95,407	127,361	7
FCA†	*1,509,550*	*4,537,811*	*6,047,361*	*14*
Volkswagen†	*392,728*	*191,593*	*584,321*	*5*
Fleet Total	**8,765,465**	**12,657,142**	**21,422,607**	**6**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide “Total” or “All” values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-13. A/C Leakage Credits, 2012-2016 Model Years (g/mi)

Manufacturer	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All
BMW	4	7	5	4	7	5	4	7	5	5	7	5	5	7	5
Ford	4	7	6	5	7	7	6	8	7	6	8	7	6	8	7
GM	6	7	6	6	7	7	6	7	7	6	7	6	6	7	7
Honda	1	2	2	1	3	2	1	3	2	2	4	2	6	5	5
Hyundai	2	5	2	2	4	2	2	3	2	3	4	3	3	2	3
Jaguar Land Rover	3	4	4	3	5	4	7	17	15	9	17	15	14	17	17
Kia	2	2	2	2	5	2	2	3	2	2	3	2	3	3	3
Mercedes	4	7	5	4	7	5	5	7	5	5	7	6	5	7	6
Mitsubishi	-	-	-	-	-	-	-	-	-	-	-	-	3	7	5
Nissan	0	2	1	0	2	1	2	4	3	4	6	4	4	7	5
Toyota	3	3	3	3	3	3	4	4	4	4	4	4	3	7	5
Volvo	6	8	7	6	7	7	6	7	7	5	8	6	5	7	7
FCA†	*6*	*8*	*7*	*6*	*8*	*7*	*9*	*10*	*9*	*13*	*15*	*14*	*12*	*15*	*14*
Volkswagen†	*2*	*4*	*2*	*3*	*5*	*3*	*4*	*7*	*5*	*5*	*7*	*5*	*5*	*7*	*5*
Fleet Total	**3**	**5**	**4**	**3**	**6**	**4**	**4**	**6**	**5**	**5**	**7**	**6**	**5**	**8**	**6**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

2. *Air Conditioning Efficiency Credits*

Manufacturers that make improvements in their A/C systems to increase efficiency, thus reducing CO_2 emissions due to A/C system operation, may be eligible for A/C efficiency credits. Most of the additional load on the engine from A/C systems comes from the compressor, which pressurizes the refrigerant and pumps it around the system loop. A significant additional load on the engine may also come from electric or hydraulic fans, which are used to move air across the condenser, and from the electric blower, which is used to move air across the evaporator and into the cabin. Manufacturers have several technological options for improving efficiency, including more efficient compressors, fans, and motors, and system controls that avoid over-chilling the air (and subsequently re-heating it to provide the desired air temperature with an associated loss of efficiency). For vehicles equipped with automatic climate-control systems, real-time adjustment of several aspects of the overall system (such as engaging the full capacity of the cooling system only when it is needed, and maximizing the use of recirculated air) can result in improved efficiency. The regulations provide manufacturers with a "menu" of technologies and associated credit values (in grams per mile of CO_2). Credits are capped at 5.7 g/mi for all vehicles in the 2012-2016 model years, and at 5.0 and 7.2 g/mi for cars and trucks, respectively, in the 2017 and later model years. The total tons of credits are then based on the total volume of vehicles in a model year using these technologies.

Fifteen manufacturers used the provisions that allow credits based on improvements to the overall efficiency of the A/C system, as shown in Table 3-14. These manufacturers reported a total of more than 12 million Mg of A/C efficiency credits in the 2016 model year, accounting for about 4 g/mi across the 2016 fleet. Table 3-15 shows the efficiency credits in grams per mile for the 2012-2016 model years.

Table 3-14. Reported A/C Efficiency Credits by Manufacturer and Fleet, 2016 Model Year (Mg)

Manufacturer	Car	Truck	Total	Grams/Mile Equivalent of Total Credits
BMW	241,276	97,329	338,605	4
Ford	533,799	877,364	1,411,163	3
GM	877,339	1,323,933	2,201,272	4
Honda	624,733	512,895	1,137,628	3
Hyundai	520,949	16,754	537,703	4
Jaguar Land Rover	18,814	125,753	144,567	6
Kia	381,366	121,382	502,748	3
Mercedes	233,353	131,987	365,340	5
Nissan	562,084	233,228	795,312	3
Subaru	88,364	246,860	335,224	3
Tesla	51,263		51,263	6
Toyota	1,314,746	945,443	2,260,189	5
Volvo	20,754	54,165	74,919	4
FCA†	*601,135*	*1,309,446*	*1,910,581*	*4*
Volkswagen†	*275,942*	*136,930*	*412,872*	*4*
Fleet Total	**6,345,917**	**6,133,469**	**12,479,386**	**4**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-15. A/C Efficiency Credits, 2012-2016 Model Years (g/mi)

Manufacturer	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All
BMW	3	4	3	4	4	4	4	4	4	4	4	4	4	4	4
Ford	0	0	0	2	1	1	2	2	2	3	3	3	3	3	3
GM	2	1	2	3	2	3	3	4	4	3	4	4	4	4	4
Honda	2	3	2	2	3	2	2	3	3	2	3	3	3	3	3
Hyundai	2	2	2	3	4	3	4	4	4	4	4	4	4	4	4
Jaguar Land Rover	2	4	4	2	4	4	5	6	5	5	6	6	6	6	6
Kia	2	1	2	2	3	3	4	2	4	4	3	4	3	3	3
Mercedes	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Nissan	2	2	2	3	2	3	3	2	3	3	2	3	3	3	3
Subaru	2	2	2	1	2	2	1	2	2	3	2	2	3	3	3
Tesla	6	-	6	6	-	6	6	-	6	6	-	6	6	-	6
Toyota	4	2	3	4	3	4	5	3	4	4	4	4	5	4	5
Volvo	4	4	4	4	4	4	1	1	1	3	1	2	3	4	4
FCA†	*3*	*2*	*3*	*3*	*3*	*3*	*4*	*4*	*4*	*4*	*5*	*5*	*5*	*4*	*4*
Volkswagen†	*4*	*5*	*4*	*4*	*5*	*4*	*4*	*5*	*4*	*4*	*5*	*4*	*3*	*5*	*4*
Fleet Total	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**4**	**4**	**4**	**4**	**4**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

E. Credits Based on "Off-Cycle" Technology

"Off-cycle" emission reductions can be achieved by employing technologies that result in real-world benefits, but where that benefit is not adequately captured on the test procedures used by manufacturers to demonstrate compliance with emission standards. EPA's light-duty vehicle greenhouse gas program acknowledges these benefits by giving automobile manufacturers three pathways by which a manufacturer may accrue off-cycle CO_2 credits. The first is a predetermined list or "menu" of credit values for specific off-cycle technologies that may be used beginning in model year 2014.[30] This pathway allows manufacturers to use conservative credit values established by EPA for a wide range of off-cycle technologies, with minimal data submittal or testing requirements. This pathway was widely used in the 2016 model year. In cases where additional laboratory testing can demonstrate emission benefits, a second pathway allows manufacturers to use a broader array of emission tests (known as "5-cycle" testing because the methodology uses five different testing procedures) to demonstrate and justify off-cycle CO_2 credits.[31] The additional emission tests allow emission benefits to be demonstrated over some elements of real-world driving not captured by the GHG compliance tests, including high speeds, rapid accelerations, and cold temperatures. Credits determined according to this methodology do not undergo additional public review. GM is currently the only manufacturer to have used this pathway in the 2012-2016 model years. The third and last pathway allows manufacturers to seek EPA approval to use an alternative methodology for determining the off-cycle technology CO_2 credits.[32] This option is only available if the benefit of the technology cannot be adequately demonstrated using the 5-cycle methodology. Manufacturers may also use this option for model years prior to 2014 to demonstrate off-cycle CO_2 reductions for off-cycle technologies that are on the menu, or to demonstrate reductions that exceed those available via use of the menu. Several manufacturers have petitioned for and been granted credits using this pathway.[33]

Table 3-16 shows the total off-cycle technology credits reported by manufacturers in the 2016 model year and the grams per mile impact on their respective fleets. Clearly the technologies involved are currently implemented to varying degrees across manufacturers, accounting for anywhere from zero g/mi (the manufacturers not shown in Table 3-16) to 6.1 g/mi for FCA. Off-cycle credits from these 12 manufacturers accounted for a benefit of 3 g/mi across the entire 2015 model year fleet.

Table 3-17 shows the off-cycle credits in grams per mile for the 2012-2015 model years. Although GM did generate off-cycle credits in the 2012 and 2013 model years, the grams per

[30] See 40 CFR 86.1869-12(b).
[31] See 40 CFR 86.1869-12(c).
[32] See 40 CFR 86.1869-12(d).
[33] EPA maintains a web page on which we publish the manufacturers' applications for these credits, the relevant Federal Register notices, and the EPA decision documents. See https://www.epa.gov/vehicle-and-engine-certification/compliance-information-light-duty-greenhouse-gas-ghg-standards.

mile equivalent of those credits rounds to 0.0, as shown, as is also the case for Subaru in model year 2014.

Table 3-16. Reported Off-Cycle Technology Credits by Manufacturer and Fleet, 2016 Model Year (Mg)

Manufacturer	Car	Truck	Total	Grams/Mile Equivalent of Total Credits
BMW	213,889	155,758	369,647	5
Ford	330,086	936,002	1,266,088	3
GM	662,961	1,227,378	1,890,339	3
Honda	354,307	379,221	733,528	2
Hyundai	162,564	21,408	183,972	1
Jaguar Land Rover	10,018	169,333	179,351	7
Kia	146,732	118,830	265,562	2
Mercedes	155,616	81,796	237,412	4
Nissan	339,915	251,409	591,324	2
Subaru	10,458	22,531	32,989	0
Toyota	360,276	762,051	1,122,327	2
FCA†	*389,320*	*2,474,713*	*2,864,033*	*7*
Fleet Total	**3,136,142**	**6,600,430**	**9,736,572**	**3**

†FCA is listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide “Total” or “All” values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-17. Off-Cycle Technology Credits by Manufacturer and Fleet, 2012-2016 Model Years (g/mi)

	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
Manufacturer	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**
BMW	3	5	3	3	6	4	3	6	4	4	7	4	4	7	5
Ford	1	0	0	1	1	1	2	3	3	2	3	3	2	4	3
GM	1	2	1	1	2	1	1	3	2	2	4	3	3	4	3
Honda	-	-	-	-	-	-	1	2	1	1	2	2	2	2	2
Hyundai	-	-	-	-	-	-	1	4	1	1	3	2	1	5	1
Jaguar Land Rover	-	-	-	-	-	-	2	6	5	2	5	5	3	8	7
Kia	-	-	-	-	-	-	1	1	1	1	2	1	1	3	2
Mercedes	1	0	0	1	1	1	3	1	2	4	3	3	4	3	4
Nissan	-	-	-	-	-	-	1	2	2	2	3	2	2	3	2
Subaru	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0
Toyota	-	-	-	-	-	-	2	3	3	3	3	3	1	3	2
FCA[†]	*1*	*2*	*2*	*1*	*3*	*2*	*3*	*7*	*6*	*3*	*7*	*6*	*3*	*8*	*7*
Volkswagen[†]	*1*	*1*	*1*	*1*	*1*	*1*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
Fleet Total	**0**	**1**	**1**	**1**	**1**	**1**	**2**	**4**	**3**	**2**	**4**	**3**	**2**	**4**	**3**

[†]FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

1. Off-Cycle Credits Based on the Menu

Starting with 2014 models, manufacturers have an option for generating GHG credits, in the form of “default” credit values specified in the regulations (a “menu” of technologies with credit values, or the calculation method for such values, clearly defined) for certain off-cycle technologies installed on vehicles. More than 95 percent of 2016 off-cycle credits were generated via this pathway, and for all but GM it was the sole pathway used to generate off-cycle credits. The impact of credits from this pathway on a manufacturer’s fleet is capped at 10 g/mi, meaning that any single vehicle might accumulate more than 10 g/mi, but the cumulative effect on a single manufacturer’s fleet may not exceed a credit, or reduction, of more than 10 g/mi.

Table 3-18 shows the total off-cycle credits based on the menu pathway reported by manufacturers in the 2016 model year and the grams per mile impact on their respective fleets.

Table 3-18. Reported Off-Cycle Technology Credits from the Menu, by Manufacturer and Fleet, 2016 Model Year (Mg)

Manufacturer	Car	Truck	Total	Grams/Mile Equivalent of Total Credits
BMW	213,889	155,758	369,647	5
Ford	330,086	936,002	1,266,088	3
GM	580,113	972,808	1,552,921	3
Honda	354,307	379,221	733,528	2
Hyundai	162,564	21,408	183,972	1
Jaguar Land Rover	10,018	169,333	179,351	7
Kia	146,732	118,830	265,562	2
Mercedes	155,616	81,796	237,412	4
Nissan	339,915	251,409	591,324	2
Subaru	10,458	22,531	32,989	0
Toyota	360,276	762,051	1,122,327	2
FCA[†]	*389,320*	*2,474,713*	*2,864,033*	*7*
Fleet Total	**3,053,294**	**6,345,860**	**9,399,154**	**3**

[†]FCA is listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide “Total” or “All” values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Tables 3-19 and 3-20 provide details regarding the specific off-cycle technologies, including how many credits were reported for each technology, and the implementation rate of each off-cycle technology by manufacturers. Several of these technologies are “thermal control technologies” in that they reduce the demand on the A/C system by venting hot air, by moving heat away from passengers, or by reducing cabin heating from the sun. Due to expected synergistic effects of the thermal technologies, the credits from the group of thermal control technologies are capped at 3.0 g/mi for cars and 4.3 g/mi for trucks. Because this category of credits is capped, the actual credits attributable to each technology in this category can't be accurately summarized. For example, credits for a car with active cabin ventilation (2.1 g/mi), active seat ventilation (1.0 g/mi), and reflective paint (0.4 g/mi) would total to 3.5 g/mi, thus exceeding the cap by 0.5 g/mi. Credits for this car would have to be truncated at 3.0 g/mi, and there is no non-arbitrary methodology to assign that 3.0 g/mi to the array of technologies involved. It's even possible that a manufacturer with such a car would not even bother to include credits for paint, since credits from the other two technologies have already exceeded the cap. Therefore, this report can only detail the credits derived from the overall category, but not from the individual technologies in the category.

