The 2022 EPA Automotive Trends Report

Greenhouse Gas Emissions, Fuel Economy, and Technology since 1975

Executive Summary

United States Environmental Protection Agency

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Executive Summary

This annual report is part of the U.S. Environmental Protection Agency's (EPA) commitment to provide the public with information about new light-duty vehicle greenhouse gas (GHG) emissions, fuel economy, technology data, and auto manufacturers' performance in meeting the agency's GHG emissions standards.

EPA has collected data on every new light-duty vehicle model sold in the United States since 1975, either from testing performed by EPA at the National Vehicle and Fuel Emissions Laboratory in Ann Arbor, Michigan, or directly from manufacturers using official EPA test procedures. These data are collected to support several important national programs, including EPA criteria pollutant and GHG standards, the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) Corporate Average Fuel Economy (CAFE) standards, and vehicle Fuel Economy and Environment labels. This expansive data set allows EPA to provide a uniquely comprehensive analysis of the automotive industry over the last 45 years.

The carbon dioxide (CO_2) emissions and fuel economy data in this report fall into one of two categories. The first is **compliance** data, which are measured using laboratory tests required by law for CAFE and adopted by EPA for GHG compliance. The second is **estimated real-world** data, which are measured using additional laboratory tests to capture a wider range of operating conditions (including hot and cold weather, higher speeds, and faster accelerations) encountered by an average driver. This report shows real-world data, except for discussions specific to GHG compliance starting on page ES-9 in this summary and Section 5 of the report.

All data in this report for model years 1975 through 2021 are **final** and based on official data submitted to EPA and NHTSA as part of the regulatory process. In some cases, this report will show data for model year 2022, which are **preliminary** and based on data provided to EPA by manufacturers prior to the model year, including projected production volumes. Given the impacts of worldwide supply chain issues and their associated impacts on the automobile industry, the projected model year 2022 data may change significantly before being finalized.

This report reflects the current light-duty GHG and fuel economy regulations as finalized by EPA and NHTSA, including updated standards through model year 2026. Any applicable regulatory changes finalized by EPA and NHTSA will be included in future versions of this report. To download the full report, or to explore the data using EPA's interactive data tools, visit the report website at www.epa.gov/automotive-trends.

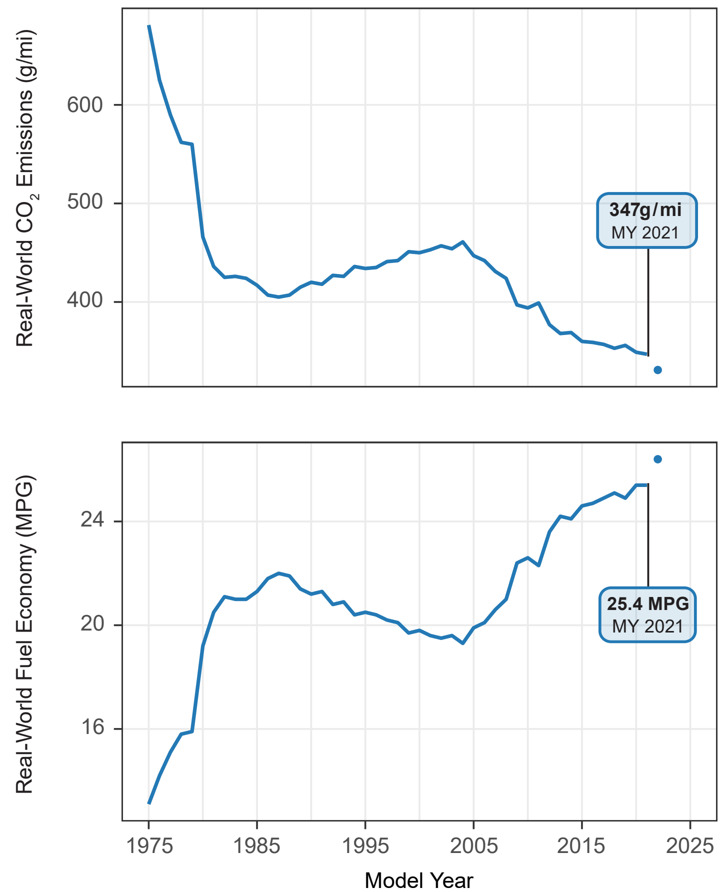
New vehicle estimated real-world CO_2 emissions are at a record low and fuel economy remains at a record high

In model year 2021, the average estimated real-world CO_2 emission rate for all new vehicles fell by 2 g/mi to 347 g/mi, the lowest ever measured. Real-world fuel economy remained at a record high 25.4 mpg.

Since model year 2004, CO_2 emissions have decreased 25%, or 114 g/mi, and fuel economy has increased 32%, or 6.1 mpg. Over that time, CO_2 emissions have improved in fourteen of seventeen years. The trends in CO_2 emissions and fuel economy since 1975 are shown in Figure ES-1.

Preliminary data suggest that CO_2 emissions and fuel economy in model year 2022 will improve from the levels achieved in 2021. These data are shown in Figure ES-1 as a dot because the values are based on manufacturer projections rather than final data.

