Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2015

Trends

Executive Summary

MPG
CO_2

United States Environmental Protection Agency

EPA-420-S-15-001 December 2015

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.*

*Data for model years (MY) 1975 through 2014 are **final**. These data are submitted to the EPA and NHTSA at the conclusion of the model year and include actual production data and the results of emission and fuel economy testing performed by the manufacturers and EPA. Data for MY 2015 are **preliminary** and based on projected production data provided to EPA by automakers prior to MY 2015 sales. The uncertainty in these projections is magnified this year as U.S. gasoline prices decreased significantly in the fall of 2014. MY 2015 values will be finalized in next year's report. All data in this report are based on production volumes delivered for sale in the U.S. by model year, and may vary from publicized data based on calendar year sales.*

*For the first time, because of increasing production, **data from alternative fuel vehicles (AFVs) are integrated into the overall database, beginning with MY 2011 data.** These vehicles include electric vehicles, plug in hybrids, and compressed natural gas vehicles. The database continues to include traditional hybrids and ethanol flexible fuel vehicles (assumed to operate on gasoline).*

*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 are EPA's best estimate of nationwide "real world" CO_2 emissions and fuel consumption. This report does not provide formal compliance values for EPA CO_2 emissions standards and NHTSA CAFE standards, which are based on **unadjusted, laboratory** values and various credits. The difference between adjusted and unadjusted values is discussed in detail in Section 10 of the full report.*

It is important to note that EPA has issued notices of violation to Volkswagen alleging that certain MY 2009-2016 diesel vehicles are in violation of the Clean Air Act for excess oxides of nitrogen emissions (see www.epa.gov/vw). 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, the revised data will be used in future reports.

The full version of this report and the appendices are available at www.epa.gov/otaq/fetrends.htm. Information about automaker compliance with EPA's GHG emissions standards is available in EPA's "Manufacturer Performance Report" at www.epa.gov/otaq/climate/ghg-report.htm. Information about automaker compliance with NHTSA's CAFE standards is available at NHTSA's CAFE Public Information Center at www.nhtsa.gov/CAFE_PIC.

1 Highlight

Average vehicle CO_2 emissions rate and fuel economy were unchanged in MY 2014

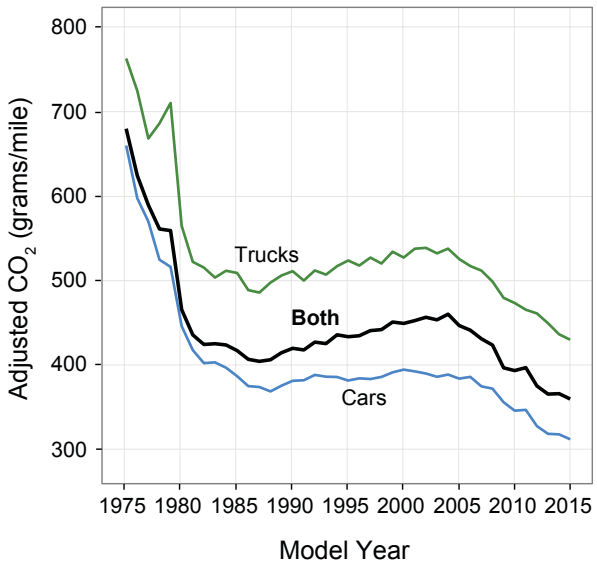
The final MY 2014 adjusted, real world CO_2 emissions rate for all new, personal vehicles is 366 g/mi, which is unchanged from MY 2013. The MY 2014 adjusted fuel economy is 24.3 mpg, which is also unchanged from MY 2013. New vehicle CO_2 emission rates remain at the lowest rate ever recorded in the Trends database, and likely the lowest rate of all-time. New vehicle fuel economy is correspondingly at the highest level ever recorded, and likely the highest of all-time.

The average MY 2014 adjusted fuel economy for cars remained at 27.9 mpg, while trucks increased 0.6 mpg to a new record high adjusted truck fuel economy of 20.4 mpg. The annual truck increase of 0.6 mpg was the second highest in the last 30 years.

