2013 Vehicle Technologies Market Report

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Quick Facts

Energy and Economics

- Transportation accounts for 28% of total U.S. energy consumption.
- Dependence on oil cost the U.S. economy $500 billion in 2012.
- The average price of a new car is just over $25,000.
- Almost 18% of household expenditures are for transportation.
- Over 9 million people are employed in the transportation industry.

Light Vehicles

- The top nine manufacturers selling vehicles in the U.S. produce about half of the world's vehicles.
- U.S. sales volumes continued to rise in 2012.
- Sales-weighted data on new light vehicles sold show a 121% increase in horsepower and 35% decrease in 0-60 time from 1980 to 2013, with the fuel economy of vehicles improving 25%.
- Nearly 17% of cars sold in 2013 have continuously variable transmissions.
- Almost two-thirds of new light vehicles sold in 2013 have transmissions with more than 5 speeds.

Heavy Trucks

- Class 8 combination trucks consume an average of 6.5 gallons per thousand ton-miles.
- Class 3 truck sales have continued to increase in 2012.
- Sales of class 4-7 trucks continued to increase in 2012, but were more than 5% below the 2008 level.
- Class 8 truck sales continued to increase in 2012 and have risen drastically above 2009 figures.
- Diesel comprised 74% of the class 3-8 trucks sold in 2012, up from 72% in 2008.
- Combination trucks are driven an average of over 66,000 miles per year.
- Idling a truck-tractor's engine can use more than a gallon of fuel per hour.
- There are 116 electrified truck stop sites across the country to reduce truck idling time.

Technologies

- Almost 500,000 hybrid vehicles were sold in 2013.
- Plug-in vehicle sales total nearly 100,000 units in 2013.
- At least 24 different models of plug-in vehicles are available or coming soon to the market.
- Eighty-two flex-fuel vehicle models were offered in model year 2013.
- There are more than 20,835 electric vehicle charging stations throughout the nation.
- Single wide tires on a Class 8 truck improve fuel economy by more than 7% on flat terrain.

Policy

- Plug-in hybrids and electric vehicle purchasers received a Federal tax credit of up to $7,500 for select 2010-2014 vehicles and possible state credits.
- The proposed EPA greenhouse gas standards for cars raises average fuel economy for new cars to 54.5 mpg by 2025, while the NHTSA Corporate Average Fuel Economy Standards are 49.0 mpg by 2025.
- Since model year 2010, diesel engine emission standards are more strict – 0.2 grams per horsepower-hour (g/HP-hr) for nitrogen oxides and 0.01 g/HP-hr for particulate matter.

ORNL/TM-2014/58

2013 VEHICLE TECHNOLOGIES MARKET REPORT

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Introduction

Welcome to the *2013 Vehicle Technologies Market Report*. This is the fifth edition of this report, which details the major trends in U.S. light-duty vehicle and medium/heavy truck markets as well as the underlying trends that caused them. This report is supported by the U.S. Department of Energy's (DOE) Vehicle Technologies Office (VTO), and, in accord with its mission, pays special attention to the progress of high-efficiency and alternative-fuel technologies.

After opening with a discussion of energy and economics, this report features a section each on the light-duty vehicle and heavy/medium truck markets, and concluding with a section each on technology and policy. The first section on Energy and Economics discusses the role of transportation energy and vehicle markets on a national (and even international) scale. For example, Figures 12 through 14 discuss the connections between global oil prices and U.S. GDP, and Figures 21 and 22 show U.S. employment in the automotive sector. The following section examines Light-Duty Vehicle use, markets, manufacture, and supply chains. Figures 24 through 51 offer snapshots of major light-duty vehicle brands in the U.S. and Figures 56 through 64 examine the performance and efficiency characteristics of vehicles sold. The discussion of Medium and Heavy Trucks offers information on truck sales (Figures 73 through 75) and fuel use (Figures 78 through 81). The Technology section offers information on alternative fuel vehicles and infrastructure (Figures 84 through 95), and the Policy section concludes with information on recent, current, and near-future Federal policies like the Corporate Average Fuel Economy standard (Figures 106 through 110).

In total, the information contained in this report is intended to communicate a fairly complete understanding of U.S. highway transportation energy through a series of easily digestible nuggets. On behalf of the DOE and VTO, I hope that you explore and find value in this report. Suggestions for future expansion, additional information, or other improvements are most welcome.

Sincerely,

Jacob Ward
Analysis Manager
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Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

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Chapter 1.

ENERGY AND ECONOMICS

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Transportation Accounts for 28% of Total U.S. Energy Consumption

In 2012, the transportation sector used 26.6 quadrillion Btu of energy, which was 28% of total U.S. energy use. Nearly all of the energy consumed in this sector is petroleum (93%), with small amounts of renewable fuels (4%) and natural gas (3%). With the future use of plug-in hybrids and electric vehicles, transportation will begin to use electric utility resources. The electric utility sector draws on the widest range of sources and uses only a small amount of petroleum (1%). Over the last five years, the energy sources have not changed significantly, although renewable fuel use has grown slightly in each sector.

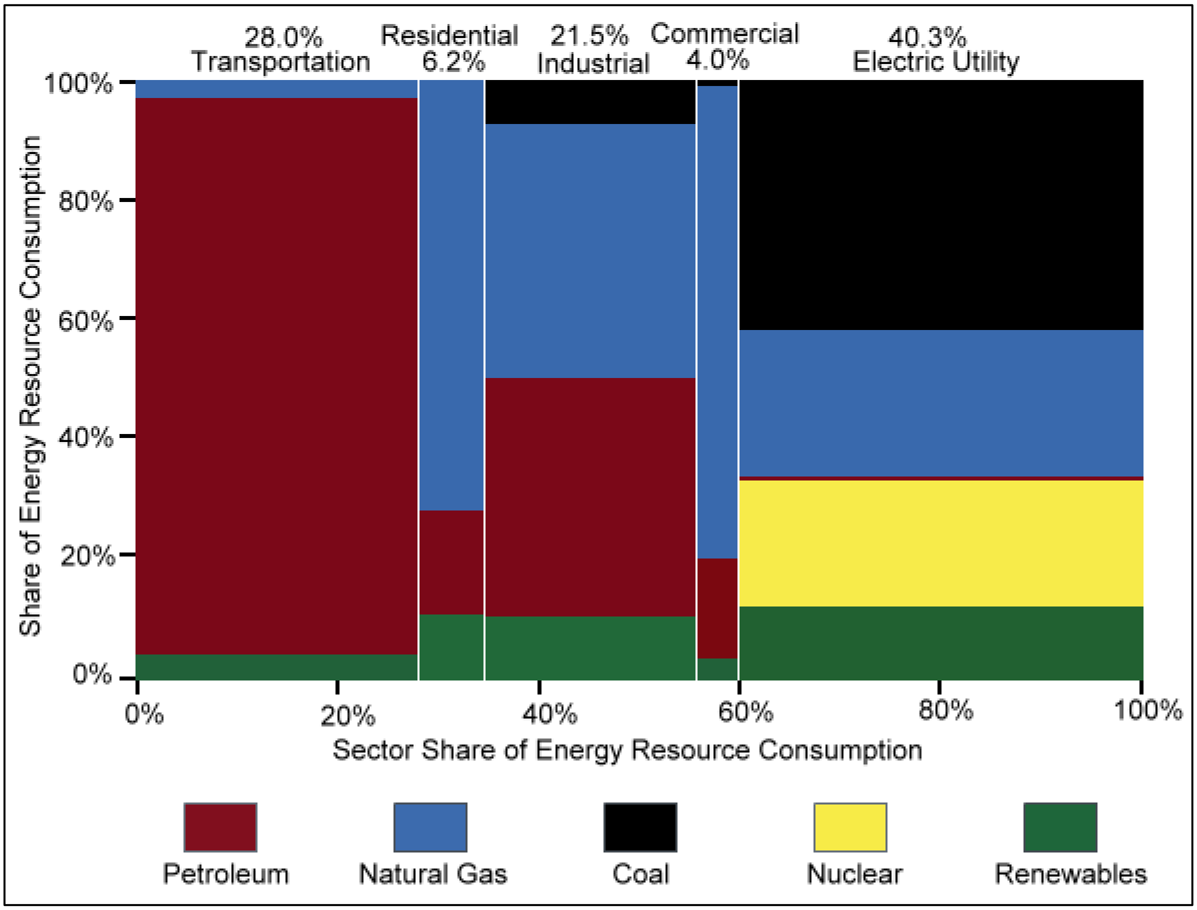


FIGURE 1. U.S. Energy Consumption by Sector and Energy Source, 2012

Source:

Energy Information Administration, *Monthly Energy Review, October 2013*, Tables 2.2, 2.3, 2.4, 2.5, and 2.6., http://www.eia.gov/totalenergy/data/monthly

The Transportation Sector Uses More Petroleum Than the United States Produces

Petroleum consumption in the transportation sector surpassed U.S. petroleum production for the first time in 1989, creating a gap that must be met with imports of petroleum. By the year 2040, transportation petroleum consumption is expected to grow to almost 14 million barrels per day; at that time, the gap between U.S. production and transportation consumption will be about 2 million barrels per day when including the non-petroleum sources and 4 million barrels per day if using only conventional sources of petroleum fuel.

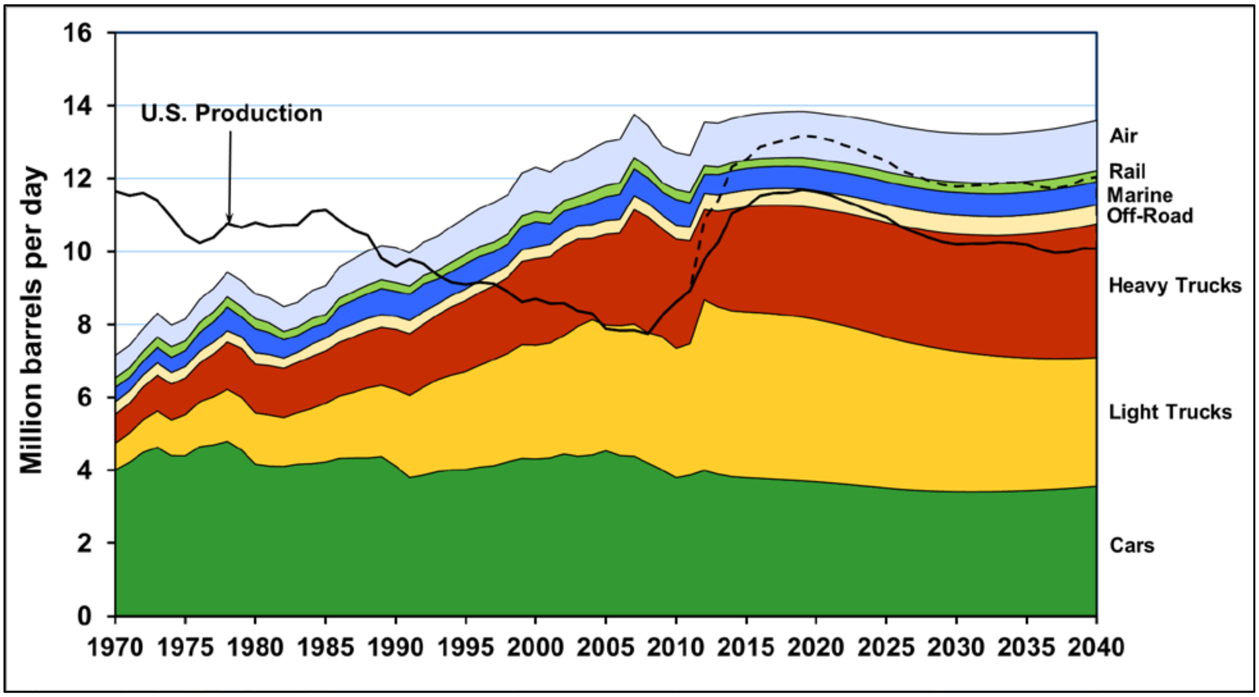


FIGURE 2. Transportation Petroleum Use by Mode and the U.S. Production of Petroleum, 1970-2040

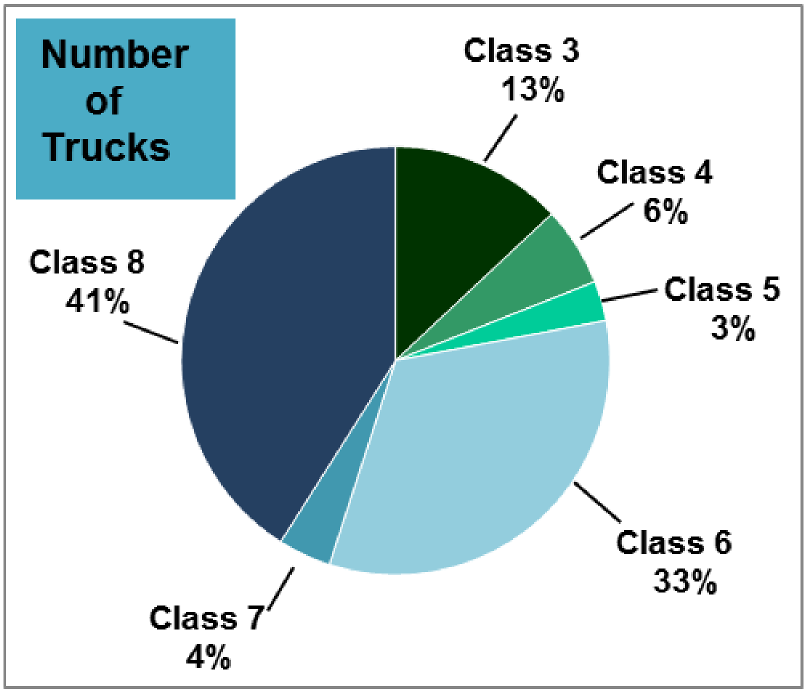
Note: The U.S. production has two lines after 2011. The solid line is conventional sources of petroleum, including crude oil, natural gas plant liquids, and refinery gains. The dashed line adds in other non-petroleum sources, including ethanol, biomass, liquids from coal, other blending components, other hydrocarbons, and ethers. The sharp increase in values between 2011 and 2012 is caused by the data change from historical to projected values. The sharp increase in the value for heavy trucks between 2006 and 2007 is the result of a methodology change in the Federal Highway Administration data.

Sources:

1970-2009: Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 32*, Oak Ridge, TN, 2013. http://cta.ornl.gov/data

2010-2040: Energy Information Administration, *Annual Energy Outlook 2013*, DOE/EIA-0383(2013), Washington, DC, 2013. http://www.eia.gov/forecasts/aeo/

Class 8 Trucks Use the Majority of Fuel Consumed by Medium/Heavy Trucks



Class 8 trucks comprise only 41% of the heavy- and medium-truck fleet, but they account for 78% of the fuel consumed by medium and heavy trucks. Though more than half of all medium and heavy trucks are Class 3-6, they use less than one-quarter of total fuel. Class 3-6 trucks tend to have higher fuel economy than Class 7-8 trucks and are typically driven fewer miles.

Note: See page 92 for truck class definitions. Data for 2002 are the latest available.

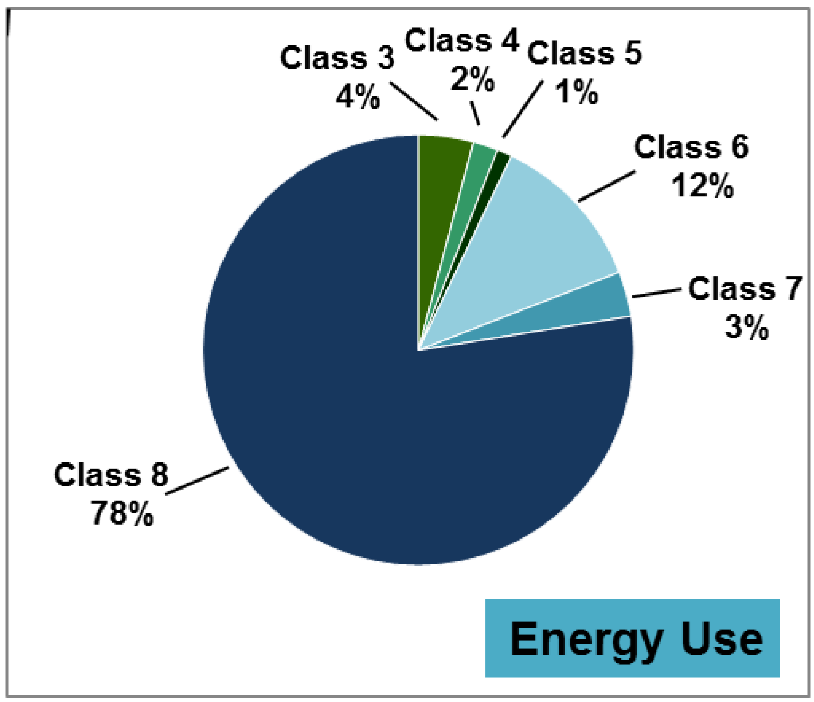


FIGURE 3. Medium and Heavy Truck Fleet Composition and Energy Usage, 2002

Source:

Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 32*, Oak Ridge, TN, 2013. http://cta.ornl.gov/data

Improvements in Fuel Economy for Low-MPG Vehicles Yield the Greatest Fuel Savings

The relationship between gallons used over a given distance and miles per gallon (mpg) is not linear. Thus, an increase in fuel economy by 5 mpg does not translate to a constant fuel savings amount. Trading a low-mpg car or truck for one with just slightly better mpg will save more fuel than trading a high-mpg car or truck for one that is even higher. For example, trading a truck that gets 10 mpg for a new one that gets 15 mpg will save 33 gallons of fuel for every 1,000 miles driven. In contrast, trading a 30 mpg car for a new car that gets 35 mpg will save 5 gallons of fuel for every 1,000 miles driven.

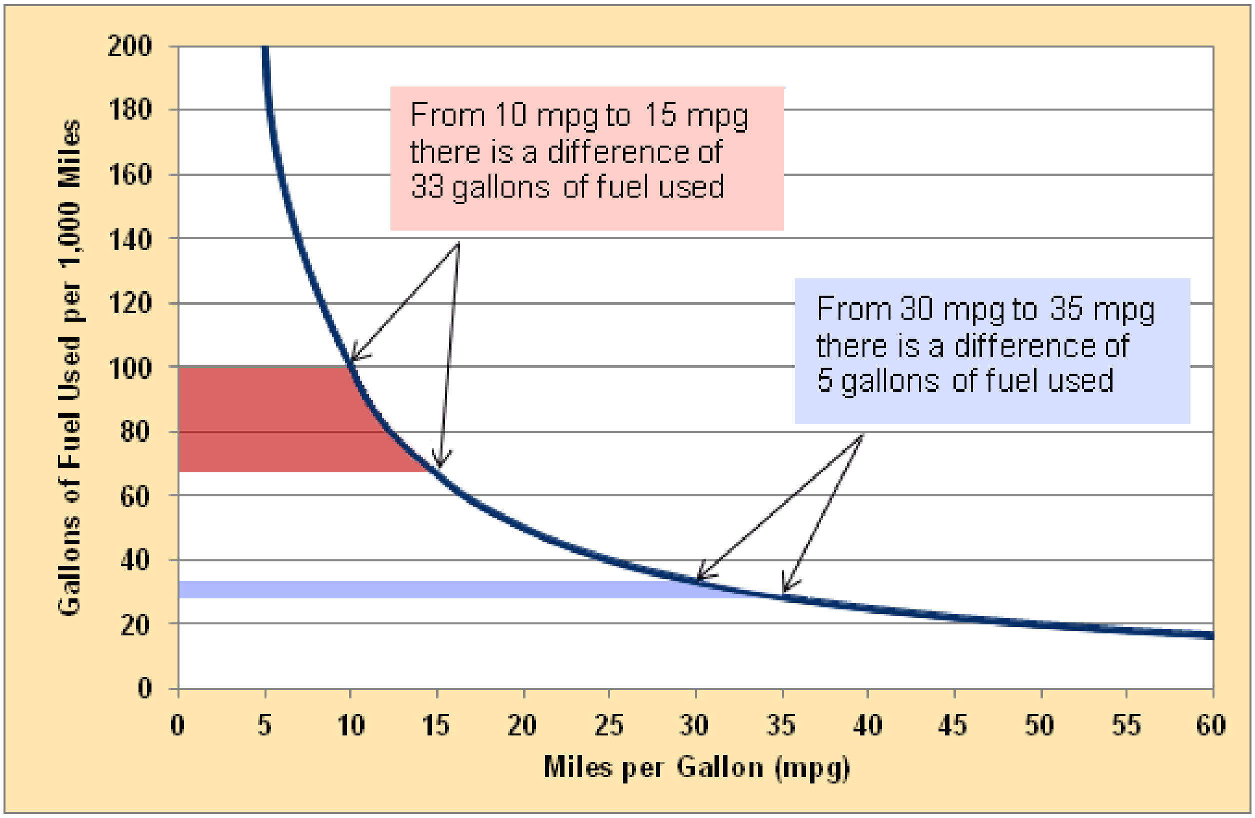


FIGURE 4. Fuel Use Versus Fuel Economy

Note: Each category on the horizontal axis shows a five mile per gallon improvement in fuel economy.

Source:
U.S. Department of Energy and Environmental Protection Agency, *Fuel Economy Guide*.
http://www.fueleconomy.gov

Carbon Dioxide Emissions from Transportation Decreased from 2007

Carbon dioxide (CO_2) emissions decreased by 8% from a high of 1,910 million metric tons (mmt) in 2007 to 1,750 mmt in 2011. Improvements in vehicle efficiency and changes in vehicle travel have likely contributed to this decrease. The increased use of ethanol in gasoline may also have played a role in lowering CO_2 emissions.

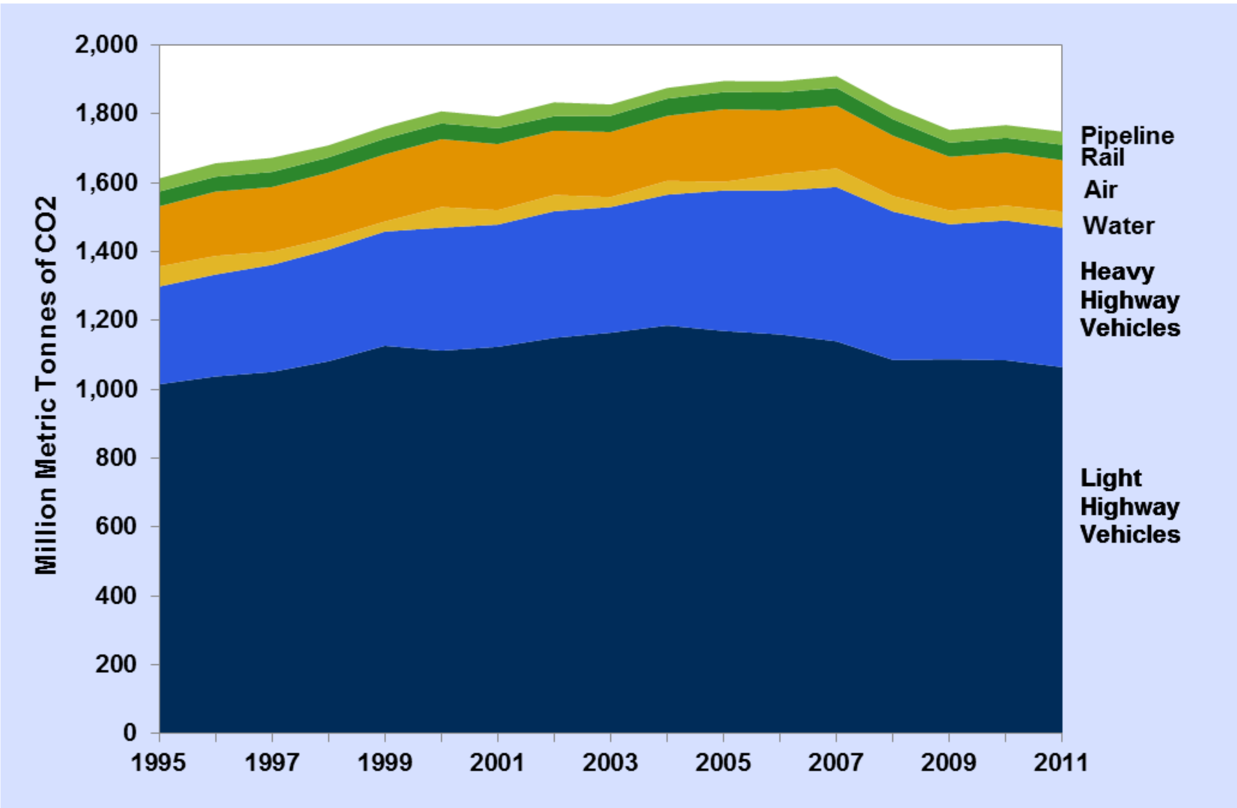


FIGURE 5. Transportation Carbon Dioxide Emissions, 1995-2011

Note: International Bunker Fuels were not included in these calculations.