Figure ES-1. Estimated Real-World Fuel Economy and CO_2 Emissions



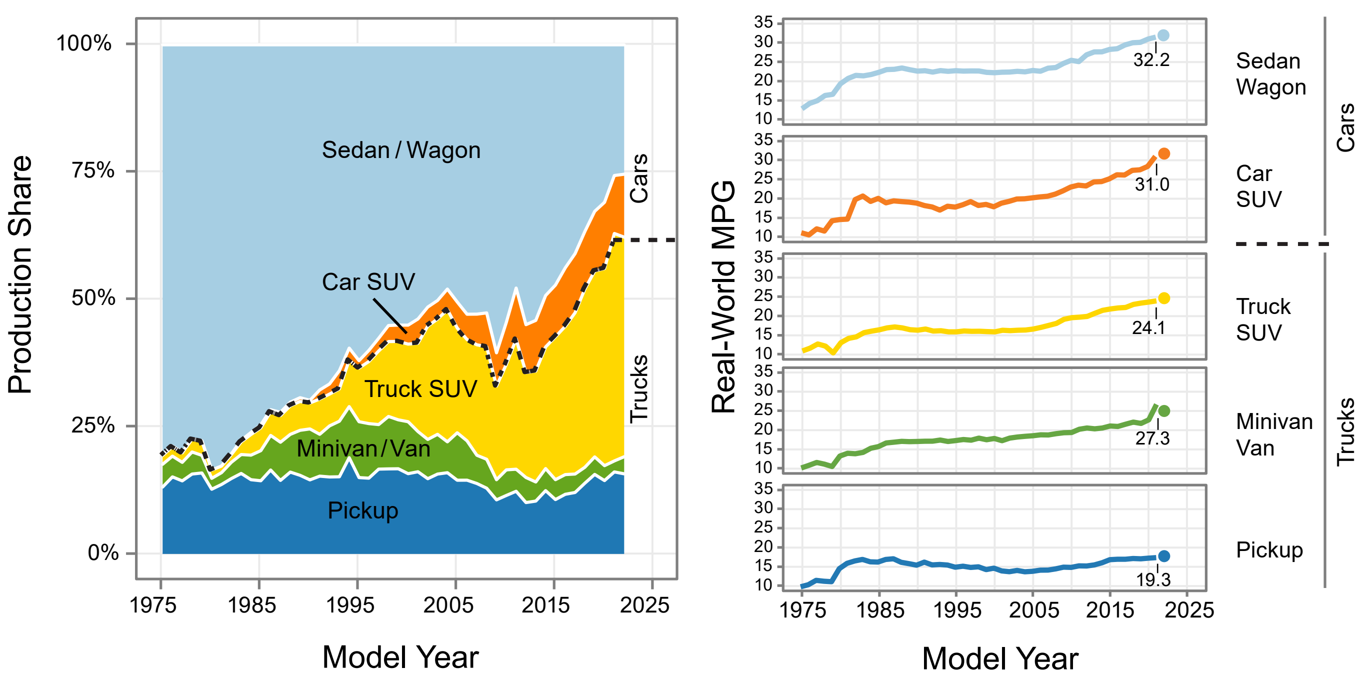
All vehicle types are at record low CO_2 emissions; however, market shifts away from cars and towards sport utility vehicles (SUVs) and pickups have offset some of the fleetwide benefits

In this report, vehicles are disaggregated into five vehicle types: sedan/wagon, car SUV, truck SUV, pickup truck, and minivan/van. The distinction between car and truck SUVs is based on regulatory definitions where SUVs that are 4WD or above a weight threshold (6,000 pounds gross vehicle weight) are generally regulated as trucks and classified at truck SUVs for this report. The remaining 2WD SUVs are subject to car standards and classified as car SUVs. All five vehicle types are at record high fuel economy and record low CO_2

emissions in model year 2021. Minivan/Vans increased fuel economy by 3.9 mpg, car SUVs increased by 2.6 mpg, sedan/wagons increased by 0.5 mpg, truck SUVs increased by 0.3 mpg, and pickups increased by 0.1 mpg.

The overall new vehicle market continues to move away from the sedan/wagon vehicle type towards a combination of truck SUVs, pickups, and car SUVs. In model year 2021, sedans and wagons fell to 26% of the market, well below the 50% market share they held as recently as model year 2013, and far below the 80% market share they held in 1975. Conversely, truck SUVs reached a record 45% of the market in model year 2021, and pickups increased to 16% market share. The trend away from sedan/wagons, which remain the vehicle type with the highest fuel economy and lowest CO_2 emissions, and towards vehicle types with lower fuel economy and higher CO_2 emissions has offset some of the fleetwide benefits that otherwise would have been achieved from the improvements within each vehicle type.

