# Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2014

# Trends

## Executive Summary

United States Environmental Protection Agency

EPA-420-S-14-001 October 2014

# Executive Summary

## Introduction

*This report is the authoritative reference for carbon dioxide ($CO_2$) emissions, fuel economy, and powertrain technology trends for **new** personal vehicles in the United States. The detailed data supporting this report were obtained by the U.S. Environmental Protection Agency (EPA), directly from automobile manufacturers, to support implementation of EPA's greenhouse gas (GHG) emissions and the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) Corporate Average Fuel Economy (CAFE) programs. These data have been collected and maintained by EPA since 1975, and comprise the most comprehensive database of its kind. This report (the "Trends" report) has been published annually since 1975 and covers all passenger cars, sport utility vehicles, minivans, and all but the largest pickup trucks and vans.*

*Sections 1-6 of this report explore trends within gasoline and diesel vehicles (including flexible fuel and conventional hybrid vehicles). These vehicles continue to make up the large majority of new vehicle sales, although production of alternative fuel vehicles, such as electric vehicles and plug-in hybrid electric vehicles, is increasing. Sections 7-9 address trends including alternative fuel vehicles. Data for model years (MY) 1975 through 2013 are final, while data for MY 2014 are preliminary, based on production values provided by automakers in the spring and summer of 2013. MY 2014 values will be finalized in next year's report. The vehicle population data in this report may vary from those discussed in press accounts for two reasons: 1) they are tabulated on a model year, not calendar year, basis, and 2) they represent production volumes delivered for sale in the U.S., rather than actual sales data.*

*All of the tailpipe $CO_2$ emissions and fuel economy values in this Executive Summary are **adjusted** values, which are very similar to new car Fuel Economy and Environment Labels and, when aggregated on a fleetwide basis, yield EPA's best estimate of nationwide "real world" $CO_2$ emissions and fuel consumption. Adjusted $CO_2$ emissions values are significantly higher than, and adjusted fuel economy values are significantly lower than, the **unadjusted, laboratory** values that form the basis for automaker compliance with EPA $CO_2$ emissions standards and NHTSA CAFE standards. Several tables in the body of the report provide unadjusted, laboratory values, and Section 10 describes the methodologies for both adjusted and unadjusted, laboratory values.*

*This report does **not** provide formal compliance values, which are based on unadjusted, laboratory values as well as various credits, for either GHG emissions or CAFE standards. Information about automaker compliance with EPA's GHG emissions standards, including EPA's Manufacturer Performance Report for the 2012 Model Year, is available at epa.gov/otaq/regs/ ld-hwy/greenhouse/ld-ghg.htm. NHTSA's "Summary of Fuel Economy Performance," summarizing automaker compliance with fuel economy standards, is available at nhtsa.dot.gov/fuel-economy.*

*While this Executive Summary includes the most important highlights of the report, the reader is encouraged to consult the full report for more depth. The full report, as well as the appendices, is available at epa.gov/otaq/fetrends.htm.*

# Highlight

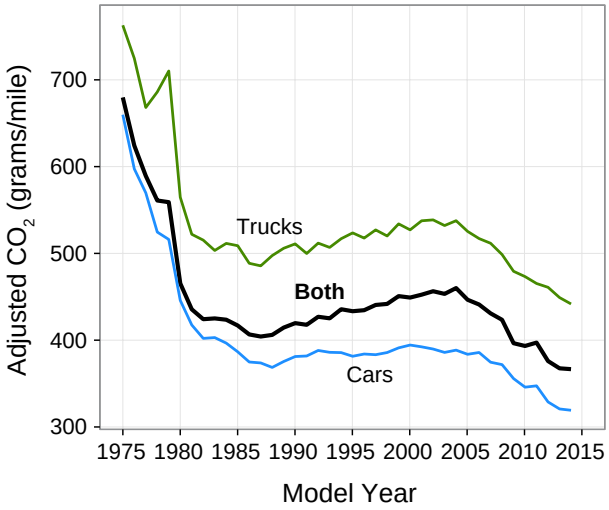
## *Average vehicle $CO_2$ emissions rate and fuel economy achieved record levels in MY 2013 and have improved in 8 of the last 9 years*