The per-vehicle grams per mile credit varies between cars and trucks; for example, the credit available for active seat ventilation is 1 g/mi for cars and 1.3 g/mi for trucks. The regulations clearly define each technology and any requirements that apply for the technology to generate credits. The definitions may be summarized as follows:

- *Active aerodynamics* – These technologies are automatically activated to improve the aerodynamics of a vehicle under certain conditions. These include grill shutters, which allow air to flow around the vehicle more efficiently, and suspension systems that improve air flow at higher speeds by reducing the height of the vehicle. Credits are variable and based on the measured improvement in the coefficient of drag, a test metric that reflects the efficiency of airflow around a vehicle.
- *Thermal control technologies* – These systems reduce the air temperature of the vehicle interior, lowering GHG tailpipe emissions by reducing the fuel demand on the A/C system. Thermal control technologies are subject to a per-vehicle cap on credits of 3.0 g/mi for cars and 4.3 g/mi for trucks.
    - *Active and passive cabin ventilation* –Active systems use mechanical means to vent the interior, while passive systems rely on ventilation through convective air flow. Credits range from 1.7 to 2.8 g/mi.
    - *Active seat ventilation* - These systems move air through the seating surface, transferring heat away from the vehicle occupants. Credits are 1.0 g/mi for cars and 1.3 g/mi for trucks.
    - *Glass or glazing* – Credits are available for glass or glazing technologies that reduce the total solar transmittance through the glass, thus reducing the heat from the sun that reaches the occupants. The credits are calculated based on the measured solar transmittance through the glass and on the total area of glass on the vehicle.
    - *Solar reflective surface coating* – Credits are available for solar reflective surface coating (e.g., paint) that reflects at least 65 percent of the infrared solar energy. Credits are 0.4 g/mi for cars and 0.5 g/mi for trucks.
- *Active engine and transmission warmup* – These systems use heat from the vehicle that would typically be wasted (exhaust heat, for example) to warm up key elements of the

engine, allowing a faster transition to warm operation. A warmed up engine and/or transmission consumes less fuel and emits less tailpipe CO_2. Systems that use a single heat-exchanging loop that serves both transmission and engine warmup functions are eligible for either engine or transmission warmup credits, but not both.

  - *Active engine warmup* – Uses waste heat from the engine to warm up the engine. Credits are 1.5 g/mi for cars and 3.2 g/mi for trucks.
  - *Active transmission warmup* – Uses waste heat from the engine to warm up the transmission. Credits are 1.5 g/mi for cars and 3.2 g/mi for trucks.

- *Engine idle stop-start* – These systems allow the engine to turn off when the vehicle is at a stop (e.g., at a stoplight), automatically restarting the engine when the driver releases the brake and/or applies pressure to the accelerator. If equipped with a switch to disable the system, EPA must determine that the predominant operating mode of the system is the "on" setting (defaulting to "on" every time the key is turned on is one basis for such a determination). Thus some vehicles with these systems are not eligible for credits. Credits range from 1.5 to 4.4 g/mi, and depend on whether the system is equipped with an additional technology that allows heat, when demanded, to continue to be circulated to the vehicle occupants when the engine is off during a stop-start event.
- *High efficiency exterior lights* – These lights reduce the total electric demand, and thus the fuel consumption and GHG emissions, of the lighting system in comparison to conventional lighting technologies. Credits are based on the specific lighting locations, ranging from 0.06 g/mi for turn signals and parking lights to 0.38 g/mi for low beams. The total of all lighting credits may not exceed 1.0 g/mi.
- *Solar panels* – Vehicles that use batteries for propulsion, such as electric, plug-in hybrid electric, and hybrid vehicles may receive credits for solar panels that are used to charge the battery directly or to provide power directly to essential vehicle systems (e.g., heating and cooling systems). Credits are based on the rated power of the solar panels.

Table 3-19. Off-Cycle Technology Credits from the Menu by Technology, 2016 Model Year (Mg)*

Off-Cycle Technology	Car	Truck	Total	Grams/Mile Equivalent of Total
Active Aerodynamics				
Grill shutters	215,801	423,866	639,667	0.2
Ride height adjustment	61	7,075	7,136	0.0
Subtotal:	*215,862*	*430,941*	*646,803*	***0.2***
Thermal Control Technologies				
Passive cabin ventilation				N/A
Active cabin ventilation				N/A
Active seat ventilation				N/A
Glass or glazing				N/A
Solar reflective surface coating				N/A
Subtotal:	*922,865*	*2,616,304*	*3,539,169*	***1.0***
Engine & Transmission Warmup				
Active engine warmup	485,989	1,182,173	1,668,162	0.5
Active transmission warmup	665,715	1,107,216	1,772,931	0.5
Subtotal:	*1,151,704*	*2,289,389*	*3,441,093*	***1.0***
Other				
Engine idle stop-start	396,464	622,385	1,018,849	0.3
High efficiency exterior lights	366,356	386,841	753,197	0.2
Solar panel(s)	43	-	43	0.0
Subtotal:	*762,863*	*1,009,226*	*1,772,089*	***0.5***
Total	**3,053,294**	**6,345,860**	**9,399,154**	**3**

*Credits are not always reported by manufacturers in a format that shows the total credits for each technology as we show here. For the purposes of this report we have used the data from manufacturers to calculate the credits shown in this table.

Table 3-20 shows the percent of each manufacturers' production volume using each of the "menu" technologies, i.e., the penetration rate of a given technology within a manufacturer's fleet. The totals of the manufacturer rows are not provided, as they would sum to more than 100% and are not meaningful values, reflecting only that some vehicles are equipped with multiple off-cycle technologies. The data is not currently collected in a format across all manufacturers that allows a determination of how many vehicles have at least one off-cycle technology or how many technologies are on a given vehicle, thus the total would only indicate how many individual technologies were used to generate credits. Note that a value of zero indicates use of a technology, but at a rate less than 0.5 percent, thus rounding to zero. As was the case in the previous model year, there was significant penetration of glass or glazing technology across these manufacturers, with a majority of them reporting installing this technology on more than 50 percent of their vehicles, and three manufacturers approaching a 100 percent implementation rate (FCA, Jaguar Land Rover, and Kia). High efficiency lighting is another technology with high penetration across a number of manufacturers; all manufacturers reported implementation on at least half of their fleet, and Jaguar Land Rover and BMW at or near 100 percent. Relative to the 2015 model year, the use of engine idle stop-start systems almost doubled, reaching 10 percent of the 2016 model year fleet. With 100 percent implementation, Jaguar Land Rover had the highest proportion of vehicles equipped with engine idle stop-start, with Mercedes following at over 80 percent. The most "popular" technologies across the manufacturers were high efficiency lights and engine idle stop-start systems, both of which were employed by more than 10 manufacturers, followed by active aerodynamic grill shutters and active seat ventilation, which were used by 10 and 9 manufacturers, respectively. Although active seat ventilation was used by many manufacturers, it remains a technology with limited offering, appearing on only about five percent of the 2016 model year fleet, with Jaguar Land Rover appearing the outlier with implementation on more almost 60 percent of their vehicles (this is consistent with this technology being largely limited to luxury brands or models). The most widely used off-cycle technology across the fleet was high efficiency lighting, which was installed on almost 10 million vehicles, or about 60 percent of the fleet. FCA was the leader in terms of the number of technologies used to generate off-cycle credits, gaining GHG reductions from ten unique technologies implemented at varying rates across their fleets. FCA used every menu technology except active cabin ventilation and solar panels. As noted previously, it is possible that some of the thermal control technologies are under-reported due to the cap on the credits allowed from that category.

Table 3-21 shows the grams per mile benefit that each manufacturer accrued from each off-cycle technology. Like the preceding table, this demonstrates the mix of technologies being used across the manufacturers and the extent to which each technology benefits each manufacturer's fleet. FCA and Jaguar Land Rover can be singled out as the manufacturers reporting the greatest benefits from off-cycle technologies (7 g/mi), with most other manufacturers gaining in the range of 2-4 g/mi from these off-cycle technologies. A closer look shows different strategies across these manufacturers of varying sizes and product lines. Jaguar Land Rover used a high penetration of engine idle stop-start and thermal control technologies to get most of their benefit, while BMW achieved most of theirs by use of thermal control and active engine warm-up technologies. FCA achieved half of their benefit from thermal control technologies, and most of the remainder from active engine and transmission warm-up strategies. Jaguar Land Rover, which, as noted earlier, has made very large GHG reductions across their fleet since the start of the program, gained half of their 7 g/mi of off-cycle credits through adoption of stop-start systems across the vast majority of their product line. Only Mercedes has approached this implementation rate for engine idle stop-start systems, accounting for more than half of their 4 g/mi benefit.

Table 3-20. Percent of 2016 Model Year Vehicle Production Volume with Credits from the Menu, by Manufacturer & Technology (%)

	Active Aerodynamics		Thermal Control Technologies					Engine & Transmission Warmup		Other		
Manufacturer	**Grill shutters**	**Ride height adjustment**	**Passive cabin ventilation**	**Active cabin ventilation**	**Active seat ventilation**	**Glass or glazing**	**Solar reflective surface coating**	**Active engine warmup**	**Active transmission warmup**	**Engine idle stop-start**	**High efficiency exterior lights**	**Solar panel(s)**
BMW	3	-	-	94	8	0	-	71	-	3	97	-
Ford	74	-	-	-	-	-	-	30	21	11	59	-
GM	15	-	-	-	9	62	21	26	-	15	67	-
Honda	-	-	-	-	3	-	-	-	79	3	83	-
Hyundai	4	-	-	-	11	69	-	-	37	3	50	-
Jaguar Land Rover	38	-	-	-	58	100	-	-	-	100	100	-
Kia	1	-	-	-	11	99	-	-	37	1	50	-
Mercedes	-	-	-	-	17	5	-	-	-	81	81	-
Nissan	27	-	-	-	5	-	17	16	71	1	66	0
Subaru	34	-	-	-	-	-	-	-	-	-	48	-
Toyota	4	0	-	-	-	-	-	20	-	9	59	-
FCA†	*28*	*2*	*92*	*-*	*11*	*99*	*3*	*51*	*23*	*12*	*69*	*-*
Fleet Total	**20**	**0**	**11**	**2**	**5**	**30**	**5**	**20**	**23**	**10**	**61**	**0**

†FCA is listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-21. Model Year 2016 Off-Cycle Technology Credits from the Menu, by Manufacturer and Technology (g/mi)

	Active Aerodynamics		Engine & Transmission Warmup			Other			
Manufacturer	Grill shutters	Ride height adjustment	Active engine warmup	Active transmission warmup	Thermal Control Technologies	Engine idle stop-start	High efficiency exterior lights	Solar panel(s)	Total
BMW	0.0	-	1.5	-	2.3	0.1	0.7	-	5
Ford	1.0	-	0.7	0.6	-	0.4	0.2	-	3
GM	0.1	-	0.5	-	1.7	0.3	0.3	-	3
Honda	-	-	-	1.6	0.0	0.1	0.3	-	2
Hyundai	0.0	-	-	0.6	0.5	0.0	0.1	-	1
Jaguar Land Rover	0.2	-	-	-	2.5	3.6	0.8	-	7
Kia	0.0	-	-	0.8	0.9	0.0	0.1	-	2
Mercedes	-	-	-	-	0.2	2.4	0.9	-	4
Nissan	0.1	-	0.3	1.5	0.1	0.0	0.2	0.0	2
Subaru	0.2	-	-	-	-	-	0.1	-	0
Toyota	0.0	0.0	0.5	-	1.3	0.3	0.2	-	2
FCA†	*0.2*	*0.0*	*1.5*	*0.8*	*3.4*	*0.5*	*0.2*	*-*	*7*
Fleet Total	**0.2**	**0.0**	**0.5**	**0.5**	**1.0**	**0.3**	**0.2**	**0.0**	**3**

†FCA is listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.
Note that "0.0" indicates that the manufacturer did implement that technology, but that the overall penetration rate was not high enough to round to 0.1 g/mi, whereas a dash indicates no use of a given technology by a manufacturer.

2. *Off-Cycle Technology Credits Based on 5-Cycle Testing*

As was the case in the 2012-2015 model years, GM is the only manufacturer to have requested and been granted off-cycle credits based on 5-cycle testing. These credits are for an off-cycle technology used on certain GM gasoline-electric hybrid vehicles. The technology is an auxiliary electric pump, which keeps engine coolant circulating in cold weather while the vehicle is stopped and the engine is off. GM received off-cycle credits in the early credits program for hybrid full size pick-up trucks that were equipped with this technology. In the 2012 model year, the technology was expanded to include two Buick hybrid passenger car models. In the 2013 model year the technology was applied to GM's full-size hybrid trucks as well as the Buick LaCrosse, Buick Regal, and Chevrolet Malibu models equipped with GM's "eAssist" technology. The 2014 model year GM vehicles receiving this credit were the eAssist-equipped Buick LaCrosse, Buick Regal, Chevrolet Malibu, and Chevrolet Impala. In the 2015 and 2016 model years, the eAssist-equipped vehicles were the Buick LaCrosse, Buick Regal, and Chevrolet Malibu, totaling almost 100,000 vehicles in the 2016 model year. These vehicles feature engine stop-start capability for improved fuel economy, and as a result the engine can frequently be turned off when the vehicle is stopped, such as at a traffic light, resulting in real-world fuel savings. However, during cold weather, a hybrid vehicle without the auxiliary heater pump would need to keep the engine idling during the stop periods solely to maintain coolant flow to the heater to maintain a comfortable temperature inside the vehicle. This would reduce the fuel economy benefits of the stop-start feature during cold weather, which is an "off-cycle" temperature condition not captured by the greenhouse gas compliance test methods. The off-cycle credits reported by GM in the 2009-2016 model years are shown in Table 3-22. The calculated fleet-wide grams per mile benefit would round to zero because of the low volume of these credits, thus the table does not display these credits in equivalent grams per mile.

Table 3-22. Reported Off-Cycle Credits Based on 5-Cycle Testing for GM, by Model Year and Fleet (Mg)

Model Year	Car	Truck	Total
2009	-	3,329	3,329
2010	-	965	965
2011	-	1,338	1,338
2012	4,984	838	5,822
2013	13,330	819	14,149
2014	46,505	-	46,505
2015	70,233	-	70,233
2016	27,814	-	27,814
Total	**162,866**	**7,289**	**170,155**

3. Off-Cycle Technology Credits Based on an Alternative Methodology

This third pathway for off-cycle technology credits allows manufacturers to seek EPA approval to use an alternative methodology for determining the off-cycle technology CO_2 credits.[34] This option is only available if the benefit of the technology cannot be adequately demonstrated using the 5-cycle methodology. Manufacturers may also use this option for model years prior to 2014 to demonstrate off-cycle CO_2 reductions for off-cycle technologies that are on the menu, or to demonstrate reductions that exceed those available via use of the menu. The regulations require that EPA seek public comment on and publish each manufacturer's application for credits sought using this pathway. Several manufacturers have petitioned for and been granted credits using this pathway.[35]

[34] See 40 CFR 86.1869-12(d).