Figure ES-2. Production Share and Fuel Economy by Vehicle Type

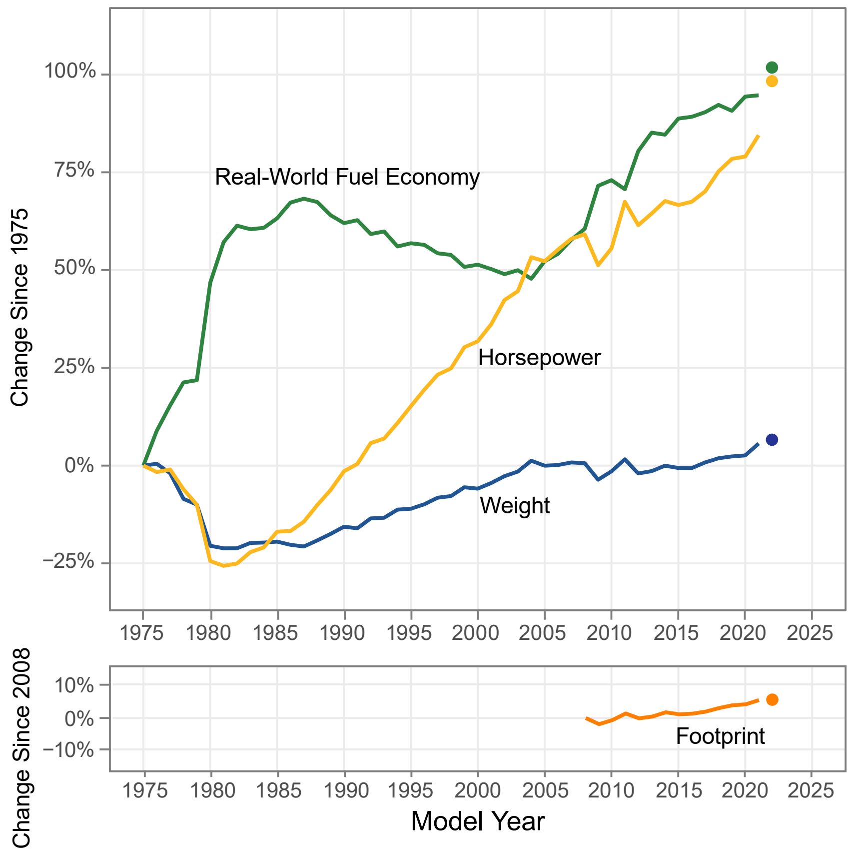


Average new vehicle fuel economy, horsepower, weight, and footprint are all at record highs

Overall vehicle trends are influenced both by vehicle technology and design, and by the changes in the distribution of vehicles being produced. For a specific vehicle, increased weight or horsepower is likely to result in higher CO_2 emissions and lower fuel economy, all else being equal. Larger vehicles, in this case measured by footprint or the area enclosed by the four tires, also tend to have higher CO_2 emissions and lower fuel economy. Footprint is also the basis for determining regulatory standards under the GHG and CAFE regulations. Electric vehicles produce zero tailpipe emissions; however, weight, horsepower, and vehicle size can still impact the vehicle fuel economy (as measured in miles per gallon of gasoline equivalent).

In the two decades prior to 2004, technology innovation and market trends generally resulted in increased vehicle power and weight (due to increasing vehicle size and content) while average new vehicle fuel economy steadily decreased and CO_2 emissions correspondingly increased. Since model year 2004, the combination of technology innovation and market trends have resulted in average new vehicle fuel economy increasing 32%, horsepower increasing 20%, and weight increasing 4%. Footprint has increased 5% since EPA began tracking it in model year 2008. These metrics are all at record highs and are projected to increase again in model year 2022, as shown in Figure ES-3.

Figure ES-3. Percent Change in Real-World Fuel Economy, Horsepower, Weight, and Footprint



The changes within each of these metrics are due to the combination of design and technology changes within each vehicle type, and the market shifts between vehicle types. For example, overall new vehicle footprint has increased within each vehicle type since model year 2008, but the average new vehicle footprint has increased more than the increase in any individual vehicle type over that time span, due to market shifts towards larger vehicle types. Fuel economy has also increased in all vehicle types since model year 2008, however the market shift towards less efficient vehicle types has offset some of the fleetwide fuel economy and CO_2 emission benefits that otherwise would have been achieved through improving technology.

Most manufacturers have improved CO_2 emissions and fuel economy over the last 5 years