Source:
U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000*, Table 2-7, April 2002; 1990-2005, Table 3-7, April 2007; and 1990-2010, Table 3-12, April 2013. http://epa.gov/climatechange/emissions/usinventoryreport.html

Many Cars Pollute Less Despite Increases in Size

As new vehicles become more efficient, the amount of carbon dioxide (CO_2) they produce decreases. Shown below are several examples of model year (MY) 2013 cars that have decreased the amount of CO_2 they produce (in grams per mile) despite the fact that they are larger (in interior volume) than they were ten years ago. Of the examples, the Kia Optima had the largest decline in CO_2 emissions in the ten-year period, and the Nissan Sentra, Volkswagen Jetta and the Hyundai Sonata had the greatest increase in interior volume while still reducing CO_2 emissions.

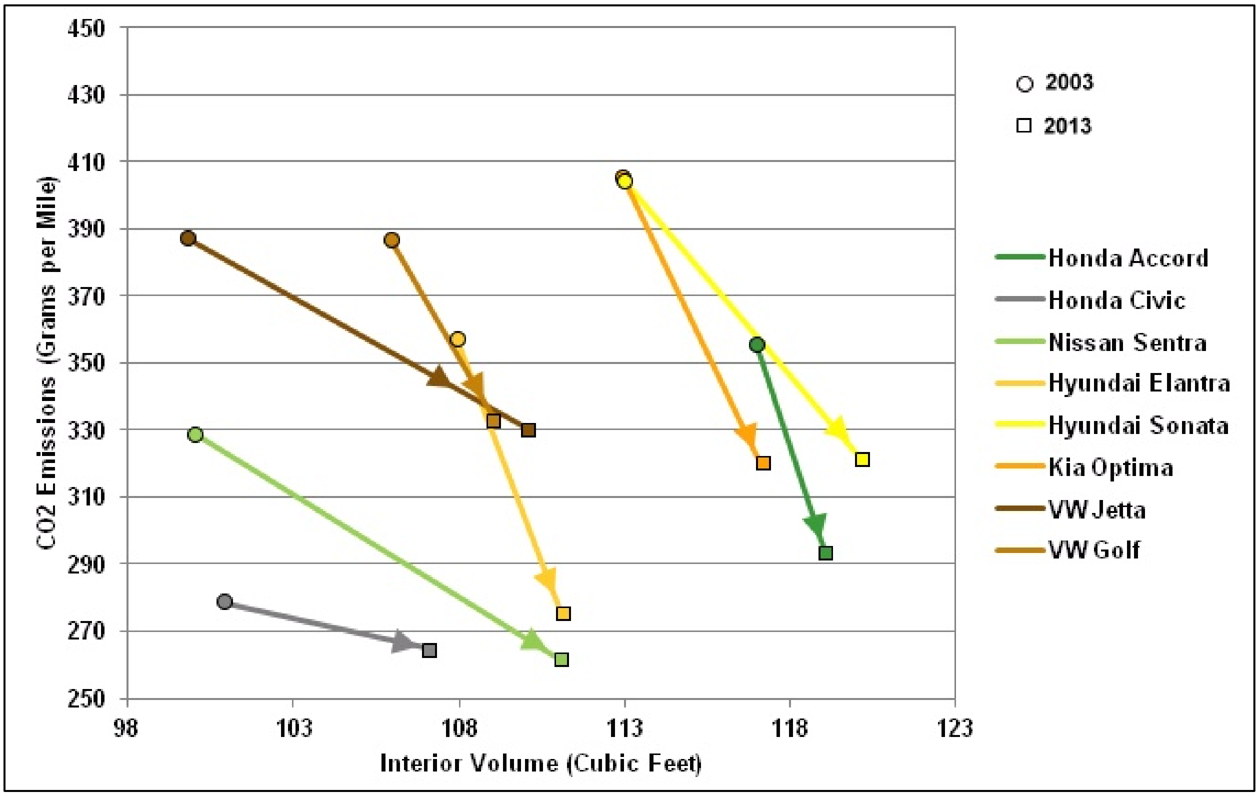


FIGURE 6. Carbon Dioxide Emissions Versus Interior Volume for Selected MY 2013 Cars

Source:

U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy website, January 2014. http://www.fueleconomy.gov/

Newer Cars and Light Trucks Emit Fewer Tons of CO_2 Annually

The carbon footprint measures a vehicle's impact on climate change in tons of carbon dioxide (CO_2) emitted annually. In model year (MY) 2013 the sales-weighted average of CO_2 emitted by cars was 6.8 tons annually per car. For light trucks, the average was 9.5 tons annually per truck.

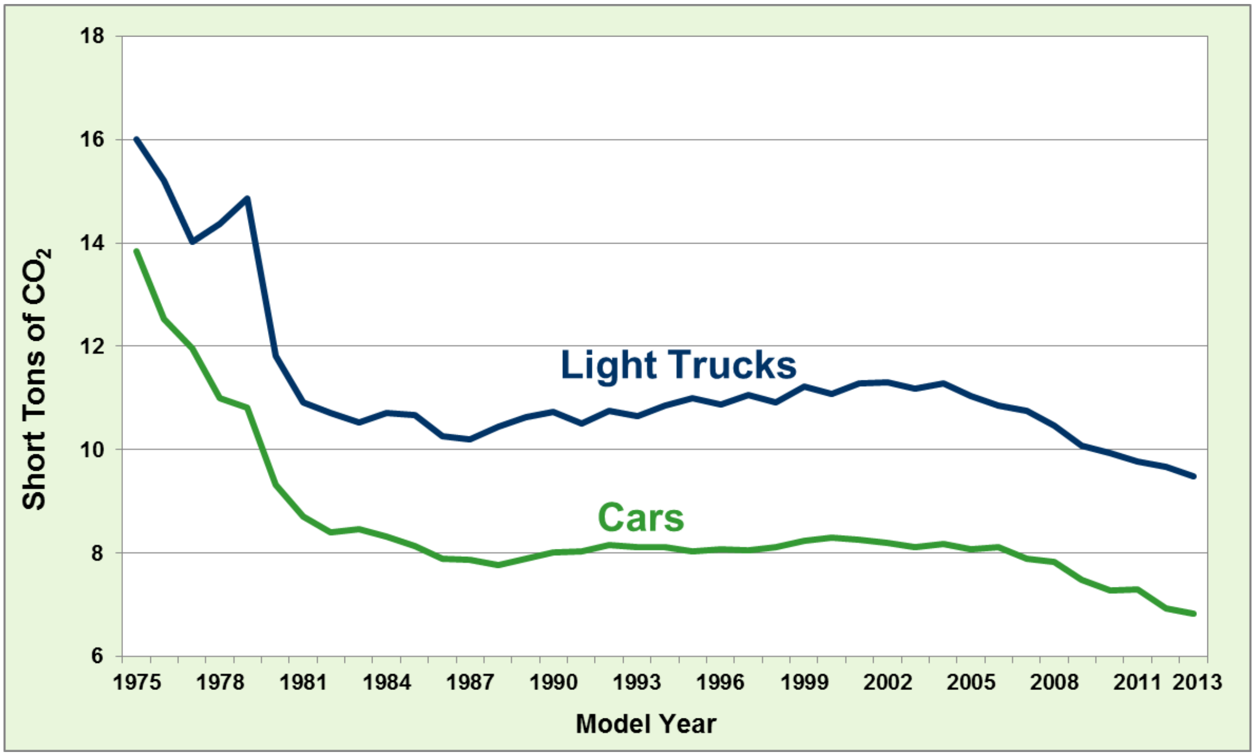


FIGURE 7. Average Carbon Footprint for Cars and Light Trucks Sold, 1975-2013

Note: Light trucks include pickups, vans, and 4-wheel drive sport utility vehicles.
Carbon footprint is calculated using results from Argonne National Laboratory's GREET model.

Carbon footprint =

$$\left(CO_2 \times LHV \times \frac{AnnualMiles}{CombinedMPG}\right) + \left(CH_4 + N_2O\right) \times AnnualMiles$$

CO_2 = (Tailpipe
CO_2 + Upstream Greenhouse Gases) in grams per million Btu
LHV = Lower (or net) Heating Value in million Btu per gallon
CH_4 = Tailpipe CO_2 equivalent methane in grams per mile
N_2O = Tailpipe CO_2 equivalent nitrous oxide in grams per mile

Source:
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Total Transportation Pollutants Decline

Due to improvements in fuels and vehicle technologies, the total amount of pollutants emitted from the transportation sector has declined. Since 2002 transportation sector emissions declined for each of the criteria pollutants tracked by the Environmental Protection Agency despite the increased number of highway and nonhighway vehicles and their miles of travel. From 2002 to 2013, carbon monoxide (CO) emissions declined by 47%; volatile organic compound (VOC) emissions declined by 41%; particulate matter emissions less than 10 microns (PM-10) declined 39%; and nitrogen oxide (NOx) emissions declined by 49%.

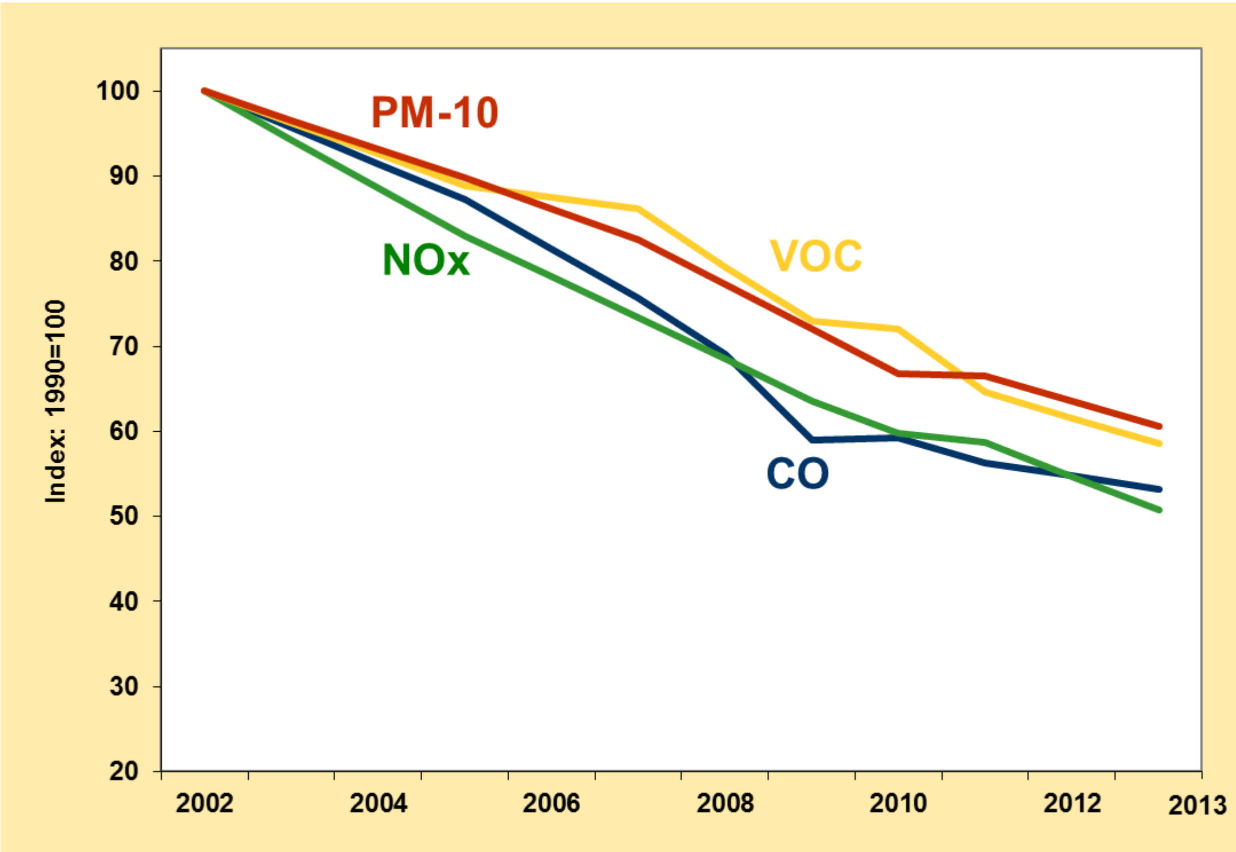


FIGURE 8. Total Transportation Pollutant Emissions, 2002-2013

Note: Includes highway, air, water, rail, and other nonroad vehicles and equipment.

Source:
U.S. Environmental Protection Agency, National Emissions Inventory Air Pollutant Emissions Trends Data. http://www.epa.gov/ttn/chief/trends/index.html

Highway Vehicles Responsible for Declining Share of Pollutants

Over 50% of carbon monoxide (CO) emissions from the transportation sector in 2002 were from highway vehicles; by 2013 that fell to 34%. The share of transportation's nitrogen oxide (NOx) emissions from highway vehicles experienced a decline from 43% in 2002 to 39% in 2013. The highway share of volatile organic compound (VOC) emissions declined by 7% during this same period.

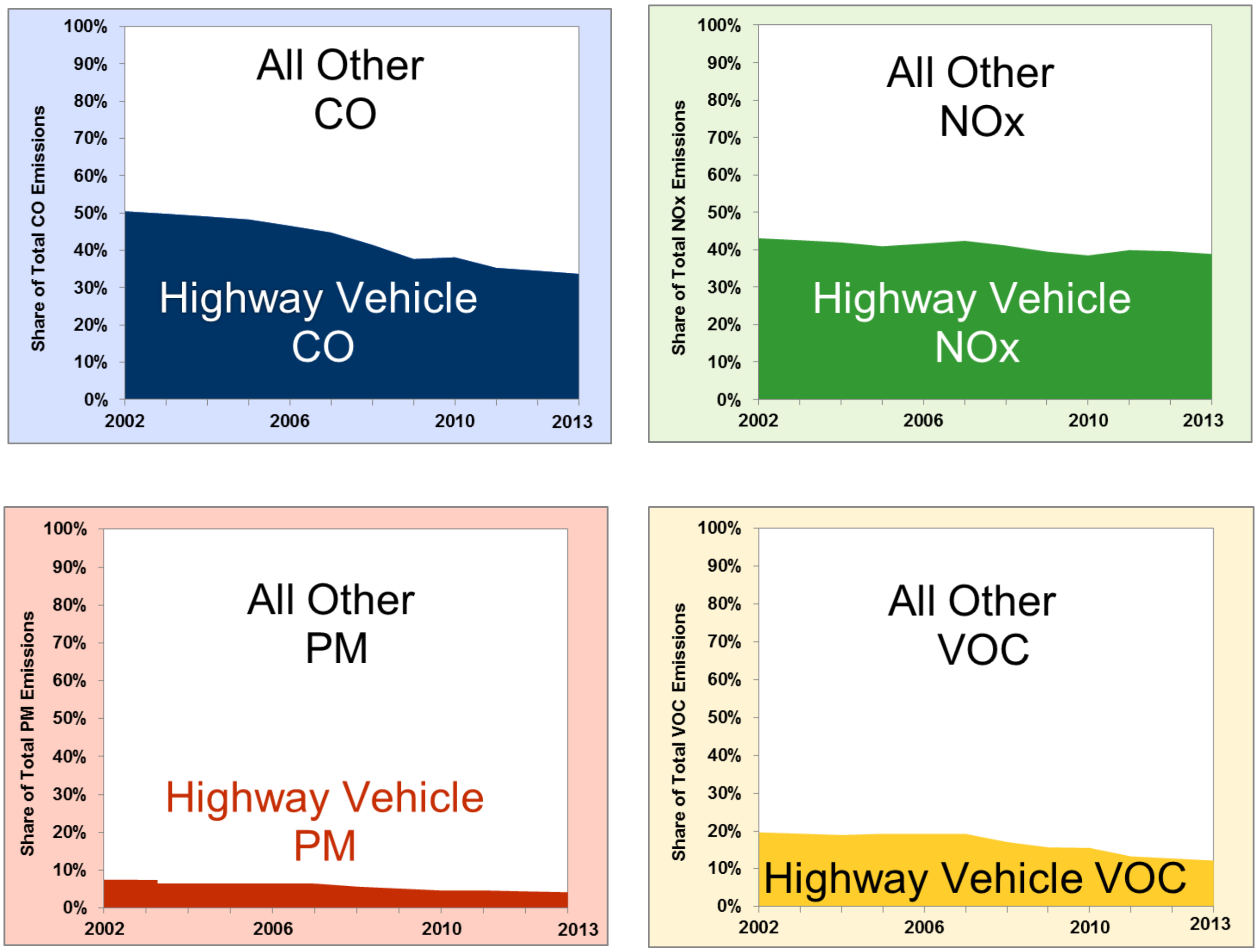


FIGURE 9. Highway and Nonhighway Share of Transportation Pollutant Emissions, 2002-2013

Source:

U.S. Environmental Protection Agency, National Emissions Inventory Air Pollutant Emissions Trends Data. http://www.epa.gov/ttn/chief/trends/index.html

Highway Transportation is More Efficient

The number of miles driven on our nation's highways has generally been growing during the past three decades, and energy use has grown with it. However, due to advances in engines, materials, and other vehicle technologies, the amount of fuel used per mile has declined from 1970. The gallons per mile declined by 27% from 1970-1990. However, the gallons per mile changed little from the early 1990's to 2012.

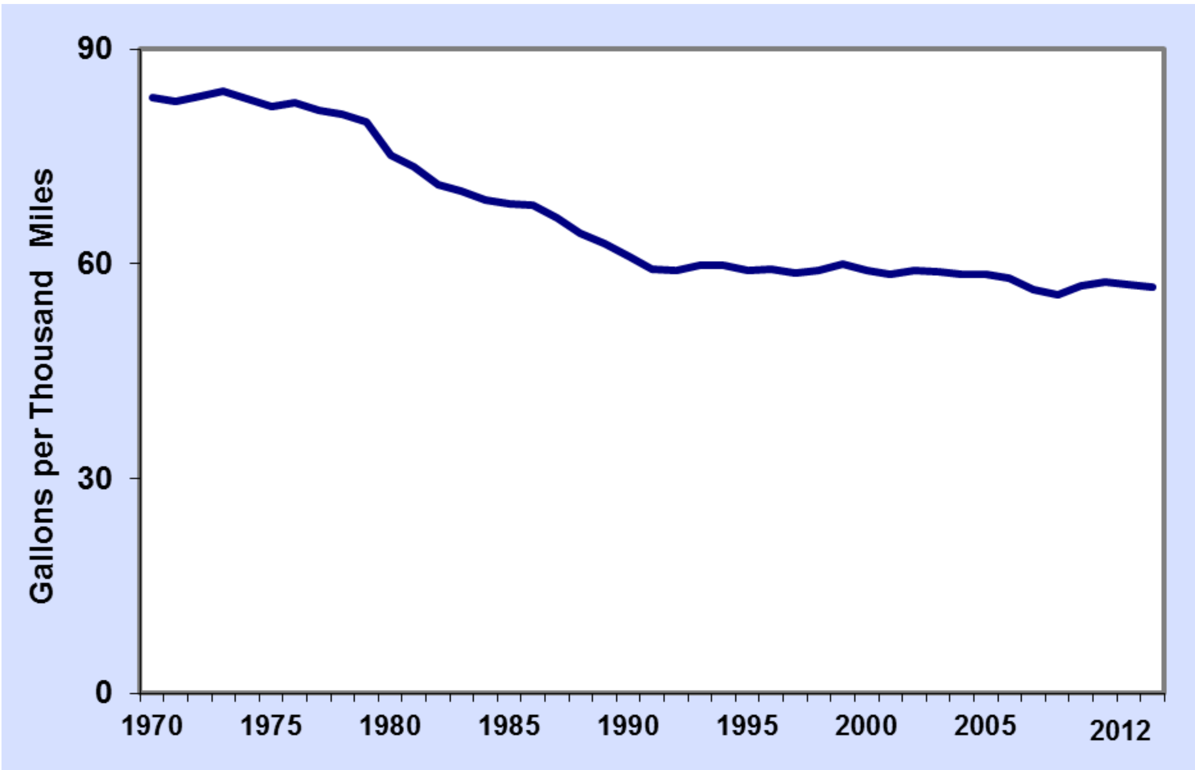


FIGURE 10. Fuel Use per Thousand Miles on the Highways, 1970-2012

Note: Includes travel by cars, light trucks, heavy trucks, buses and motorcycles.

Sources:
Federal Highway Administration, *Highway Statistics 2012*, Table VM-1 and previous annual editions.
http://www.fhwa.dot.gov/policyinformation/statistics/2012

Vehicle Miles Are Increasingly Disconnected from the Economy

From 1960 to 1998, the growth in vehicle-miles of travel (VMT) closely followed the growth in the U.S. Gross Domestic Product (GDP). Since 1998, however, the growth in VMT has slowed and not kept up with the growth in GDP. Though the distance between the two series has widened in recent years, they continue to follow the same trend showing that there continues to be a relationship between the U.S. economy and the transportation sector.

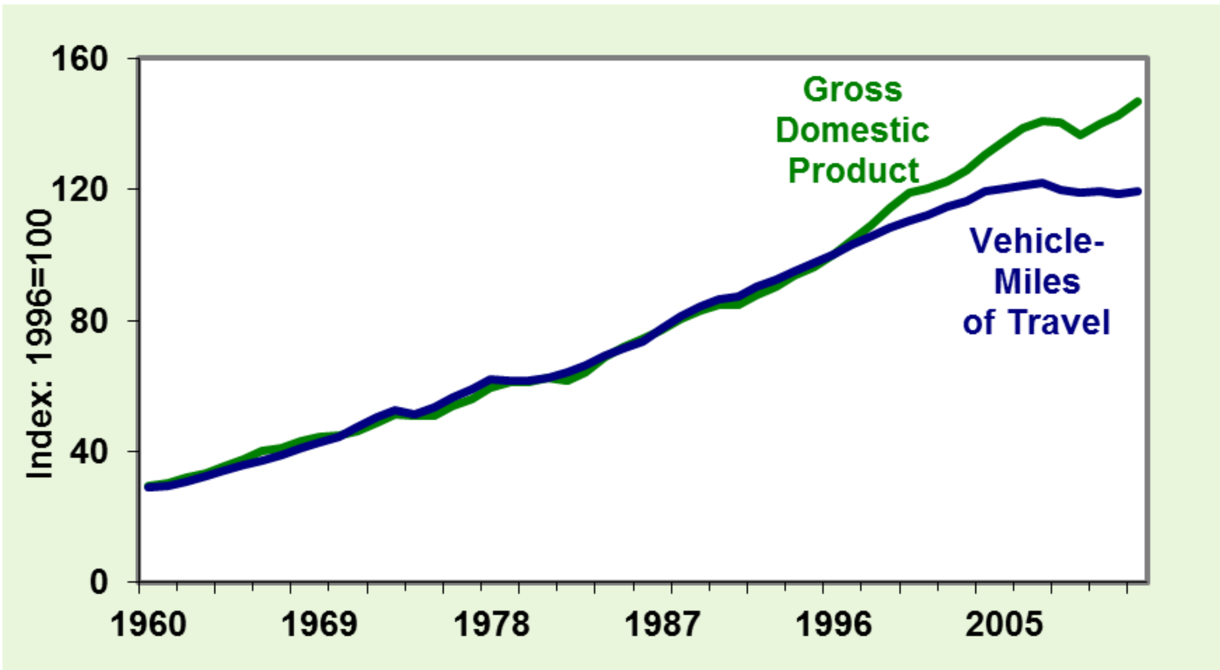


FIGURE 11. Relationship of VMT and GDP, 1960-2012

Sources:

Bureau of Economic Analysis, "Current Dollar and Real Gross Domestic Product."
http://www.bea.gov/national/xls/gdplev.xls

Federal Highway Administration, *Highway Statistics 2012*, Table VM-1 and previous annual editions.
http://www.fhwa.dot.gov/policyinformation/statistics/2012

Price of Crude Oil Is Affected by World Political and Economic Events

Crude oil prices have been extremely volatile over the past few decades. World events can disrupt the flow of oil to the market or cause uncertainty about future supply or demand for oil, leading to volatility in prices. Supply disruptions caused by political events, such as the Arab Oil Embargo of 1973-74, the Iranian revolution in the late 1970's, and the Persian Gulf War in 1990, were accompanied by major oil price shocks. Recently, a conflict in Syria caused uncertainty in the oil markets and the price of oil has been affected.