[35] EPA maintains a web page on which we publish the manufacturers' applications for these credits, the relevant Federal Register notices, and the EPA decision documents. See https://www.epa.gov/vehicle-and-engine-certification/compliance-information-light-duty-greenhouse-gas-ghg-standards.

In the fall of 2013, Mercedes requested off-cycle credits for the following off-cycle technologies in use or planned for implementation in the 2012-2016 model years: stop-start systems, high-efficiency lighting, infrared glass glazing, and active seat ventilation. EPA approved methodologies for Mercedes to determine these off-cycle credits in September of 2014.[36] Subsequently, FCA, Ford, and GM requested off-cycle credits under this pathway. FCA and Ford submitted applications for off-cycle credits from high efficiency exterior lighting, solar reflective glass/glazing, solar reflective paint, and active seat ventilation. Ford's application also demonstrated off-cycle benefits from active aerodynamic improvements (grill shutters), active transmission warm-up, active engine warm-up technologies, and engine idle stop-start. GM's application described the real-world benefits of an A/C compressor made by Denso with variable crankcase suction valve technology. EPA approved the credits for FCA, Ford, and GM in September of 2015.[37] EPA approved additional credits under this pathway in January of 2017 for BMW, Ford, GM, and Volkswagen.[38]

Most of the credits that have been approved have been for credits for previous model years, and thus won't be included in the detailed reporting in this section for the 2016 model year. Credit balances have been updated to include retroactive credits that have been reported to EPA, thus any relevant tables that included data from previous model years will reflect the addition of these credits. GM is the only manufacturer to report credits via this pathway in the 2016 model year, for the Denso A/C compressor. They reported 309,604 Mg of credits from this technology in the 2016 model year.

F. Deficits Based on Methane and Nitrous Oxide Standards

EPA finalized emission standards for methane (CH_4) and nitrous oxide (N_2O) emissions as part of the rule setting the 2012-2016 model year GHG standards. The standards that were set in that rulemaking were 0.010 g/mi for N_2O and 0.030 g/mi for CH_4. These standards were established to cap emissions of GHGs, given that current levels of CH_4 and N_2O are generally significantly below these established standards. These capping standards were intended to prevent future increases in emissions of these GHGs, and were generally not expected to result in the application of new technologies or significant costs for manufacturers using current designs.

There are three different ways for a manufacturer to demonstrate compliance with these standards. First, and used by most manufacturers, manufacturers may demonstrate compliance with these standards with test data as they do for all other non-GHG emission standards. Because there are no credits or deficits involved with this approach, and there are no consequences with respect to the CO_2 fleet average calculation, the manufacturers are

[36] "EPA Decision Document: Mercedes-Benz Off-cycle Credits for MYs 2012-2016," U.S. EPA-420-R-14-025, Office of Transportation and Air Quality, September 2014.
[37] "EPA Decision Document: Off-cycle Credits for FCA Automobiles, Ford Motor Company, General Motors Corporation, and Volkswagen Group of America" U.S. EPA-420-R-15-014, Office of Transportation and Air Quality, September 2015.
[38] "EPA Decision Document: Off-cycle Credits for BMW Group, Ford Motor Company, and General Motors Corporation," U.S. EPA-420-R-17-003, Office of Transportation and Air Quality, January 2017.

not required to submit this data as part of their GHG reporting and hence this GHG compliance report does not include information from manufacturers using this option. Second, EPA also allows an alternative CO_2-equivalent standard option, which manufacturers may choose in lieu of complying with the cap standards. This CO_2-equivalent standard option allows manufacturers to include CH_4 and N_2O, on a CO_2-equivalent basis, in their CO_2 emissions fleet average compliance level. This is done without adjusting the fleet average CO_2 standard to account for the addition of CH_4 and N_2O emissions. Manufacturers that choose this option are required to include the CH_4 and N_2O emissions of all their vehicles for the purpose of calculating their fleet average. In other words, the value of CREE (the carbon-related exhaust emissions, as described earlier) for these manufacturers will include CO_2, hydrocarbons, and carbon monoxide, as well as CH_4 and N_2O emissions (which are adjusted to account for their higher global warming potential than CO_2), for all their vehicles. Analyses of emissions data have shown that use of this option may add approximately 3 g/mi to a manufacturer's fleet average. Only Mazda and Subaru chose to use this approach in the 2016 model year.

The third option for complying with the CH_4 and N_2O standards was initially limited to the 2012-2014 model years, but was subsequently expanded to include all model years of the program. Under this approach, manufacturers can essentially define an alternative, less stringent CH_4 and/or N_2O standard for any vehicle that may have difficulty meeting the specific standards. This alternative standard is treated as any other emission standard in that it must be met for the full useful life of the vehicle. This method provides some additional flexibility relative to the other two options in that (1) a manufacturer can target specific vehicles for alternative standards without incurring a fleet-wide impact, and (2) CH_4 and N_2O are delinked, in that a manufacturer can meet the default regulatory standard for one and select an alternative standard for the other. However, the key aspect of this approach is that manufacturers that use it must calculate a deficit (in Megagrams) based on the less stringent standards and on the production volumes of the vehicles to which those standards apply. Eight manufacturers made use of the flexibility offered by this approach in the 2016 model year, as shown in Table 3-23. Like any other deficit, these deficits must ultimately be offset by CO_2 credits. While these deficits could be carried forward to the next three model years like other deficits, all of the manufacturers using this approach were able to cover these incremental deficits with credits, either carried forward from 2010-2015 or generated in 2016.

Table 3-23. Reported CH_4 and N_2O Deficits by Manufacturer and Fleet, 2016 Model Year (Mg)

Manufacturer	Car		Truck		Total	Grams/Mile Equivalent of Total
	CH_4	N_2O	CH_4	N_2O		
BMW	879	6,982	1,130	8,976	17,967	0.2
Ford	8,479	3,489	78,171	56,591	146,730	0.3
GM	2,922	-	11,055	17,554	31,531	0.1
Mazda	-	-	-	6,763	6,763	0.1
Nissan	4,401	56,360	7,320	87,252	155,333	0.6
Toyota	-	18,288	-	24,344	42,632	0.1
FCA†	*38*	*-*	*5,071*	*-*	*5,109*	*0.0*
Volkswagen†	*200*	*1,096*	*481*	*3,546*	*5,323*	*0.0*
Fleet Total	**16,919**	**86,215**	**103,228**	**205,026**	**411,388**	**0.1**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Tables 3-24 and 3-25 show the grams per mile equivalent CH_4 and N_2O deficits for the 2012-2016 model years. As in all of the tables in this document, the final Fleet Total row indicates the impact across the entire fleet, including manufacturers and vehicles that did not participate in the alternative CH_4 and/or N_2O standards.

Table 3-24. CH_4 Deficits by Manufacturer and Fleet, 2012-2016 Model Years (g/mi)

	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
Manufacturer	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**
BMW	0.0	0.3	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.0	0.2	0.1	0.0	0.1	0.0
Ford	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.2	0.2	0.0	0.3	0.2
GM	0.1	0.4	0.2	0.1	0.4	0.2	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Nissan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0
FCA†	*0.1*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Volkswagen†	*0.6*	*0.1*	*0.5*	*0.5*	*0.0*	*0.5*	*0.5*	*0.0*	*0.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Fleet Total	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.0**	**0.1**	**0.1**	**0.0**	**0.1**	**0.0**	**0.0**	**0.1**	**0.0**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-25. N_2O Deficits by Manufacturer and Fleet, 2012-2016 Model Years (g/mi)

	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
Manufacturer	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**
BMW	0.0	1.1	0.3	0.0	0.2	0.1	0.6	0.6	0.6	0.2	1.3	0.4	0.1	0.4	0.2
Ford	0.0	0.9	0.4	0.0	0.9	0.5	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.2	0.1
GM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Honda	0.0	0.0	0.0	1.2	0.0	0.8	1.4	0.0	0.8	0.1	0.6	0.3	0.0	0.0	0.0
Mazda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
Nissan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.2	0.6	0.3	0.9	0.5
Toyota	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Volkswagen†	*1.4*	*1.2*	*1.4*	*1.4*	*0.7*	*1.3*	*1.3*	*0.8*	*1.2*	*0.9*	*0.4*	*0.8*	*0.0*	*0.1*	*0.0*
Fleet Total	**0.1**	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.0**	**0.1**	**0.1**	**0.2**	**0.1**	**0.0**	**0.1**	**0.1**

†Volkswagen is listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

G. 2016 Model Year Compliance Values

As described at the outset of this section, there are a number of "building blocks" that are assembled to describe a manufacturer's performance in a given model year. These elements cumulatively make up a manufacturer's "compliance value," i.e., the performance value specific to a given model year and fleet that is compared to an emissions standard (or target) to determine whether a fleet generates a net credit or deficit balance in that model year. Table 3-26 summarizes all of these building blocks (described in previous sections) for the 2016 model year fleet for each manufacturer. The values in Table 3-26 are calculated for each manufacturer's combined car and truck fleet by weighting car and truck values according to the relative production volumes and VMT of cars and trucks.[39] The final row shows values for the total 2016 fleet. Note that the compliance value for each manufacturer can be derived from the values in the table by applying the credits and deficits to the 2-cycle tailpipe value. For example, Ford's 2-cycle tailpipe emissions of 311 g/mi is reduced by applying A/C and off-cycle credits totaling 13 g/mi, yielding a final compliance value of 298 g/mi (any apparent mathematical differences are the result of rounding). Tables 3-27 and 3-28 show the same information for car and truck fleets, respectively.[40] The resulting compliance values can then be compared to the target values for each fleet to determine whether a manufacturer will report credits or deficits in the 2016 model year. Again, these values are not regulatory values, but are calculated from the Megagrams of credits reported by the manufacturers to EPA and presented this way to more easily communicate compliance in understandable metrics.

[39] The compliance and target values do not represent official regulatory values. Regulatory target values are determined separately for car and truck fleets. The compliance value is not a regulatory value, but rather is a calculated value based on each manufacturers' unique car and truck sales weighting for a given model year, and is shown as a way of portraying the cumulative impact of a manufacturer's tailpipe performance and any optional credits used by a manufacturer.

[40] Versions of Tables 3-19, 3-20, and 3-21 for the 2012-2014 model years are shown in Appendix C.

Table 3-26. 2016 Compliance Values - Combined Passenger Car & Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) A/C	Credits (g/mi) Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	276	10	5	0	262
Ford	311	10	3	0	298
GM	319	11	3	0	305
Honda	245	8	2	0	234
Hyundai	239	7	1	0	231
Jaguar Land Rover	356	22	7	0	326
Kia	267	6	2	0	259
Mazda	231	0	0	0	231
Mercedes	296	11	4	0	281
Mitsubishi	248	5	0	0	242
Nissan	246	8	2	1	237
Subaru	246	3	0	0	243
Tesla	0	6	0	0	-6
Toyota	279	9	2	0	267
Volvo	283	11	0	0	273
FCA†	*331*	*18*	*7*	*0*	*306*
Volkswagen†	*264*	*9*	*0*	*0*	*256*
Fleet Total	**285**	**10**	**3**	**0**	**272**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-27. 2016 Compliance Values - Passenger Car Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi)		CH_4 & N_2O Deficit	Compliance Value
		A/C	Off-Cycle		
BMW	262	9	4	0	249
Ford	254	9	2	0	243
GM	260	10	3	0	246
Honda	213	9	2	0	202
Hyundai	236	7	1	0	228
Jaguar Land Rover	322	19	3	0	299
Kia	246	6	1	0	239
Mazda	214	0	0	0	214
Mercedes	269	11	4	0	254
Mitsubishi	241	3	0	0	238
Nissan	221	7	2	0	212
Subaru	244	3	0	0	241
Tesla		6	0	0	-6
Toyota	224	8	1	0	214
Volvo	249	8	0	0	241
FCA†	*288*	*17*	*3*	*0*	*267*
Volkswagen†	*247*	*8*	*0*	*0*	*239*
Fleet Total	**240**	**9**	**2**	**0**	**229**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-28. 2016 Compliance Values - Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) A/C	Credits (g/mi) Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	310	11	7	0	292
Ford	354	11	4	1	339
GM	365	11	4	0	350
Honda	285	8	2	0	275
Hyundai	339	5	5	0	329
Jaguar Land Rover	361	23	8	0	330
Kia	330	6	3	0	321
Mazda	259	0	0	0	259
Mercedes	342	12	3	0	326
Mitsubishi	251	7	0	0	244
Nissan	297	9	3	1	286
Subaru	246	3	0	0	243
Toyota	342	11	3	0	328
Volvo	300	12	0	0	288
FCA†	*348*	*19*	*8*	*0*	*321*
Volkswagen†	*320*	*12*	*0*	*0*	*308*
Fleet Total	**332**	**11**	**4**	**0**	**317**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table 3-29 shows the calculated compliance values for each manufacturer's car and truck fleet for the 2012-2016 model years. As can be seen in the table, the increases in manufacturer compliance values from 2015 to 2016 outweighed the decreases, leading to a net increase of 4 g/mi across the fleet of combined cars and trucks.