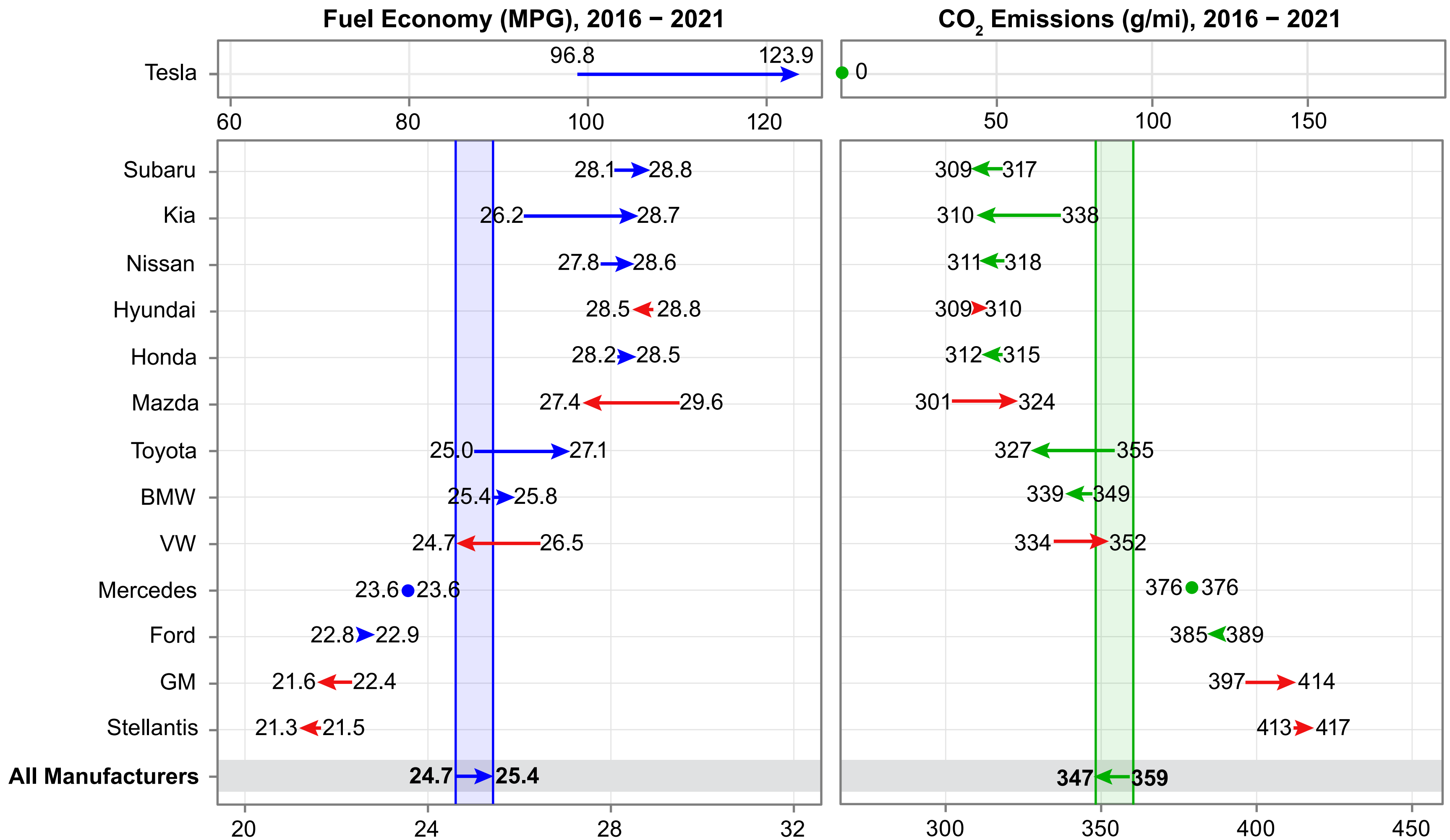
Manufacturer trends over the last five years are shown in Figure ES-4. This span covers the approximate length of a vehicle redesign cycle, and it is likely that most vehicles have undergone design changes in this period, resulting in a more accurate depiction of recent manufacturer trends than focusing on a single year. Changes over this time period can be attributed to changes in both vehicle design and the significant change to the mix of vehicle types produced, as shown in ES-2.

Over the last five years, seven of the fourteen largest manufacturers selling vehicles in the U.S. decreased new vehicle estimated real-world CO_2 emission rates. Tesla was unchanged because their all-electric fleet produces no tailpipe CO_2 emissions, and Mercedes was also unchanged. Between model years 2016 and 2021, Kia achieved the largest reduction in CO_2 emissions, at 29 g/mi. Kia decreased emissions in all vehicle types that they offer, and decreased overall emissions even as their truck SUV share increased from 15% to 41%. Toyota achieved the second largest reduction in overall CO_2 tailpipe emissions, at 28 g/mi, and BMW had the third largest reduction in overall CO_2 tailpipe emissions at 10 g/mi. Toyota and BMW also achieved overall emission reductions by improving all vehicle types, even as their truck SUV production share increased.

Five manufacturers increased new vehicle CO_2 emission rates between model years 2016 and 2021. Mazda had the largest increase at 24 g/mi, due to increased CO_2 emission rates within their sedan/wagon and car SUV vehicle types, along with a shift in production from 33% to 61% truck SUVs. Volkswagen had the second largest increase at 18 g/mi, as a shift in production from 21% to 66% truck SUVs more than offset emission reductions within each vehicle type. GM had the third largest increase at 17 g/mi, with a production shift towards truck SUVs and pickups and an increase in pickup emission rates more than offsetting emission improvements in all other vehicle types.

For model year 2021 alone, Tesla's all-electric fleet had by far the lowest tailpipe CO_2 emissions and highest fuel economy of all large manufacturers. Tesla was followed by a close grouping of Subaru, Kia, Hyundai, Nissan, and Honda. Stellantis had the highest new vehicle average CO_2 emissions and lowest fuel economy of the large manufacturers in model year 2021, followed by GM and Ford. Tesla also had the highest overall fuel economy, followed by the close grouping of Subaru, Kia, Nissan, Hyundai, and Honda.

Figure ES-4. Changes in Estimated Real-World Fuel Economy[1] and CO_2 Emissions for Large Manufacturers



[1]Electric vehicles, including Tesla's all-electric fleet, are measured in terms of miles per gallon of gasoline equivalent, or mpge.