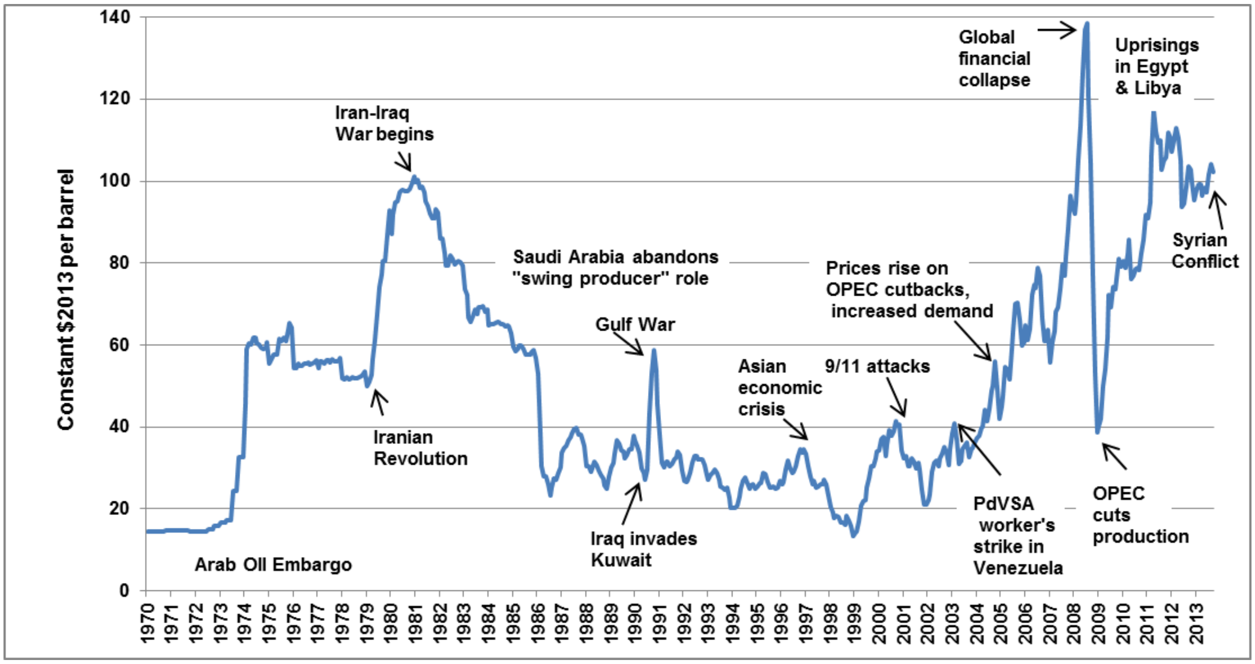


FIGURE 12. World Crude Oil Price and Associated Events, 1970-2013

Note: Refiner acquisition cost of imported crude oil.

Sources:

Energy Information Administration, "What Drives Crude Oil Prices?" November 2013. http://www.eia.gov/finance/markets/spot_prices.cfm

Pew Center on Global Climate Change, *Reducing Greenhouse Gas Emissions from U.S. Transportation*, January 2011.

Oil Price Shocks Are Often Followed by an Economic Recession

Major oil price shocks have disrupted world energy markets five times in the past 30 years (1973-74, 1979-80, 1990-91, 1999-2000, and 2008). Most of the oil price shocks were followed by an economic recession in the United States.

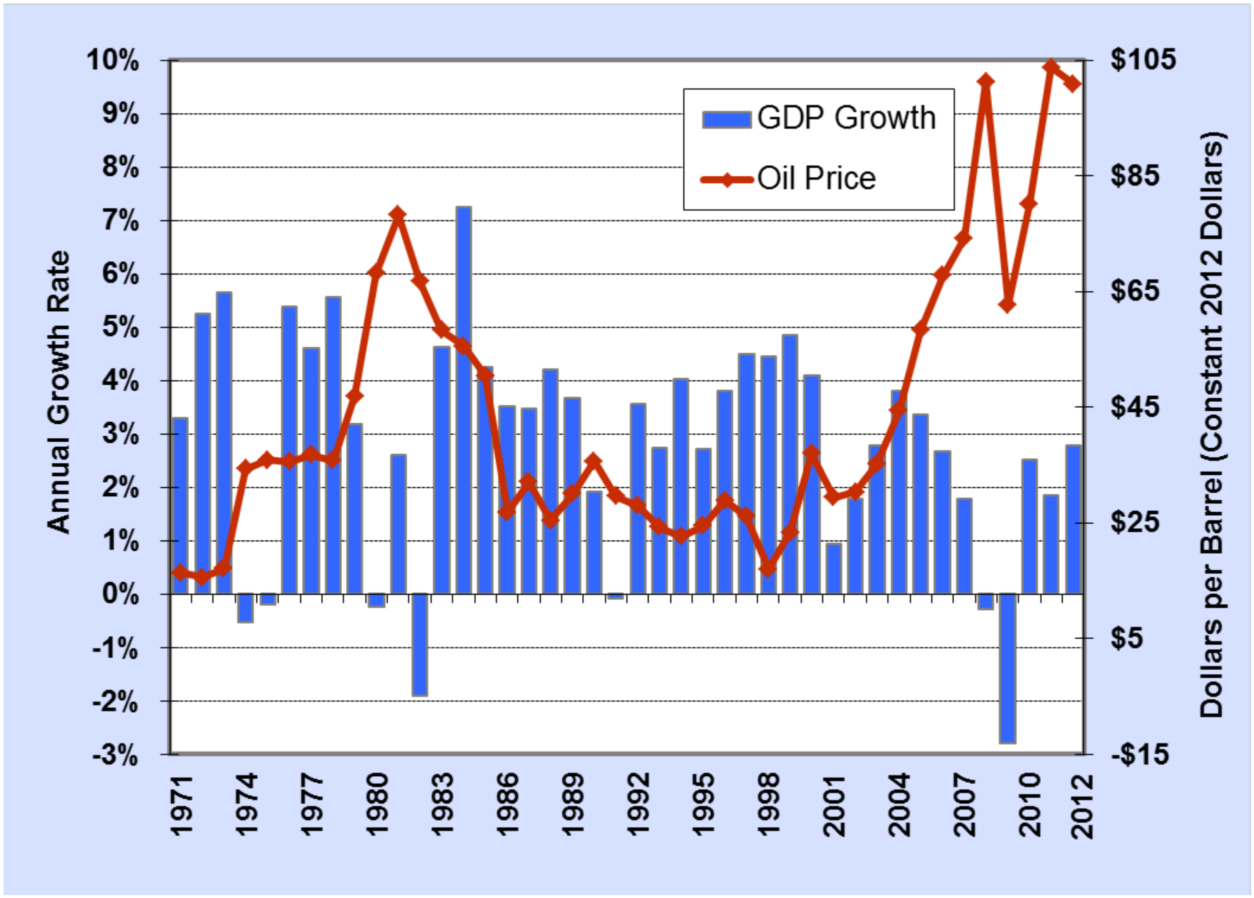


FIGURE 13. The Price of Crude Oil and Economic Growth, 1971-2012

Note: GDP = gross domestic product.

Source:

Greene, D.L. and N. I. Tishchishyna, *Costs of Oil Dependence: A 2000 Update*, Oak Ridge National Laboratory, ORNL/TM-2000/152, Oak Ridge, TN, 2000, and data updates, 2013. http://cta.ornl.gov/data

ORNL Estimates that 2012 Direct and Indirect Oil Dependence Costs $500 Billion

The United States has long recognized the problem of oil dependence and the economic problems that arise from it. Greene et al. define oil dependence as a combination of four factors: (1) a noncompetitive world oil market strongly influenced by the Organization of the Petroleum Exporting Countries (OPEC) cartel, (2) high levels of U.S. imports, (3) the importance of oil to the U.S. economy, and (4) the lack of economical and readily available substitutes for oil. The most recent study shows that the U.S. economy suffered the greatest losses in 2008 when wealth transfer and gross domestic product (GDP) losses (combined) amounted to over half a trillion dollars. However, when comparing oil dependence to the size of the economy, the year 1980 is the highest. Oil dependence costs were almost 5.0% of GDP in 1980, but were 3.6% in 2008. In 2009, the average oil price fell to about $60 per barrel and oil dependence costs fell to about $300 billion for 2009 and 2010. However, the cost rose again in 2011 and 2012.

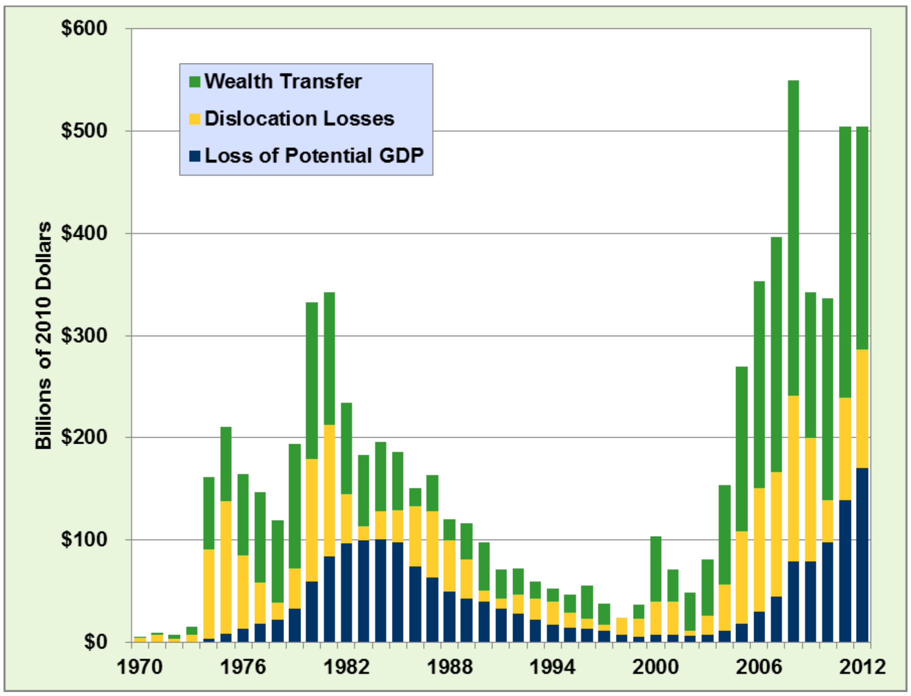


FIGURE 14. Costs of Oil Dependence to the U.S. Economy, 1970-2012

Notes: ***Wealth Transfer*** is the product of total U.S. oil imports and the difference between the actual market price of oil (influenced by market power) and what the price would have been in a competitive market. ***Dislocation Losses*** are temporary reductions in GDP as a result of oil price shocks. ***Loss of Potential GDP*** results because a basic resource used by the economy to produce output has become more expensive. As a consequence, with the same endowment of labor, capital, and other resources, our economy cannot produce quite as much as it could have at a lower oil price.

Source:

Greene, David L., Roderick Lee, and Janet L. Hopson, "OPEC and the Costs to the U.S. Economy of Oil Dependence: 1970-2010," Oak Ridge National Laboratory Memorandum, 2011, and updates.

Changes in Energy Prices and Vehicle-Miles of Travel Mirror Each Other

The prices of gasoline and diesel fuel affect the transportation sector in many ways. For example, fuel prices can impact the number of miles driven and affect the choices consumers make when purchasing vehicles. The graph below shows a three-month moving average of the percentage change of monthly data from one year to the next (i.e., February 2001 data were compared with February 2000 data). The vehicle travel often mirrors the price of gasoline – when the price of gasoline rises, the vehicle travel declines and when the price of gasoline declines, the vehicle travel rises. Still, the price of gasoline is just one of the many factors influencing vehicle travel.

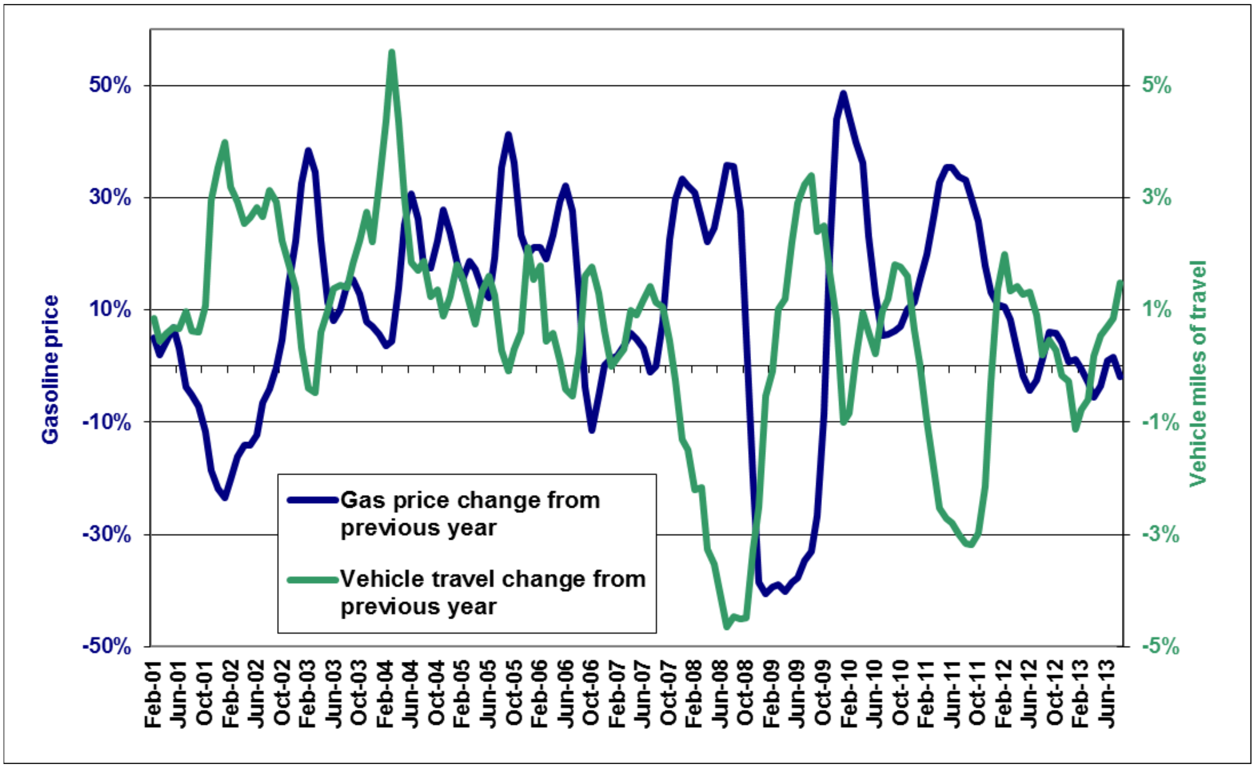


FIGURE 15. Relationship of Vehicle-Miles of Travel and the Price of Gasoline, 2001-2013

Sources:

Federal Highway Administration, *September 2013 Traffic Volume Trends,* and previous monthly editions. http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Energy Information Administration, *Monthly Energy Review, November 2013*, Table 9.4. http://www.eia.gov/totalenergy/data/monthly

The Average Price of a New Car Is Just over $25,000

The average price of a car in 2012 was $25,517, about the same as the 2011 average (constant 2012 dollars). That price is down, however, from a high of $28,684 in 1998, mainly driven by the high price of import cars. The price of imports peaked in 1998 at $41,713. Until 1981, domestic cars were more expensive than imports.

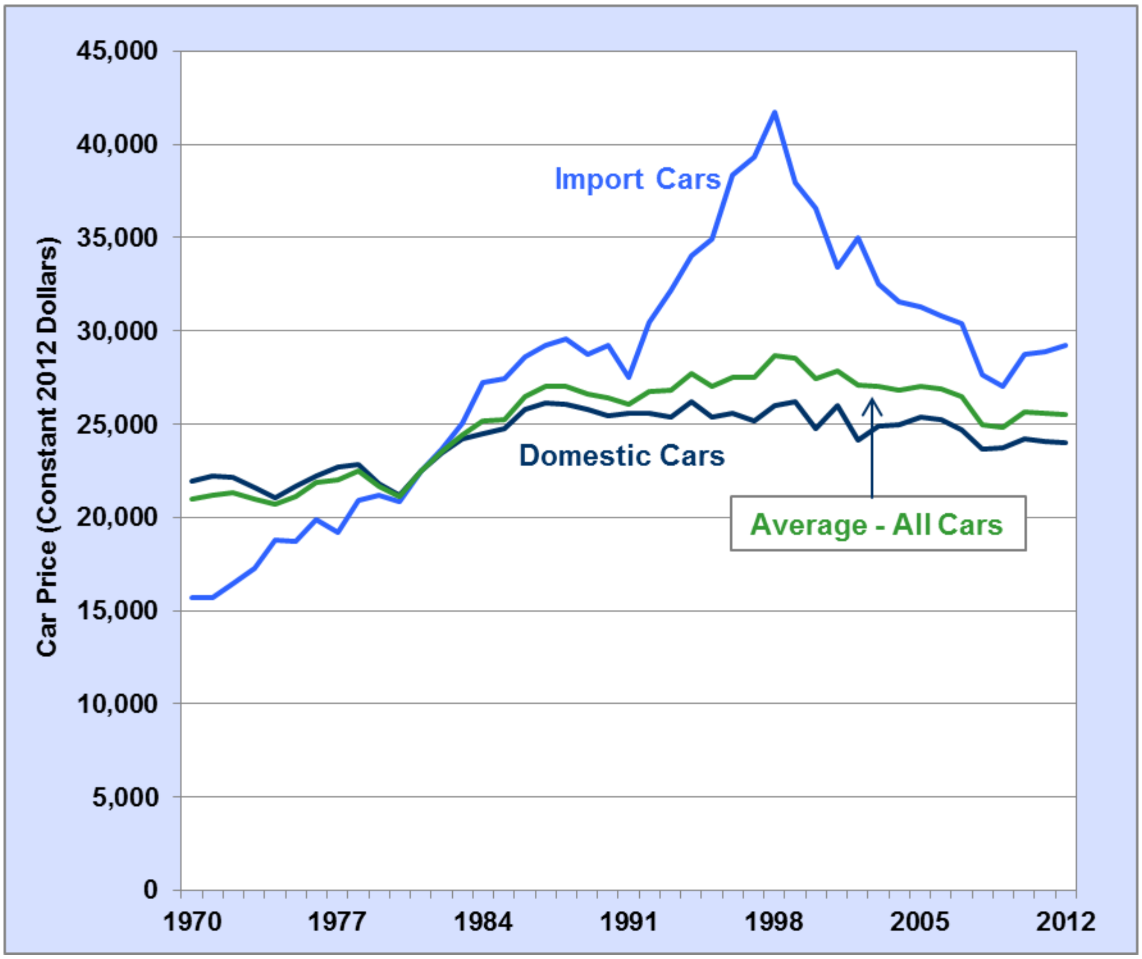


FIGURE 16. Average Price of a New Car, 1970-2012

Note: Data exclude light trucks.

Source:

U.S. Department of Commerce, Bureau of Economic Analysis, *National Income and Product Accounts*, underlying detail estimates for Motor Vehicle Output, Washington, DC 2013.

Twenty-Nine Percent of Survey Respondents Consider Fuel Economy Most Important When Purchasing a Vehicle

A 2012 survey of the general population asked the question "Which one of the following attributes would be MOST important to you in your choice of your next vehicle?" The choices were fuel economy, dependability, low price, quality, and safety. This same question was asked in previous surveys and the results are compared in the graph below. Dependability was chosen most often in nearly every survey, but fuel economy surpassed it in 2011 and 2012. Twenty-nine percent of the survey respondents indicated that fuel economy would be the most important vehicle attribute, while only 25% of respondents chose dependability.

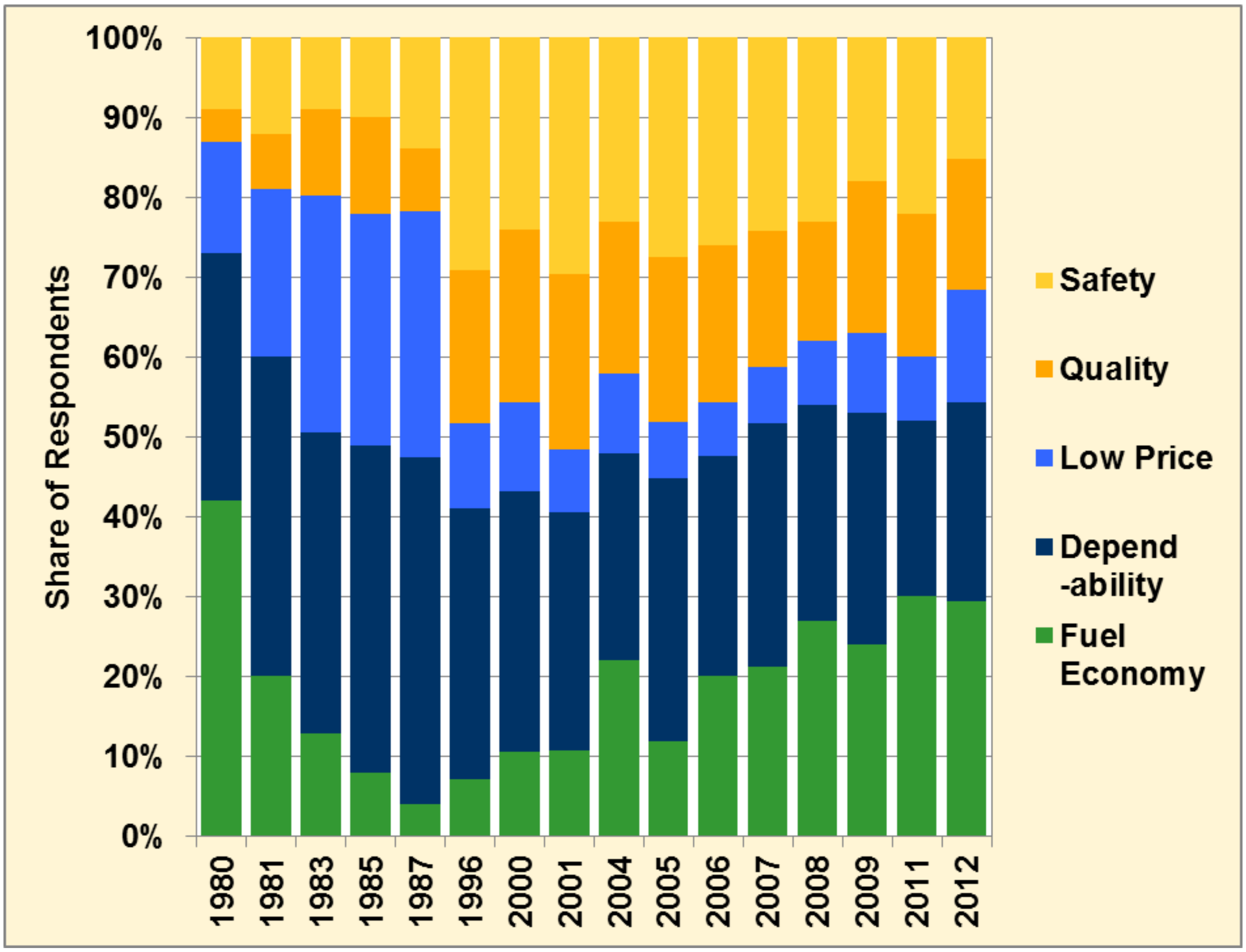


FIGURE 17. Most Important Vehicle Attribute, 1980-2012

Sources:

1980-87: J. D. Power (based on new car buyers). 1998-2012: Opinion Research Corporation International for the National Renewable Energy Laboratory (Sample size ≈ 1,000 in the general population).