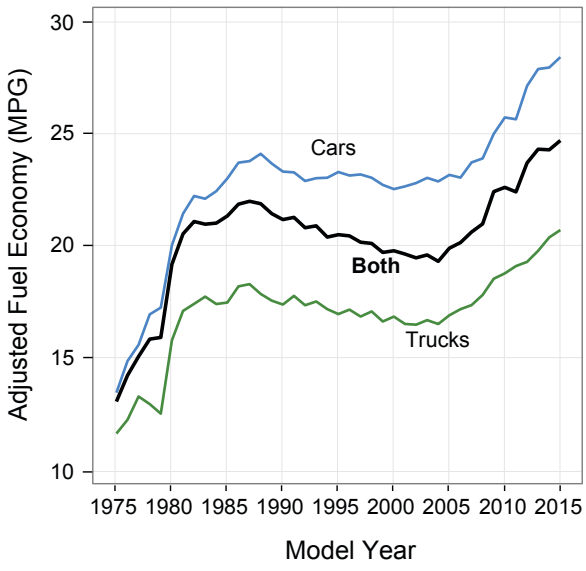
The greatest value of the historical Trends database is the documentation of long-term trends. CO_2 emissions and fuel economy have improved in eight out of the last ten years. Based on the final data through MY 2014, CO_2 emissions have decreased by 95 g/mi, or 21%, since MY 2004, and fuel economy has increased by 5.0 mpg, or 26%, with an average annual improvement of about 0.5 mpg per year.

Preliminary MY 2015 adjusted CO_2 emissions are projected to be 360 g/mi and fuel economy is projected to be 24.7 mpg, which would represent an improvement over MY 2014. These values are based on production estimates provided by automakers in early 2014 and are particularly uncertain given market conditions, including lower gasoline prices. MY 2015 values will be finalized in next year's report.

Adjusted CO_2 Emissions for MY 1975-2015[1]



Adjusted Fuel Economy for MY 1975-2015[1]



[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, 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 that form the starting point for CAFE standards compliance.

2 Highlight

Light truck fuel economy reached a record high at the same time as consumer demand for light trucks increased in MY 2014

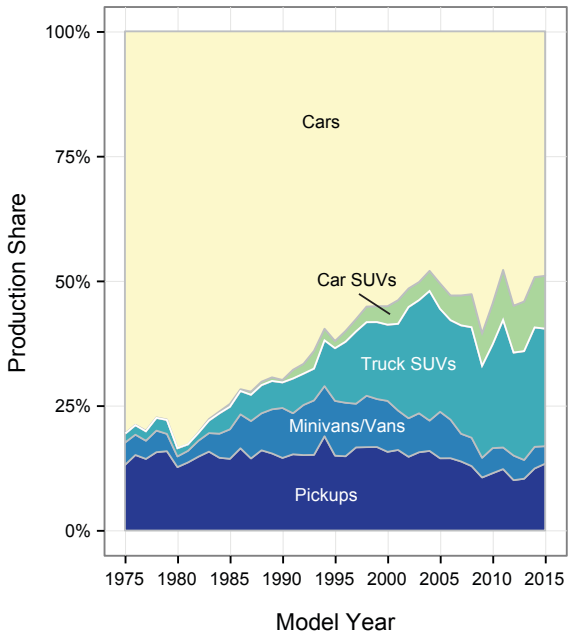
Light truck fuel economy increased by 0.6 mpg in MY 2014 to a record 20.4 mpg. Light trucks, which include pickups, minivans/vans, and truck SUVs (SUVs that are light trucks for purposes of compliance with GHG emissions and fuel economy standards), accounted for 41% of all light-duty vehicle production in MY 2014. This represents an increase of 5% relative to MY 2013. MY 2014 truck share is the same as MY 2008, even though it has fluctuated by 4% or more in five out of the six years. Truck share is still well below the record 48% in MY 2004.

In MY 2014, the 5% increase in truck share offset all of the fleetwide benefits that would otherwise have been achieved due to the 0.6 mpg increase in truck fuel economy, the second highest truck fuel economy increase in the last 30 years. Truck share impacts many important fleetwide metrics, since light trucks on average have higher CO_2 emissions, lower fuel economy, higher weight, and horsepower, and larger footprint than cars.

Of the five vehicle types in Trends, cars have the highest average adjusted fuel economy of 28.7 mpg, followed by car SUVs (SUVs that must meet car GHG and fuel economy standards) at 24.6 mpg.

The most inefficient vehicle types, truck SUVs and pickups, have been achieving the greatest improvements in recent years. Truck SUVs and pickups had the highest annual improvements from MY 2013 to MY 2014 of 0.8 and 0.6 mpg, respectively. Truck SUVs and pickups have also achieved the largest absolute improvements in both CO_2 emissions and fuel consumption since MY 2010.