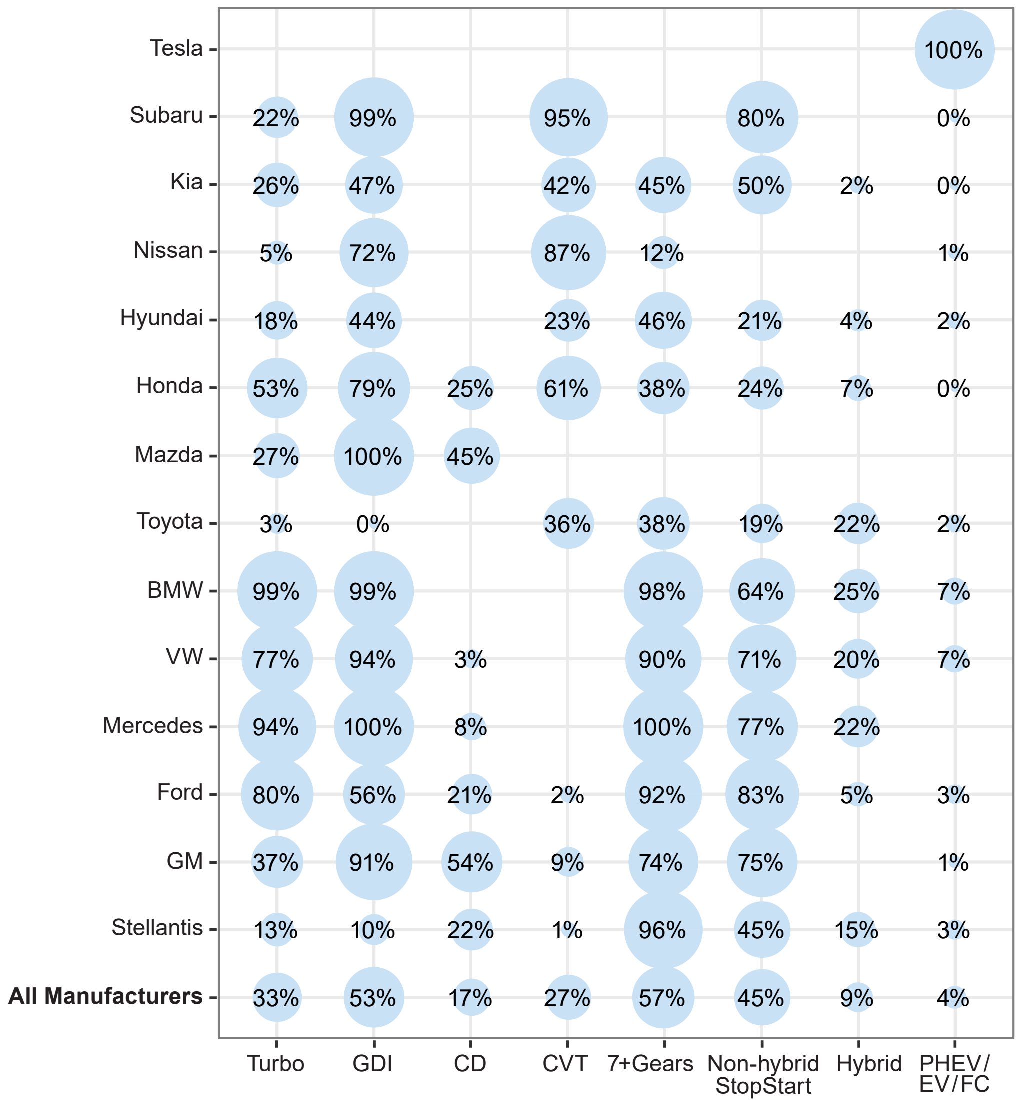
Manufacturers continue to use a wide array of advanced technologies

Innovation in the automobile industry has led to a wide array of technology available to manufacturers to achieve CO_2 emissions, fuel economy, and performance goals. Figure ES-5 illustrates manufacturer-specific technology usage for model year 2021, with larger circles representing higher usage rates. The technologies in Figure ES-5 are all being used by manufacturers to, in part, reduce CO_2 emissions and increase fuel economy. Each of the fourteen largest manufacturers have adopted several of these technologies into their vehicles, with many manufacturers achieving very high penetrations of several technologies. It is also clear that manufacturers' strategies to develop and adopt new technologies are unique and vary significantly. Each manufacturer is choosing technologies that best meet the design requirements of their vehicles, and in many cases, that technology is changing quickly.

Engine technologies such as turbocharged engines (Turbo) and gasoline direct injection (GDI) allow for more efficient engine design and operation. Cylinder deactivation (CD) allows for use of only a portion of the engine when less power is needed, while stop/start systems can turn off the engine entirely at idle to save fuel. Hybrid vehicles use a larger battery to recapture braking energy and provide power when necessary, allowing for a smaller, more efficiently operated engine. The hybrid category includes "full" hybrid systems that can temporarily power the vehicle without engaging the engine and smaller "mild" hybrid systems that cannot propel the vehicle on their own. Transmissions that have more gear ratios, or speeds, allow the engine to more frequently operate near peak efficiency. Two categories of advanced transmissions are shown in Figure ES-5: transmission with seven or more discrete speeds (7+Gears), and continuously variable transmissions (CVTs).

In model year 2021, hybrid vehicles reached a new high of 9% of all production. This increase was mostly due to the growth of hybrids in the truck SUV and pickup vehicle types. The combined category of electric vehicles (EVs), plug-in hybrid vehicles (PHEVs), and fuel cell vehicles (FCVs) increased to 4% of production in model year 2021 and are projected to reach 8% of production in model year 2022, due to expected growth in EV production across the industry.