Internet Is Most Influential When Purchasing Vehicle

Autotrader.com and R. L. Polk and Company conducted a study of recent car buyers to find out which media influenced their vehicle purchases. About 4,000 U.S. consumers who had purchased a new or used vehicle from a dealership within the previous six months were asked*: Which media, if any, led you to the dealer you purchased from?* More than half of the respondents answered that the Internet led them to their final purchase site. The study also determined that researching vehicle price and comparing models were most often the reasons that the Internet was used.

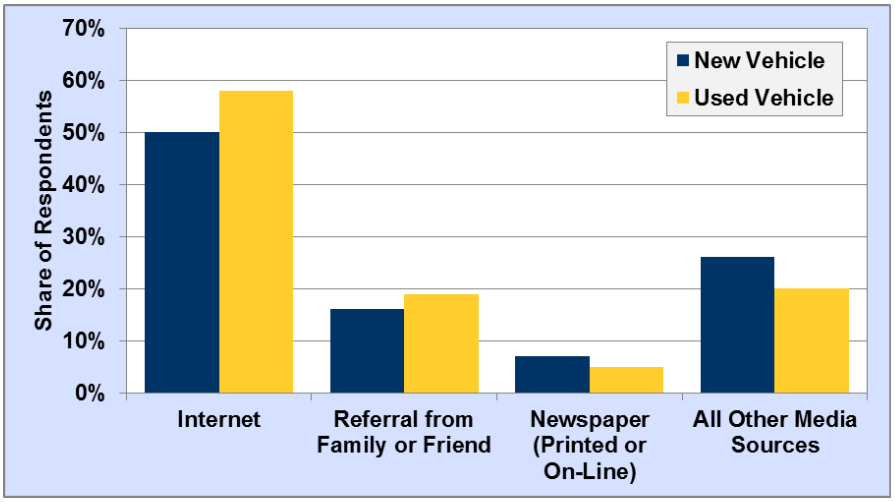


FIGURE 18. Media Which Led a Consumer to the Vehicle Dealer, 2011

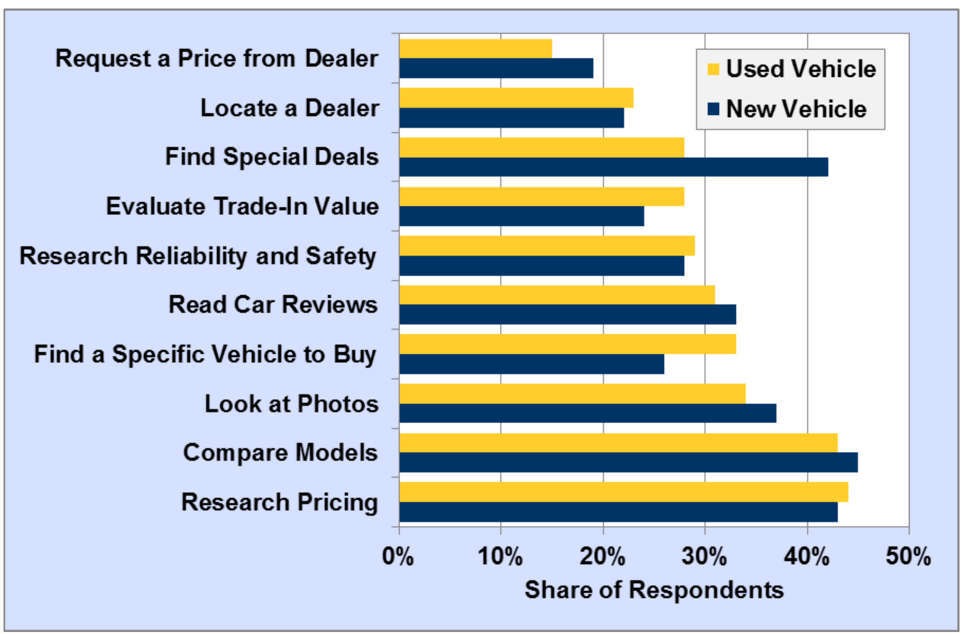


FIGURE 19. Reasons for Using the Internet While Shopping for a Vehicle, 2011

Source:

R. L. Polk and Company, *Polk View*, "The Role of the Internet in the New and Used Vehicle Purchase Process," February 2011. https://www.polk.com/knowledge/polk_views

Almost 18% of Household Expenditures Are for Transportation

Except for housing, transportation was the largest single expenditure for the average American household in 2012. Of the transportation expenditures, vehicle purchases and gas and oil were the largest expenditures. In 1984, transportation was closer to 20% of all household expenditures and the share has generally fluctuated between 16% and 20% over time. In 2009, however, the transportation share reached a low of 15.6%.

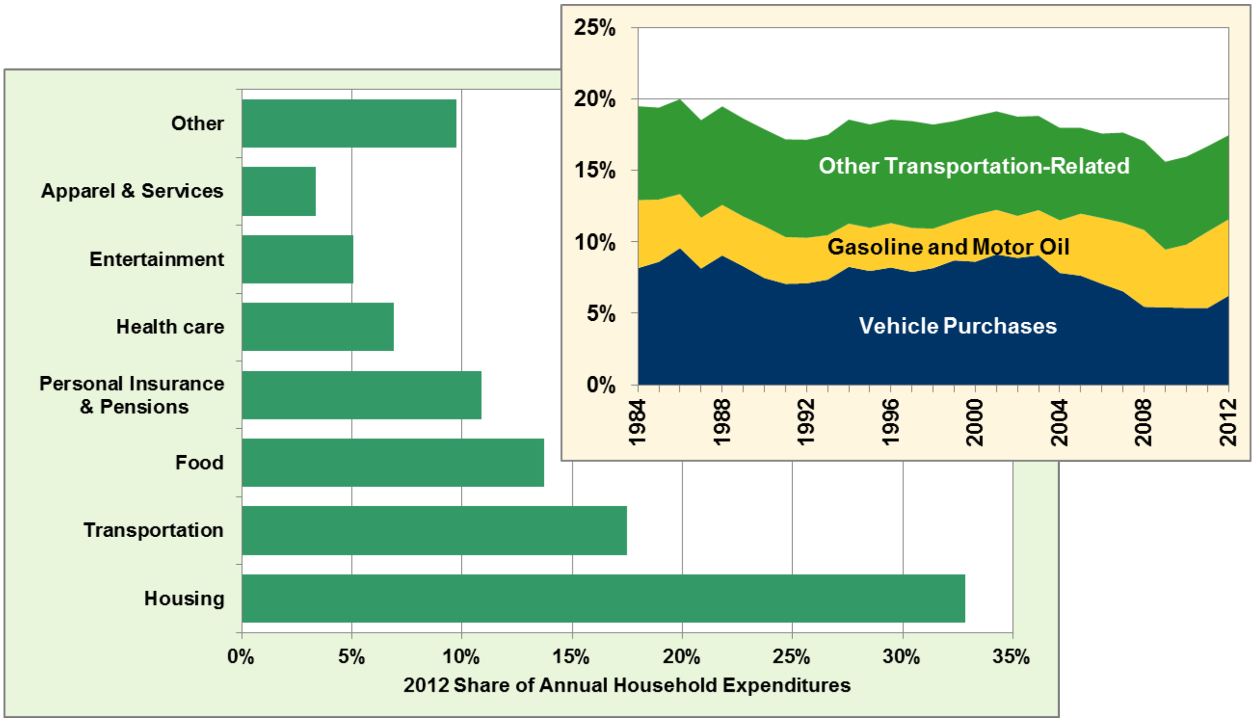


FIGURE 20. Share of Household Expenditures by Category, 2012, and Transportation Share of Household Expenditures, 1984-2012

Sources:

U.S. Department of Labor, *Consumer Expenditure Survey 2012*, Table 1202, Washington, DC, 2013, and multiyear survey tables. http://www.bls.gov/cex/

Over 9 Million People Are Employed in the Transportation Industry

The transportation industry employs a wide variety of people in many different fields. From the manufacture of vehicles and parts to travel reservation services, 9.8 million people are employed in transportation-related jobs. These transportation-related jobs account for 7.3% of the total non-farm employment. Retail sales of motor vehicles and parts, which include dealerships, retail parts stores, and more, accounts for the most employees. Truck transportation, which includes truck drivers, is the category with the second highest number of employees.

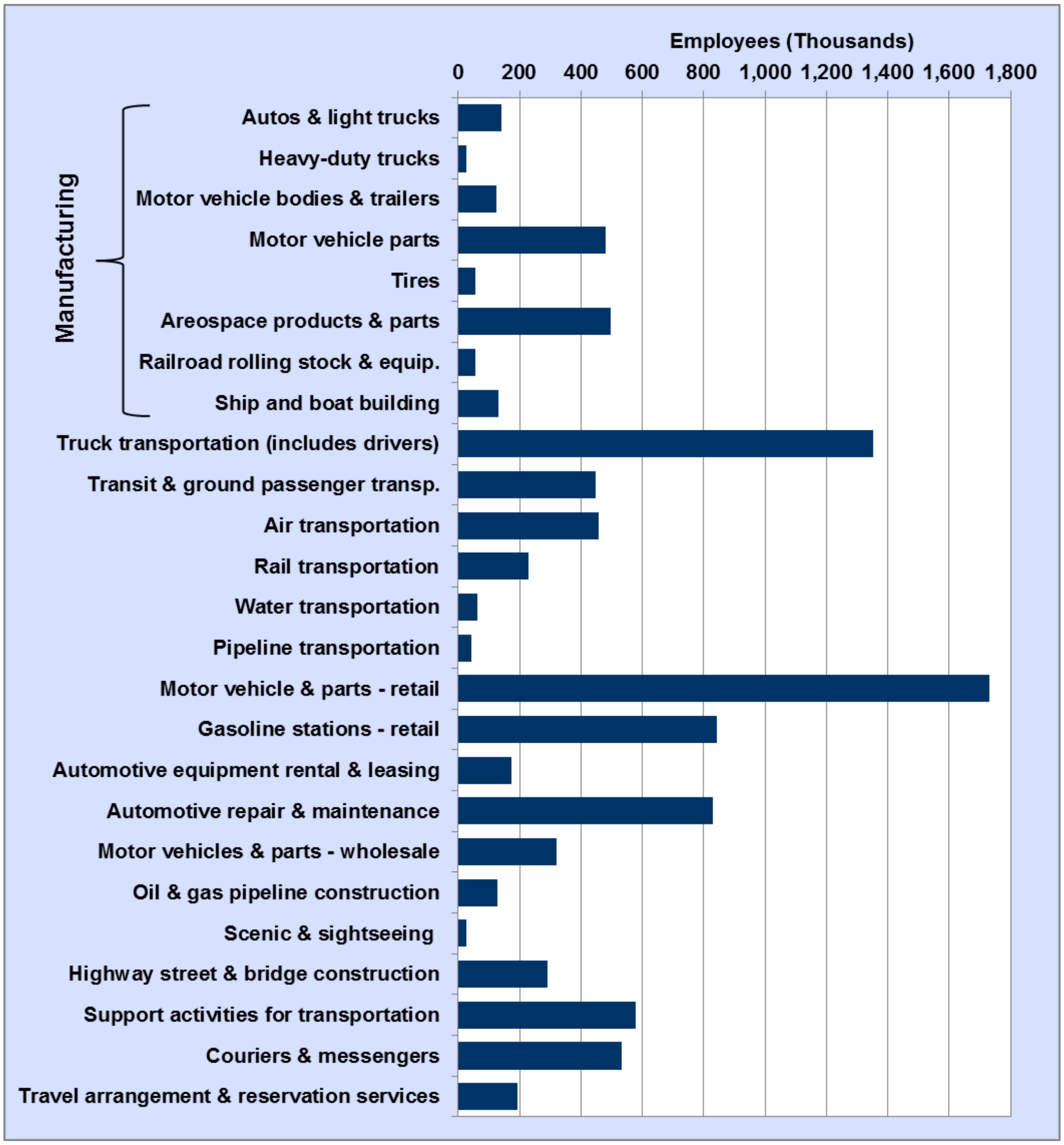
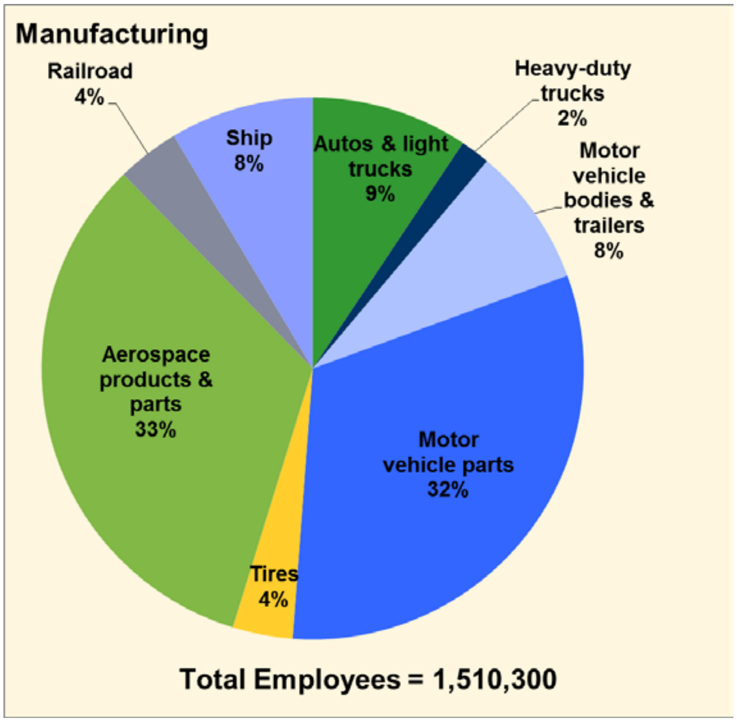


FIGURE 21. Transportation-Related Employment, 2012

Source:
Bureau of Labor Statistics, website Query System. http://www.bls.gov/data/

Americans Employed in Transportation have Diverse Jobs—From Aerospace Manufacturing to Trucking



The manufacture of vehicles and parts (left) employs over a million people. The highway mode – vehicles, parts, and tires – accounts for just over half of all transportation manufacturing employees; aerospace products (e.g., airplanes) and their parts account for another third.

When looking at jobs related to the movement of people and goods (right), the trucking industry is responsible for more than half of the 2.6 million employees. Transit and ground transportation, which includes bus drivers and other transit and ground transportation employees, makes up 17% of the total. Air transportation, which includes everything from pilots to airport workers, makes up 18% of the total.

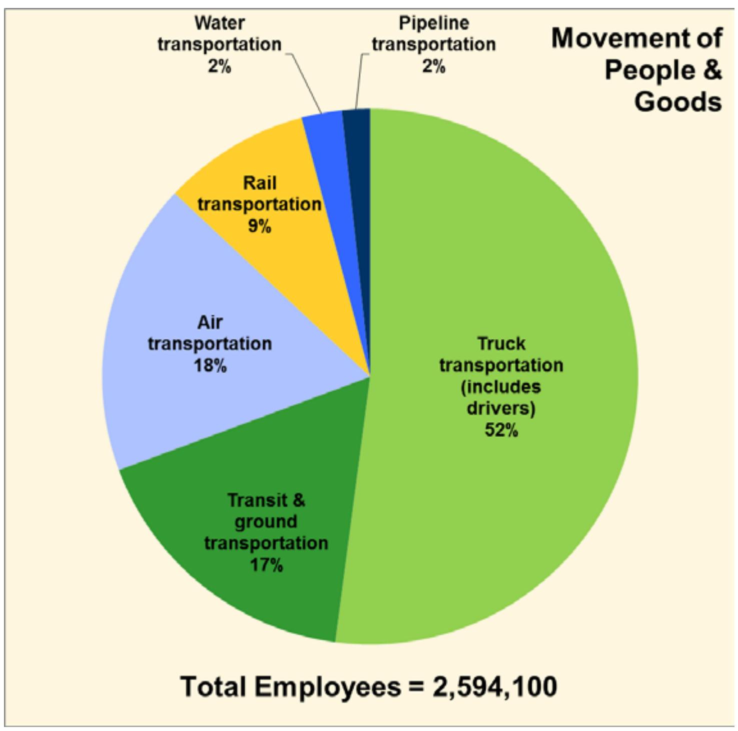


FIGURE 22. Transportation Manufacturing-Related and Mode-Related Employment, 2012

Source:
Bureau of Labor Statistics, website Query System. http://www.bls.gov/ces/cesnaics.htm

Manufacturers' Stock Prices Have Their Ups and Downs

Weekly stock prices are shown on the graph below. Nearly all of the manufacturers show a sharp decline in late 2008 as a result of the economic recession. Most manufacturers have now recovered to near 2006-prices. Volkswagen (VW) stock experienced a "wild ride" of ups and downs in late October 2008 due to Porsche's increased holdings in VW. Tesla's stock remained consistently under $40 per share until 2013 when it skyrocketed to $193 per share. Chrysler stock is not currently traded and historical prices are not shown due to company changes from Daimler-Chrysler to Chrysler to Fiat-Chrysler. General Motors (GM) is shown twice – once before bankruptcy (GM-Old) and after the initial public stock offering in late 2010 (GM-New).

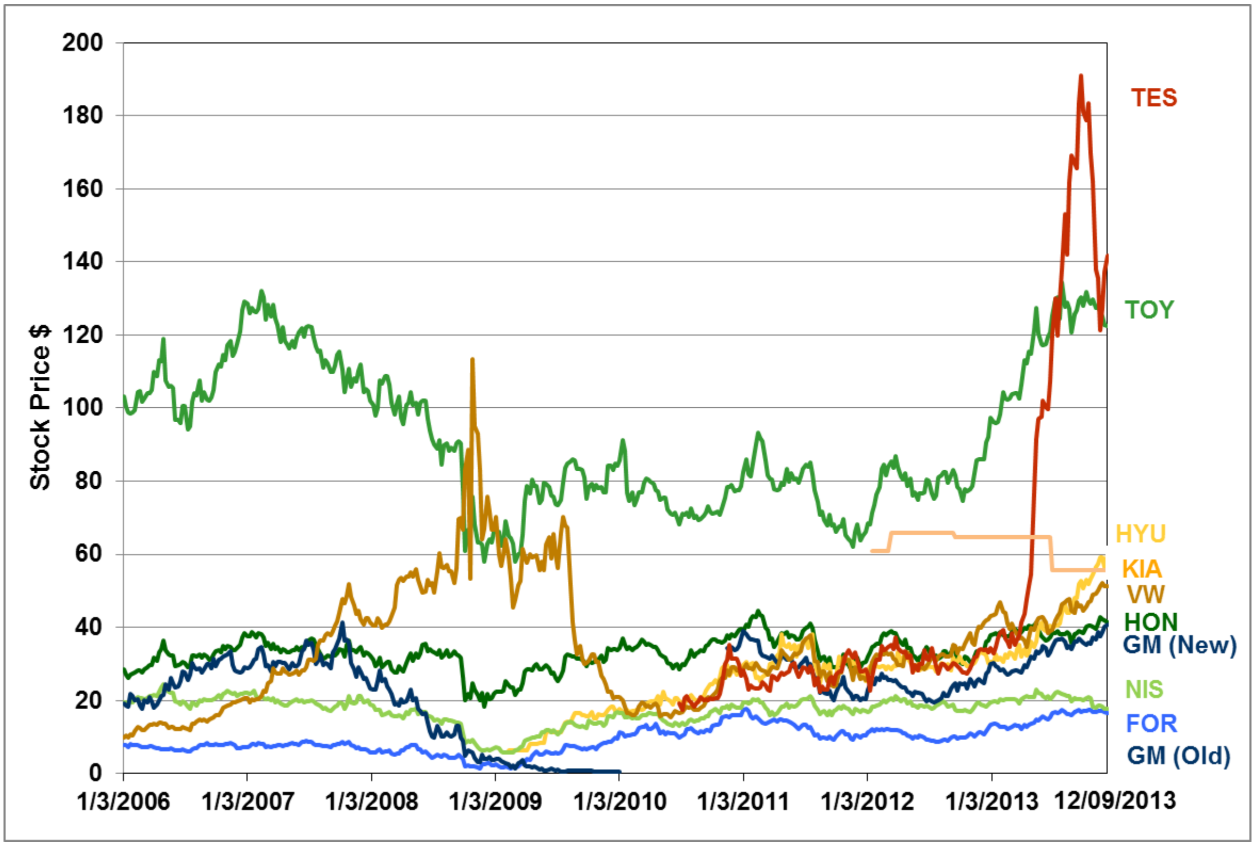


FIGURE 23. Stock Price by Manufacturer, 2006-2013

Source:
Yahoo Finance. http://www.yahoofinance.com

American Full-Size Pickups Top the Most Profitable Vehicles List

Max Warburton and others at Bernstein Research in London have developed estimates for the vehicles which have made the most money for their companies from the 1990's to today. They discovered three categories of vehicles that topped the list: American full-size pickups; German luxury cars; and Japanese mid-size sedans. These vehicles combined high prices, large sales volume and long production periods that spread development costs over a long period.

TABLE 1. List of Twelve Most Profitable Vehicles Since the 1990's

Rank	Vehicle Model
1	Ford F-Series
2	GM Full-Size Pickups
3	Dodge Ram
4	Mercedes S Class
5	BMW 5 Series/X5
6	BMW 3 Series
7	Mercedes E Class
8	Lexus RX SUV
9	Jeep Grand Cherokee
10	Honda Accord
11	Porsche 911
12	Toyota Camry

Source:

Crain Communications, *Automotive News,* "Cash cows: The most profitable vehicles ever," November 21, 2011. http://www.autonews.com/apps/pbcs.dll/article?AID=/20111121/RETAIL07/311219969/1254

Hybrid Vehicles Can Save Money over Time

The following table shows a selection of hybrid vehicles paired with a comparably equipped non-hybrid vehicle from the same manufacturer. Price difference is derived from manufacturers' comparably equipped manufacturer's suggested retail price (MSRP) as shown in the manufacturers' online comparison tools. Annual fuel savings and years to payback are based on 15,000 annual miles, a mix of 55% city and 45% highway driving, and a national average fuel price of $4.00 per gallon for regular and premium gasoline.

TABLE 2. Selected 2013 and 2014 Model Year Hybrid Vehicles Paired with a Comparably Equipped Non-Hybrid Vehicle

Model Year	Make & Model	EPA Combined MPG	Price Difference	Annual Fuel Cost Savings	Years to Payback
2014	Buick LaCrosse eAssist[1]	29	$0	$714	0
	Buick LaCrosse	21			
2014	Lincoln MKZ Hybrid[1]	45	$0	$959	0
	Lincoln MKZ FWD	26			
2013	Ford Fusion Hybrid Titanium	47	$1,900	$1,010	1.9
	Ford Fusion Titanium FWD	26			
2014	Toyota Avalon Hybrid Limited	40	$1,750	$910	1.9
	Toyota Avalon Limited	25			
2013	Cadillac Escalade Hybrid 4WD	21	$2,175	$1,113	2
	Cadillac Escalade AWD	15			
2014	Lexus ES 300h	40	$2,561	$949	2.7
	Lexus ES 350	24			
2013	Hyundai Sonata Hybrid Limited	38	$1,805	$576	3.1
	Hyundai Sonata Limited	28			
2013	Toyota Highlander Hybrid 4WD	28	$3,145	$1,013	3.1
	Toyota Highlander 4WD	19			
2014	Acura ILX Hybrid[2]	38	$2,000	$598	3.3
	Acura ILX	28			
2013	Honda Civic Hybrid w/ Nav	44	$1,795	$517	3.5
	Honda Civic w/Nav	32			
2013	Kia Optima Hybrid	38	$2,510	$570	4.4
	Kia Optima	28			
2014	Honda Accord Hybrid	47	$3,475	$726	4.8
	Honda Accord	30			
2014	Toyota Camry Hybrid XLE	40	$2,815	$571	4.9
	Toyota Camry XLE	28			

The hybrid models shown have a payback period of 5 years or less based on the assumptions shown in the text box above. Hybrid models with no conventional counterpart are not considered and models available in multiple trim levels are shown only once. No two vehicles from the same manufacturer will be exactly comparable, however, every effort was made to match the vehicles as closely as possible in terms of amenities and utility. Ultimately, consumers will have to judge the vehicles' similarity for themselves.