Production Share by Vehicle Type for MY 1975-2015



3 Highlight

Vehicle power and footprint are trending higher while weight is fairly flat

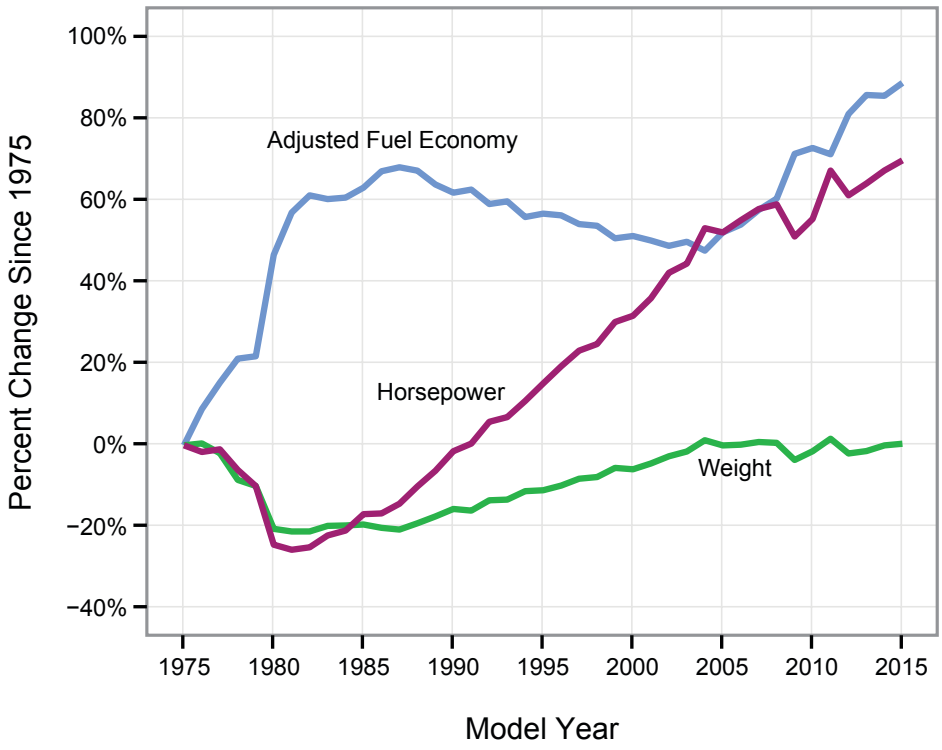
Vehicle weight, power, and footprint are three important design parameters that help determine a vehicle's CO_2 emissions and fuel economy.

For nearly two decades 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, utility, and other attributes. Beginning in MY 2005, technology has generally been used to increase both fuel economy (which has reduced CO_2 emissions) and power, while keeping vehicle weight relatively constant.

The MY 2014 fleet averaged 4,060 pounds, an increase of 57 pounds (1.4%) compared to MY 2013. This increase was primarily due to the 5% increase in truck share, as car weight was 0.5% higher but truck weight was 0.7% lower. Average MY 2014 vehicle power was 230 horsepower, an increase of 4 horsepower (1.8%) from MY 2013, also driven primarily by truck share as car power increased by 1 hp while truck power was unchanged. This power level tied the all-time high reached in MY 2011. Average MY 2014 vehicle footprint increased by 0.6 square feet (1.2%) to 49.7 square feet, the highest level since data began in MY 2008, with both car and truck footprint rising about 0.5%. The average 0-to-60 mph acceleration time was essentially unchanged in MY 2014.

Preliminary MY 2015 values suggest that average weight will be relatively unchanged, horsepower will increase to a record high, and footprint will reach the highest level since we began reporting data in MY 2008. EPA will not have final MY 2015 data until next year's report.

Change in Adjusted Fuel Economy, Weight, and Horsepower for MY 1975-2015



4 Highlight

Many technologies continue to gain 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 2010 through MY 2015, for several key engine and transmission technologies for which Trends gathers data.