The final MY 2013 adjusted, real world $CO_2$ emissions rate for all light-duty gasoline and diesel-fueled vehicles is 369 g/mi, which is a 7 g/mi decrease relative to MY 2012. The MY 2013 adjusted fuel economy is 24.1 mpg, which is 0.5 mpg higher than MY 2012. Both values represent records since the database began in MY 1975, and the authors believe that these represent historical records as well. The average MY 2013 adjusted fuel economy for cars is 27.6 mpg (0.6 mpg higher than MY 2012), and for trucks is 19.8 mpg (annual increase of 0.5 mpg), both of which are all-time highs.

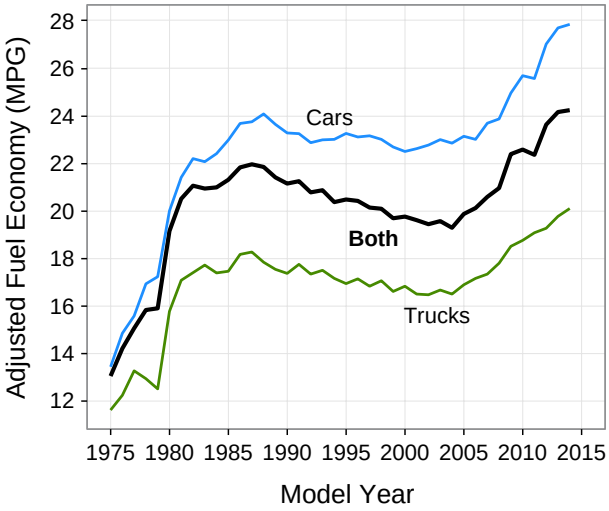
The greatest value of the historical Trends database is the documentation of long-term trends. For the first time, $CO_2$ emissions and fuel economy have improved in eight out of nine consecutive years. This positive trend reversed the long negative trend from MY 1987 through MY 2004. Based on the final data through MY 2013, $CO_2$ emissions have decreased by 92 g/mi, or 20%, since MY 2004, and fuel economy has increased by 4.8 mpg, or 25%, with an average annual improvement of about 0.5 mpg per year.

Preliminary MY 2014 adjusted values are 367 g/mi $CO_2$ emissions and 24.2 mpg fuel economy, which would represent a slight improvement over MY 2013. These MY 2014 projections, based on production estimates provided by automakers in early 2013, are uncertain and EPA will not have final data until next year's report. Two manufacturers projected unusually short MY 2014 production time frames and thus substantially reduced production for their highest fuel economy vehicles, and the authors believe that this is one important reason why the projected MY 2014 fleetwide values don't show much improvement relative to MY 2013. The final fleetwide fuel economy value has been more favorable than the preliminary value in 7 of the last 10 years.

### *Adjusted $CO_2$ Emissions for MY 1975-2014[1]*




### *Adjusted Fuel Economy for MY 1975-2014[1]*




[1] *Adjusted $CO_2$ and fuel economy values reflect real world estimates and are not comparable to automaker standards compliance levels. Adjusted $CO_2$ values are, on average, about 25% higher than the unadjusted laboratory $CO_2$ values that form the starting point for GHG standards compliance, and adjusted fuel economy values are about 20% lower, on average, than unadjusted fuel economy values.*