[1]Hybrid models shown with an MSRP difference of $0 are available to consumers as a no cost option although, performance is not necessarily compatible.

[2]Uses premium gasoline.

Source:

U.S. Department of Energy and Environmental Protection Agency, *Fuel Economy Guide*. http://www.fueleconomy.gov - Data accessed February 11, 2014.

Chapter 2.

LIGHT VEHICLES

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Company Profile Section

Following are company profiles for nine different manufacturers.

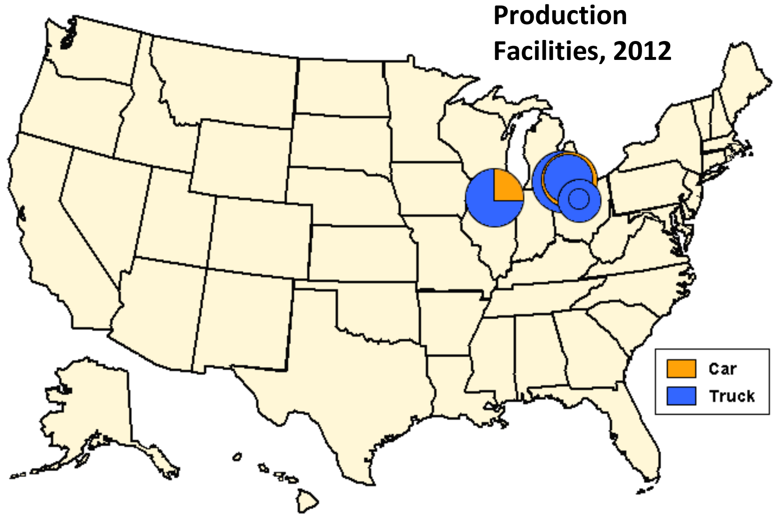
- The first page of each profile is an overview page containing the company's Corporate Average Fuel Economy, average vehicle footprint, number of alternative fuel models, production plant locations, production, and a brief summary of fuel saving technologies.
- The second page of each profile contains a figure showing an overview of the company's vehicle offerings in various market segments. A tabular listing of the vehicle models in each size class follows.
- The third page of each profile includes a figure of hybrid vehicle sales by model and year. Also included is a pie chart depicting the manufacturer's share of the 2013 hybrid vehicle market. Since the number of hybrid sales by manufacturer varies, use caution when comparing one manufacturer's chart to another as the scales may be different.
- The last page of each profile shows the interworking relationships that each manufacturer has with other manufacturers around the world.

The nine manufacturers for which we have profiles are:

- three from Detroit
    - Chrysler,
    - Ford, and
    - GM
- three from Japan
    - Honda,
    - Nissan, and
    - Toyota,
- two from Korea
    - Hyundai, and
    - Kia, and
- one from Germany
    - VW.

Chrysler Company Profile

Corporate Average Fuel Economy, MY 2013	
Domestic Cars	32.1 mpg
Import Cars	None
Light Trucks	24.5 mpg
Average Vehicle Footprint, MY 2013	
Cars	47.3 sq ft
Light trucks	52.2 sq ft
All	49.8 sq ft
Number of Alternative Fuel Models, MY 2013	
Flex Fuel	14
Natural Gas	0
Propane	0
Hybrid-Electric	0
Plug-In Hybrid-Electric	0
Electric	0



Chrysler Plants	Type	2012 Production
Detroit, MI - Jefferson North	Truck	275,003
Toledo, OH - North & South	Truck	291,403
Warren, MI	Car	227,453
Sterling Heights, MI	Truck	265,180
Belvidere, IL	Truck	202,099
Belvidere, IL	Car	69,645

FIGURE 24. Chrysler Company Profile

Fuel Saving Technologies

On January 21, 2014, Fiat North America completed the acquisition of the remaining 41.46% stake in Chrysler that it did not already own, making Chrysler a fully-owned subsidiary of Fiat S.p.A. With backing from Fiat, Chrysler is developing more diesel models to meet new CAFE regulations, particularly with large SUVs and trucks where diesel offers the benefit of greater towing and higher fuel economy than gasoline engines. A diesel option is available on the 2014 Jeep Grand Cherokee and a new Ram1500 EcoDiesel full size pickup will be available in 2014. Like other manufactures, Chrysler is increasing fuel economy throughout its line-up by downsizing engines and shifting away from 8-cylinder and 6-cylinder engines in favor of 4-cylinder engines. To meet consumer expectations for performance, Chrysler is also using turbocharging and direct injection to maximize engine output from their smaller engines while increasing efficiency. For the larger V8 engines, Chrysler is employing cylinder deactivation to provide 4-cylinder efficiency and V8 power when needed.

Chrysler developed an 8-speed transmission for 2012 that is now widely used throughout their line-up and a new 9-speed transmission is available on the 2014 Jeep Cherokee. Additionally, a 6-speed automatic double clutch transmission is available to consumers in the all-new 2013 Dodge Dart. This transmission is mechanically similar to a manual transmission but without the clutch pedal and it provides the option of automated shifts. The dual clutch system also eliminates the break in power between gear-shifts which improves efficiency and performance. In addition to engine and transmission technologies, Chrysler brought stop-start technologies to the 2013 Ram 1500 HFE models and is expanding use of active grill shutters to improve aerodynamics at highway speeds. Also, the all-electric Fiat 500e debuted in select markets in 2013.

Chrysler's Market Leans Towards Pickups, Vans, and SUVs

Chrysler's vehicle offerings and sales lean heavily toward trucks which tend to have lower fuel economy than cars. The Ram pickup is their largest seller with an EPA-combined fuel economy below 20 MPG. Though Chrysler has some models that average above 30 MPG (shown in dark yellow) they sell in relatively low volume compared to most of their other models.

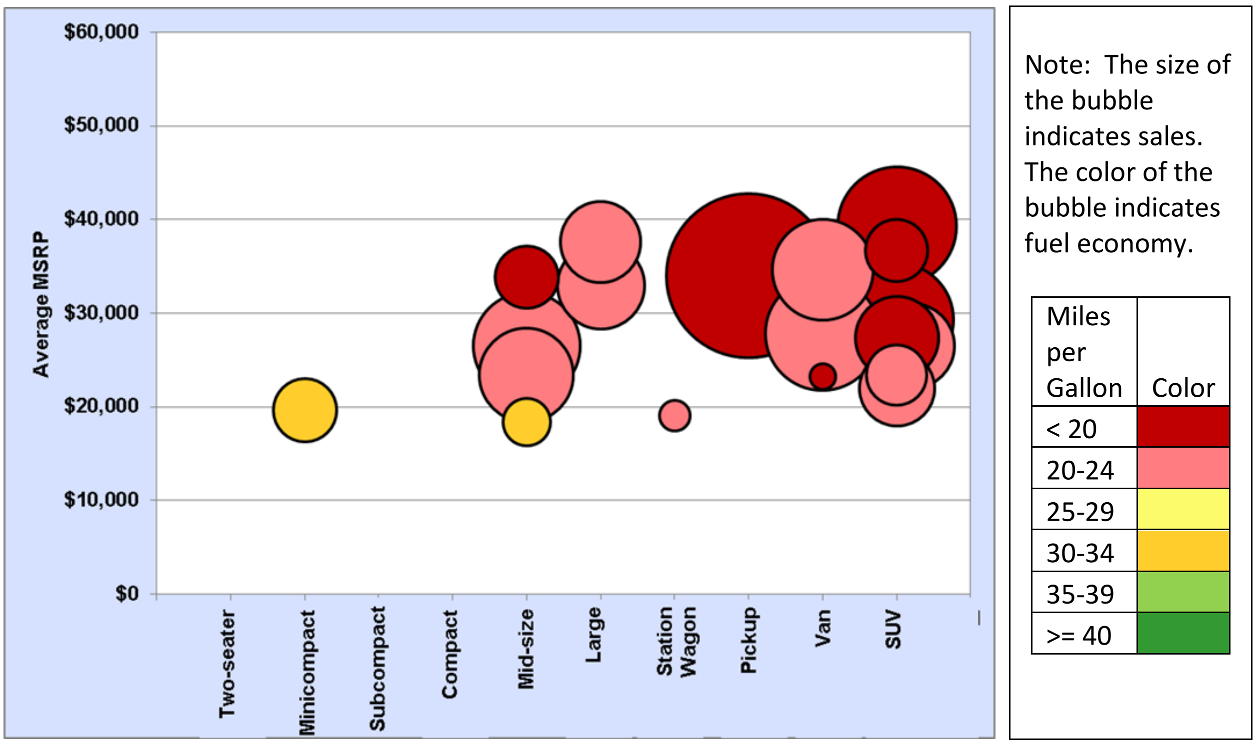


FIGURE 25. Chrysler Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 3. Chrysler Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
	Fiat 500			Challenger 200 Avenger Dart	300/300M Charger	Caliber	Ram	Town & Country Caravan Cargo	Grand Cherokee Durango Wrangler Liberty Journey Compass Patriot

Note: Includes Chrysler and Fiat.

Chrysler Produced Hybrids in 2008 and 2009

Chrysler has had only two hybrid-electric models, the Chrysler Aspen and the Dodge Durango, whose sales in 2008 and 2009 are shown below.

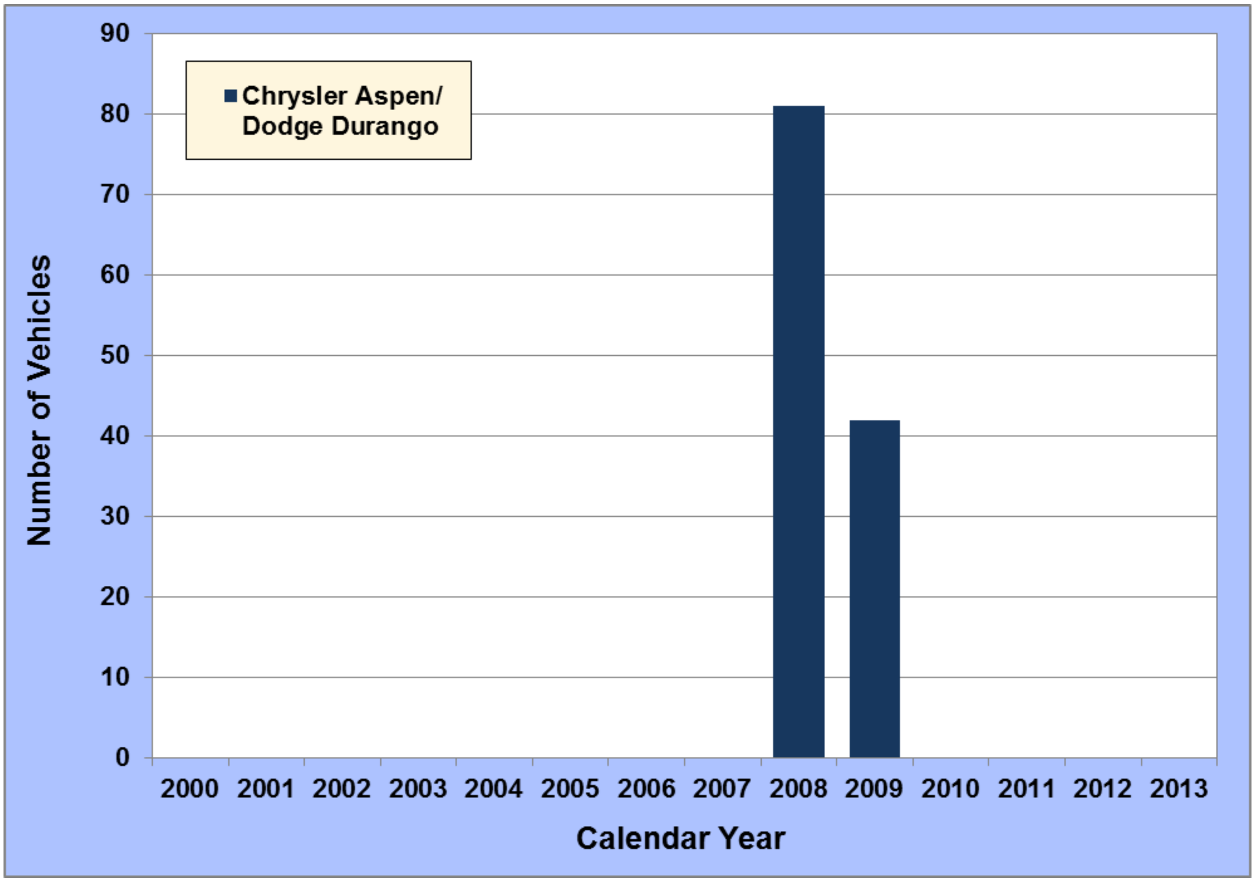


FIGURE 26. Chrysler Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 36, 40, 44, 48, 52, 56, 60, 64) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Fiat Owns All of Chrysler as of January 2014

TABLE 4. Chrysler Interrelationships with Other Automotive Manufacturers

Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
China Motors						✓	Manufacturers Chrysler minivans for Taiwanese market
Fiat	✓						Owns 100% of Chrysler as of January 2014
Fiat						✓	Builds Jeep vehicles in its Mirafiori, Italy plant
Fiat			✓		✓		Share technology, engines, transmissions & platforms
Fiat				✓			Utilizes Chrysler's distribution network and North American Plants; distributes Chrysler vehicles in overseas markets
GM, Ford					✓		Co-research projects under the USCAR
Hyundai				✓			Sells Hyundai Atos in Mexico as a Dodge

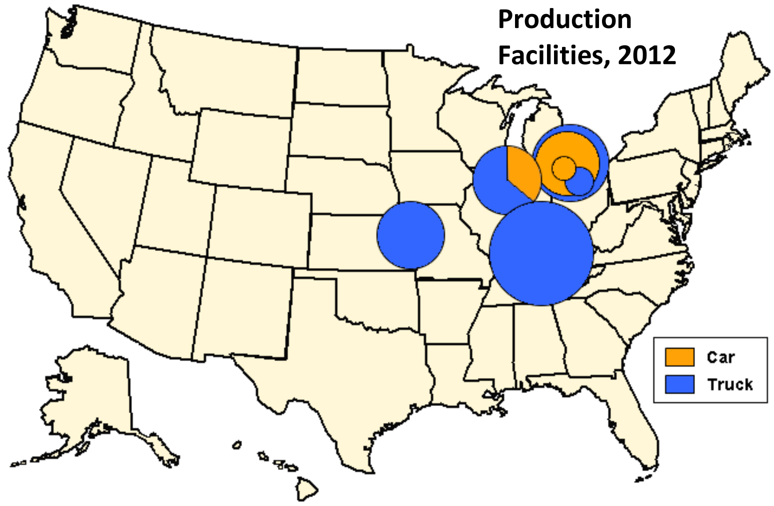
Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

Ford Company Profile

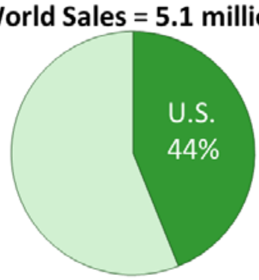
Corporate Average Fuel Economy, MY 2013	
Domestic Cars	36.3 mpg
Import Cars	31.3 mpg
Light Trucks	24.9 mpg

Average Vehicle Footprint, MY 2013	
Cars	46.9 sq ft
Light Trucks	58.9 sq ft
All	52.9 sq ft

Number of Alternative Fuel Models, MY 2013	
Flex Fuel	13
Natural Gas	0
Propane	0
Hybrid-Electric	3
Plug-In Hybrid-Electric	2
Electric	1



World Sales = 5.1 million



Ford Plants	Type	2012 Production
Louisville, KY	Truck	512,848
Dearborn, MI	Truck	370,713
Kansas City, MO	Truck	323,637
Wayne, MI	Car	303,337
Chicago, IL	Truck	210,968
Avon Lake, OH	Truck	135,231
Chicago, IL	Car	116,570
Flat Rock MI	Car	95,438

FIGURE 27. Ford Company Profile

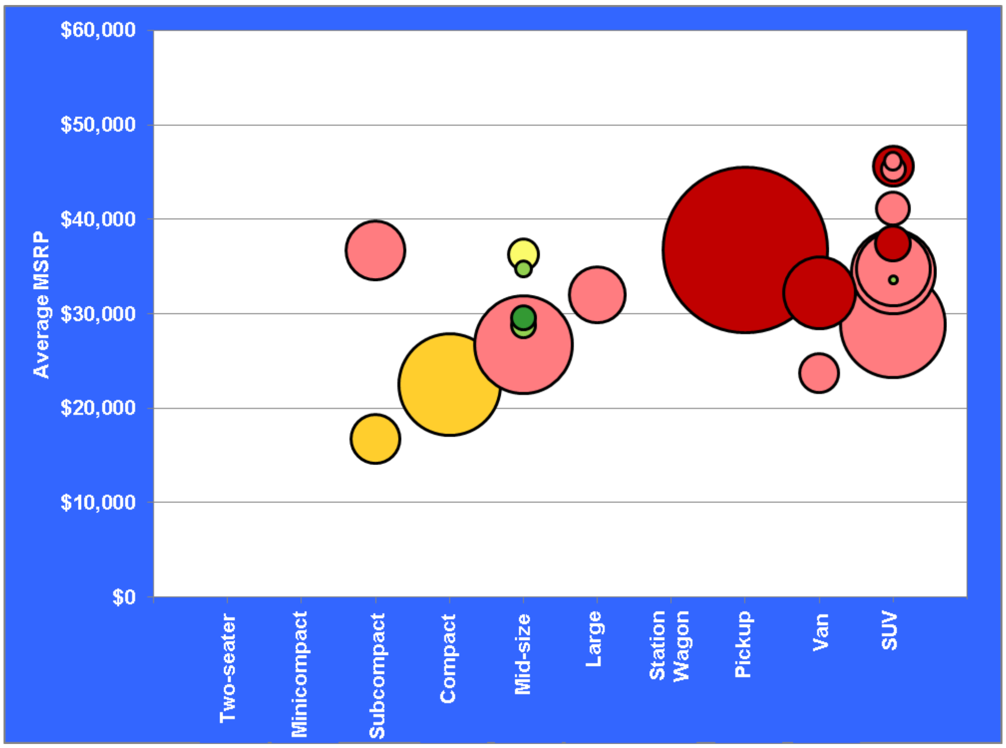
Fuel Saving Technologies

Ford, in pursuit of improved fuel economy and performance, has made a large commitment to reducing vehicle weight. This is evident in the redesigned 2015 Ford F-150 , which is more than 700 lbs lighter than it's predecessor. Weight savings come primarily through the use of aluminum body panels and bed but also from greater use of high-strength steel in the frame as well as changes to the drive train. Ford is also continuing to expand their EcoBoost technology that uses gasoline direct injection and variable valve timing combined with turbocharging to increase engine output relative to engine displacement. The EcoBoost technology is being deployed throughout Ford's line-up of vehicles from work trucks down to their smallest entry-level passenger cars. Other engine technologies include twin independent variable camshaft timing (Ti-VCT) and aggressive deceleration fuel shut-off as well as active grille shutters

Ford has also developed transmission technology like the automatic 6-speed PowerShift transmission used in the Ford Fiesta SFE (Super Fuel Economy). This transmission shifts automatically but uses a dry double clutch similar to a manual transmission but without the loss of power between shifts to improve efficiency. Ford is working with GM to develop 9 speed automatic transmissions for cars and 10 speed transmissions for larger vehicles like full-size trucks and SUVs. With regard to electrification, Ford has implemented full hybrid systems like those used in the Ford Fusion hybrid, C-Max, and Lincoln MKZ hybrid and has launched two plug-in hybrids – the 2013 C-Max Energi and Ford Fusion Energi, both capable of about 21 miles of all electric operation. The Ford Focus EV is an all-electric vehicle with an EPA rated range of 76 miles.

Many of Ford's Sport Utility Vehicles Have Fuel Economy of 20 mpg or Higher

Ford Motor Company has a fairly even distribution of vehicles from the Subcompact segment to SUVs. The Ford F-150 is by far their largest selling model. It is noteworthy that most of their SUV models have a combined fuel economy of 20 MPG or higher. Ford's car models and sales are about evenly split between those that average above 30 MPG and those that are below.



Note: The size of the bubble indicates sales. The color of the bubble indicates fuel economy.

Miles per Gallon	Color
< 20	
20-24	
25-29	
30-34	
35-39	
>= 40	

FIGURE 28. Ford Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 5. Ford Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
		Mustang Fiesta	Focus	Zephyr/MKZ Zephyr/MKZ-Hybrid C-Max PHEV Energi Fusion-Hybrid Fusion	Taurus		F-150	Econoline E-Series Transit Connect	Navigator MKT Expedition MKS MKX Flex Edge Explorer Escape-Hybrid Escape

Note: Includes Ford and Lincoln.

Ford Hybrid Sales More than Double in 2013

Ford began selling hybrids in 2004 with the Ford Escape/Mercury Mariner sport utility vehicle. In 2013, sales of the Ford Fusion/Mercury Milan alone were higher than all of Ford's hybrid sales combined in previous years. The C-Max Hybrid was also a big seller in 2013.