Table 3-29. 2012-2016 Model Year Compliance Values by Manufacturer and Fleet, 2012-2016 Model Years (g/mi)

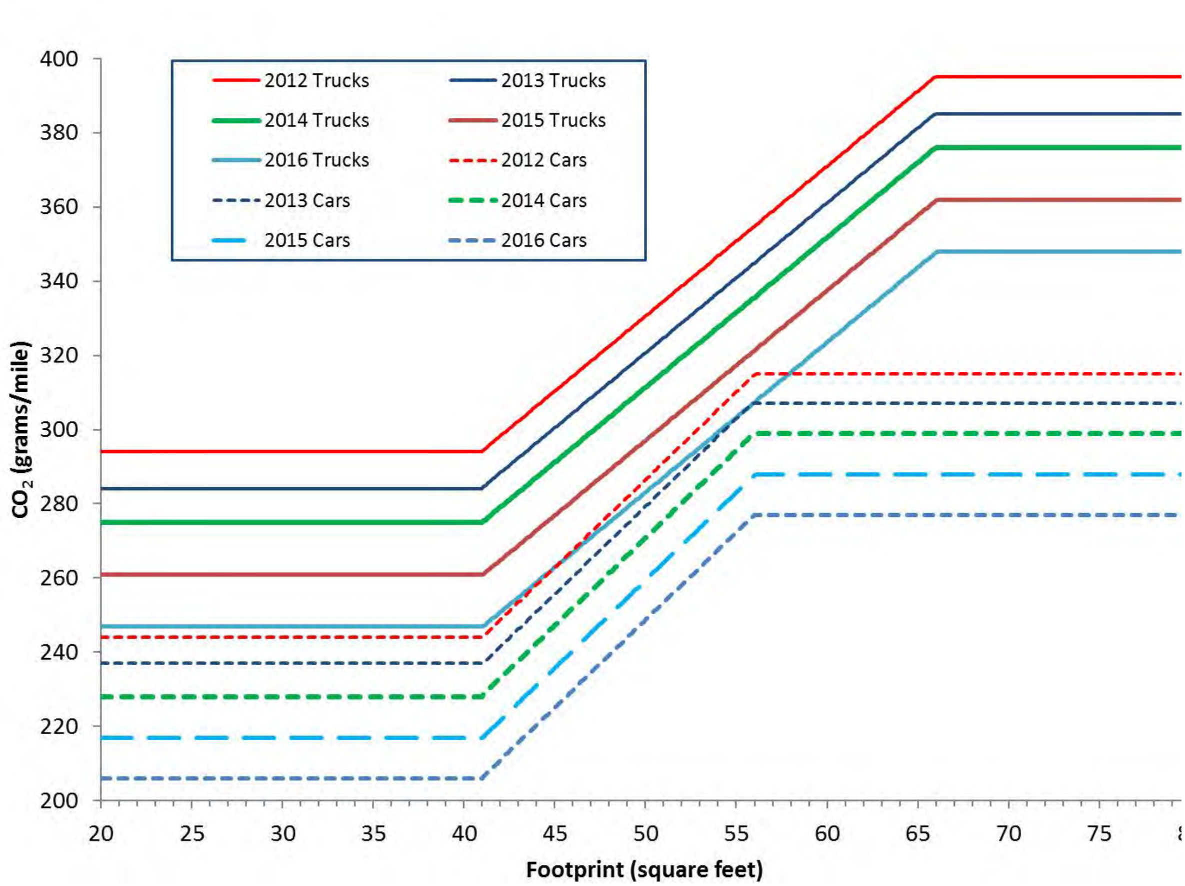
Manufacturer	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All	Car	Truck	All
BMW	267	348	290	260	329	279	245	295	257	244	300	257	249	292	262
BYD Motors	0		0	0		0	0		0	No production volume					
Coda	0		0	0		0	No production volume								
Ford	247	357	295	239	347	298	237	342	289	239	324	287	243	339	298
GM	263	364	306	253	362	299	246	336	288	247	332	296	246	350	305
Honda	234	315	263	226	306	254	225	291	254	212	275	236	202	275	234
Hyundai	239	305	244	233	310	236	241	315	247	238	313	244	228	329	231
Jaguar Land Rover	371	431	418	337	405	390	316	331	328	308	315	313	299	330	326
Karma Auto	102		102	No production volume											
Kia	253	321	261	247	293	249	258	324	262	253	319	258	239	321	259
Mazda	241	324	263	232	296	251	220	287	240	217	285	238	214	259	231
Mercedes	295	366	320	273	346	297	262	342	284	253	327	281	254	326	281
Mitsubishi	262	283	267	254	267	258	224	256	236	215	254	228	238	244	242
Nissan	256	363	288	228	328	260	222	318	253	209	291	235	212	286	237
Porsche	325	362	342	309	363	336	Included in Volkswagen								
Subaru	255	294	280	253	268	262	249	252	251	238	244	243	241	243	243
Suzuki	267	361	287	266	330	273	No production volume								
Tesla	-6		-6	-6		-6	-6		-6	-6		-6	-6		-6
Toyota	214	339	263	218	332	268	211	333	257	215	323	265	214	328	267
Volvo	286	331	300	282	337	307	280	340	311	246	324	277	241	288	273
FCA†	*277*	*351*	*327*	*267*	*345*	*314*	*270*	*324*	*309*	*246*	*312*	*291*	*267*	*321*	*306*
Volkswagen†	*268*	*323*	*275*	*259*	*301*	*264*	*249*	*309*	*261*	*236*	*311*	*252*	*239*	*308*	*256*
Fleet Total	**249**	**347**	**287**	**240**	**337**	**278**	**237**	**322**	**274**	**230**	**311**	**268**	**229**	**317**	**272**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

H. 2016 Model Year Footprint-Based CO_2 Standards

The final values needed to determine the relative performance for a manufacturer in a model year are the emissions standards that apply to each manufacturer's fleets in that model year. At the end of each model year, manufacturers calculate unique CO_2 standards for each fleet (cars and trucks) using equations specified in the regulations based on the footprint of their vehicles.[41] The footprint "curves" for the 2012-2016 model years are shown in Figure 3-1. The unique CO_2 standard for each manufacturer's fleet is a production-weighted average of the CO_2 target values determined from the curves based on all of the unique footprint values for the vehicles in a manufacturer's fleet. Trends in the overall average footprint value are thus important because of the direct impact on the stringency of the GHG standards.

Figure 3-1. 2012-2016 Model Year CO_2 Footprint Target Curves



[41] A vehicle's footprint is defined specifically in regulations as the product of vehicle track width and wheelbase, but it can be simply viewed as the area of the rectangle enclosed by the four points where the tires touch the ground.

The calculated CO_2 standards for the 2012-2016 model years are shown in Table 3-30. Manufacturers use these unique footprint-based car and truck standards – which are required by regulation – to determine their compliance status. A third value for each manufacturer – a sales- and VMT-weighted standard for the combined car and truck fleet – is provided for convenience and comparative purposes, but it is not a compliance value required by the regulations. The numerical CO_2 standards decreased from 2015 to 2016 for every manufacturer except Mitsubishi, resulting in an increase in the overall stringency of the program of 11 g/mi in the 2016 model year.

Table 3-30. 2012-2016 Model Year CO_2 Standards by Manufacturer and Fleet, 2012-2016 Model Years (g/mi)

	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
Manufacturer	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**
BMW	269	336	288	263	324	280	258	313	271	244	301	257	235	286	250
BYD Motors	277	0	277	269	0	269	261	0	261	No production volume					
Coda	246	0	246	239	0	239	No production volume								
Ford	265	364	308	265	355	315	254	345	299	245	329	292	234	315	280
GM	272	369	313	263	360	304	254	357	302	244	336	296	233	318	281
Honda	263	333	288	256	318	278	250	308	275	236	294	258	227	281	251
Hyundai	269	316	273	261	309	263	253	301	257	246	285	249	231	280	233
Jaguar Land Rover	293	400	377	283	354	338	271	332	322	257	338	322	250	288	283
Karma	315	0	315	No production volume											
Kia	266	338	274	258	303	259	251	312	255	241	308	247	229	288	243
Mazda	259	323	276	250	311	268	251	300	265	241	285	254	228	271	244
Mercedes	277	360	306	262	354	292	258	330	278	249	311	273	239	290	258
Mitsubishi	261	307	271	249	296	264	236	287	254	225	273	241	219	260	247
Nissan	263	337	285	259	324	280	249	318	271	239	300	258	229	284	247
Porsche	332	422	374	314	410	363	Included in Volkswagen								
Subaru	260	309	291	251	299	281	243	289	279	234	276	265	224	262	253
Suzuki	251	325	267	243	296	249	No production volume								
Tesla	304	0	304	296	0	296	288	0	288	276	0	276	267	0	267
Toyota	264	342	295	257	330	289	250	326	279	239	305	269	228	292	258
Volvo	272	325	288	264	316	288	258	307	283	247	325	277	238	289	272
FCA†	*277*	*345*	*323*	*270*	*338*	*311*	*262*	*327*	*309*	*247*	*307*	*288*	*237*	*295*	*278*
Volkswagen†	*263*	*327*	*271*	*257*	*317*	*264*	*250*	*311*	*262*	*236*	*297*	*249*	*226*	*279*	*239*
Fleet Total	**267**	**349**	**299**	**261**	**339**	**292**	**253**	**330**	**287**	**241**	**312**	**274**	**231**	**297**	**263**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Overall, the standards decreased by 11 g/mi from 2015 to 2016, an increase in stringency driven by the more stringent target curves for the 2016 model year. However, the target curves represent only one of several key factors that influence the standards. While increased stringency overall from one year to the next is expected because of the structure of the target curves, there are other contributing factors that can result in – and explain – occasional exceptions that may occur. For example, Table 3-30 shows that Mitsubishi's calculated fleet-wide standard increased – or became less stringent – by 6 g/mi, despite the fact that their car and truck standards both increased in stringency. The factor driving this apparent contradiction is that Mitsubishi's truck production (with standards numerically less stringent than cars) increased dramatically, from 30 percent in 2015 to 65 percent of their fleet in the 2016 model year.

The average footprint for the overall fleet increased in the 2016 model year by 0.1 square feet, to 49.5 square feet. The average car footprint remained unchanged at 46.1 square feet, and the truck footprint decreased by 0.2 square feet to 53.7 square feet, the smallest truck footprint since the GHG standards took effect. Of the 17 manufacturers shown in Table 3-31 with 2016 vehicles, fleet average footprint increased for eleven, decreased for four, and was unchanged for two. Increases in footprint spanned from 0.1 square feet (Toyota) to 2.5 square feet (Volvo). Decreases in footprint ranged from 0.1 square feet (Volkswagen) to 0.9 square feet (Hyundai). Note that a change in the overall fleet footprint does not necessarily indicate that manufacturers built smaller or larger vehicles; because the footprint is weighted by production volume, shifts in volumes can result in a change to an overall fleet footprint. Thus, a change in footprint could be a result of either of these factors independently, or more likely, a mix of both factors.

Table 3-31. Average Footprint by Manufacturer and Fleet, 2012-2016 Model Years (square feet)

	2012 Model Year			2013 Model Year			2014 Model Year			2015 Model Year			2016 Model Year		
Manufacturer	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**
BMW	45.9	51.4	47.3	46.2	50.8	47.4	47.1	50.4	47.8	46.6	51.0	47.5	47.1	50.6	48.0
BYD Motors	47.9		47.9	47.9		47.9	47.9		47.9	No production volume					
Coda	41.5		41.5	41.5		41.5	No production volume								
Ford	45.3	59.4	50.9	47.0	59.5	53.4	46.4	59.4	52.4	46.8	58.9	53.1	46.7	59.0	53.3
GM	46.9	60.1	52.0	46.5	60.4	51.9	46.3	62.6	53.2	46.7	60.3	53.9	46.6	59.3	53.3
Honda	45.0	50.5	46.8	44.9	49.3	46.3	45.6	49.2	47.0	45.0	49.1	46.5	45.3	49.6	47.0
Hyundai	46.2	46.4	46.2	46.1	47.0	46.2	46.1	47.5	46.2	47.2	47.0	47.2	46.3	49.2	46.3
Jaguar Land Rover	51.0	48.4	49.0	50.8	48.2	48.8	49.3	52.0	51.5	49.6	50.6	50.4	50.2	51.2	51.0
Karma	58.1		58.1	No production volume											
Kia	45.6	51.9	46.2	45.5	45.6	45.5	45.8	50.0	46.1	46.2	52.6	46.7	45.9	51.3	47.1
Mazda	43.9	48.1	44.9	43.6	47.6	44.7	45.6	47.2	46.0	46.1	47.1	46.3	45.4	47.1	46.0
Mercedes	46.5	51.9	48.2	45.4	51.5	47.3	46.6	51.4	47.8	47.3	50.4	48.4	47.5	51.7	48.9
Mitsubishi	44.5	44.0	44.4	43.6	43.9	43.7	41.5	44.0	42.3	41.3	43.9	42.1	43.8	44.2	44.1
Nissan	45.0	51.6	46.8	45.8	50.8	47.2	45.4	51.6	47.2	45.8	50.6	47.1	45.8	50.1	47.1
Porsche	44.7	51.8	47.7	43.7	51.9	47.6	Included in Volkswagen								
Subaru	44.3	44.7	44.5	44.0	44.6	44.4	44.1	44.4	44.3	44.7	44.7	44.7	44.7	44.8	44.7
Suzuki	42.1	48.7	43.4	41.8	44.0	42.0	No production volume								
Tesla	53.6		53.6	53.6		53.6	53.6		53.6	53.6		53.6	53.9		53.9
Toyota	45.0	53.4	48.0	45.1	52.5	48.1	45.6	54.1	48.6	45.6	52.2	48.4	45.5	52.5	48.5
Volvo	46.8	48.6	47.3	46.8	49.0	47.7	47.2	48.9	48.0	47.3	48.0	47.5	47.7	51.4	50.0
FCA†	*47.2*	*53.6*	*51.4*	*47.6*	*54.5*	*51.5*	*48.0*	*54.1*	*52.2*	*47.1*	*52.7*	*50.7*	*47.5*	*53.2*	*51.4*
Volkswagen†	*45.2*	*49.0*	*45.6*	*45.2*	*49.0*	*45.6*	*45.5*	*50.0*	*46.3*	*45.1*	*50.1*	*46.0*	*45.1*	*48.9*	*45.9*
Fleet Total	**45.7**	**54.5**	**48.8**	**45.9**	**54.7**	**49.1**	**46.1**	**55**	**49.7**	**46.1**	**53.9**	**49.4**	**46.1**	**53.7**	**49.5**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

I. Overall Compliance Summary

Final compliance for the 2012-2016 model years is summarized in Table 3-32 for the overall model year fleet, and separately for cars and trucks in Tables 3-33 and 3-34, respectively. As in the tables in Section 3.G, these show how the 2-cycle tailpipe values and the credits are used to "build" the overall compliance value, which is then compared to the model year standards described in Section 3.H. The tables also show, in the final column, the value achieved by subtracting the standard from the compliance value. This value is negative in the 2012 to 2015 model years, indicating that, overall, the industry was generating credits in these model years. A positive value for the 2016 model year indicates that the industry generated a deficit. In both the 2012 and 2013 model years, the industry's over-compliance was almost entirely driven by the compliance margin seen in the car fleet, since the truck compliance values essentially equaled the overall fleet standards. This was not true for the 2014 model year, where the truck fleet achieved a compliance margin relative to the truck standard of -8 g/mi, thus contributing to the overall fleet compliance margin and credit generation. In the 2015 model year the bulk of the credit generation was again attributable to passenger cars, although the trucks also generated credits with a performance value of 311 g/mi and an applicable fleet standard of 312 g/mi. The generation of deficits in the 2016 model year can be traced to the truck fleet, as seen in Table 3-34, whereas passenger cars generated credits by achieving a performance value slightly lower than the applicable standard.