## 2 Highlight

### *Light truck market share increased slightly in MY 2013, after several years of volatility*

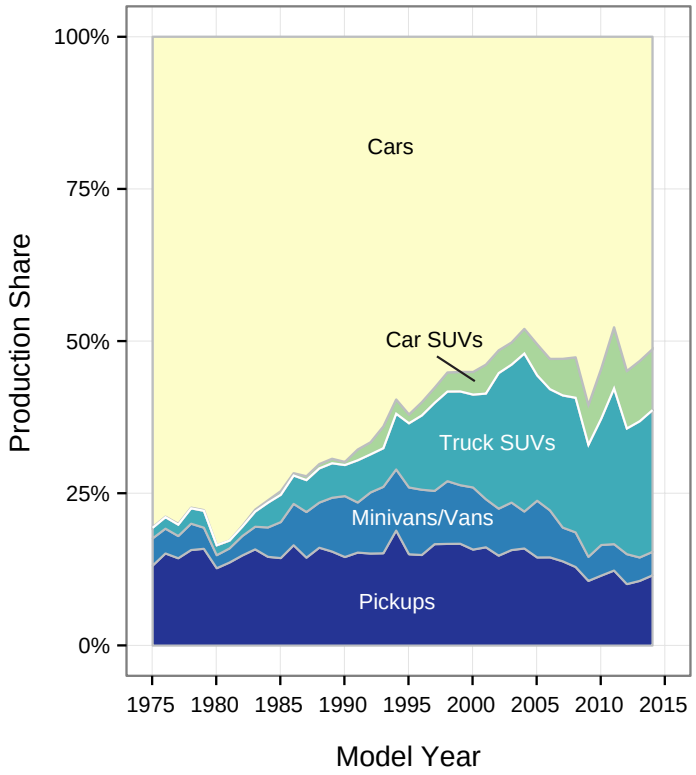
Light trucks, which include pickups, minivans/vans, and truck SUVs (SUVs that are light trucks for purposes of compliance with GHG emissions and fuel economy standards), accounted for 37% of all light-duty vehicle production in MY 2013. This represents a 1% increase relative to MY 2012.

Light truck market share had been more variable in recent years, e.g., truck share changed by 4% or more in each year for MY 2009-2012, with two years of increases and two years of decreases. Truck share impacts many important fleetwide metrics, of course, since light trucks on average have higher $CO_2$ emissions, lower fuel economy, and higher weight, horsepower, and footprint than cars.

Of the five vehicle types, cars have the highest average adjusted fuel economy of 28.3 mpg, followed by car SUVs at 24.5 mpg. Car SUVs (SUVs that must meet car GHG and fuel economy standards) and truck SUVs had the highest annual improvement from MY 2012 to MY 2013 of 1.1 and 0.9 mpg, respectively. Based on longer term trends since MY 2004, truck SUVs have the largest cumulative percentage fuel economy improvement of 27%, followed by both cars and car SUVs at 23%.

The MY 2014 light truck market share is projected to increase by 2%, based on pre-model year projections by automakers.

#### *Production Share by Vehicle Type for MY 1975-2014*



## 3 Highlight

### *Vehicle weight trend is flat and vehicle power trend is increasing more slowly*

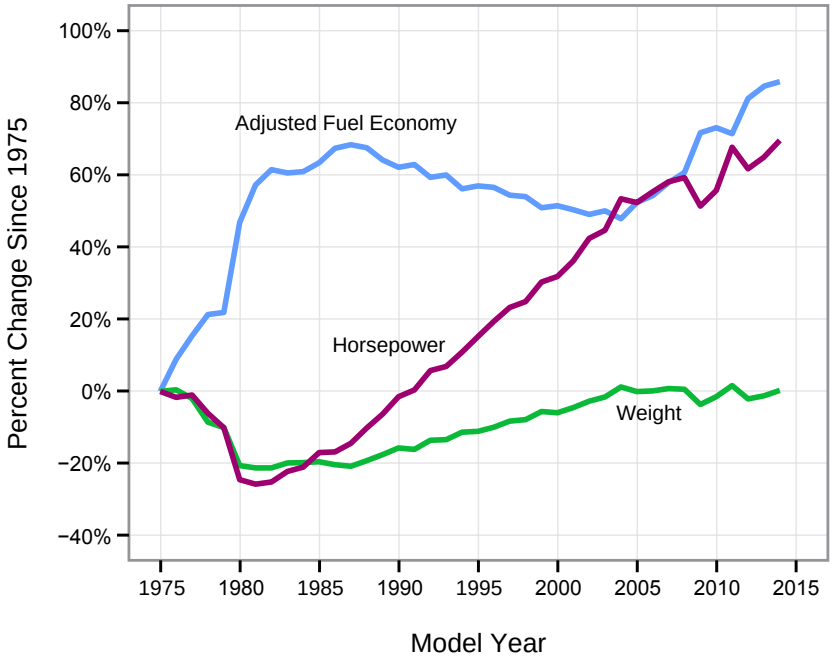
Vehicle weight and acceleration performance are two of the most important design parameters that help determine a vehicle's $CO_2$ emissions and fuel economy. In general, all other factors being equal, higher vehicle weight and faster acceleration performance (e.g., lower 0-to-60 miles-per-hour acceleration time) both increase a vehicle's $CO_2$ emissions and decrease fuel economy.