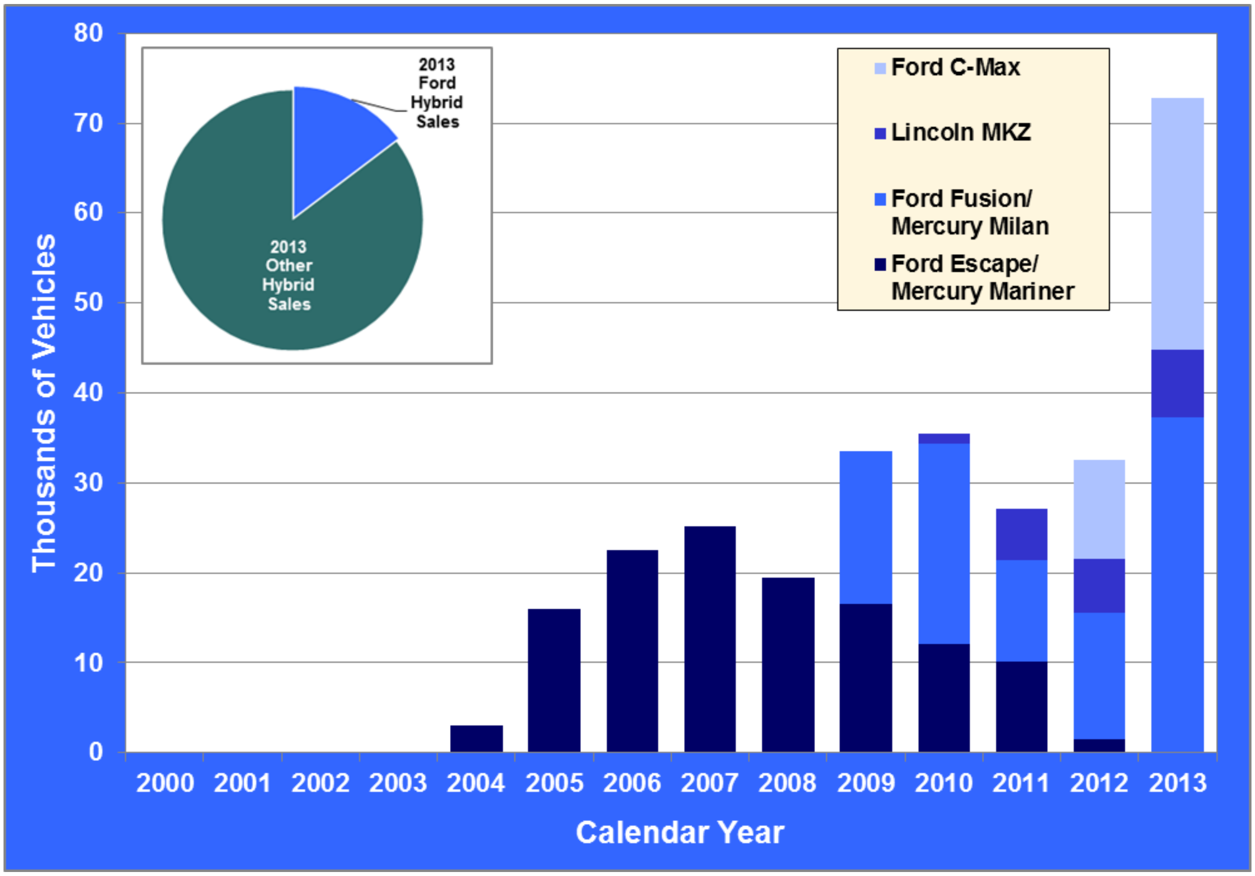


FIGURE 29. Ford Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 40, 44, 48, 52, 56, 60, 64) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Ford Continues to Work Closely with Mazda

TABLE 6. Ford Interrelationships with Other Automotive Manufacturers

Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Mnufacturing/ Assembly Agreement	Description
Chongqing Changan		✓				✓	Assembles Ford vehicles in Chongqing, China
BMW, Ford Daimler, GM, Honda, Toyota, VW					✓		Partners in Clean Energy Partnership
Daimler, Nissan					✓		Partnering in R&D called Automotive Fuel Cell Cooperation
Fiat						✓	Builds Ford Ka, which shares Fiat 500 platform at its Tychy, Poland plant
GM					✓		Developing 9- and 10-speed automatic transmissions
GM, Chrysler					✓		Co-research projects under the USCAR
Mazda		✓				✓	Joint ventures in Flat Rock, MI, Thailand, and Malaysia
Mazda			✓		✓		Share platforms and parts
Mazda	✓						Ford has equity stake.
Peugeot					✓		Partnered on development and production of several diesel engines
Sollers		✓		✓		✓	Assembles Ford vehicles at Ford's Vsevolozhsk plant & Soller's facilities in Chelny & Elabuga. All Ford's Russian prior activitives handled by Sollers through this venture

Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

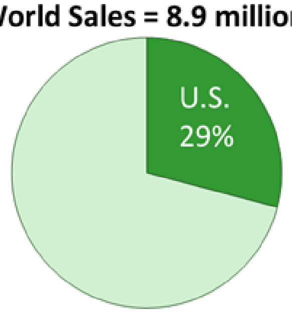
General Motors (GM) Company Profile

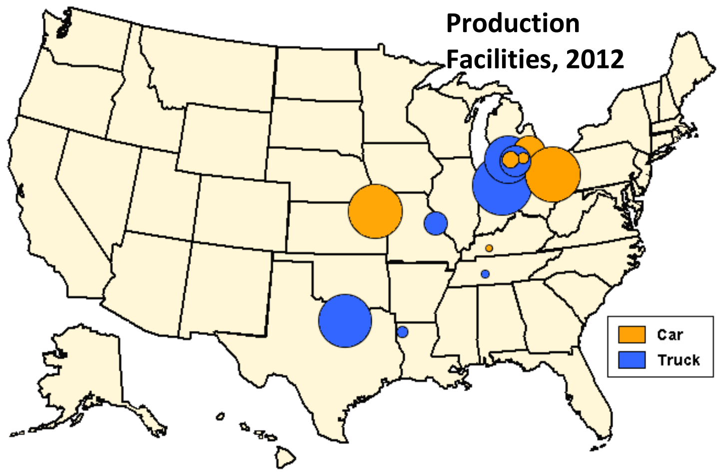
Corporate Average Fuel Economy, MY 2013	
Domestic Cars	33.6 mpg
Import Cars	39.5 mpg
Light Trucks	23.6 mpg

Average Vehicle Footprint, MY 2013	
Cars	46.4 sq ft
Light Trucks	61.9 sq ft
All	52.2 sq ft

Number of Alternative Fuel Models, MY 2013	
Flex Fuel	39
Natural Gas	2
Propane	2
Hybrid-Electric	7
Plug-In Hybrid-Electric	1
Electric	0

World Sales = 8.9 million





GM Plants	Type	2012 Production
Fort Wayne, IN	Truck	307,296
Lordstown, OH	Car	279,382
Fairfax, KS	Car	277,454
Arlington, TX	Truck	275,758
Lansing, MI - Delta	Truck	239,622
Orion, MI	Car	155,275
Flint, MI	Truck	154,268
Wentzville, MO	Truck	117,901
Lansing, MI - Grand River	Car	74,525
Shreveport, LA	Truck	39,330
Hamtramck, MI	Car	39,104
Bowling Green, KY	Car	14,960
Spring Hill, TN	Truck	9,767

FIGURE 30. GM Company Profile

Fuel Saving Technologies

General Motors has begun moving away from their two-mode hybrid system in full sized trucks and large SUVs for 2014 in favor of cylinder deactivation combined with direct injection and variable valve timing. This is a cost effective way to allow for full, uncompromised 8-cylinder power when needed for towing and other high load situations while providing 4-cylinder efficiency when full engine displacement is not necessary.

For lighter passenger vehicles, GM is using smaller displacement engines by employing direct injection and turbo charging to increase performance while improving efficiency. This technology is finding its way into entry-level vehicles like the Chevrolet Cruze and Sonic. Aerodynamics, both passive like underbody panels as well as dynamic technologies like active shutters in the front grille that close at higher speed to reduce drag, are increasingly used to boost efficiency. Another technology being actively employed is light vehicle electrification, termed eAssist. This has been offered as standard equipment on the Buick LaCrosse and Buick Regal since 2013 and as an option on the 2013 Malibu. There are plans to expand eAssist into other models.

General Motors launched the fist mass-marketed plug-in hybrid vehicle with the 2011 Chevrolet Volt and has built on that technology with the launch the 2014 Cadillac ELR. In 2013 the all-electric Chevrolet Spark EV and a diesel version of the Chevrolet Cruze also became available as 2014 models. Additionally, GM has been working on fuel cell vehicles for more than a decade and is collaborating with Honda on the development of new fuel cell technologies with plans to commercialize fuel cell vehicles by 2020.

GM Has Many Models of Sport Utility Vehicles

GM encompasses a wide range of brands and models. GM sells a high volume of pickup trucks and SUVs, many of which are large with a combined fuel economy below 20 MPG. The Chevrolet Cruze is the highest selling car with a combined fuel economy of more than 30 MPG.

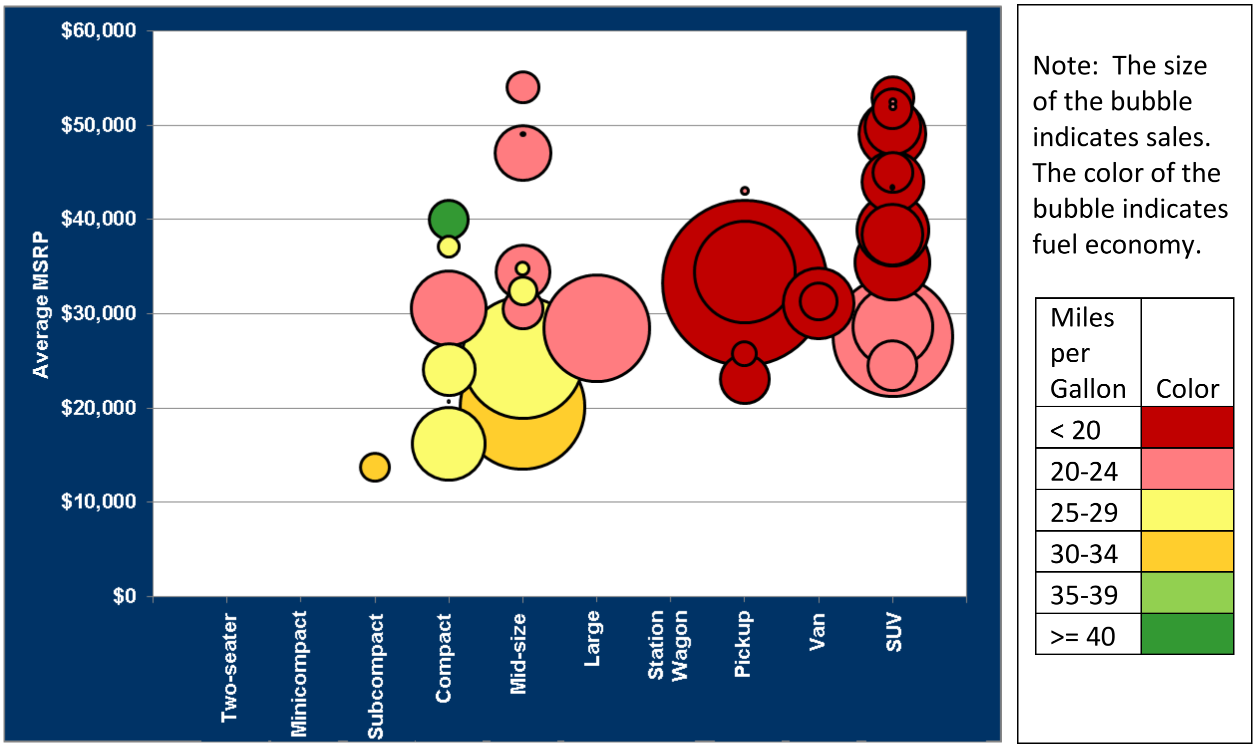


FIGURE 31. GM Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 7. GM Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
Corvette		Spark	Volt ATS Camaro Verano HHR Sonic	XTS STS CTS Regal-Hybrid LaCrosse LaCrosse-Hybrid Regal Malibu Cruze	Impala		Silverado-Hybrid Sierra Silverado Canyon Colorado	Savana/G Express/G	Escalade-Hybrid Escalade Escalade ESV Escalade EXT Yukon Yukon-Hybrid Tahoe-Hybrid Yukon XL Suburban Tahoe Avalanche SRX Sierra-Hybrid Acadia Enclave Traverse Terrain Equinox Captiva Sport

Note: Includes Buick, Cadillac, Chevrolet, GMC

GM Hybrids Include Both Cars and Light Trucks

GM began selling hybrid-electric vehicles in 2007 with the Saturn Vue sport utility vehicle and then expanded to four different hybrid models the next year. None of the GM hybrid models had sales over 10,000 units until 2012, when the Chevrolet Malibu and Buick Lacrosse sales were about 16,000 and 12,000, respectively.

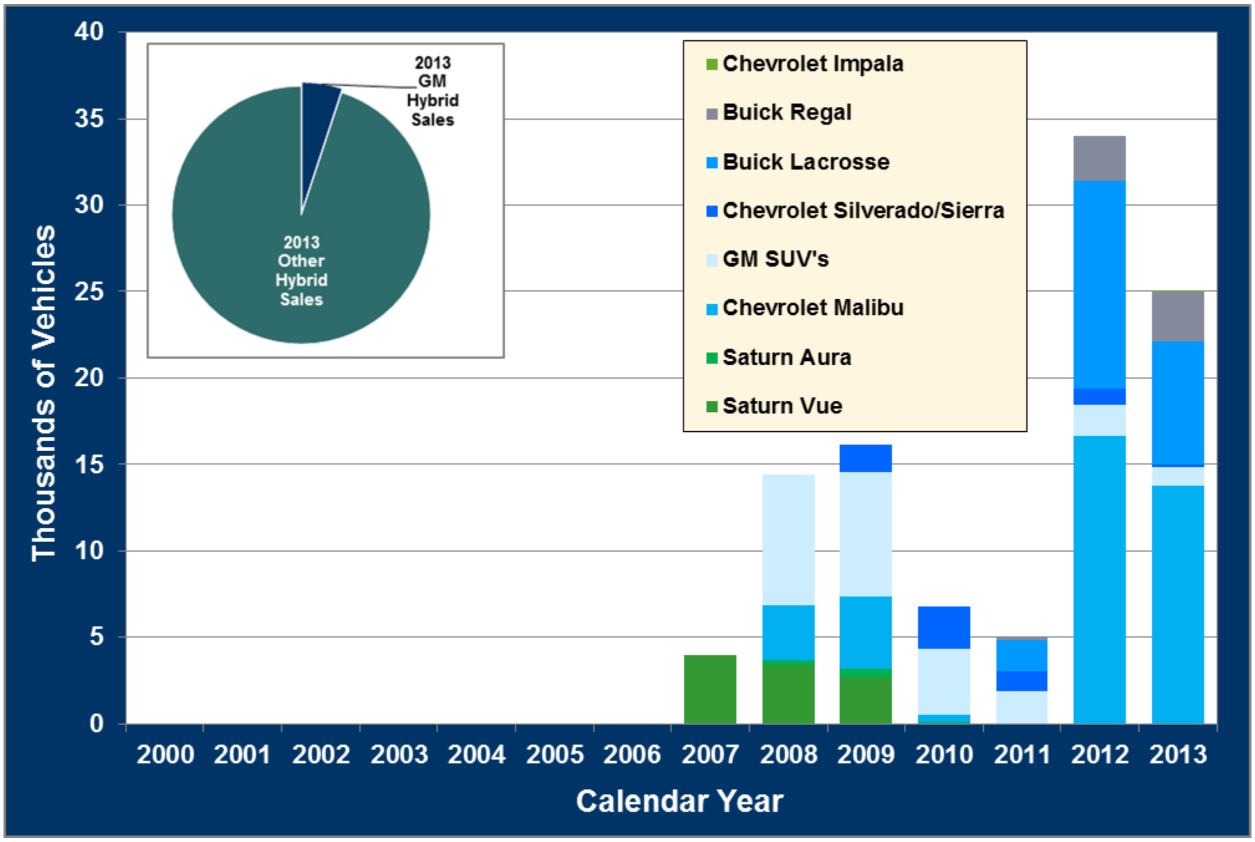


FIGURE 32. GM Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 36, 44, 48, 52, 56, 60, 64) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

GM Has Many Technology/Design Relationships with Other Manufacturers

TABLE 8. GM Interrelationships with Other Automotive Manufacturers

Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
AvtoVaz		✓				✓	Assembly joint venture in Togliatti, Russia for Chevy Niva
BMW					✓		Developing hydrogen refueling standards
BMW, Ford Daimler, GM, Honda, Toyota, VW					✓		Partners in Clean Energy Partnership
FAW		✓				✓	Production & sales of light trucks & vans in China
Fiat				✓			Supplies light vehicles to Opel to sell as the Combo
Ford					✓		Developing 9- and 10-speed automatic transmissions
Ford & Chrysler					✓		Co-research projects under the USCAR
GAZ						✓	Assembles Chevy Aveo in Nizhny, Norgorod
Honda					✓		Co-developing next generation fuel cell system and hydrogen storage technologies
Isuzu					✓		Memorandum of Understanding to jointly develop a pickup truck
Isuzu				✓		✓	Build and distribute trucks in South Africa, Kenya, Egypt & Tunisia
Nissan				✓			Supply NV200 vans to sell as Chevy City Express in Canada & U.S
Peugeot	✓			✓	✓		Jointly develop small engines & vehicles for European market
Shanghai Automotive			✓		✓		Co-develop architecture and components for electric cars sold in China
Shanghai Automotive		✓		✓			Co-handles production, sales and after-sales services for GM vehicles
Shanghai Automotive						✓	Partner in vehicle assembly operation in Liuzhou, China
Shanghai Automotive	✓						Holds stakes in GM Korea and GM India
ZAZ						✓	Assembles Chevy models

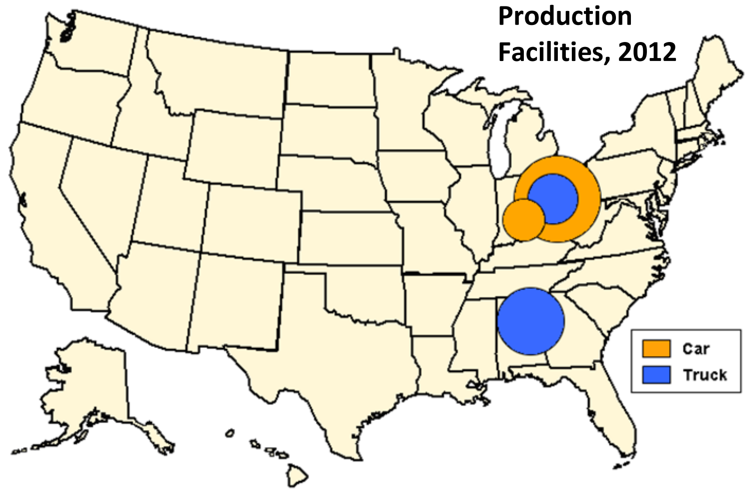
Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

Honda Company Profile

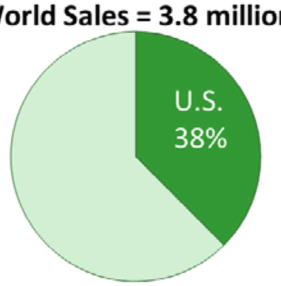
Corporate Average Fuel Economy, MY 2013	
Domestic Cars	38.8 mpg
Import Cars	41.9 mpg
Light Trucks	28.7 mpg

Average Vehicle Footprint, MY 2013	
Cars	45.1 sq ft
Light Trucks	49.7 sq ft
All	46.6 sq ft

Number of Alternative Fuel Models, MY 2013	
Flex Fuel	0
Natural Gas	1
Propane	0
Hybrid-Electric	4
Plug-In Hybrid-Electric	0
Electric	1



World Sales = 3.8 million



Honda Plants	Type	2012 Production
Marysville, OH	Car	439,564
Lincoln, AL	Truck	336,790
East Liberty, OH	Truck	243,346
Greensburg, IN	Car	199,544
Marysville, OH	Truck	82

FIGURE 33. Honda Company Profile

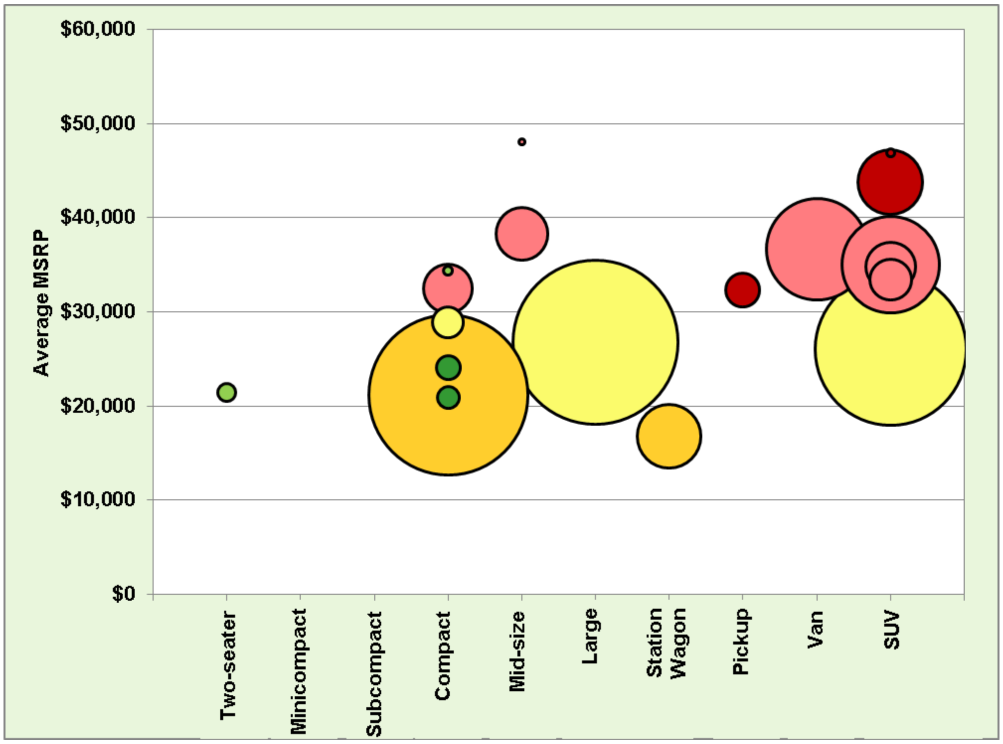
Fuel Saving Technologies

The effectiveness of Honda's new hybrid systems for improving fuel economy became clear in 2013 with the arrival of the 2014 Accord Hybrid which garnered an EPA City rating of 50 MPG. The 2014 Accord Plug-in Hybrid with an all-electric range of 13 miles also became available in 2013 as a 2014 model. Honda has developed several new hybrid systems for different vehicle configurations and sizes that will be installed throughout their vehicle offerings. In addition to the newly developed hybrid systems, Honda has been implementing a suite of drivetrain technologies marketed under the name "Earth Dreams" that includes a new generation of direct injection engines, turbocharging, and greater use of continuously variable transmissions. Improvements to previously used technologies like cylinder deactivation is also part of the strategy. Cylinder deactivation or Variable Cylinder Management (VCM) began in 2005 with the top trim level of the Odyssey and in select trim levels of the Accord in 2008. VCM is now standard in all Odyssey models.

The 2013 Honda Fit EV was launched in select markets in 2012 and is their first fully electric vehicle for the U.S. Besides electric vehicles, Honda has been the only major manufacturer to produce a natural gas car for the U.S. consumer market and has also developed hydrogen fuel cell technology which has led to the development of the FCX Clarity. The FCX Clarity has been available to consumers as a lease vehicle since 2008 for those living in Southern California. Honda is now working with GM on the development of the next generation of fuel cell technologies for wider commercialization of fuel cell vehicles.

Honda Best Sellers Have Fuel Economy Greater than 25 mpg

Honda Motor Company has very few models with a combined average fuel economy of less than 20 MPG and they represent a small portion of their total sales. Those models that sell in the greatest number have combined fuel economies of 25 MPG or higher. The Honda Civic is the highest selling model with a combined average fuel economy of more than 30 MPG. All of Honda's models have an average MSRP of less than $50,000.



Note: The size of the bubble indicates sales. The color of the bubble indicates fuel economy.

Miles per Gallon	Color
< 20	
20-24	
25-29	
30-34	
35-39	
>= 40	

FIGURE 34. Honda Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 9. Honda Models by EPA Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
CR-Z Hybrid			ILX Hybrid TSX ILX Civic-Hybrid Civic Insight	TL RL	Accord	Fit	Ridgeline	Odyssey	ZDX MDX Pilot RDX Crosstour CRV

Includes Honda and Accura.

Honda Hybrid Sales Down in 2012 and 2013

Honda was the first company to bring hybrid-electric vehicles to the market with the Honda Insight, sold in late 1999. The Honda Civic Hybrid, however, dominated the company's hybrid sales beginning in 2002. A redesign of the Insight in 2009 put the Insight back on top for several years. An Acura ILX Hybrid was introduced in 2012. In 2012 and 2013, Honda hybrid sales have declined from the years before, totaling less than 20,000 units in each year.