Figure ES-5. Technology Share for Large Manufacturers, Model Year 2021

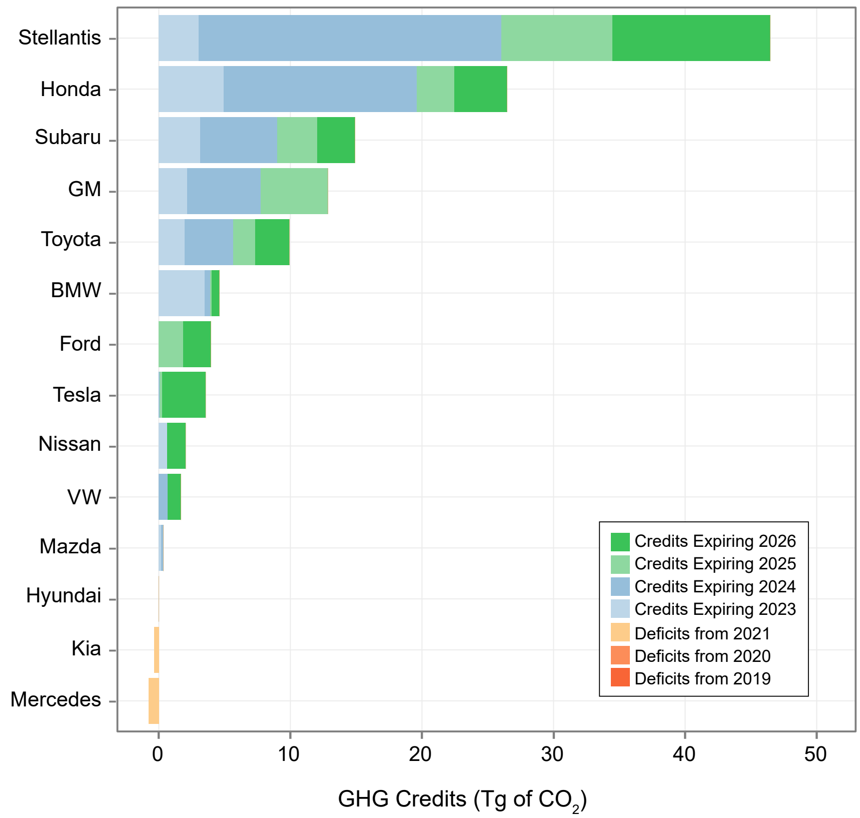


All large manufacturers have achieved compliance with the GHG standards through at least model year 2020

EPA's GHG program is an averaging, banking, and trading (ABT) program. An ABT program means that the standards may be met on a fleet **average** basis, manufacturers may earn and **bank** credits to use later, and manufacturers may **trade** credits with other manufacturers. This provides manufacturers flexibility in meeting the standards while accounting for vehicle design cycles, introduction rates of new technologies and emission improvements, and evolving consumer preferences.

Within a model year, manufacturers with average fleet emissions lower than the standards generate credits, and manufacturers with average fleet emissions higher than the standards generate deficits. Any manufacturer with a deficit at the end of the model year has up to three years to offset the deficit with credits earned in future model years or purchased from another manufacturer.

Figure ES-6. GHG Credit Balance for Large Manufacturers, after Model Year 2021



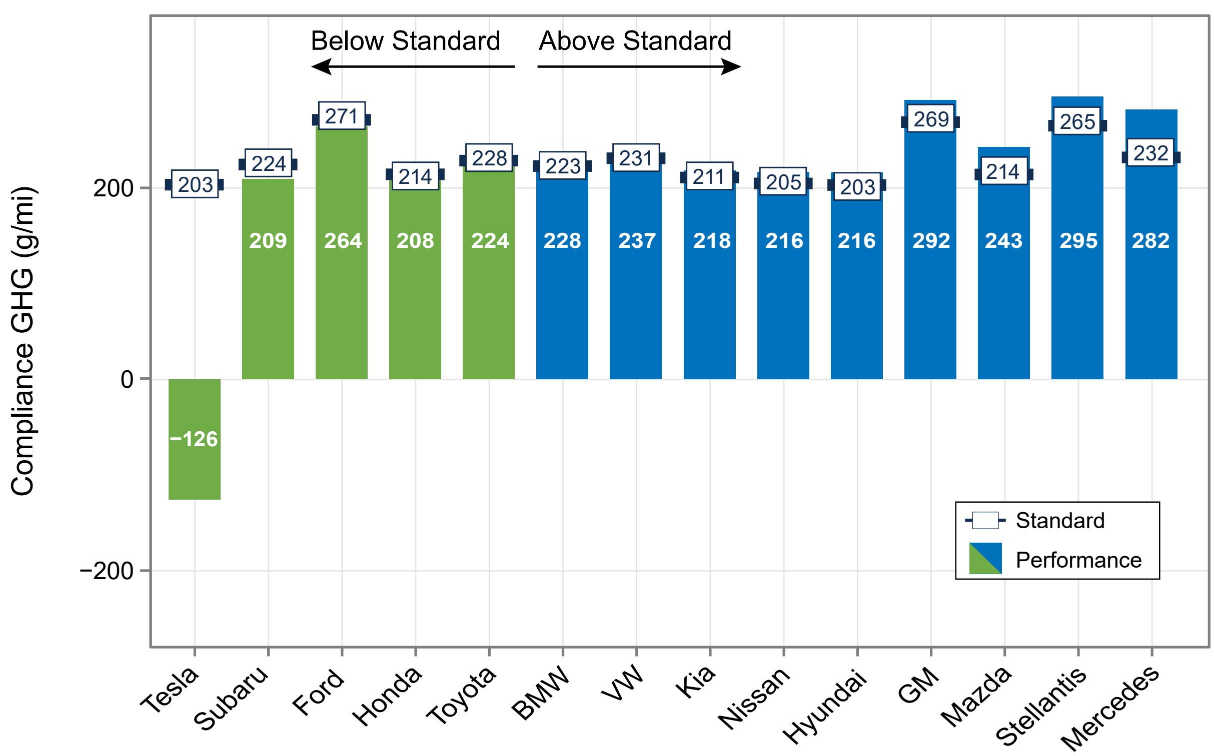
Twelve of the fourteen largest manufacturers ended model year 2021 with positive or zero credit balances and are thus in compliance for model year 2021 and all previous years of the GHG program, as credits may not be carried forward unless deficits from all prior model years have been resolved. Kia and Mercedes have achieved compliance for model year 2020 and all previous years of the GHG program but ended model year 2021 with deficits. However, because the GHG program allows a manufacturer up to three years to offset a deficit, Kia and Mercedes have up to three years before their model year 2021 deficits result in non-compliance or enforcement actions from EPA.