From MY 1987 through MY 2004, on a fleetwide basis, automotive technology innovation was generally utilized to support vehicle attributes other than $CO_2$ emissions and fuel economy, such as weight, performance, and utility. Beginning in MY 2005, technology has been used to increase both fuel economy (which has reduced $CO_2$ emissions) and power, while keeping vehicle weight relatively constant.

The MY 2013 gasoline and diesel vehicle weight averaged 4,015 pounds, an increase of 38 pounds (1.0%) compared to MY 2012. Average MY 2013 vehicle power was 227 horsepower, an increase of 5 horsepower (2.3%) from MY 2012. Average vehicle footprint increased by 0.4 square feet (0.8%) in MY 2013. The average 0-to-60 acceleration time decreased by 0.1 second in MY 2013.

Preliminary MY 2014 values suggest that average weight will be relatively unchanged relative to the last decade, and horsepower will increase slightly to a record high. EPA will not have final data until next year's report.

***Change in Adjusted Fuel Economy, Weight, and Horsepower for MY 1975-2014***



# 4 Highlight

## *Many new technologies are rapidly gaining market share*

Technological innovation is a major driving force in the industry. The majority of the carbon and oil savings from current vehicles is due to new gasoline vehicle technologies. The figure below shows changes in market share over the five-year period from MY 2009 through MY 2014 for several key gasoline and diesel engine and transmission technologies for which Trends gathers data.