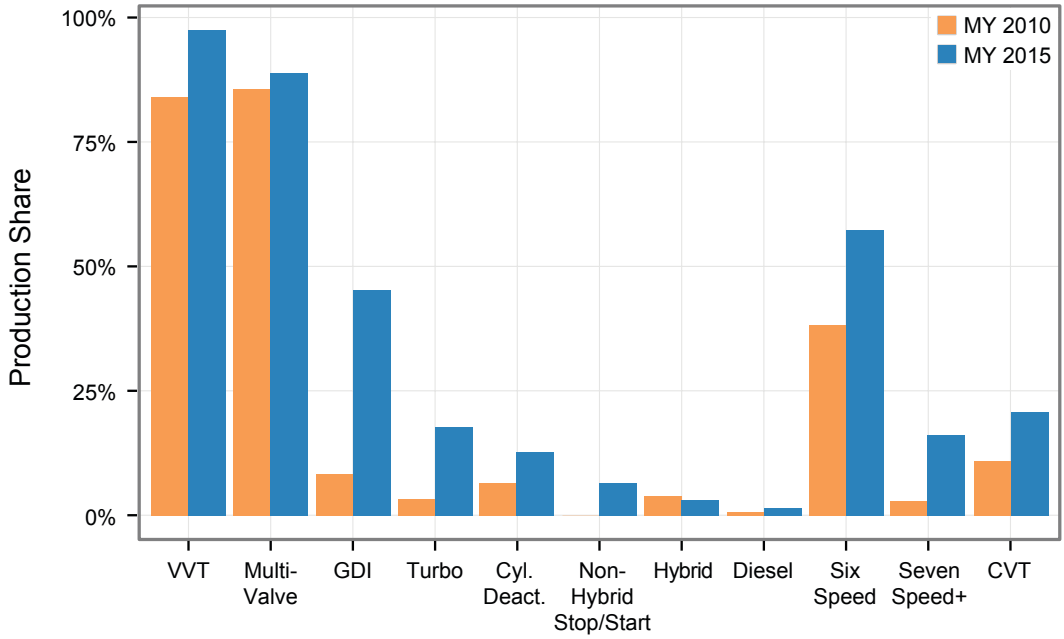
Two engine technologies first introduced over 20 years ago—variable valve timing (VVT) and multi-valve engines—are both projected to be used on nearly all MY 2015 vehicles. Gasoline direct injection (GDI) engines have increased market share by more than a factor of 5 from 8% in MY 2010 to 46% in MY 2015. Turbochargers, which are often used in conjunction with GDI, have also increased market share by more than a factor of five since MY 2010.

Non-hybrid stop/start systems represent about 7% of the projected MY 2015 market. Accounting for hybrids, stop/start systems are used on nearly 10% of MY 2015 vehicles.

Transmissions with 6 or more speeds and continuously variable transmissions (CVTs) cumulatively accounted for 52% of vehicle production in MY 2010, but are projected to achieve 94% market share in MY 2015. CVTs and advanced transmissions with 7 or more speeds are projected to reach 37% market penetration in MY 2015.

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 individual hybrid and diesel models, as well as for the number of alternative fuel vehicle models.

Technology Production Share for MY 2010 and MY 2015



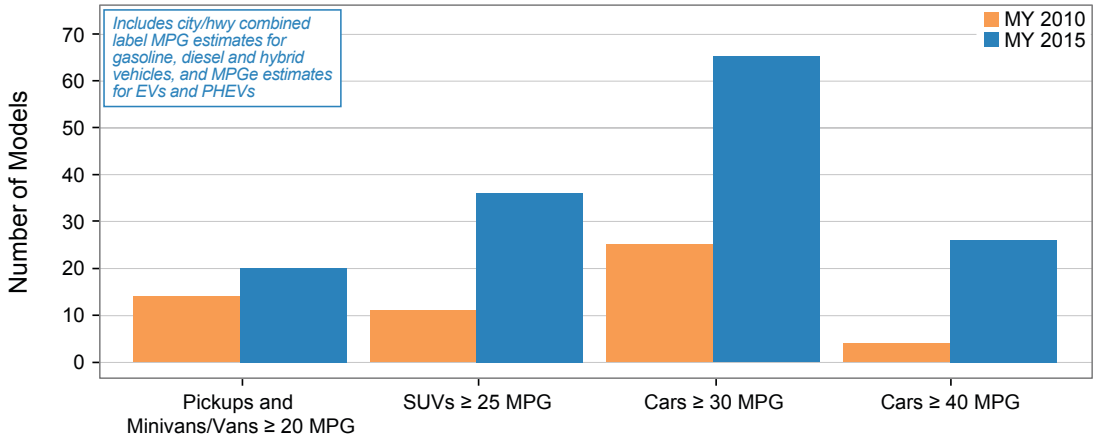
5 Highlight

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

In MY 2015, consumers have many more choices when shopping for vehicles with higher fuel economy and lower tailpipe CO_2 emissions compared to MY 2010. 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.