Table 3-32. Performance & Credit Summary, 2012-2016 Model Years - Combined Cars and Trucks (g/mi)*

Model Year	2-Cycle Tailpipe	Credits			CH_4 & N_2O Deficit	Performance	Standard	Performance minus Standard
		FFV	A/C	Off-Cycle				
2012	302	8.1	6.1	0.7	0.2	287	299	-12
2013	294	7.8	6.9	0.8	0.3	278	292	-13
2014	294	8.9	8.4	2.5	0.2	274	287	-13
2015	286	6.4	9.4	2.7	0.2	268	274	-7
2016	285	-	10.0	2.9	0.1	272	263	9

*Values stated in this table and in the text are correct, although rounding of values may result in some apparent differences.

Table 3-33. Performance & Credit Summary, 2012-2016 Model Years – Passenger Cars (g/mi)*

Model Year	2-Cycle Tailpipe	Credits			CH_4 & N_2O Deficit	Performance	Standard	Performance minus Standard
		FFV	A/C	Off-Cycle				
2012	259	4.0	5.4	0.4	0.1	249	267	-18
2013	251	4.0	6.3	0.6	0.3	240	261	-20
2014	250	4.6	7.4	1.6	0.3	237	253	-16
2015	243	3.1	8.0	1.9	0.1	230	241	-11
2016	240	-	8.6	1.8	0.1	229	231	-1

*Values stated in this table and in the text are correct, although rounding of values may result in some apparent differences.

Table 3-34. Performance & Credit Summary, 2012-2016 Model Years – Light Trucks (g/mi)*

Model Year	2-Cycle Tailpipe	Credits			CH_4 & N_2O Deficit	Performance	Standard	Performance minus Standard
		FFV	A/C	Off-Cycle				
2012	369	14.5	7.3	1.0	0.3	347	349	-2
2013	360	13.8	7.9	1.1	0.3	337	339	-2
2014	349	14.3	9.7	3.6	0.1	322	330	-8
2015	336	10.2	10.9	3.7	0.2	311	312	-1
2016	332	-	11	4	0	317	297	20

*Values stated in this table and in the text are correct, although rounding of values may result in some apparent differences.

A comparison between compliance values and standards for each manufacturer and fleet is shown in Table 3-35. The final row shows values for the total 2016 fleet. The comparison of the compliance and standards in Table 3-35, shown in the "Net Compliance" columns, indicates whether a manufacturer generated net credits or deficits in the 2016 model year. Negative values indicate over-compliance with the standards, or compliance values that are lower than the standard by the stated value. Positive values are thus an indication of compliance values that exceed (i.e., do not meet) the applicable standards. BMW, for example, generated a 2016 model year deficit because their overall compliance value of 262 g/mi is above their fleet-wide standard of 250 g/mi. Honda, on the other hand, reported net credits based on a compliance value of 234 g/mi, 16 g/mi lower than their fleet-wide standard. Note, however, that the generation of a net deficit in the 2016 model year by any manufacturer does not necessarily indicate that the manufacturer has failed to comply with the 2016 model year standards. BMW, for example, will offset their 2016 deficit by using credits either purchased from another manufacturer or generated in previous model years, thereby complying with the 2016 standards.[42] The final row of Table 3-35 shows the conclusion that the 2016 model year was a deficit-generating year overall, based on the compliance value that is 9 g/mi above the 2016 model year standard. A comparison of the values in the three previous tables to EPA projections for these values is in Appendix A.[43]

Table 3-35. 2016 Model Year Compliance Summary by Manufacturer and Fleet (g/mi)

	Compliance Value			Standard			Net Compliance		
Manufacturer	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**	**Car**	**Truck**	**All**
BMW	249	292	262	235	286	250	14	6	12
Ford	243	339	298	234	315	280	9	24	18
GM	246	350	305	233	318	281	13	32	24
Honda	202	275	234	227	281	251	-25	-6	-16
Hyundai	228	329	231	231	280	233	-3	49	-1
Jaguar Land Rover	299	330	326	250	288	283	49	42	43
Kia	239	321	259	229	288	243	10	33	15
Mazda	214	259	231	228	271	244	-14	-12	-13
Mercedes	254	326	281	239	290	258	15	36	23
Mitsubishi	238	244	242	219	260	247	19	-16	-5
Nissan	212	286	237	229	284	247	-17	2	-10
Subaru	241	243	243	224	262	253	17	-19	-10
Tesla	-6		-6	267		267	-273		-273
Toyota	214	328	267	228	292	258	-14	36	10
Volvo	241	288	273	238	289	272	3	-1	0
FCA†	*267*	*321*	*306*	*237*	*295*	*278*	*30*	*26*	*27*
Volkswagen†	*239*	*308*	*256*	*226*	*279*	*239*	*13*	*29*	*17*
Fleet Total	**229**	**317**	**272**	**231**	**297**	**263**	**-1**	**20**	**9**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

[42] This section deals only with manufacturer performance within a model year, and does not consider the implications on compliance of the use of credits or deficits from previous model years or of sold and purchased credits. See Section 5 for a discussion of the current compliance status of each manufacturer that considers all of these factors.
[43] EPA projections are from the previously-referenced rulemakings from May 7, 2010 and October 15, 2012.

4. Credit Transactions

Credits may be traded among manufacturers with a great deal of flexibility (with the exception of 2009 model year credits and credits generated by manufacturers using the TLAAS program, which are restricted to use only within a manufacturer's own fleets). There are only a few regulatory requirements that relate to credit transactions between manufacturers (other than the restrictions just noted), and these are generally designed to protect those involved in these transactions. While it may seem obvious, it is worth stating that a manufacturer may not trade credits that it does not have. Credits that are available for trade are only those available (1) at the conclusion of a model year when all the data is available with which to calculate the number of credits generated by a manufacturer, and not before; and (2) after a manufacturer has offset any deficits they might have. Credit transactions that result in a negative credit balance for the selling manufacturer are not allowed and can result in severe punitive actions. Although a third party may facilitate transactions, EPA's regulations allow only the automobile manufacturers to engage in credit transactions and hold credits.

Since the 1990's, many of EPA's vehicle emissions regulatory programs have included the flexibilities of averaging, banking, and trading (ABT). The incorporation of ABT provisions in EPA emissions regulations has been generally supported by a wide range of stakeholders: by manufacturers for the increased flexibility that ABT offers and by environmental groups because ABT enhances EPA's ability to introduce standards of greater stringency in an earlier time frame than might otherwise be achieved. Historically, manufacturers tended to make use of the ability to average emissions and bank emissions credits for use in subsequent years, but until recently there has been almost no credit trading activity between companies. The use of trading provisions in EPA's light-duty GHG program is a historic development, and one that EPA welcomes because we believe it will allow greater GHG reductions, lower compliance costs, and greater consumer choice.

The credit transactions reported by manufacturers through the 2016 model year are shown in Table 4-1. Note that manufacturers do not report transactions to EPA as they occur. Thus there may be additional credit transactions that have occurred that are not reported here, but because of the timing of those transactions (after the manufacturers submitted their 2014 model year data) those transactions will be reported in the 2015 model year reports of the manufacturers involved, and thus will be included in EPA's performance report regarding the 2015 model year. As of the close of the 2016 model year, more than 30 million Megagrams of CO_2 credits had changed hands. Credit distributions are shown as negative values, in that a disbursement represents a deduction of credits from the specified model year for the selling manufacturer. Credit acquisitions are indicated as positive values because acquiring credits represents an increase in credits for the purchasing manufacturer. The model year represents the "vintage" of the credits that were sold, i.e., the model year from which the credits originated. The vintage always travels with the credits, regardless of when a transaction takes place and in what model year the credits are ultimately used. A manufacturer with 2010 model year credits can hold them until 2021, meaning, for example, that a sale of 2010 credits could potentially be reported to EPA as late as the reporting deadline for the 2021 model year, and those 2010 credits traded in model year 2021 could be used by the buyer to offset deficits from the 2018-2021 model years. The overall impact of these credit transactions on the compliance position of each manufacturer is discussed in Section 5, which pulls together all the credits and deficits, including early credits, discussed in the preceding sections. Note that each value in the table is simply an indication of the quantity of credits from a given model year that has been acquired or disbursed by a manufacturer, and thus may represent multiple transactions with multiple buyers or sellers.

Table 4-1. Cumulative Reported Credit Sales and Purchases (Mg)

	Manufacturer	Model Year "Vintage" 2010	2011	2012	2013	2014	2015	2016	Total
Credits Disbursed	Coda	-	-	5,524	1,727	-	-	-	7,251
	Honda	14,182,329	6,590,901	-	-	-	-	-	20,773,230
	Nissan	950,000	1,345,570	250,000	1,000,000	-	-	-	3,545,570
	Tesla	35,580	14,192	177,941	1,049,384	1,020,296	1,337,853	2,452,519	3,635,246
	Toyota	2,507,000	-	-	-	831,358	-	-	3,338,358
Credits Acquired	BMW	2,000,000	-	-	-	-	-	-	2,000,000
	Ferrari	265,000							265,000
	FCA	11,424,329	7,090,901	-	1,049,384	1,020,296	1,337,853	2,452,519	21,922,763
	GM	-	-	5,524	1,727	-	-	-	7,251
	Jaguar Land Rover	-	39,063	-	-	831,358	-	-	870,421
	McLaren		6,507						6,507
	Mercedes	3,985,580	814,192	427,941	1,000,000	-	-	-	6,227,713

5. COMPLIANCE STATUS AFTER THE 2016 MODEL YEAR

Based on the information reported to EPA, the vast majority of manufacturers have successfully demonstrated compliance with the 2012-2016 model year standards and are carrying a positive credit balance into the 2017 model year. The manufacturers that report compliance with all model years represent more than 99 percent of all cars and light trucks produced for U.S. sale in the 2012-2016 model years, the first phase of EPA's GHG standards. Table 5-1 shows one view of the accumulated credits for each manufacturer. Each manufacturer reporting a positive balance in the final column is, by definition, in compliance with the 2012-2016 model years (because all deficits must be offset before carrying credits forward).

Table 5-1 shows the total credits (or deficits) for each manufacturer in the last column. Table 5-1 also shows the credits (or deficits) generated by each manufacturer in the 2009-2016 model years, as well as the net impact of credit transactions on each manufacturer's credit balance. However, to fully understand the current compliance position of each manufacturer, we also need to know the makeup of the credit balance in terms of the origin, or vintage, of the credits. Knowing the vintage is important both for credits and deficits, because we need to know when credits expire and must be forfeited, and we need to know when a manufacturer is in violation of the regulations as a result of failing to offset a deficit within the required time frame.

Table 5-1. Cumulative Credit Status After the 2016 Model Year (Mg)

Manufacturer	Early Credits (2009-2011) Earned	Early Credits (2009-2011) Bought, Sold, Forfeited, or Expired	2012 Earned	2012 Bought, Sold, Forfeited, or Expired	2013 Earned	2013 Bought, Sold, Forfeited, or Expired	2014 Earned	2014 Bought, Sold, Forfeited, or Expired	2015 Earned	2015 Bought, Sold, Forfeited, or Expired	2016 Earned	2016 Bought, Sold, Forfeited, or Expired	Total Carried Forward to 2017
Toyota	80,435,498	(32,239,098)	13,163,009	0	9,875,003	0	9,839,348	(831,358)	2,564,396	0	(4,727,835)	0	78,078,963
Honda	35,842,334	(34,906,583)	7,941,932	0	7,307,995	0	6,480,503	0	7,192,274	0	6,166,021	0	36,024,476
Nissan	18,131,200	(10,485,694)	(729,937)	(250,000)	5,190,521	(1,000,000)	4,854,133	0	8,089,026	0	2,883,585	0	26,682,834
Ford	16,116,453	(5,882,011)	4,789,580	0	8,238,561	0	4,843,648	0	2,047,791	0	(8,069,883)	0	22,084,139
Hyundai	14,007,495	(4,482,649)	3,535,510	0	5,777,836	(169,775)	1,113,812	0	647,751	0	153,564	0	20,583,544
GM	25,510,557	(6,894,611)	3,575,173	5,524	2,438,654	1,727	7,823,425	0	396,674	0	(13,190,423)	0	19,666,700
Subaru	5,755,171	(491,789)	646,317	0	1,444,372	0	2,882,640	0	3,044,329	0	1,220,109	0	14,501,149
Mazda	5,482,642	(1,340,917)	734,887	0	786,431	0	1,547,009	0	970,540	0	1,243,959	0	9,424,551
Kia	10,444,192	(2,362,882)	1,303,379	0	1,330,236	(123,956)	(771,893)	0	(1,588,713)	0	(2,218,748)	0	6,011,615
BMW	1,251,522	1,865,209	(110,996)	0	48,709	0	1,075,752	0	26,118	0	(953,972)	0	3,202,342
Mercedes	378,272	4,799,772	(723,216)	427,941	(298,662)	1,000,000	(401,140)	(28,416)	(597,785)	0	(1,565,261)	0	2,991,505
Mitsubishi	1,449,336	(583,146)	57,837	0	58,209	0	351,031	0	348,232	0	73,971	0	1,755,470
Suzuki	876,650	(265,311)	(127,699)	0	(55,398)	0	0	0	0	0	0	0	428,242
Karma Automotive	0	0	58,852	0	0	0	0	0	0	0	0	0	58,852
BYD Motors	0	0	595	0	1,681	0	2,548	0	0	0	0	0	4,824
Tesla	49,772	(49,772)	178,517	(177,941)	1,049,384	(1,049,384)	1,020,296	(1,020,296)	1,337,853	(1,337,853)	2,452,519	(2,452,519)	576
Coda	0	0	5,524	(5,524)	1,727	(1,727)	0	0	0	0	0	0	0
Volvo	730,187	0	(175,195)	0	(297,006)	0	(183,695)	0	10,872	(85,163)	(9,218)	0	(9,218)
Jaguar Land Rover	0	39,063	(488,109)	0	(716,448)	0	(90,192)	831,358	135,773	0	(1,099,226)	0	(1,387,781)
FCA†	*10,411,321*	*18,515,230*	*(1,221,514)*	*0*	*(1,003,146)*	*1,049,384*	*(45,458)*	*1,020,296*	*(1,462,661)*	*1,337,853*	*(11,836,032)*	*2,452,519*	*19,217,792*
Volkswagen†	*6,441,405*	*(1,404,947)*	*(426,200)*	*0*	*31,148*	*0*	*112,228*	*0*	*(385,236)*	*0*	*(1,929,790)*	*0*	*2,438,608*
Fleet Total	**233,314,007**	**(76,170,136)**	**32,186,594**	**0**	**41,437,898**	**(293,731)**	**40,453,995**	**(28,416)**	**22,777,234**	**(85,163)**	**(31,406,660)**	**0**	**261,759,183**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Because manufacturers accumulate car and truck credits separately, and because they are allowed to move credits around between cars and trucks, the situation can get far more complex than seen in the Ferrari example.[44] Consider this example, where a manufacturer generates 1500 Mg of car credits and a -500 Mg deficit in trucks in 2012, and where credits all have a 5-year lifespan:

Fleet	2012 Credits (Mg)
Cars	1500
Trucks	-500
Total	**1000**

The manufacturer must use the car credits to offset the truck deficit in this case, because there are no credits available from prior model years to use, and credits cannot be carried forward until deficits are addressed. Thus the manufacturer carries a balance of 1000 Mg of credits from 2012 into 2013. Then in this example let's assume that in 2013 they generate 1000 Mg of credits in the car fleet and a deficit of -1000 Mg in the truck fleet, as shown below:

Fleet	2012 Credits (Mg)	2013 Credits (Mg)
Cars	1500	1000
Trucks	-500	-1000
Total	**1000**	**0**

Here, the manufacturer would have 1000 Mg of 2012 credits

There are multiple choices for a manufacturer faced with such a situation. As shown above, all deficits are adequately addressed within each model year, and a manufacturer could leave it at that. Doing so would mean carrying forward the 1000 Mg of credits remaining from 2012 into 2014. There is, however, a smarter – but not mandatory – option. Because the regulations allow car and truck credits and deficits to be managed as separate "bins," and because newer credits are generally more valuable than older credits (because they last longer) it would be smarter for this manufacturer to use the 1000 Mg of credits from 2012 to offset the deficit of -1000 Mg in the 2013 truck fleet, as shown below:

Fleet	2012 Credits (Mg)	2013 Credits (Mg)
Cars	1500	1000
Trucks	-500	-1000
Total	**1000**	**1000**

Here, the manufacturer would have 1000 Mg of 2013 credits

[44] Note that the regulations require that all credits and deficits within a vehicle class (passenger cars or light trucks) be aggregated before transfers between vehicle classes may occur. See 40 CFR 86.1865-12(k)(5).