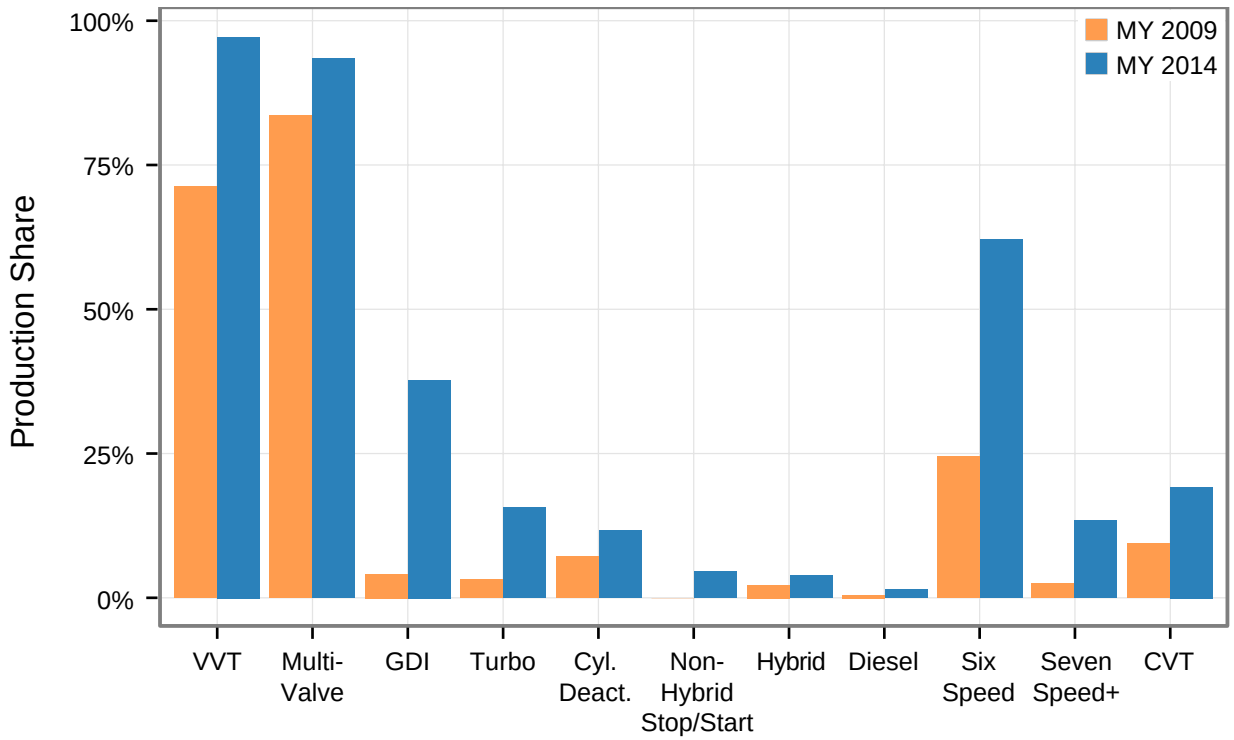
Two engine technologies first introduced over 20 years ago—variable valve timing (VVT) and multi-valve engines—are both projected to be used on nearly all MY 2014 vehicles. Gasoline direct injection (GDI) engines have increased market share nearly ten-fold from 4% in MY 2009 to 38% in MY 2014. Turbochargers, which are often used in conjunction with GDI, have increased market share by a factor of five since MY 2009.

Transmissions with 6 or more speeds and continuously variable transmissions (CVTs) cumulatively accounted for 37% of vehicle production in MY 2009, but are projected to exceed 90% market share in MY 2014. CVTs and advanced transmissions with 7 or more speeds are projected to reach 30% market penetration in MY 2014.

Non-hybrid stop/start systems represent about 5% of the projected MY 2014 market. Accounting for hybrids, stop/start systems are used on over 8% of MY 2014 vehicles.

Compared to the engine and transmission technologies discussed above, there has been far less growth in the absolute production shares of cylinder deactivation (CD), hybrid and diesel powertrains. See Highlight 5 for the increase in the number of hybrid and diesel models, as well as for the number of alternative fuel vehicle models.