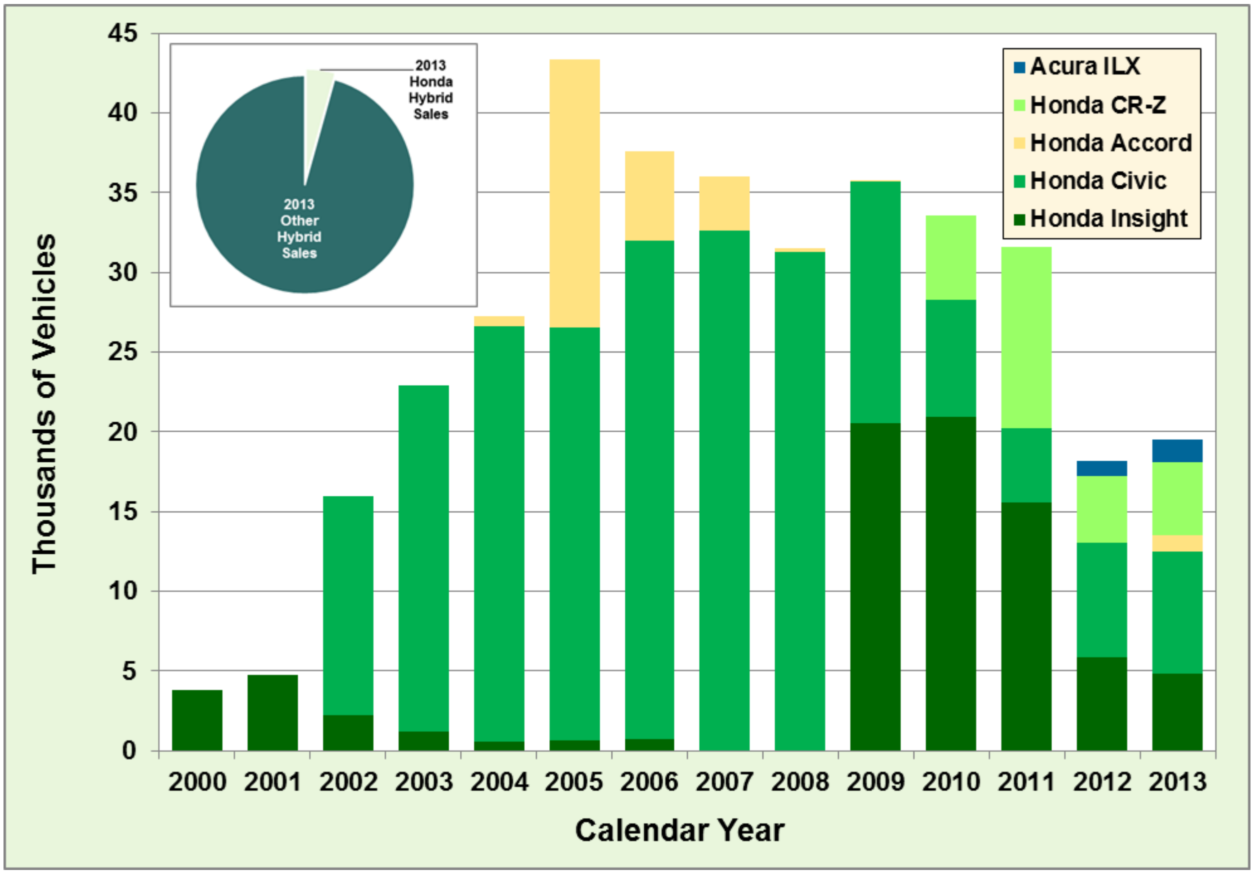


FIGURE 35. Honda Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 36, 40, 48, 52, 56, 60, 64) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Honda Has Few Interrelationships for a Manufacturer of Its Size

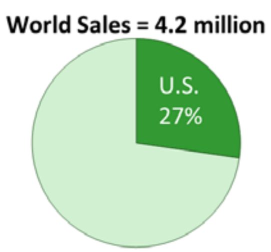
TABLE 10. Honda Interrelationships with Other Automotive Manufacturers

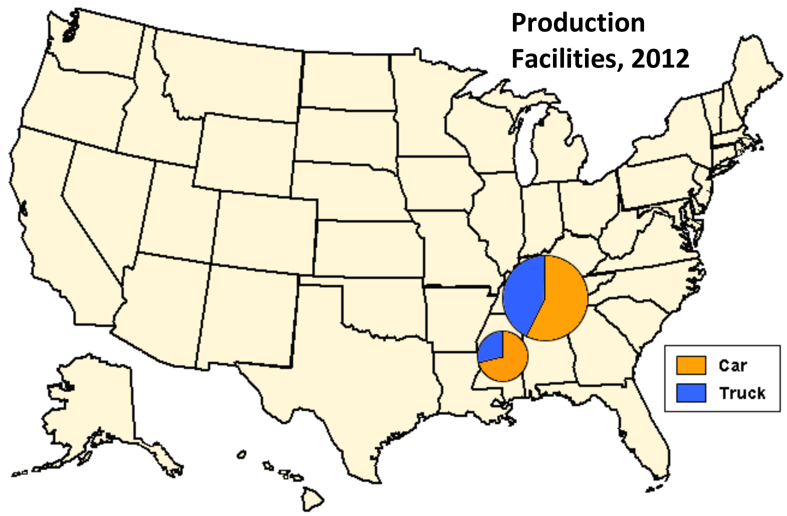
Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
BMW, Ford Daimler, GM, Honda, Toyota, VW					✓		Partners in Clean Energy Partnership
Dongfeng		✓				✓	Joint venture to build cars to sell cars in Wuhan, China
Guangzhou		✓				✓	Joint venture to build cars and vans in Guangzhou, China
GM					✓		Co-developing next generation fuel cell system and hydrogen storage technologies
Proton				✓	✓		Planning partnership to include platform sharing and distribution arrangements

Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

Nissan Company Profile

Corporate Average Fuel Economy, MY 2013	
Domestic Cars	40.0 mpg
Import Cars	34.3 mpg
Light Trucks	26.3 mpg
Average Vehicle Footprint, MY 2013	
Domestic Cars	45.9 sq ft
Import Cars	51.1 sq ft
Light Trucks	47.7 sq ft
Number of Alternative Fuel Models, MY 2013	
Flex Fuel	2
Natural Gas	0
Propane	0
Hybrid-Electric	2
Plug-In Hybrid-Electric	0
Electric	1





Nissan Plants	Type	2012 Production
Smyrna, TN	Car	234,724
Smyrna, TN	Truck	176,739
Canton, MS	Car	172,058
Canton, MS	Truck	61,418

FIGURE 36. Nissan Company Profile

Fuel Saving Technologies

Of the major manufacturers, Nissan has been the most aggressive in promoting all-electric vehicles, not only in the U.S., but also around the world. By the end of 2012, production of the Nissan Leaf and its battery pack was shifted from Japan to Smyrna, TN, for the U.S. market, lowering production costs and better positioning Nissan to trim $6,400 from the base price of the 2013 model.. Nissan also developed a more heat resistant battery to address concerns of premature degradation and range loss in extremely hot climates. The all-electric e-NV200 commercial van is scheduled for 2014 and a luxury EV is planned with the Infiniti LE sedan. However, the launch of the Infiniti LE has been delayed until at least 2015 as inductive (cordless) charging technology matures. For the 2014 model year, Nissan also introduced new hybrid technology with the Nissan Pathfinder.

Nissan has employed gasoline direct injection with turbocharging, but they have also developed a lower cost dual port injection system that produces similar benefits of better performance and an increase in fuel economy of about 4% over an engine with a single fuel injector. The 2012 Versa was the first model to receive this new dual fuel injector technology. Nissan has also been a leader in the development and implementation of Continuously Variable Transmissions or CVTs. Nissan's CVT allows engines to operate at an optimum speed throughout the entire range of gear ratios, helping to improve efficiency. Without fixed gear ratios, the CVT provides smooth "stepless" acceleration and Nissan's XTRONIC CVT offers one of the widest gear ratio ranges in the industry. CVTs are typically used on vehicles with small displacement engines with limited torque. However, Nissan was the first to offer the CVT for engines as large as 3.5 liters and now offers them throughout their line-up including high-powered luxury vehicles.

Nissan's Best Sellers Are Compact and Midsize Cars

Nissan sells a large number of models that have a combined fuel economy of less than 20 MPG; however, they sell in relatively low numbers. Most of the highest selling models are cars in the compact and mid-size segment. The Nissan Versa (dark yellow bubble) and Nissan Leaf (dark green bubble) are the two models shown in the figure with a combined rating of more than 30 MPG.

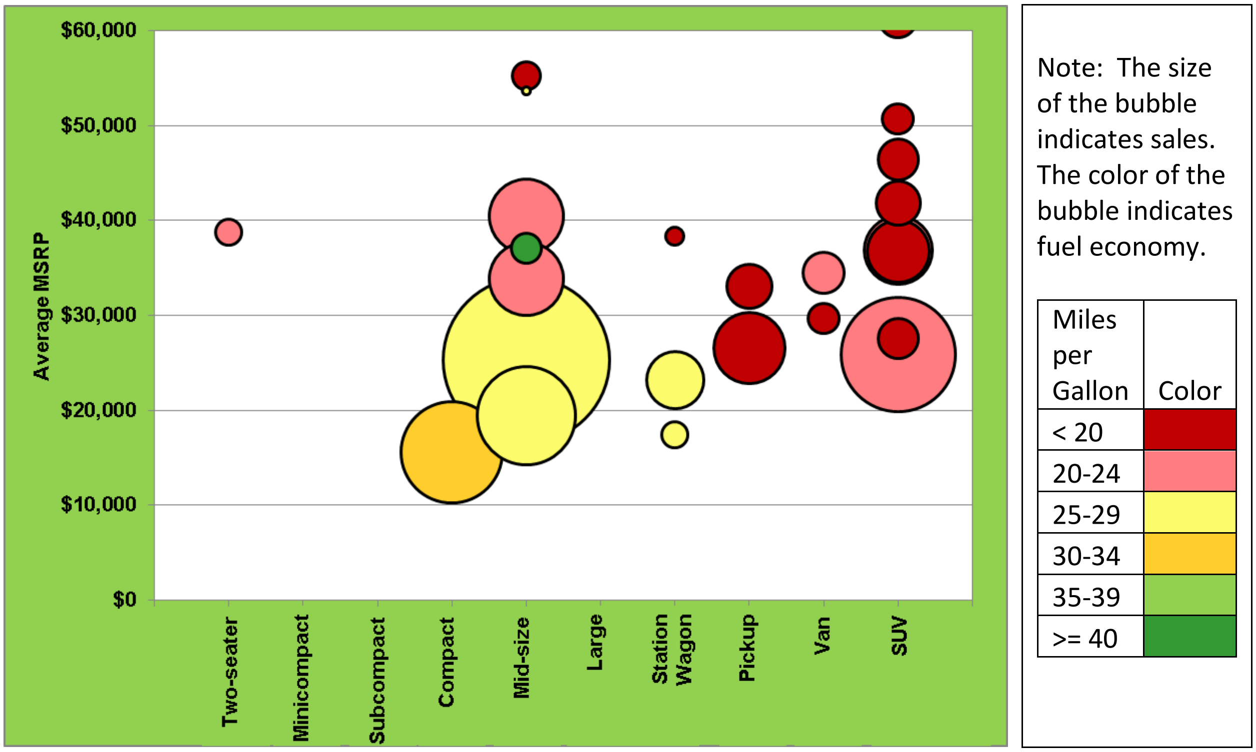


FIGURE 37. Nissan Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 11. Nissan Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
350Z/370Z		GT-R	Versa	M Series M Series-Hybrid G Series LEAF Maxima Altima Sentra		Juke Cube EX	Frontier Titan	Quest NV	QX FX Armada JX Murano Pathfinder Xterra Rogue

Note: Models with average MSRP over $60,000 are not shown on the chart above, but are included in the table.Includes Nissan and Infiniti.

Nissan Altima Hybrid was Discontinued in 2012

Nissan sold the Altima Hybrid from 2007 until 2011 but discontinued it for model year 2012 (some residual sales of the MY 2011 Altima Hybrid are shown in calendar year 2012 data). In 2014, however, a new Altima Hybrid will be available. The Infiniti M35h was the only hybrid available from Nissan in MY 2012, but by MY 2013, several other Infiniti hybrids and the Nissan Pathfinder hybrid were sold.

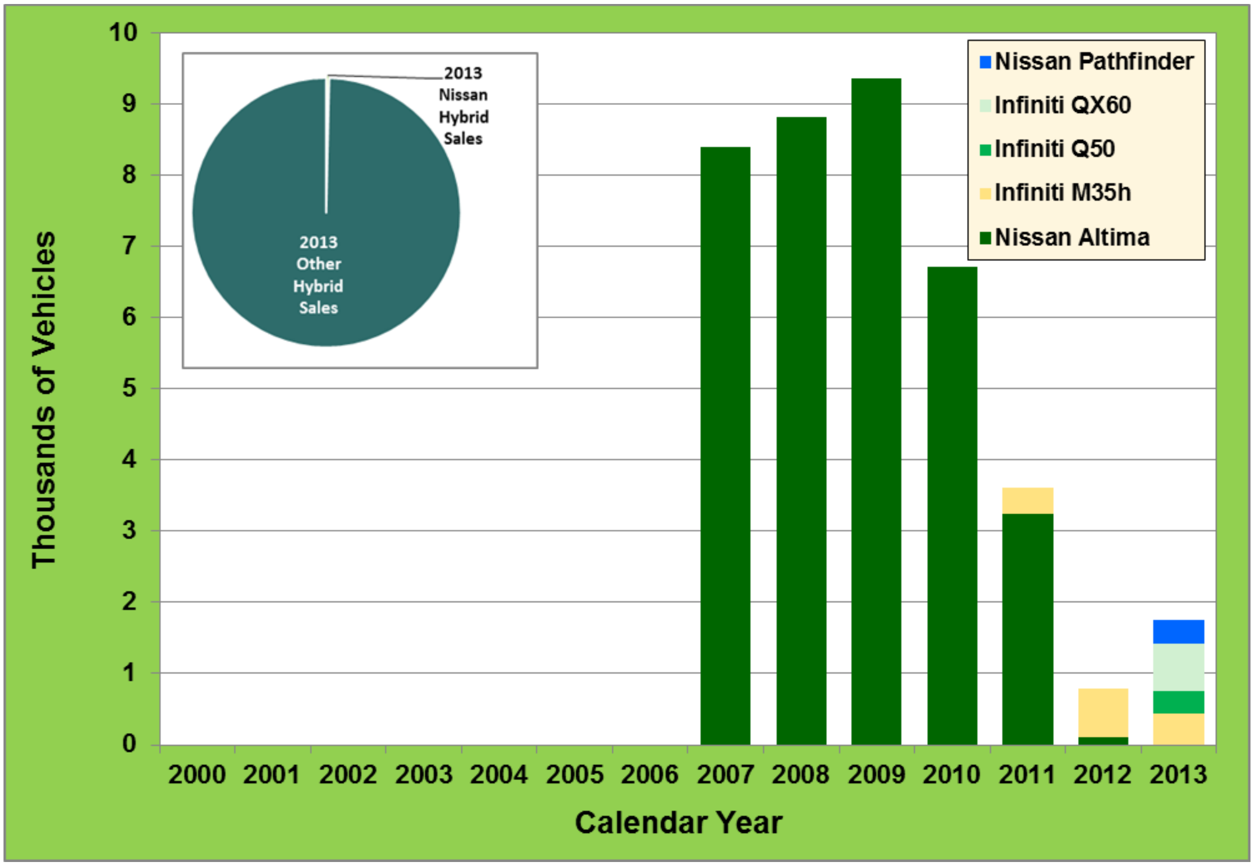


FIGURE 38. Nissan Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 36, 40, 44, 52, 56, 60, 64) will have different vertical axis scales.

Altima sales in 2012 are Y2011 Altimas.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Nissan Has Many Manufacturing/Assembly Agreements with Other Manufacturers

TABLE 12. Nissan Interrelationships with Other Automotive Manufacturers

Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
AvtoVaz	✓						Joint venture with Renault-Nissan
Dacia					✓		Co-engineered Nissan Logan platform built by Dacia
Daimler, Ford					✓		Automotive Fuel Cell Cooperation
Daimler					✓		Partner with Renault-Nissan to develop small cars, vans, & powertrains
Daimler			✓	✓			Supplies diesel engines for European Infiniti models
Daimler			✓				Allows Nissan to manufacture automatic transmissions for Nissan & Infiniti vehicles
Daimler						✓	Engines for Infiniti & Mercedes Benz built by Nissan in 2014
Dongfeng		✓		✓		✓	Joint venture in Guangzhou, China to make & sell Venucia cars
Dongfeng				✓	✓		Co-developed medium truck in Avila, Spain
GM				✓			Nissan supplies NV200 vans to GM in U.S. & Canada
Mazda			✓	✓	✓		Supplies vehicles & develops components
Mitsubishi		✓			✓	✓	Joint venture in minicars called NMKV
Mitsubishi				✓		✓	Supplies light duty trucks in Japanese market
Renault			✓	✓	✓		Share platforms, components & marketing
Renault	✓					✓	Owns a stake and builds vehicles for Nissan
Renault, AvtoVaz		✓					Joint venture in Tangier, Morocco
Suzuki, Mitsubishi	✓						Co-ownership with Nissan in Jatco Ltd transmission making
Suzuki				✓	✓	✓	Produces mini commercial vehicles & minicars in Japan

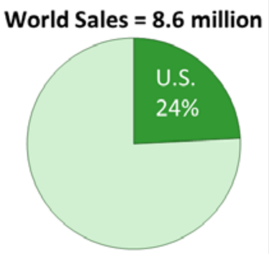
Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

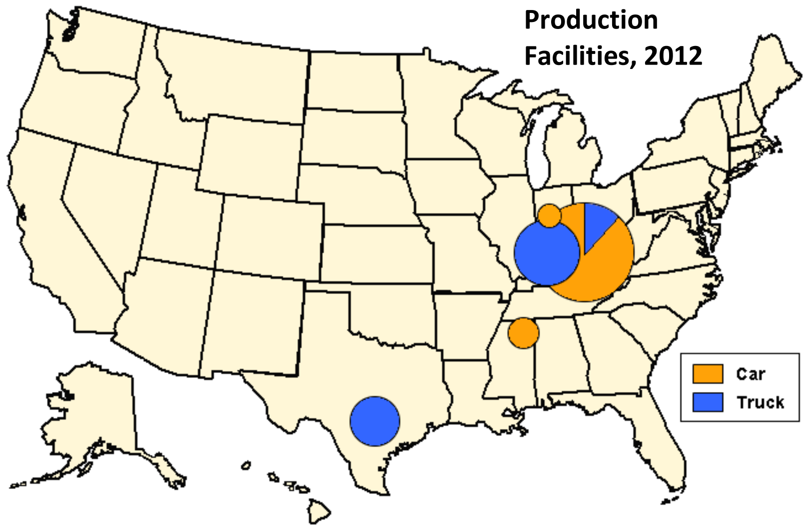
Toyota Company Profile

Corporate Average Fuel Economy, MY 2013	
Domestic Cars	36.2 mpg
Import Cars	47.6 mpg
Light Trucks	25.6 mpg

Average Vehicle Footprint, MY 2013	
Cars	44.8 sq ft
Light Trucks	53.9 sq ft
All	48.2 sq ft

Number of Alternative Fuel Models, MY 2013	
Flex Fuel	2
Natural Gas	0
Propane	0
Hybrid-Electric	6
Plug-In Hybrid-Electric	1
Electric	2





Toyota Plants	Type	2012 Production
Georgetown, KY	Car	402,274
Princeton, IN	Truck	297,346
San Antonio, TX	Truck	219,198
Blue Springs, MS	Car	129,602
Lafayette, IN	Car	93,126
Georgetown, KY	Truck	59,806

FIGURE 39. Toyota Company Profile

Fuel Saving Technologies

In 2013, Toyota announced their intent to commercialize fuel cell vehicles and to bring their first fuel cell vehicle to market by 2015. Toyota's strategy for fuel cell vehicles differs somewhat from other manufactures; they are combining the efficiency benefits of their electric Synergy hybrid system with a hydrogen tank and fuel cell stack. This provides long-range electric operation and refueling times of about three minutes.

Toyota has been successful in expanding the Prius hybrid into a family of hybrid vehicles adding a larger station wagon model called the Prius V and a smaller more economical hybrid called the Prius c with a base price of less than $20,000. A plug-in version of the standard Prius is also offered with an all-electric range of about 11 miles. To reduce weight in the Prius models, aluminum was used in the hood, rear hatch, front stabilizer bar and brake calipers and high strength steel is used in the inner rocker panel, center pillar and roof reinforcement. Beyond the dedicated Prius hybrid family, Toyota has expanded their hybrid Synergy drive throughout their lineup in models like the Camry, Highlander, Avalon, and various Lexus models. For full electric vehicles, Toyota worked with Tesla to develop the latest version of the RAV4 EV and they have also produced the Scion iQ EV, both of which were introduced as 2013 models with limited availability in California.

For conventional passenger vehicles, Toyota is employing direct injection and turbo charging on some models to increase engine output and efficiency. Toyota is also is also increasing their use of six and eight speed automatic transmissions and CVT transmissions in their small and midsize cars. Like other manufactures aerodynamics is an important part of Toyota's strategy for increasing fuel economy as evidenced by the standard Prius and plug-in Prius which has among the lowest coefficients of drag in the industry.

Toyota Sells Many Fuel Efficient Compact and Midsize Cars

Toyota produces many models and they are fairly evenly split between cars and trucks. Among the truck models, about half achieve a combined fuel economy of more than 20 MPG. Most of the car models had a combined fuel economy of 25 mpg or higher and those models also represented a large portion of Toyota's overall sales. Seven of those models (shown in dark green) had a combined average fuel economy of 40 MPG or higher.

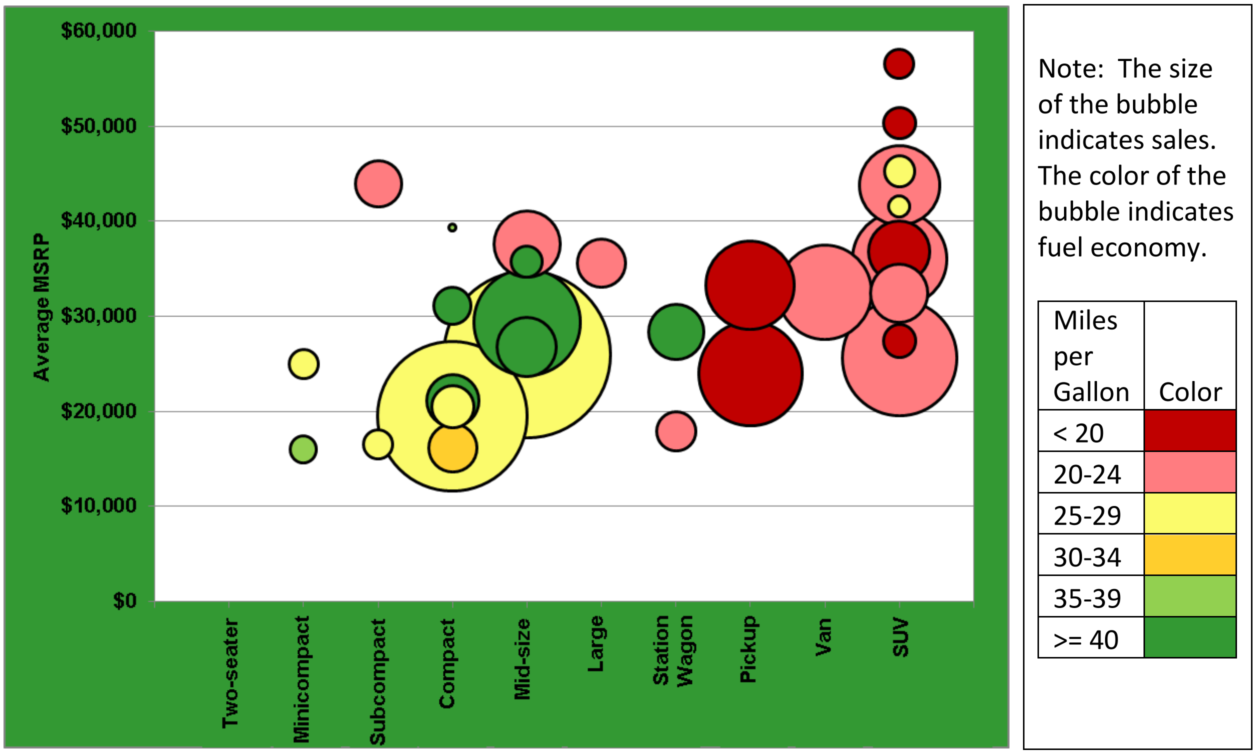


FIGURE 40. Toyota Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 13. Toyota Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
LFA	FR-S iQ	IS xA/xD	HS Hybrid CT Hybrid Prius c tC Corolla/Matrix Echo/Yaris	LS600hL-Hybrid LS ES Prius-PHEV Prius Camry-Hybrid Camry	Avalon	Prius v xB	Tacoma Tundra	Sienna	GX Sequoia RX Hybrid RX Highlander-Hybrid 4Runner Highlander Venza FJ Cruiser RAV4

Note: Models with average MSRP over $60,000 are not shown on the chart above, but are included in the table.Includes Toyota, Lexus, and Scion.

Toyota Prius Has the Most Sales of Any Hybrid Model

The Toyota Prius, first introduced in 2000, is by far the hybrid model with the most sales – about 220,000 in 2012 and 2013. Toyota has a large line-up of hybrid models with eight different models sold in 2013. The Camry Hybrid is Toyota's second-largest hybrid seller. In 2005, Toyota began selling two hybrid sport utility vehicles, the Lexus RX450h and the Toyota Highlander. The newest addition to Toyota's hybrid models is the Avalon Hybrid.