The bottom line remains the same (1000 Mg of credits are carried into 2014), except that in this case the credits carried forward have a vintage from the newer 2013 model year. Theoretically, a manufacturer could use any mix of 2012 and 2013 credits to offset the 2013 truck deficit, in which case the credits remaining to carry forward would be a mix of 2012 and 2013 credits. The value of a given vintage is based on its expiration date, and the expiration date of 2010-2016 model year credits in EPA's GHG program is fixed at the 2021 model year, meaning that for the 2010-2016 model years it is less important to treat credits in this way. Nevertheless, this "first in, first out" accounting method is being used to determine the makeup of credit balances held by manufacturers (unless a manufacturer expresses a preference for an alternative accounting). It is challenging to display all the credit transfers, transactions, and vintages in a single data table in an easily understandable manner. However, we can display the current state of each manufacturer and the vintage of all the credits currently held by each manufacturer.

Table 5-2 reveals the credit balances for each manufacturer, after adjusting for credit transactions and transfers, by the vintage of the credits reported by the manufacturer. The model year column headings represent the vintages that make up the total credits (or deficit) being carried forward into the 2017 model year. This table shows, for example, the extent to which some manufacturers have used credits from prior model years.

Volvo, for example, reported generating about 730,000 early credits (see Table 2-1 or 5-1). With the exception of the 2015 model year, in which Volvo generated credits, they have consistently been generating deficits in each year. The early credits have been sufficient to offset almost all of these deficits. A small deficit of about 9200 Mg remains from the 2016 model year. A deficit may be carried forward for three years after the year in which it is generated, meaning that deficits from the 2016 model year must be reconciled by the end of the 2019 model year.

Note that Tables 5-1 and 5-2 over-simplify the data with respect to the manufacturers using the TLAAS program in order to present the data concisely. In model years 2012-2015, Jaguar Land Rover and Mercedes reported vehicles subject to the primary standards <u>and</u> subject to the less stringent TLAAS standards, yet for the purpose of these tables we have aggregated the credits accumulated in both the primary and TLAAS fleets into a single row in the table. Although they are not separated for the purposes of these tables, EPA maintains careful records (as do the manufacturers) of the credits within the Primary and TLAAS programs, as is necessary because of the different treatment and restrictions for the different fleets. The data we are making available online and in this report will identify the source of each credit (e.g., whether from the Primary or TLAAS fleets).

Table 5-2. Credits Available After the 2016 Model Year, Reflecting Trades & Transfers (Mg)

Manufacturer	2010	2011	2012	2013	2014	2015	2016	Total Carried Forward to 2017
Toyota	18,943,388	14,651,963	13,163,009	10,336,958	10,139,675	7,231,364	3,612,606	78,078,963
Honda	100	935,651	7,941,932	7,307,995	6,480,503	7,192,274	6,166,021	36,024,476
Nissan	4,653,920	507,179	989,226	4,510,993	4,871,086	8,089,026	3,061,404	26,682,834
Ford	0	2,164,559	4,789,580	8,238,561	4,843,648	2,047,791	0	22,084,139
Hyundai	4,899,895	4,012,969	3,535,510	5,613,813	1,231,344	916,265	373,748	20,583,544
GM	0	4,157,560	3,580,697	2,853,416	7,823,425	1,251,602	0	19,666,700
Subaru	1,578,137	2,876,413	646,317	1,487,331	3,001,354	3,189,186	1,722,411	14,501,149
Mazda	3,201,708	925,179	749,725	786,431	1,547,009	970,540	1,243,959	9,424,551
Kia	0	3,501,956	1,303,379	1,206,280	0	0	0	6,011,615
BMW	1,429,755	444,856	63,382	162,479	1,075,752	26,118	0	3,202,342
Mercedes	591,687	971,877	427,941	1,000,000	0	0	0	2,991,505
Mitsubishi	423,438	302,394	67,976	90,090	351,031	348,232	172,309	1,755,470
Suzuki	329,382	98,860	0	0	0	0	0	428,242
Karma Auto	0	0	58,852	0	0	0	0	58,852
BYD Motors	0	0	595	1,681	2,548	0	0	4,824
Tesla	0	0	576	0	0	0	0	576
Coda	0	0	0	0	0	0	0	0
Volvo	0	0	0	0	0	0	(9,218)	(9,218)
Jaguar Land Rover	0	0	0	0	(134,941)	(153,614)	(1,099,226)	(1,387,781)
FCA†	*2,057,965*	*9,682,875*	*31,342*	*1,484,695*	*1,957,144*	*1,551,252*	*2,452,519*	*19,217,792*
Volkswagen†	*496,637*	*1,528,432*	*60,107*	*241,204*	*112,228*	*0*	*0*	*2,438,608*
Fleet Total	**38,606,012**	**46,756,216**	**37,410,146**	**45,321,927**	**43,301,806**	**32,660,036**	**17,696,533**	**261,759,183**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

APPENDIX A: COMPARING ACTUAL PERFORMANCE TO RULEMAKING PROJECTIONS

As described in Section 1, EPA's GHG program was promulgated in two regulatory actions conducted jointly with NHTSA. The first rulemaking established standards for the 2012-2016 model years, and the second rulemaking set standards for the 2017 and later model years. [45] [46] In each of these rulemakings we included tables summarizing our projections of what the fleet-wide standards would be and how we expected manufacturers would comply with the standards. When evaluating these projections and how they compare to the actual performance as described in this report, consider that the projections for the 2012-2016 model years were finalized in early 2010, and the 2017 and later projections were determined in the middle of 2012. The projections were made with the best available information at the time, but it should not be surprising that actual performance differs from the rulemaking projections. Factors such as consumer preferences, technology innovation, fuel prices, and manufacturer behavior can change in unanticipated ways, leading current, actual performance to diverge from projections made in the past. While a comparison of actual performance to projections is interesting, and helps illuminate whether or not the program is achieving its expected benefits, this is secondary in the context of this report, which is focused on actual compliance. Compliance of manufacturers with EPA's standards is not determined by comparing current model year results to projections made a number of years ago, but is instead determined by comparing achieved compliance values to the regulatory footprint-based standards covered in Sections 1-5 of this report.

Table A-1 shows key projected values for the combined car and truck fleet for the 2012-2025 model years. All of the values in this table (and Tables A-2 and A-3) come directly from the regulatory actions noted above and footnoted below. Note that we projected that the industry, on average, would comply exactly with the target, i.e., the compliance value equals the target value in each model year. This table illustrates a fundamental principle: EPA projections from the rulemaking analysis assumed manufacturers would achieve significant GHG emission reductions (and hence compliance) through a variety of technologies. In the early years, until the incentive is phased out in the 2016 model year, we projected significant use of credits from flexible fuel vehicles (FFV). We also projected relatively high use of improved A/C systems across the fleet, resulting in projected reductions ranging from 3.5 g/mi in 2012 and increasing to over 20 g/mi late in the program. As shown in Table A-1, we projected that manufacturers would start with a 2-cycle tailpipe value of 261 g/mi in the 2016 model year, reducing that by total credits and incentives of about 11 g/mi, thus yielding a net compliance value of 250 g/mi. We did not make any estimations of the use of N_2O and CH_4 alternative standards for two reasons: (1) the overall impact was expected to

[45] Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Final Rule, Federal Register 75 (7 May 2010): 25469.

[46] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Final Rule, Federal Register 77 (15 October 2012): 62889.

be very small, and (2) manufacturers are required to offset deficits accumulated with CO_2-equivalent credits as a result of using this flexibility, thus there is no net impact on the program.

Tables A-2 and A-3 show the same projected values as Table A-1, but separately for cars and trucks, respectively. In the regulatory action establishing the standards we did not publish car- and truck-specific estimated values for the 2-cycle tailpipe emissions or the use of credits and incentives in the 2012-2015 model years, thus these values are shown as N/A in these tables.

Table A-1. Projected CO_2 Performance in Rulemaking Analyses for the Combined Passenger Car and Light Truck Fleet (g/mi)

Model Year	2-Cycle Tailpipe Emissions	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Standard
2012	307	6.5	3.5	1.2	0.0	N/A	295	295
2013	298	5.8	5.0	0.9	0.0	N/A	286	286
2014	290	5.0	7.5	0.6	0.0	N/A	276	276
2015	277	3.7	10.0	0.3	0.0	N/A	263	263
2016	261	0.0	10.6	0.1	0.5	N/A	250	250
2017	256	0.0	12.5	0.0	0.6	N/A	243	243
2018	249	0.0	14.9	0.0	0.8	N/A	234	234
2019	242	0.0	17.5	0.0	0.9	N/A	223	223
2020	234	0.0	19.2	0.0	1.0	N/A	214	214
2021	222	0.0	20.8	0.0	1.1	N/A	200	200
2022	212	0.0	20.8	0.0	1.4	N/A	190	190
2023	203	0.0	20.8	0.0	1.7	N/A	181	181
2024	194	0.0	20.6	0.0	1.9	N/A	172	172
2025	186	0.0	20.6	0.0	2.3	N/A	163	163

Table A-2. Projected CO_2 Performance in Rulemaking Analyses for Passenger Cars (g/mi)

Model Year	2-Cycle Tailpipe Emissions	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Standard
2012	N/A	N/A	N/A	N/A	N/A	N/A	263	263
2013	N/A	N/A	N/A	N/A	N/A	N/A	256	256
2014	N/A	N/A	N/A	N/A	N/A	N/A	247	247
2015	N/A	N/A	N/A	N/A	N/A	N/A	236	236
2016	235	0.0	10.2	0.0	0.4	N/A	225	225
2017	226	0.0	12.8	0.0	0.5	N/A	213	213
2018	218	0.0	14.3	0.0	0.6	N/A	203	203
2019	210	0.0	15.8	0.0	0.7	N/A	193	193
2020	201	0.0	17.3	0.0	0.8	N/A	183	183
2021	193	0.0	18.8	0.0	0.8	N/A	173	173
2022	184	0.0	18.8	0.0	0.9	N/A	164	164
2023	177	0.0	18.8	0.0	1.0	N/A	157	157
2024	170	0.0	18.8	0.0	1.1	N/A	150	150
2025	163	0.0	18.8	0.0	1.4	N/A	143	143

Table A-3. Projected CO_2 Performance in Rulemaking Analyses for Light Trucks (g/mi)

Model Year	2-Cycle Tailpipe Emissions	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Standard
2012	N/A	N/A	N/A	N/A	N/A	N/A	346	346
2013	N/A	N/A	N/A	N/A	N/A	N/A	337	337
2014	N/A	N/A	N/A	N/A	N/A	N/A	326	326
2015	N/A	N/A	N/A	N/A	N/A	N/A	312	312
2016	310	0.0	11.4	0.0	0.7	N/A	298	298
2017	308	0.0	12.0	0.0	0.9	N/A	295	295
2018	304	0.0	16.0	0.0	1.0	N/A	287	287
2019	299	0.0	20.6	0.0	1.2	N/A	278	278
2020	294	0.0	22.5	0.0	1.4	N/A	270	270
2021	276	0.0	24.4	0.0	1.5	N/A	250	250
2022	264	0.0	24.4	0.0	2.2	N/A	238	238
2023	253	0.0	24.4	0.0	2.9	N/A	226	226
2024	242	0.0	24.4	0.0	3.6	N/A	214	214
2025	233	0.0	24.4	0.0	4.3	N/A	204	204

Table A-4 shows a comparison of the projected values (in Tables A-1, A-2, and A-3) with the actual performance for the 2012-2016 model years for the combined car and truck fleet. As is the case throughout this report, values for the combined fleet of cars and trucks are calculated as a weighted average of the individual car and truck fleet values. However, the methodology used for weighting and combining car and truck values in this section differs from the methodology used elsewhere in this report. As noted in Chapter 1, the general methodology used in this report to create a complete fleet value from separate car and truck fleet values incorporates weighting by the relative lifetime vehicle miles traveled (VMT) of cars and trucks (lifetime VMT values for cars and trucks are specified in the regulations as 195,264 and 225,865 miles, respectively). Because credits are calculated based on differing car and truck VMT values, the methodology for combining car and truck grams per mile values must include weighting by VMT for the result to be internally and mathematically consistent with the total Megagrams of credits generated by the fleet. However, past rulemaking projections for the combined car and truck fleet were determined by weighting car and truck fleet values by their relative production only, ignoring the impact of VMT. In order to provide an accurate comparison, the actual performance values in Table A-4 are calculated in the same manner as the projected values: without weighting by VMT. For this reason, the actual values in Table A-4 are not the same as values with the same labels presented elsewhere in this report. For example, the 2012 model year 2-cycle tailpipe value in Table A-4 is 298 g/mi, whereas the same metric is shown as 302 g/mi in Table 3-1. Both of these values are correct, as the former is not VMT-weighted and the latter is VMT-weighted. It is only within this appendix section that a different methodology is used, specifically to facilitate an apples-to-apples comparison between actual fleet performance and EPA's rulemaking projections. Note that values for the car and truck fleets are identical to those shown elsewhere in the report; only the values for the combined fleet will differ based on the different methods of calculating combined values from the individual car and truck values.