### *Technology Production Share for MY 2009 and MY 2014*



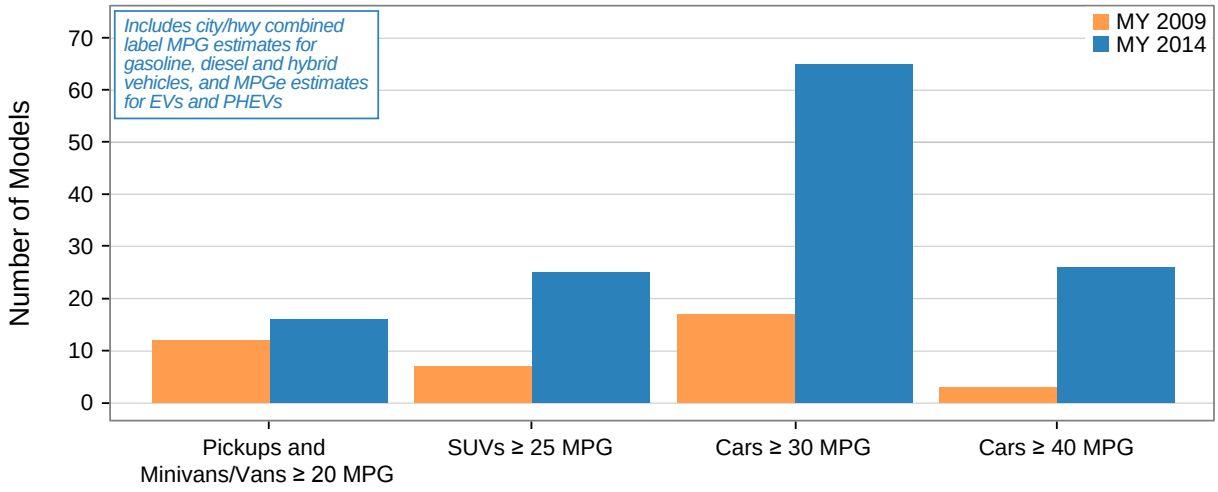
# 5 Highlight

## *Consumers have an increasing number of high fuel economy/low $CO_2$ vehicle choices*

Consumers have many more choices when shopping for vehicles with higher fuel economy and lower tailpipe $CO_2$ emissions compared to just five years ago. These choices reflect both a more diverse range of technology packages on conventional gasoline vehicles as well as more advanced technology and alternative fueled vehicles.

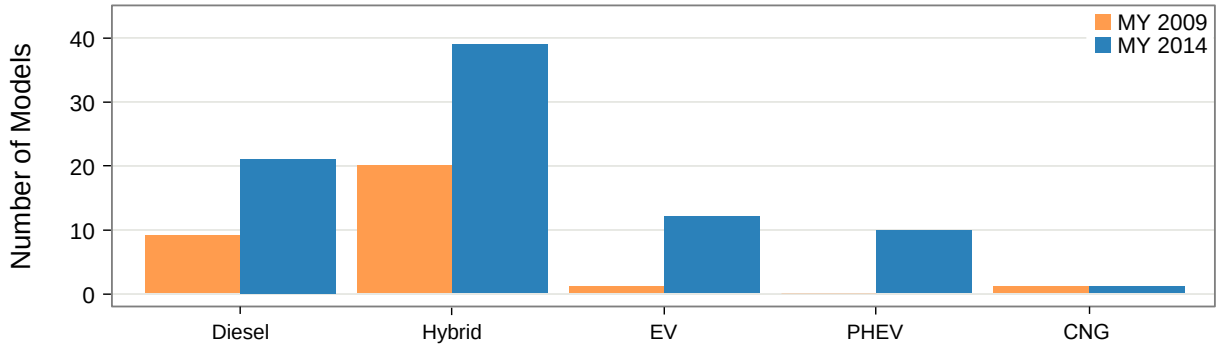
There are sixteen MY 2014 pickup and minivan/van models for which at least one variant of the model has a combined city/highway label fuel economy rating of 20 mpg or more, a slight increase over five years ago. There are three times as many SUV models that achieve 25 mpg or more in MY 2014 (with more than 20 conventional gasoline or diesel models) than in MY 2009. The number of car models, where at least one variant has a combined city/ highway label fuel economy of at least 30 mpg, more than tripled, and the number of car models at 40 mpg or more have increased from 3 to 26 (comprised of one conventional gasoline car with the rest being hybrid, electric and plug-in hybrid electric cars).

### *Vehicle Models Meeting Fuel Economy Thresholds in MY 2009 and MY 2014*




There are also many more advanced technology vehicle choices. In MY 2014, there are twice as many diesel and nearly twice as many hybrid offerings as there were in MY 2009. There are now over 20 electric and plug-in hybrid electric vehicles, a significant increase over MY 2009.

### *Advanced Technology and Alternative Fuel Vehicle Models in MY 2009 and MY 2014*



# Highlight

## *Nearly every manufacturer increased fuel economy and decreased $CO_2$ emissions in MY 2013*

Nine of the eleven manufacturers shown below increased average gasoline and diesel vehicle fuel economy from MY 2012 to MY 2013, the last two years for which we have final data.