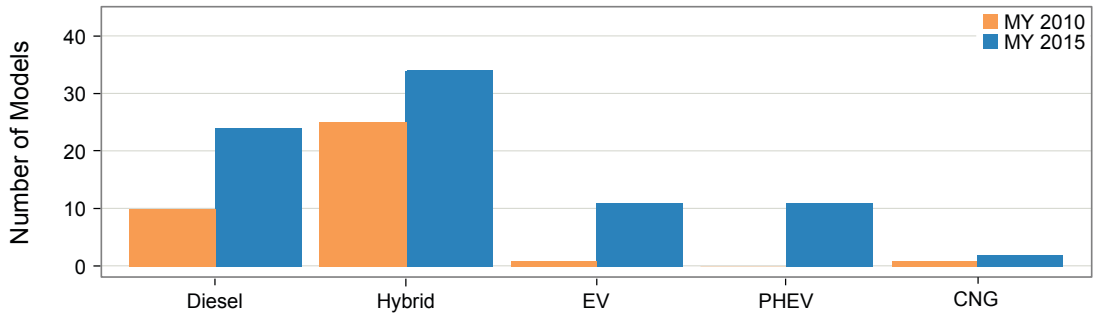
There are 20 MY 2015 pickup and minivan/van models for which at least one variant of the model has a combined city/highway label fuel economy rating of 20 mpg or more, a small increase over MY 2010. There are more than three times as many SUV models that achieve 25 mpg or more in MY 2015 than there were in MY 2010. 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 doubled, and the number of car models at 40 mpg or more have increased from 4 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 2010 and MY 2015



There are also many more advanced technology vehicle choices. In MY 2015, there are more than twice as many diesel offerings and nine more hybrids than there were in MY 2010. There are now over 20 electric and plug-in hybrid electric vehicles, nearly all of which are new since MY 2010.

Advanced Technology and Alternative Fuel Vehicle Models in MY 2010 and MY 2015



6 Highlight

Most manufacturers decreased CO_2 emissions and improved fuel economy in MY 2014

Eight of the twelve largest manufacturers shown below increased fuel economy and decreased CO_2 emissions from MY 2013 to MY 2014, the last two years for which we have final data.

In MY 2014, Mazda had the lowest fleetwide adjusted composite CO_2 emissions and highest adjusted fuel economy performance, followed by a grouping of Subaru, Hyundai, Honda, and Nissan. Fiat-Chrysler had the highest CO_2 emissions and lowest fuel economy, followed by GM, Ford, and Mercedes. BMW accomplished the biggest improvement in adjusted CO_2 emissions performance from MY 2013 to MY 2014, followed by Mercedes and Mazda. BMW also had the biggest fuel economy improvement from MY 2013 to MY 2014, followed by Mazda.

MY 2014 values for Hyundai and Kia are both about 1.5 mpg less than MY 2013 values. These two manufacturers had very short MY 2014 production time frames, and therefore significantly reduced production in MY 2014, for their highest fuel economy vehicles. Excluding these two manufacturers, fleetwide fuel economy would have increased by 0.3 mpg and fleetwide CO_2 emissions would have decreased by 4 g/mi in MY 2014, rather than being flat.

Preliminary values suggest that most manufacturers will improve in MY 2015 as well, though these projections are uncertain, and EPA will not have final MY 2015 data until next year's report.

MY 2013-2015 Manufacturer Adjusted Fuel Economy and Adjusted CO_2 Emissions[1, 2]