Table A-4 shows that actual industry-wide compliance targets for the combined car and truck fleets are slightly higher than EPA's projections for both model year 2012 (by 1 g/mi) and model year 2013 (by 3 g/mi). This gap grew further in subsequent model years, to 10 g/mi in 2016, because the industry-wide truck fraction of the fleet is higher than projected in the rulemaking analyses (for more information on footprint trends, see EPA's CO_2 and Fuel Economy Trends report at https://www.epa.gov/fuel-economy-trends).

Tables A-5 and A-6 provide comparative data separately for cars and trucks for the 2012-2016 model years (though projected values for use of credits by vehicle category are not available until model year 2016).

Table A-4. Actual and Projected CO_2 Values, Cars and Trucks Combined (g/mi)

Model Year	ACTUAL 2-Cycle Tailpipe	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Target	PROJECTED 2-Cycle Tailpipe	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Target
2012	298	7.8	6.1	0.6	0.6	0.2	284	296	307	6.5	3.5	1.2	0.0	N/A	295	295
2013	290	7.5	6.9	0.5	0.7	0.3	275	289	298	5.8	5.0	0.9	0.0	N/A	286	286
2014	290	8.5	8.3	0.2	2.4	0.2	271	284	290	5.0	7.5	0.6	0.0	N/A	276	276
2015	282	6.1	9.3	0.3	2.6	0.2	265	272	277	3.7	10.0	0.3	0.0	N/A	263	263
2016	281	0.0	9.9	0.0	2.8	0.1	269	260	261	0.0	10.6	0.1	0.5	N/A	250	250

Table A-5. Actual and Projected CO_2 Values, Passenger Cars (g/mi)

Model Year	ACTUAL 2-Cycle Tailpipe	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Target	PROJECTED 2-Cycle Tailpipe	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Target
2012	259	4.0	5.4	0.2	0.4	0.1	249	267	N/A	N/A	N/A	N/A	0.0	N/A	263	263
2013	251	4.0	6.3	0.1	0.6	0.3	240	261	N/A	N/A	N/A	N/A	0.0	N/A	256	256
2014	250	4.6	7.4	0.1	1.6	0.3	237	253	N/A	N/A	N/A	N/A	0.0	N/A	247	247
2015	243	3.1	8.0	0.0	1.9	0.1	230	241	N/A	N/A	N/A	N/A	0.0	N/A	236	236
2016	240	0.0	8.6	0.0	1.8	0.1	230	231	235	0.0	10.2	0.0	0.4	N/A	225	225

Table A-6. Actual and Projected CO_2 Values, Light Trucks (g/mi)

Model Year	ACTUAL 2-Cycle Tailpipe	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Target	PROJECTED 2-Cycle Tailpipe	FFV Credit	A/C Credit	TLAAS Credit	Off-Cycle Credit	N_2O & CH_4 Deficit	Compliance	Target
2012	369	14.5	7.3	1.3	1.0	0.3	347	349	N/A	N/A	N/A	N/A	0.0	N/A	346	346
2013	360	13.8	7.9	1.1	1.1	0.3	337	339	N/A	N/A	N/A	N/A	0.0	N/A	337	337
2014	349	14.3	9.7	0.3	3.6	0.1	322	330	N/A	N/A	N/A	N/A	0.0	N/A	326	326
2015	336	10.2	10.9	0.6	3.7	0.2	311	312	N/A	N/A	N/A	N/A	0.0	N/A	312	312
2016	332	0.0	11.4	0.0	4.0	0.2	317	297	310	0.0	11.4	0.0	0.7	N/A	298	298

Appendix B: Vehicle Production Volume & Market Share

Table B-1. Vehicle Production Volume by Manufacturer and Vehicle Category, Last Three Years

Manufacturer	Model Year 2014			Model Year 2015			Model Year 2016		
	Car	Truck	All	Car	Truck	All	Car	Truck	All
BMW	297,388	81,938	379,326	338,704	87,135	425,839	289,036	99,451	388,487
BYD Motors	50	-	50						
FCA	648,377	1,446,365	2,094,742	769,687	1,416,487	2,186,174	632,859	1,365,868	1,998,727
Ford	1,258,732	1,075,502	2,334,234	888,604	972,891	1,861,495	978,827	1,127,520	2,106,347
GM	1,556,701	1,164,610	2,721,311	1,331,442	1,525,017	2,856,459	1,222,917	1,354,255	2,577,172
Honda	868,337	577,828	1,446,165	1,020,610	556,864	1,577,474	1,071,532	731,659	1,803,191
Hyundai	509,920	38,441	548,361	604,286	41,839	646,125	698,686	19,927	718,613
Jaguar Land Rover	12,323	55,233	67,556	15,600	54,435	70,035	16,903	97,677	114,580
Kia	507,630	28,757	536,387	626,285	49,219	675,504	562,876	158,062	720,938
Mazda	217,333	78,826	296,159	207,100	78,793	285,893	305,635	153,192	458,827
Mercedes	278,126	92,312	370,438	231,899	123,727	355,626	220,201	109,864	330,065
Mitsubishi	60,679	29,828	90,507	91,822	39,366	131,188	26,172	49,097	75,269
Nissan	935,995	389,639	1,325,634	1,216,392	481,583	1,697,975	943,334	409,137	1,352,471
Subaru	109,078	356,818	465,896	175,352	447,383	622,735	153,926	402,071	555,997
Tesla	17,791	-	17,791	24,322	-	24,322	46,058	-	46,058
Toyota	1,423,148	770,302	2,193,450	1,524,190	1,127,056	2,651,246	1,355,012	1,022,967	2,377,979
Volkswagen	487,086	103,524	590,610	487,108	112,382	599,490	442,775	119,437	562,212
Volvo	16,526	15,063	31,589	43,901	24,284	68,185	32,207	57,283	89,490
All	**9,205,220**	**6,304,986**	**15,510,206**	**9,597,304**	**7,138,461**	**16,735,765**	**8,998,956**	**7,277,467**	**16,276,423**

Table B-2. Vehicle Category Market Share by Manufacturer and Model Year (%)

Manufacturer	2012		2013		2014		2015		2016	
	Car	Truck	Car	Truck	Car	Truck	Car	Truck	Car	Truck
BMW	74	26	75	25	78	22	80	20	74	26
BYD Motors	100	0	100	0	100	0				
Coda	100	0	100	0						
FCA	35	65	43	57	31	69	35	65	32	68
Ford	60	40	49	51	54	46	48	52	46	54
GM	61	39	61	39	57	43	47	53	47	53
Honda	68	32	68	32	60	40	65	35	59	41
Hyundai	93	7	97	3	93	7	94	6	97	3
Jaguar Land Rover	23	77	25	75	18	82	22	78	15	85
Karma Automotive	100	0								
Kia	90	10	97	3	95	5	93	7	78	22
Mazda	76	24	73	27	73	27	72	28	67	33
Mercedes	68	32	70	30	75	25	65	35	67	33
Mitsubishi	81	19	70	30	67	33	70	30	35	65
Nissan	73	27	71	29	71	29	72	28	70	30
Porsche	57	43	53	47						
Subaru	39	61	41	59	23	77	28	72	28	72
Suzuki	81	19	90	10						
Tesla	100	0	100	0	100	0	100	0	100	0
Toyota	64	36	60	40	65	35	57	43	57	43
Volkswagen	89	11	89	11	82	18	81	19	79	21
Volvo	73	27	57	43	52	48	64	36	36	64
All	**64**	**36**	**64**	**36**	**59**	**41**	**57**	**43**	**55**	**45**

APPENDIX C: 2012-2015 MODEL YEAR COMPLIANCE VALUES

Table C-1. 2012 Compliance Values - Combined Passenger Car & Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) FFV	A/C	Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	302	0	8	3	0	290
BYD Motors	0	0	0	0	0	0
Coda	0	0	0	0	0	0
Ford	315	14	6	0	1	295
GM	331	16	8	1	0	306
Honda	266	0	4	0	0	263
Hyundai	249	0	4	0	0	244
Jaguar Land Rover	426	0	7	0	0	418
Karma Automotive	102		0	0	0	102
Kia	266	0	5	0	0	261
Mazda	263	0	0	0	0	263
Mercedes	343	13	10	0	0	320
Mitsubishi	267	0	0	0	0	267
Nissan	295	4	3	0	0	288
Porsche	342	0	0	0	0	342
Subaru	282	0	2	0	0	280
Suzuki	287	0	0	0	0	287
Tesla	0	0	6	0	0	-6
Toyota	273	4	7	0	0	263
Volvo	311	0	11	0	0	300
FCA†	*357*	*18*	*10*	*2*	*0*	*327*
Volkswagen†	*282*	*1*	*7*	*1*	*2*	*275*
Fleet Total	**302**	**8**	**6**	**1**	**0**	**287**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-2. 2012 Compliance Values - Passenger Car Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) FFV	Credits (g/mi) A/C	Credits (g/mi) Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	277	0	7	3	0	267
BYD Motors	0	0	0	0	0	0
Coda	0	0	0	0	0	0
Ford	261	9	5	1	0	247
GM	283	11	8	1	0	263
Honda	237	0	3	0	0	234
Hyundai	243	0	4	0	0	239
Jaguar Land Rover	376	0	5	0	0	371
Karma Automotive	102		0	0	0	102
Kia	258	0	5	0	0	253
Mazda	241	0	0	0	0	241
Mercedes	316	11	9	1	0	295
Mitsubishi	262	0	0	0	0	262
Nissan	258	0	2	0	0	256
Porsche	325	0	0	0	0	325
Subaru	257	0	2	0	0	255
Suzuki	267	0	0	0	0	267
Tesla	0	0	6	0	0	-6
Toyota	221	0	7	0	0	214
Volvo	297	0	11	0	0	286
FCA†	*300*	*13*	*9*	*1*	*0*	*277*
Volkswagen†	*274*	*1*	*6*	*1*	*2*	*268*
Fleet Total	**259**	**4.0**	**5**	**0**	**0**	**249**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-3. 2012 Compliance Values - Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi)			CH_4 & N_2O Deficit	Compliance Value
		FFV	A/C	Off-Cycle		
BMW	363	0	11	5	1	348
Ford	385	21	8	0	1	357
GM	397	23	8	2	0	364
Honda	320	0	5	0	0	315
Hyundai	312	0	7	0	0	305
Jaguar Land Rover	439	0	8	0	0	431
Kia	324	0	3	0	0	321
Mazda	324	0	0	0	0	324
Mercedes	393	15	11	0	0	366
Mitsubishi	283	0	0	0	0	283
Nissan	382	15	4	0	0	363
Porsche	362	0	0	0	0	362
Subaru	296	0	2	0	0	294
Suzuki	361	0	0	0	0	361
Toyota	354	9	6	0	0	339
Volvo	343	0	12	0	0	331
FCA†	*384*	*21*	*10*	*2*	*0*	*351*
Volkswagen†	*332*	*0*	*9*	*1*	*1*	*323*
Fleet Total	**369**	**14**	**7**	**1**	**0**	**347**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide “Total” or “All” values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-4. 2013 Compliance Values - Combined Passenger Car & Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi)			CH_4 & N_2O Deficit	Compliance Value
		FFV	A/C	Off-Cycle		
BMW	292	0	9	4	0	279
BYD Motors	0	0	0	0	0	0
Coda	0	0	0	0	0	0
Ford	321	15	8	1	1	298
GM	325	15	9	1	0	299
Honda	257	0	4	0	1	254
Hyundai	241	0	5	0	0	236
Jaguar Land Rover	399	1	8	0	0	390
Kia	254	0	5	0	0	249
Mazda	251	0	0	0	0	251
Mercedes	321	12	10	1	0	297
Mitsubishi	258	0	0	0	0	258
Nissan	266	3	4	0	0	260
Porsche	336	0	0	0	0	336
Subaru	264	0	2	0	0	262
Suzuki	273	0	0	0	0	273
Tesla	0	0	6	0	0	-6
Toyota	278	3	7	0	0	268
Volvo	318	0	10	0	0	307
FCA[†]	*344*	*17*	*10*	*2*	*0*	*314*
Volkswagen[†]	*279*	*8*	*7*	*1*	*2*	*264*
Fleet Total	**294**	**8**	**7**	**1**	**0**	**278**