In MY 2013, for the eleven manufacturers shown in the table, Mazda had the lowest fleetwide adjusted composite $CO_2$ emissions and highest adjusted fuel economy performance, followed by Honda and Subaru. Chrysler-Fiat had the highest $CO_2$ emissions and lowest fuel economy, followed by GM. Nissan had the biggest improvement in adjusted $CO_2$ emissions performance from MY 2012 to MY 2013, followed by Daimler. Nissan also had the biggest fuel economy improvement from MY 2012 to MY 2013, followed by Subaru. Ford and Toyota had higher $CO_2$ emissions and lower fuel economy in MY 2013, both driven by increases in truck production share.

Preliminary values suggest that most manufacturers will improve in MY 2014 as well, though these projections are uncertain, and EPA will not have final data until next year's report. Section 7 provides additional data for alternative fuel vehicles that are not included in these gasoline/diesel vehicle values.

### *MY 2012-2014 Manufacturer Adjusted Fuel Economy and Adjusted $CO_2$ Emissions[1]*

| | MY 2012 Final | | MY 2013 Final | | | | MY 2014 Preliminary | |
|---|---|---|---|---|---|---|---|---|
| **Manufacturer[2]** | **Adj. Fuel Economy (MPG)** | **$CO_2$ (g/mi)** | **Adj. Fuel Economy (MPG)** | **Change MY 2012-13 (MPG)** | **$CO_2$ (g/mi)** | **Change MY 2012-13 (g/mi)** | **Adj. Fuel Economy (MPG)** | **$CO_2$ (g/mi)** |
| Mazda | 27.1 | 328 | 28.1 | +1.0 | 316 | -12 | 28.8 | 309 |
| Honda | 26.6 | 334 | 27.4 | +0.8 | 324 | -10 | 27.6 | 322 |
| Subaru | 25.2 | 352 | 26.7 | +1.5 | 332 | -20 | 27.5 | 324 |
| Nissan | 24.1 | 369 | 26.2 | +2.1 | 339 | -30 | 26.8 | 332 |
| VW | 25.5 | 355 | 25.7 | +0.2 | 353 | -2 | 26.7 | 340 |
| Toyota | 25.6 | 347 | 25.1 | -0.5 | 354 | +7 | 25.8 | 344 |
| BMW | 23.7 | 377 | 24.5 | +0.8 | 363 | -14 | 26.0 | 344 |
| Daimler | 21.1 | 426 | 22.4 | +1.3 | 399 | -27 | 22.8 | 393 |
| Ford | 22.8 | 390 | 22.2 | -0.6 | 400 | +10 | 23.4 | 380 |
| GM | 21.7 | 410 | 22.0 | +0.3 | 404 | -6 | 22.0 | 404 |
| Chrysler-Fiat | 20.1 | 442 | 20.9 | +0.8 | 425 | -17 | 21.1 | 420 |
| **All** | **23.6** | **376** | **24.1** | **+0.5** | **369** | **-7** | **24.2** | **367** |

*[1] Adjusted $CO_2$ and fuel economy values reflect real world performance and are not comparable to automaker standards compliance levels. Adjusted $CO_2$ values are higher and adjusted fuel economy values are lower than compliance values.*

*[2] Hyundai and Kia are not included in this table due to a continuing investigation. In November 2012, Hyundai and Kia corrected fuel economy labels for many vehicle models. Based on these corrected data, Hyundai's values are 28.3 mpg and 314 g/mi $CO_2$ for MY 2012, 29.0 mpg and 306 g/mi for MY 2013, and 27.3 mpg and 326 g/mi for MY 2014. Kia's values are 26.5 mpg and 336 g/mi $CO_2$ for MY 2012, 27.4 mpg and 324 g/mi for MY 2013, and 25.7 mpg and 345 g/mi for MY 2014. Hyundai and Kia adopted unusually short MY 2014 production time frames for some high fuel economy models, which the authors believe is the primary reason for their lower fuel economy and higher $CO_2$ preliminary values for MY 2014. These corrected data for Hyundai and Kia are included in industry-wide or "All" values.*