Total credits in Figure ES-6 are shown in **teragrams** (one million Megagrams), and account for manufacturer performance compared to their standards, expected vehicle lifetime miles driven, and the number of vehicles produced by each manufacturer, for all years of the GHG program. The credits accumulated by each manufacturer will be carried forward for use in future model years or until they expire. Credit expiration dates are based on the model year in which they were earned.

Manufacturers used different combinations of technology improvements and banked credits in model year 2021

Determining manufacturer compliance with EPA's GHG program requires accounting for a manufacturer's credit balance over the life of the program. However, it is also useful to look at manufacturer performance within the most recent model year. Figure ES-7 illustrates the performance of individual large manufacturers in model year 2021 compared to their effective overall standard, in terms of an average vehicle grams per mile emission rate. This "snapshot" provides insight into how the large manufacturers performed against the standards in model year 2021, however it cannot be used to determine individual manufacturer compliance status with the overall program.

Figure ES-7. CO_2 Performance and Standards by Manufacturer, Model Year 2021



In model year 2021, Tesla, Ford, Honda, Toyota, and Subaru produced vehicles with GHG emission performance below their overall standard. This result, combined with the fact that these manufacturers all had a credit balance at the end of model year 2020, allowed Tesla, Ford, Honda, Toyota, and Subaru to achieve compliance with the GHG program through model year 2021 and bank or sell additional credits in model year 2021.

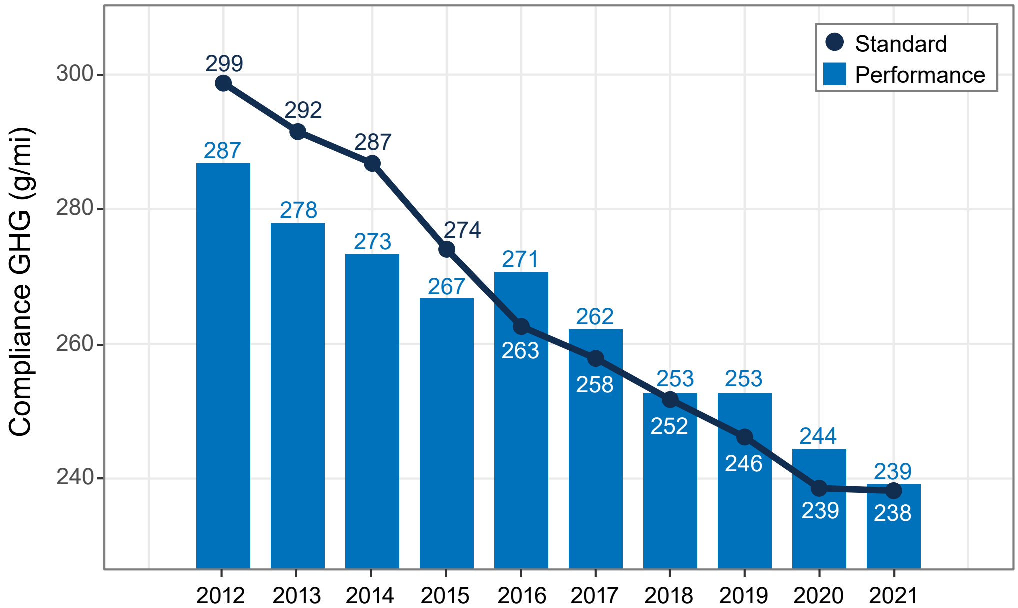
Nine of the fourteen large manufacturers ended model year 2021 with emission performance above their overall standard. Seven of these manufacturers used banked or purchased credits, along with technology improvements, to achieve compliance in model year 2021. As noted above, Mercedes and Kia ended the model year with deficits, but the program allows manufacturers up to three years to offset any deficits and remain in compliance. These two manufacturers have up to three years to offset the deficits before they result in non-compliance or enforcement actions from EPA.