[†]FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-5. 2013 Compliance Values - Passenger Car Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) FFV	Credits (g/mi) A/C	Credits (g/mi) Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	271	0	8	3	0	260
BYD Motors	0	0	0	0	0	0
Coda	0	0	0	0	0	0
Ford	256	9	7	1	0	239
GM	273	10	9	1	0	253
Honda	228	0	4	0	1	226
Hyundai	238	0	5	0	0	233
Jaguar Land Rover	347	5	5	0	0	337
Kia	252	0	5	0	0	247
Mazda	232	0	0	0	0	232
Mercedes	296	12	9	1	0	273
Mitsubishi	254	0	0	0	0	254
Nissan	232	0	4	0	0	228
Porsche	309	0	0	0	0	309
Subaru	254	0	1	0	0	253
Suzuki	266	0	0	0	0	266
Tesla	0	0	6	0	0	-6
Toyota	225	0	7	0	0	218
Volvo	292	0	10	0	0	282
FCA†	*289*	*12*	*10*	*1*	*0*	*267*
Volkswagen†	*272*	*7*	*6*	*1*	*2*	*259*
Fleet Total	**251**	**4**	**6**	**1**	**0**	**240**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-6. 2013 Compliance Values - Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi)			CH_4 & N_2O Deficit	Compliance Value
		FFV	A/C	Off-Cycle		
BMW	346	0	11	6	0	329
Ford	375	20	8	1	1	347
GM	395	22	9	2	0	362
Honda	312	0	6	0	0	306
Hyundai	317	0	7	0	0	310
Jaguar Land Rover	414	0	9	0	0	405
Kia	301	0	8	0	0	293
Mazda	296	0	0	0	0	296
Mercedes	371	12	12	1	0	346
Mitsubishi	267	0	0	0	0	267
Nissan	340	8	4	0	0	328
Porsche	363	0	0	0	0	363
Subaru	270	0	2	0	0	268
Suzuki	330	0	0	0	0	330
Toyota	347	8	7	0	0	332
Volvo	348	0	11	0	0	337
FCA†	*380*	*21*	*11*	*3*	*0*	*345*
Volkswagen†	*327*	*15*	*10*	*1*	*1*	*301*
Fleet Total	**360**	**14**	**8**	**1**	**0**	**337**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-7. 2014 Compliance Values - Combined Passenger Car & Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi)			CH_4 & N_2O Deficit	Compliance Value
		FFV	A/C	Off-Cycle		
BMW	270	0	9	4	1	257
BYD Motors	0	0	0	0	0	0
Ford	315	14	9	3	0	289
GM	314	14	10	2	0	288
Honda	259	0	5	1	1	254
Hyundai	253	0	6	1	0	247
Jaguar Land Rover	369	15	21	5	0	328
Kia	269	0	6	1	0	262
Mazda	240	0	0	0	0	240
Mercedes	309	12	11	2	0	284
Mitsubishi	236	0	0	0	0	236
Nissan	263	3	6	2	0	253
Subaru	253	0	2	0	0	251
Tesla	0	0	6	0	0	-6
Toyota	274	6	8	3	0	257
Volvo	319	0	8	0	0	311
FCA†	*346*	*17*	*14*	*6*	*0*	*309*
Volkswagen†	*280*	*11*	*9*	*0*	*2*	*261*
Fleet Total	**294**	**9**	**8**	**3**	**0**	**274**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-8. 2014 Compliance Values - Passenger Car Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi)			CH_4 & N_2O Deficit	Compliance Value
		FFV	A/C	Off-Cycle		
BMW	256	0	8	3	1	245
BYD Motors	0	0	0	0	0	0
Ford	256	9	8	2	0	237
GM	267	10	9	1	0	246
Honda	228	0	4	1	1	225
Hyundai	247	0	6	1	0	241
Jaguar Land Rover	330	1	12	2	0	316
Kia	265	0	6	1	0	258
Mazda	220	0	0	0	0	220
Mercedes	285	11	10	3	0	262
Mitsubishi	224	0	0	0	0	224
Nissan	229	0	5	1	0	222
Subaru	250	0	1	0	0	249
Tesla	0	0	6	0	0	-6
Toyota	221	0	8	2	0	211
Volvo	288	0	8	0	0	280
FCA†	*298*	*12*	*13*	*3*	*0*	*270*
Volkswagen†	*266*	*10*	*8*	*0*	*2*	*249*
Fleet Total	**250**	**5**	**7**	**2**	**0**	**237**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-9. 2014 Compliance Values - Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) FFV	A/C	Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	312	0	11	6	1	295
Ford	375	20	10	3	0	342
GM	369	19	11	3	0	336
Honda	299	0	6	2	0	291
Hyundai	325	0	7	4	0	315
Jaguar Land Rover	377	18	22	6	0	331
Kia	330	0	5	1	0	324
Mazda	287	0	0	0	0	287
Mercedes	372	17	12	1	0	342
Mitsubishi	256	0	0	0	0	256
Nissan	335	8	6	2	0	318
Subaru	254	0	2	0	0	252
Toyota	358	15	7	3	0	333
Volvo	348	0	8	0	0	340
FCA†	*364*	*19*	*14*	*7*	*0*	*324*
Volkswagen†	*336*	*16*	*12*	*0*	*1*	*309*
Fleet Total	**349**	**14**	**10**	**4**	**0**	**322**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-10. 2015 Compliance Values - Combined Passenger Car & Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi)			CH_4 & N_2O Deficit	Compliance Value
		FFV	A/C	Off-Cycle		
BMW	270	0	9	4	0	257
Ford	311	12	10	3	0	287
GM	321	12	10	3	0	296
Honda	243	0	5	2	0	236
Hyundai	252	0	6	2	0	244
Jaguar Land Rover	346	7	21	5	0	313
Kia	266	0	6	1	0	258
Mazda	238	0	0	0	0	238
Mercedes	301	6	11	3	0	281
Mitsubishi	228	0	0	0	0	228
Nissan	245	2	7	2	1	235
Subaru	245	0	2	0	0	243
Tesla	0	0	6	0	0	-6
Toyota	279	4	8	3	0	265
Volvo	285	0	8	0	0	277
FCA†	*329*	*13*	*19*	*6*	*0*	*291*
Volkswagen†	*269*	*8*	*9*	*0*	*1*	*252*
Fleet Total	**286**	**6**	**9**	**3**	**0**	**268**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide “Total” or “All” values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-11. 2015 Compliance Values - Passenger Car Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) FFV	A/C	Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	256	0	9	4	0	244
Ford	258	8	9	2	0	239
GM	267	8	10	2	0	247
Honda	217	0	4	1	0	212
Hyundai	246	0	6	1	0	238
Jaguar Land Rover	337	13	14	2	0	308
Kia	260	0	6	1	0	253
Mazda	217	0	0	0	0	217
Mercedes	273	6	11	4	0	253
Mitsubishi	215	0	0	0	0	215
Nissan	217	0	7	2	0	209
Subaru	241	0	3	0	0	238
Tesla	0	0	6	0	0	-6
Toyota	225	0	8	3	0	215
Volvo	254	0	8	0	0	246
FCA†	*275*	*9*	*17*	*3*	*0*	*246*
Volkswagen†	*251*	*7*	*9*	*0*	*1*	*236*
Fleet Total	**243**	**3**	**8**	**2**	**0**	**230**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide “Total” or “All” values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

Table C-12. 2015 Compliance Values - Light Truck Fleet (g/mi)

Manufacturer	2-Cycle Tailpipe	Credits (g/mi) FFV	A/C	Off-Cycle	CH_4 & N_2O Deficit	Compliance Value
BMW	316	0	11	7	1	300
Ford	353	15	11	3	0	324
GM	362	15	11	4	0	332
Honda	283	0	7	2	1	275
Hyundai	324	0	7	3	0	313
Jaguar Land Rover	349	6	23	5	0	315
Kia	327	0	6	2	0	319
Mazda	285	0	0	0	0	285
Mercedes	347	5	12	3	0	327
Mitsubishi	254	0	0	0	0	254
Nissan	307	6	8	3	1	291
Subaru	247	0	2	0	0	244
Toyota	342	8	8	3	0	323
Volvo	333	0	9	0	0	324
FCA†	*354*	*15*	*19*	*7*	*0*	*312*
Volkswagen†	*336*	*13*	*12*	*0*	*0*	*311*
Fleet Total	**336**	**10**	**11**	**4**	**0**	**311**

†FCA and Volkswagen are listed separately in this table due to an ongoing investigation and/or corrective actions. These data are based on initial certification data, and are included in industry-wide "Total" or "All" values. Should the investigation and corrective actions yield different CO_2 data, any relevant changes will be used in future reports.

APPENDIX D: 2016 MODEL YEAR REPORT CREDITS AND DEFICITS

Table D-1. 2016 Model Year Reported Credits and Deficits

Manufacturer	Pathway	Fleet	Credit Type	Fleet Average (g/mi)	Fleet Standard (g/mi)	Production Volume	Credits (Mg)
BMW	Primary	Car	Fleet Average	262	235	289,036	(1,523,835)
			A/C Leakage				261,750
			A/C Efficiency				241,276
			Off-Cycle				213,889
			N2O Deficit				(6,982)
			CH4 Deficit				(879)
			Advanced Technology			6,292	
		Truck	Fleet Average	310	286	99,451	(539,100)
			A/C Leakage				156,928
			A/C Efficiency				97,329
			Off-Cycle				155,758
			N2O Deficit				(8,976)
			CH4 Deficit				(1,130)
			Advanced Technology			5,463	
FCA	Primary	Car	Fleet Average	288	237	632,859	(6,302,304)
			A/C Leakage			631,774	1,509,550
			A/C Efficiency			631,223	601,135
			Off-Cycle				389,320
			CH4 Deficit			551	(38)
			Advanced Technology			4,639	
		Truck	Fleet Average	348	295	1,365,868	(16,350,594)
			A/C Leakage			1,365,868	4,537,811
			A/C Efficiency			1,365,148	1,309,446
			Off-Cycle				2,474,713
			CH4 Deficit			32,073	(5,071)
Ford	Primary	Car	Fleet Average	254	234	978,827	(3,822,594)
			A/C Leakage				1,202,274
			A/C Efficiency				533,799
			Off-Cycle				330,086
			N2O Deficit				(3,489)
			CH4 Deficit				(8,479)
			Advanced Technology			22,343	

Table D-1. 2016 Model Year Reported Credits and Deficits

Manufacturer	Pathway	Fleet	Credit Type	Fleet Average (g/mi)	Fleet Standard (g/mi)	Production Volume	Credits (Mg)
		Truck	Fleet Average	354	315	1,127,520	(9,932,025)
			A/C Leakage				1,951,941
			A/C Efficiency				877,364
			Off-Cycle				936,002
			N2O Deficit				(56,591)
			CH4 Deficit				(78,171)
GM	Primary	Car	Fleet Average	260	233	1,222,917	(6,447,375)
			A/C Leakage				1,529,206
			A/C Efficiency				877,339
			Off-Cycle				662,961
			CH4 Deficit				(2,922)
			Advanced Technology			12,447	
		Truck	Fleet Average	365	318	1,354,255	(14,376,304)
			A/C Leakage				2,043,970
			A/C Efficiency				1,323,933
			Off-Cycle				1,227,378
			N2O Deficit				(17,554)
			CH4 Deficit				(11,055)
Honda	Primary	Car	Fleet Average	213	227	1,071,532	2,929,243
			A/C Leakage				1,242,114
			A/C Efficiency				624,733
			Off-Cycle				354,307
		Truck	Fleet Average	285	281	731,659	(661,025)
			A/C Leakage				784,533
			A/C Efficiency				512,895
			Off-Cycle				379,221
Hyundai	Primary	Car	Fleet Average	236	231	698,686	(682,141)
			A/C Leakage				372,376
			A/C Efficiency				520,949
			Off-Cycle				162,564
			Advanced Technology			1,432	
		Truck	Fleet Average	339	280	19,927	(265,548)
			A/C Leakage				7,202
			A/C Efficiency				16,754
			Off-Cycle				21,408
Jaguar Land Rover	Primary	Car	Fleet Average	322	250	16,903	(237,639)

Table D-1. 2016 Model Year Reported Credits and Deficits

Manufacturer	Pathway	Fleet	Credit Type	Fleet Average (g/mi)	Fleet Standard (g/mi)	Production Volume	Credits (Mg)
			A/C Leakage				45,546
			A/C Efficiency				18,814
			Off-Cycle				10,018
		Truck	Fleet Average	361	288	97,677	(1,610,513)
			A/C Leakage				379,462
			A/C Efficiency				125,753
			Off-Cycle				169,333
Kia	Primary	Car	Fleet Average	246	229	562,876	(1,868,460)
			A/C Leakage				283,543
			A/C Efficiency				381,366
			Off-Cycle				146,732
			Advanced Technology			2,788	
		Truck	Fleet Average	330	288	158,062	(1,499,428)
			A/C Leakage				97,287
			A/C Efficiency				121,382
			Off-Cycle				118,830
Mazda	Primary	Car	Fleet Average	214	228	305,635	835,513
		Truck	Fleet Average	259	271	153,192	415,209
			N2O Deficit				(6,763)
Mercedes	Primary	Car	Fleet Average	269	239	220,201	(1,289,920)
			A/C Leakage				236,227
			A/C Efficiency				233,353
			Off-Cycle				155,616
			Advanced Technology			2,171	
		Truck	Fleet Average	342	290	109,864	(1,290,350)
			A/C Leakage				176,030
			A/C Efficiency				131,987
			Off-Cycle				81,796
			Advanced Technology			194	
Mitsubishi	Primary	Car	Fleet Average	241	219	26,172	(112,430)
			A/C Leakage				14,092
			Advanced Technology			130	
		Truck	Fleet Average	251	260	49,097	99,804
			A/C Leakage				72,505
Nissan	Primary	Car	Fleet Average	221	229	943,334	1,473,593

Table D-1. 2016 Model Year Reported Credits and Deficits

Manufacturer	Pathway	Fleet	Credit Type	Fleet Average (g/mi)	Fleet Standard (g/mi)	Production Volume	Credits (Mg)
			A/C Leakage				746,573
			A/C Efficiency				562,084
			Off-Cycle				339,915
			N2O Deficit				(56,360)
			CH4 Deficit				(4,401)
			Advanced Technology			13,128	
		Truck	Fleet Average	297	284	409,137	(1,201,326)
			A/C Leakage				633,442
			A/C Efficiency				233,228
			Off-Cycle				251,409
			N2O Deficit				(87,252)
			CH4 Deficit				(7,320)
Subaru	Primary	Car	Fleet Average	244	224	153,926	(601,124)
			A/C Efficiency				88,364
			Off-Cycle				10,458
		Truck	Fleet Average	246	262	402,071	1,453,020
			A/C Efficiency				246,860
			Off-Cycle				16,419
Tesla	Primary	Car	Fleet Average	0	267	46,058	2,401,256
			A/C Efficiency			49,058	51,263
			Advanced Technology			46,058	
Toyota	Primary	Car	Fleet Average	224	228	1,355,012	1,058,340
			A/C Leakage				897,532
			A/C Efficiency				1,314,746
			Off-Cycle				360,276
			N2O Deficit				(18,288)
		Truck	Fleet Average	342	292	1,022,967	(11,552,622)
			A/C Leakage				1,529,031
			A/C Efficiency				945,443
			Off-Cycle				762,051
			N2O Deficit				(24,344)
Volkswagen	Primary	Car	Fleet Average	247	226	442,775	(1,815,618)
			A/C Leakage				392,728
			A/C Efficiency				275,942
			N2O Deficit				(1,096)
			CH4 Deficit				(200)

Table D-1. 2016 Model Year Reported Credits and Deficits

Manufacturer	Pathway	Fleet	Credit Type	Fleet Average (g/mi)	Fleet Standard (g/mi)	Production Volume	Credits (Mg)
			Advanced Technology			10,676	
		Truck	Fleet Average	320	279	119,437	(1,106,042)
			A/C Leakage				191,593
			A/C Efficiency				136,930
			N2O Deficit				(3,546)
			CH4 Deficit				(481)
			Advanced Technology			2,100	
Volvo	Primary	Car	Fleet Average	249	238	32,207	(69,178)
			A/C Leakage				31,954
			A/C Efficiency				20,754
		Truck	Fleet Average	300	289	57,283	(142,320)
			A/C Leakage				95,407
			A/C Efficiency				54,165