## Highlight

### *Manufacturers are selling many vehicles today that can meet future $CO_2$ emissions targets*

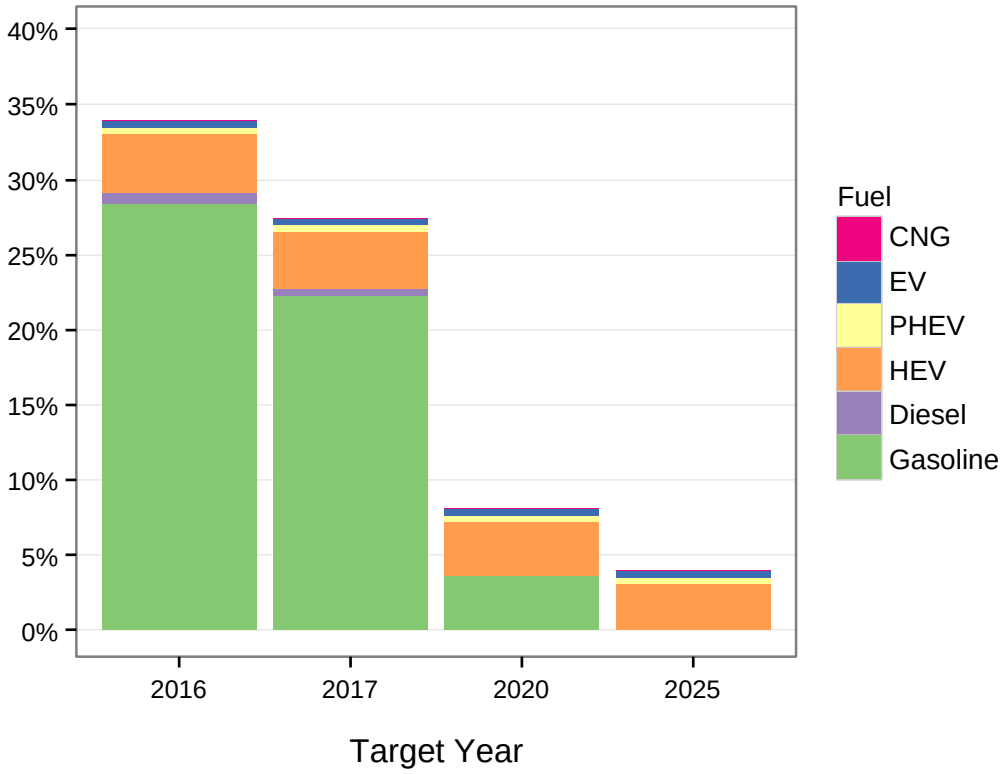
EPA evaluated MY 2014 vehicle emissions performance against future footprint-based $CO_2$ emissions regulatory targets to determine which current vehicles could meet or exceed their future targets in MY 2016-2025. These comparisons were based on current powertrain designs, assuming future improvements only in air conditioner refrigerants and efficiency. EPA assumed air conditioning improvements since these are considered to be among the most straightforward and least expensive technologies available to reduce $CO_2$ and other greenhouse gas emissions.

It is important to note there are no $CO_2$ emissions standards for individual vehicles. Overall manufacturer compliance will be determined based on the production volume-weighted distribution of vehicles by each manufacturer, and how each model performs relative to the footprint-based $CO_2$ emissions target curves. Vehicles with emissions levels below their $CO_2$ targets will generate credits, and those above their targets will generate debits.

The figure below shows that 34% of projected MY 2014 vehicle production already meets the MY 2016 $CO_2$ emissions targets, or can meet these targets with the addition of future expected air conditioning improvements. The bulk of this production share is accounted for by non-hybrid gasoline vehicles, although other technologies are also represented.

Looking ahead, about 4% of projected MY 2014 production could meet the MY 2025 $CO_2$ emissions targets. Vehicles meeting the MY 2025 $CO_2$ targets are comprised solely of hybrids, plug-in hybrids, and electric vehicles. Since the MY 2025 standards are over a decade away, there's considerable time for continued improvements in gasoline vehicle technology.

#### *MY 2014 Vehicle Production That Meets Future $CO_2$ Emissions Targets*



*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.*