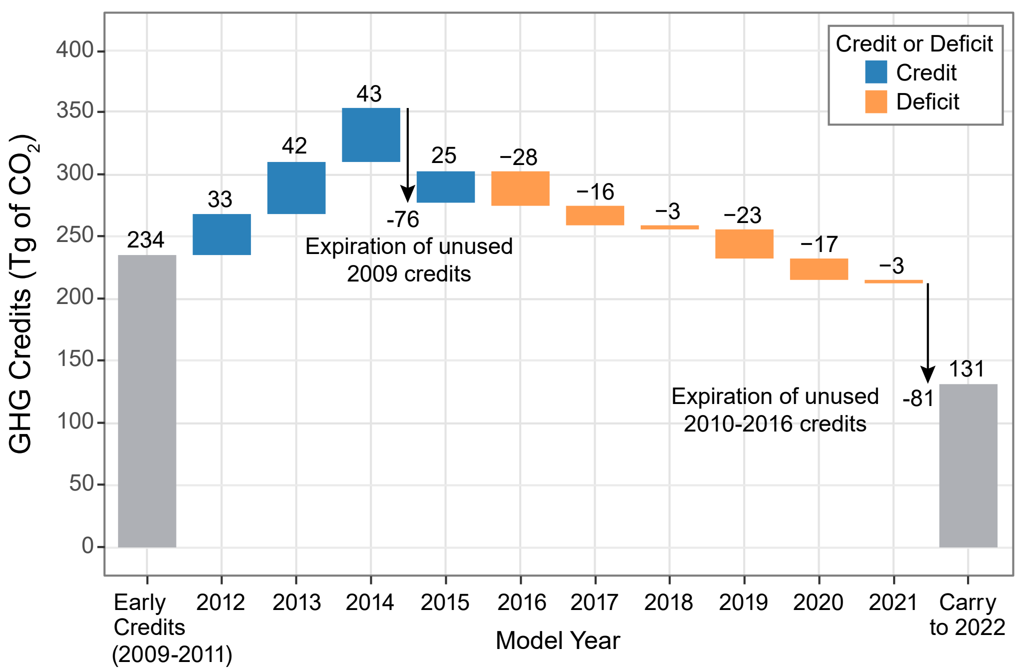
The manufacturer performance values shown in Figure ES-7 are based on the average new vehicle tailpipe emissions for each manufacturer and include various optional credits available to manufacturers in model year 2021. One notable provision in the regulations is an incentive multiplier that increases the credits each electric vehicle creates. The impact of this incentive is particularly evident for Tesla, since Tesla produces only electric vehicles, and is the reason for the negative performance value for Tesla shown in Figure ES-7.

The overall industry used credits to maintain compliance, and there remains a large bank of credits for future years

The industry ended model year 2021 with a credit balance of 131 Tg. This credit balance is the result of the overall industry performance against the standards within each model year, as well as the generation of early credits, credit expirations, and the sum of all credit averaging, banking, and trading allowed by EPA's GHG program. Under the GHG Program, manufacturers were able to accrue "early credits," before the GHG standards took effect in model year 2012, for early deployment of efficient vehicles and technology. Overall, the industry was able to accrue a large number of credits due to this provision, although some of these credits had restrictions on their use, and all credits have regulatory expiration dates. In model years 2012 through 2014, manufacturers continued to generate credits, as the industry GHG performance was below the industry-wide average standard. At the end of model year 2014, unused early credits generated from model year 2009 expired, which reduced the overall credit balance. In model year 2015, the industry again generated credits, however from model year 2016-2021 the industry GHG performance has been above the standard, resulting in net withdrawals from the bank of credits to maintain compliance.

Figure ES-8. Industry Performance and Standards, and Overall Credit Balance





In addition, unused credits generated in model years 2010-2016 expired at the end of model year 2021, which further drew down the overall industry credit balance.

In model year 2021, the industry achieved an overall GHG performance of 239 g/mi, while the standard fell from 239 g/mi to 238 g/mi. The gap between the standard and GHG performance decreased from 6 g/mi in model year 2020 to 1 g/mi in model year 2021.

Overall, manufacturers drew down the industry-wide total credit bank by about 3 Tg, which was about 1% of the total available credit balance (before credits expired at the end of the model year). The overall industry emerged from model year 2021 with a bank of 131 Tg of GHG credits available for future use, as seen in Figure ES-8.

The credits available at the end of model year 2021 will expire according to the schedule defined by the GHG Program and detailed in Section 5 of this report. The next group of credits to expire will do so at the end of model year 2023. An active credit market has allowed manufacturers to purchase credits to demonstrate compliance, with nine manufacturers selling credits, thirteen manufacturers purchasing credits, and approximately 100 credit trades since 2012. As of October 31, 2022, about 169 Tg of credits have been traded between manufacturers.

The automobile industry continues to innovate, improve, and meet the GHG standards

The analysis here is a snapshot of the data collected by EPA in support of several important regulatory programs and is presented with the intent of providing as much transparency to the public as possible. The data show the change and innovation in the industry since model year 1975, and the manufacturers' performance under EPA's GHG standards.

To download the full report, or to explore the data using EPA's interactive data tools, visit the report webpage at www.epa.gov/automotive-trends.