	MY 2013 Final		MY 2014 Final				*MY 2015 Preliminary*	
Manufacturer	**Adj. Fuel Economy (MPG)**	**CO_2 (g/mi)**	**Adj. Fuel Economy (MPG)**	**Change from MY 2013 (MPG)**	**CO_2 (g/mi)**	**Change from MY 2013 (g/mi)**	***Adj. Fuel Economy (MPG)***	**CO_2 (g/mi)**
Mazda	28.1	316	29.4	+1.3	302	-14	*30.1*	*295*
Subaru	26.7	332	27.6	+0.9	321	-11	*28.7*	*309*
Hyundai	29.1	305	27.5	-1.6	323	+18	*27.4*	*325*
Honda	27.4	324	27.3	-0.1	326	+2	*28.9*	*307*
Nissan	26.6	332	27.0	+0.4	329	-3	*28.3*	*312*
BMW	24.5	364	26.4	+1.9	338	-26	*26.6*	*335*
Kia	27.4	324	25.9	-1.5	343	+19	*26.1*	*341*
Toyota	25.2	352	25.6	+0.4	347	-5	*25.4*	*350*
Mercedes Benz	22.3	401	23.2	+0.9	385	-16	*23.7*	*375*
Ford	22.3	397	22.8	+0.5	389	-8	*23.5*	*378*
GM	22.1	401	22.8	+0.7	390	-11	*21.9*	*406*
Fiat-Chrysler	20.9	425	20.8	-0.1	428	+3	*21.8*	*409*
All	**24.3**	**366**	**24.3**	**0**	**366**	**0**	***24.7***	***360***

[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] Volkswagen is not included in this table due to an ongoing investigation. Based on the original compliance data, Volkswagen values are 25.7 mpg and 353 g/mi CO_2 for MY 2013, 26.2 mpg and 347 g/mi for MY 2014, and 27.6 mpg and 329 g/mi for preliminary MY 2015. These Volkswagen data are included in industry-wide or "All" values. If corrective actions yield different fuel economy and CO_2 data, revised data will be used in future reports.

7 Highlight

Manufacturers are producing many vehicles today that can meet future CO_2 emissions targets

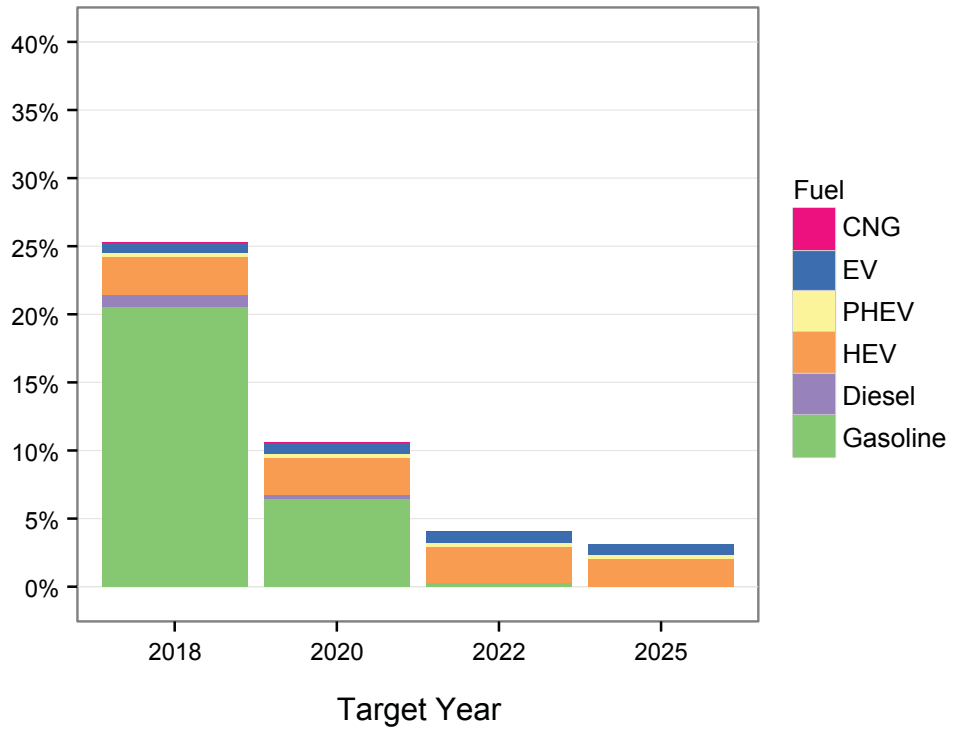
EPA evaluated MY 2015 vehicle emissions performance against future footprint-based CO_2 emissions regulatory targets to determine which current vehicles could meet or exceed their future targets in MY 2018-2025. These comparisons were based on current powertrain designs, assuming future improvements 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 is 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 26% of projected MY 2015 vehicle production already meets the MY 2018 CO_2 emissions targets, or can meet these targets with the addition of 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 3% of projected MY 2015 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 a decade away, there's considerable time for continued improvements in gasoline vehicle technology.

MY 2015 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.