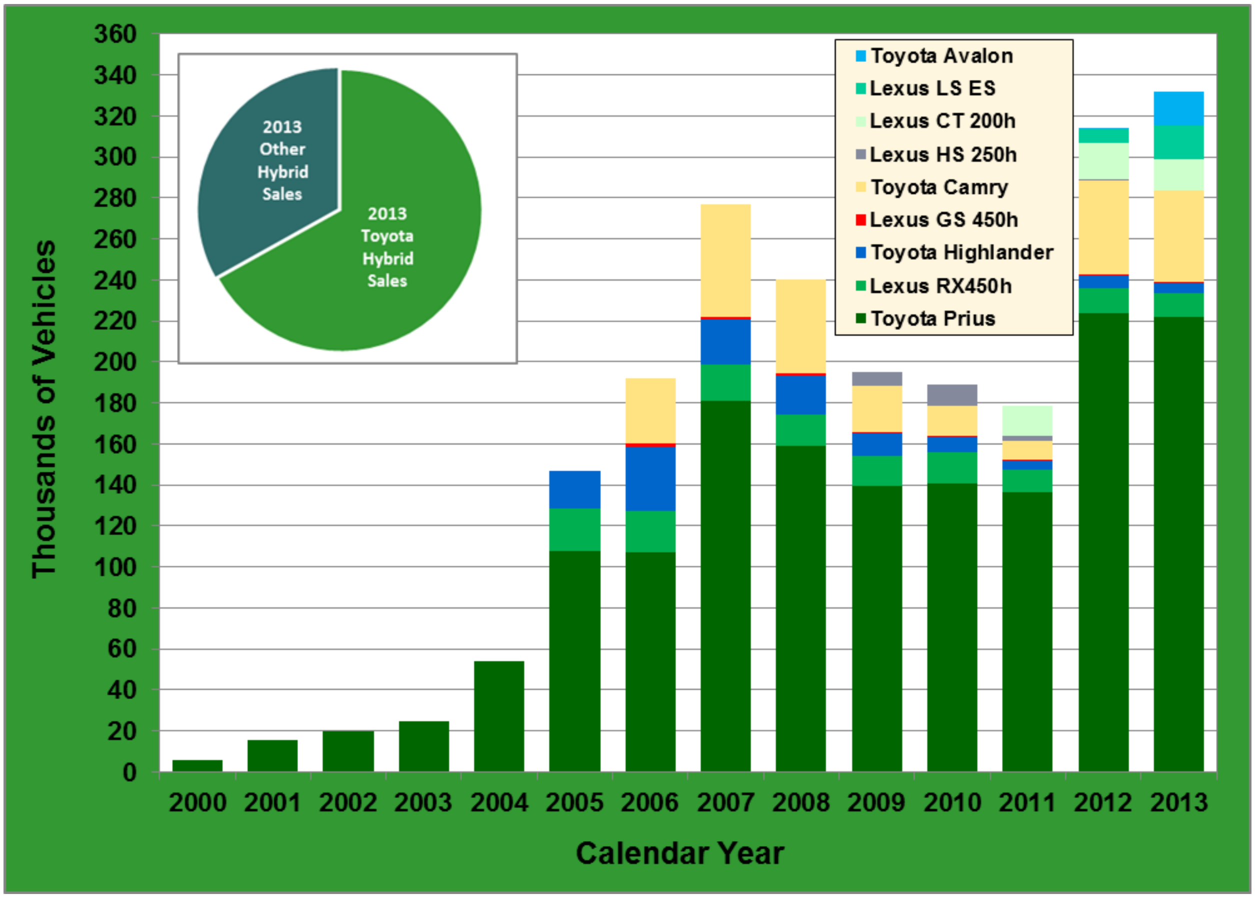


FIGURE 41. Toyota Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 36, 40, 44, 48, 56, 60, 64) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Toyota Has the Most Interrelationships

TABLE 14. Toyota Interrelationships with Other Automotive Manufacturers

Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
BMW, Ford Daimler, GM, Honda, Toyota, VW					✓		Partners in Clean Energy Partnership
BMW					✓		Jointly developing a sports-car platform
BMW			✓				Will supply diesel engines to Toyota Motor Europe
Brilliance China						✓	Manufactures Toyota minibuses
Daihatsu	✓	✓		✓			Owned mostly by Toyota
Daihatsu			✓		✓	✓	Develop components & vehicles, build vehicles
Daihatsu						✓	Toyota builds vehicles in Pakistan & Venezuela for Daihatsu
FAW	✓	✓					Three joint ventures in Asia
FAW				✓		✓	Engine manufacturing in China
Fuji	✓						Toyota owns stake in Fuji Heavy Industries
Fuji					✓	✓	Subaru of Indiana Automotive builds Toyota
Guangzhou		✓				✓	Joint venture that builds Toyota-based vehicles in Guangzhou, China
Isuzu	✓				✓		Toyota has a stake in Isuzu. The two companies collaborate on powertrain technology
Peugeot		✓		✓		✓	Joint venture car production in Czech Republic. Peugeot will supply rebadged vans to Toyota to sell in Europe
Renault		✓				✓	Colombian SOFASA is owned by Renault, Toyota & Mitsui Engineering
Tesla					✓		Tesla developed the battery pack & powertrain for the Toyota RAV4 EV electric CUV
Tianjin		✓					Tianjin FAW Toyota Motor Co. is a joint venture with three manufacturing facilities in Tianjin Province
Tianjin						✓	Builds Toyota-based vehicles

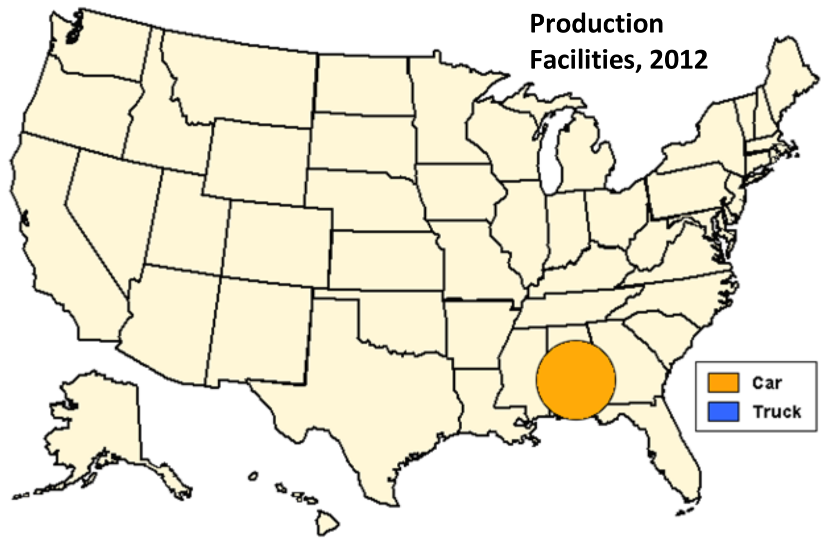
Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

Hyundai Company Profile

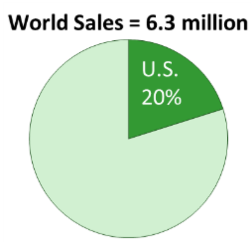
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	None
Import Cars	N/A
Light Trucks	N/A

Average Vehicle Footprint, MY 2013	
Cars	46.3 sq ft
Light Trucks	46.2 sq ft
All	46.3 sq ft

Number of Alternative Fuel Models, MY 2013	
Flex Fuel	0
Natural Gas	0
Propane	0
Hybrid-Electric	1
Plug-In Hybrid-Electric	0
Electric	0



Hyundai Plants	Type	2012 Production
Montgomery, AL	Car	361,348



Note: World sales figure includes Kia. All other data on the page are Hyundai only. Hyundai vehicles assembled in Alabama do not meet CAFE criteria for domestic vehicles due to the low percentage of domestic content. CAFE data for Hyundai was not final at time of publication.

FIGURE 42. Hyundai Company Profile

Fuel Saving Technologies

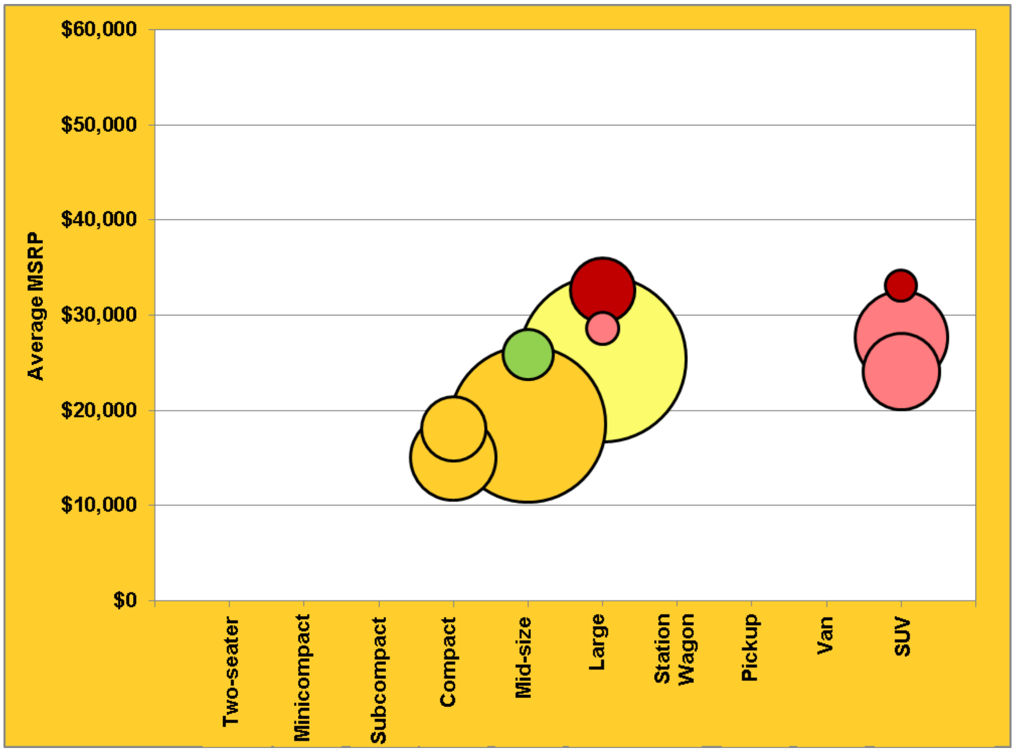
In 2013, Hyundai announced their intention to produce the 2015 Tucson Fuel Cell SUV and make it available for lease in 2014. A range of about 300 miles is expected with a refuel time of about 10 minutes. Cold temperatures are not expected to have as large of an affect on hydrogen fuel cell vehicle range compared with electric vehicles that rely on temperature-sensitive batteries for energy storage. The introduction of the Tucson Fuel Cell will initially be limited to select markets where hydrogen refueling stations exist, like California.

Hyundai is employing a wide array of other technologies to achieve their goals for higher fuel economy. A key component for achieving greater fuel economy is downsizing their engine offerings. In order to do this while still meeting consumer expectations for performance, Hyundai is combining weight reduction with high output turbocharged direct injection engines. The Hyundai Sonata was the first large sedan to be offered without a V6 option in 2011. The 2013 Sonata is offered with a base 2.4 liter gasoline direct injection (GDI) 4 cylinder engine that produces 200 horsepower or an optional 2.0 liter turbocharged 4 cylinder engine that delivers 274 horsepower. Hyundai is also developing a gasoline engine that operates like a diesel which they refer to as GDCI or Gasoline Direct Compression Ignition. This engine holds the promise of offering diesel efficiency as a lower cost to build and operate than a diesel engine.

For 2013, Hyundai offered a full hybrid version of the Sonata along with continual improvements to aerodynamics. However, Hyundai is not embracing the CVT transmission. Due to the frictional losses inherent to CVT transmissions, Hyundai is instead turning to dual clutch transmissions. The distinct shift points offered by a dual clutch transmission are well suited to performance oriented vehicles like the Veloster where it is offered as an option.

Hyundai's Market Dominated by Cars

Hyundai's model offerings, as well as sales, are dominated by cars that have a combined fuel economy of 25 MPG or higher. About half of their car models have a combined rating of 30 MPG or higher. Only two models, including an SUV, fall below 20 MPG and they have relatively low sales. All of Hyundai's models have an average MSRP of below $40,000.



Note: The size of the bubble indicates sales. The color of the bubble indicates fuel economy.

Miles per Gallon	Color
< 20	
20-24	
25-29	
30-34	
35-39	
>= 40	

FIGURE 43. Hyundai Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 15. Hyundai Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
			Accent Veloster	Sonata-Hybrid Elantra	Genesis Azera Sonata				Veracruz Santa Fe Tucson

Hyundai Begins Hybrid Sales in 2011

In 2011, Hyundai began selling its first hybrid-electric vehicle – the Sonata Hybrid. First year sales of the hybrid were about 17,000 vehicles. For 2012 and 2013, sales reached over 20,000 units.

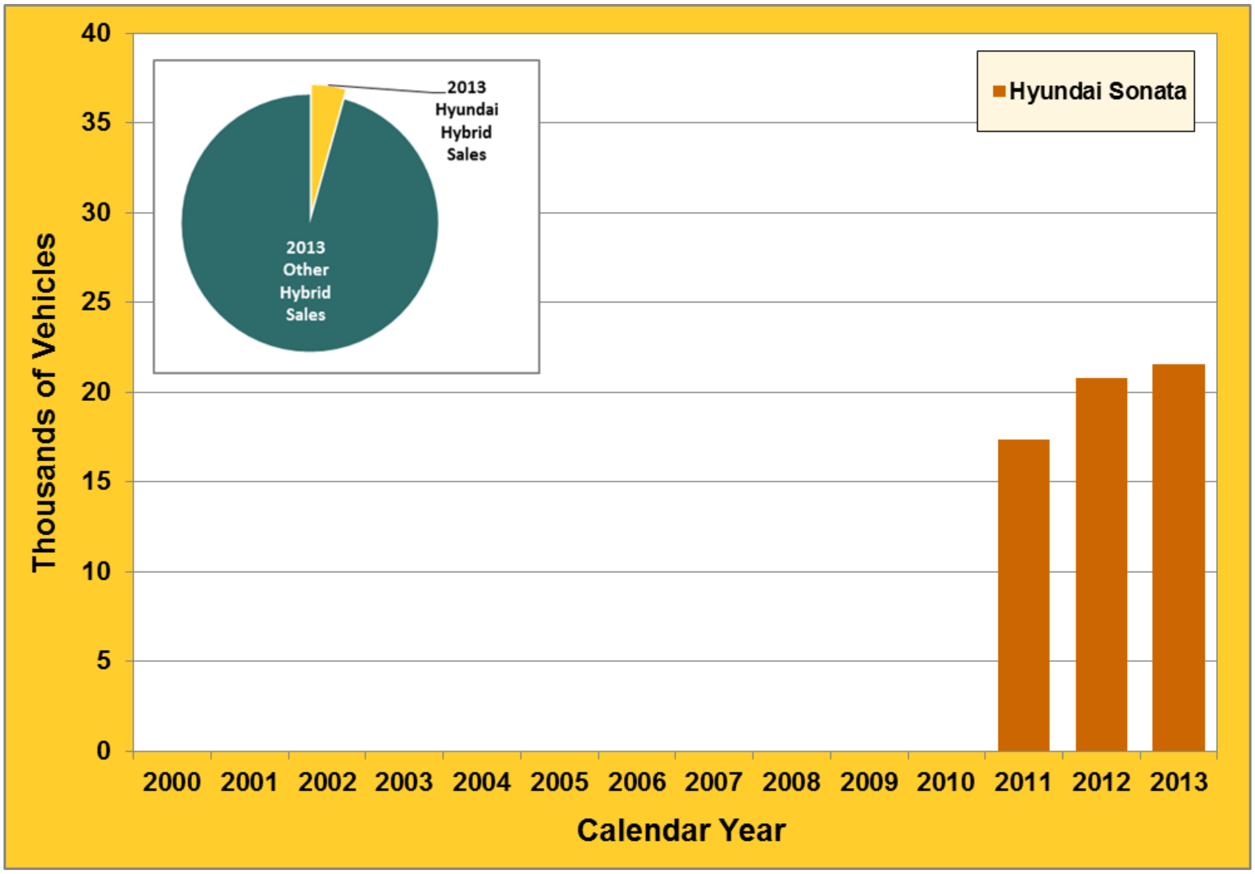


FIGURE 44. Hyundai Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 36, 40, 44, 48, 52, 60, 64) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Hyundai Has a Joint Venture in China

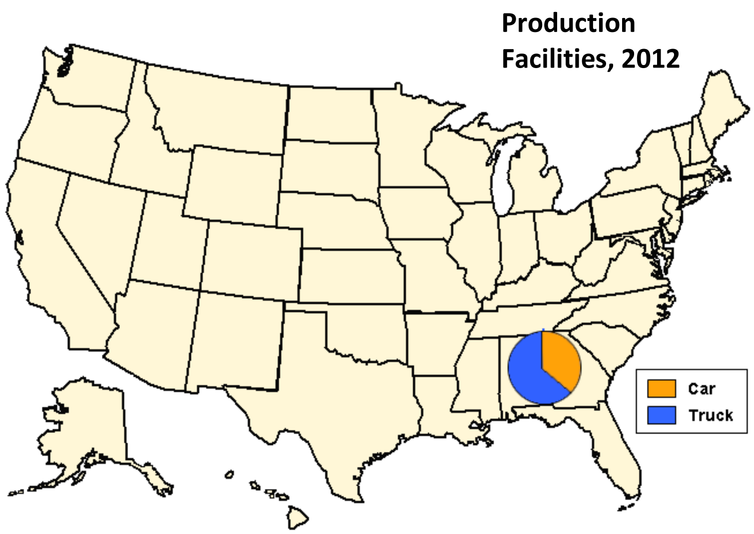
TABLE 16. Hyundai Interrelationships with Other Manufacturers

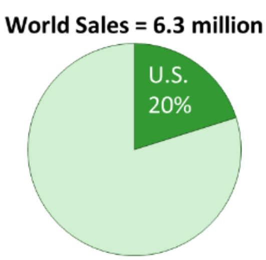
Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
Beijing Automotive		✓				✓	Car building joint venture
Chrysler				✓			Sells Hyundai Atos in Mexico as a Dodge
Kia			✓		✓		Share vehicle platforms, components and some R&D resources
Kia	✓						Partial ownership by Hyundai Motor & Hyundai Capital
Kia						✓	Builds the Hyundai Santa Fe

Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

Kia Company Profile

Corporate Average Fuel Economy, MY 2013	
Domestic Cars	None
Import Cars	N/A
Light Trucks	N/A
Corporate Average Fuel Economy, MY 2013	
Cars	45.8 sq ft
Light Trucks	46.0 sq ft
All	45.8 sq ft
Number of Alternative Fuel Models, MY 2013	
Flex Fuel	0
Natural Gas	0
Propane	0
Hybrid-Electric	1
Plug-In Hybrid-Electric	0
Electric	0





Kia Plants	Type	2012 Production
West Point, GA	Truck	229,663
West Point, GA	Car	128,536

Note: World sales figure includes Hyundai. All other data on the page are Kia only. Kia vehicles assembled in Georgia do not meet CAFE criteria for domestic vehicles due to the low percentage of domestic content. CAFE data for Kia was not final at time of publication.

FIGURE 45. Kia Company Profile

Fuel Saving Technologies

At the 2014 Chicago Auto Show, Kia unveiled the 2015 Soul EV, scheduled to go on sale in the second half of 2014. The Soul EV will be Kia's first all-electric vehicle sold in the U.S. and is expected to have a range of 80 to 100 miles. Sales will begin in California, Oregon, and a few Eastern states with growing EV sales; nationwide sales may follow as demand dictates. Kia's only other electrified model is the Optima hybrid, which is a full hybrid model offered since the 2011 model year. Other future hybrid models are under development.

There are a number of other approaches that Kia is taking to increase fuel economy including weight reduction, aerodynamics and "Idle Stop & Go" or ISG. This is a simple system that reduces unnecessary idle time by shutting down the engine when a vehicle comes to a stop and then automatically restarting it when the break is released. Kia estimates that ISG reduces fuel consumption by 10 to 15% in city driving and is offering it on several models including the Rio and Soul.

Like other manufacturers, Kia has embraced Gasoline Direct Injection (GDI) for maximizing engine performance and fuel economy. Other notable technologies for improved fuel economy include Kia's Active Eco System that proactively controls the engine, transmission, and air conditioning system for maximum efficiency, improving fuel economy by as much as 11%. Kia's Advanced Smart Cruise Control improves efficiency by adapting the vehicle speed to that of the vehicle in front to achieve the optimal speed. Kia's Eco Driving Point System rates the efficiency of a driver on a scale from 0 to 8 and if a level of 8 is maintained, a flower begins to grow providing user feedback to encourage more efficient driving behavior.

Kia's Cars All Have Fuel Economy Greater than 25 mpg

Kia has comparatively few models and all have an average MSRP of less than $30,000. About two-thirds of Kia's models have a combined rating of 25 MPG or higher while none of their models are rated below 20 MPG. About one-third of Kia's models and sales come from light trucks which all fall into the fuel economy range of 20-24 MPG.

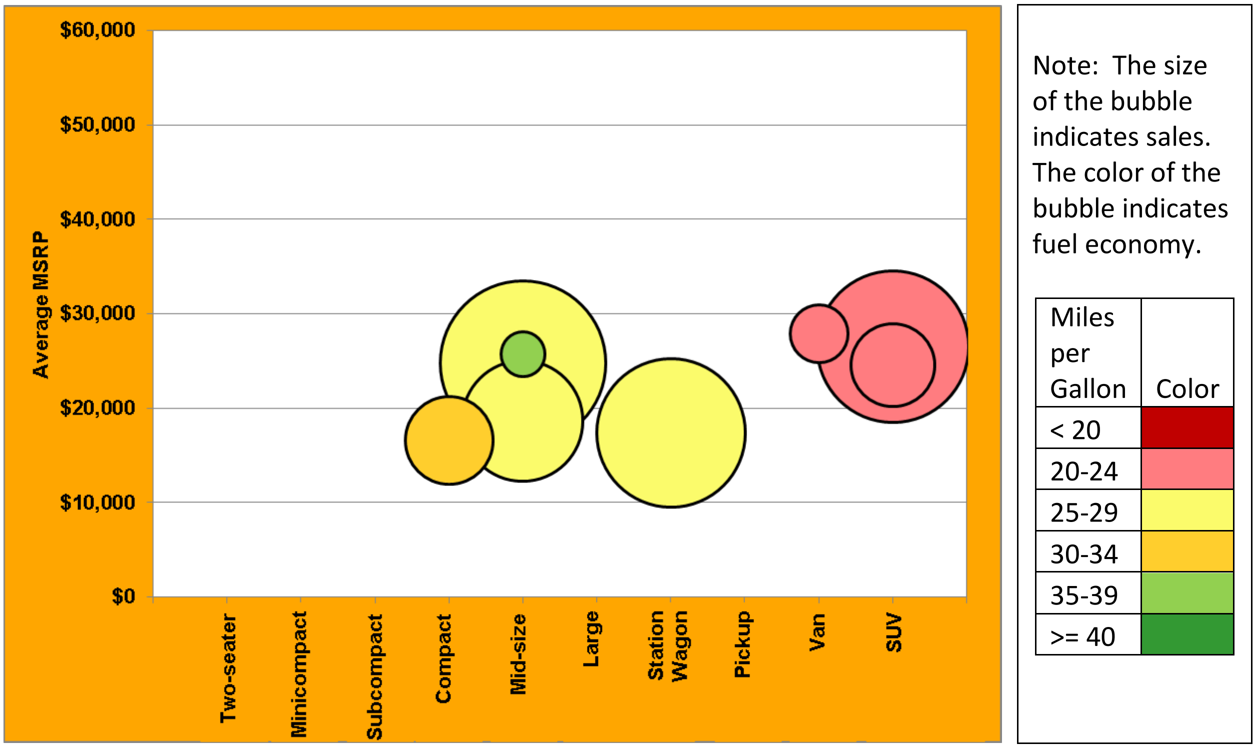


FIGURE 46. Kia Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 17. Kia Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
			Rio	Optima-Hybrid Optima Forte		Soul		Sedona	Sorento Sportage

Kia Optima Hybrid Debuted in 2012

Beginning in 2012, Kia introduced the Optima Hybrid. Sales were about 10,000 units the first year, and grew to nearly 14,000 the next year.

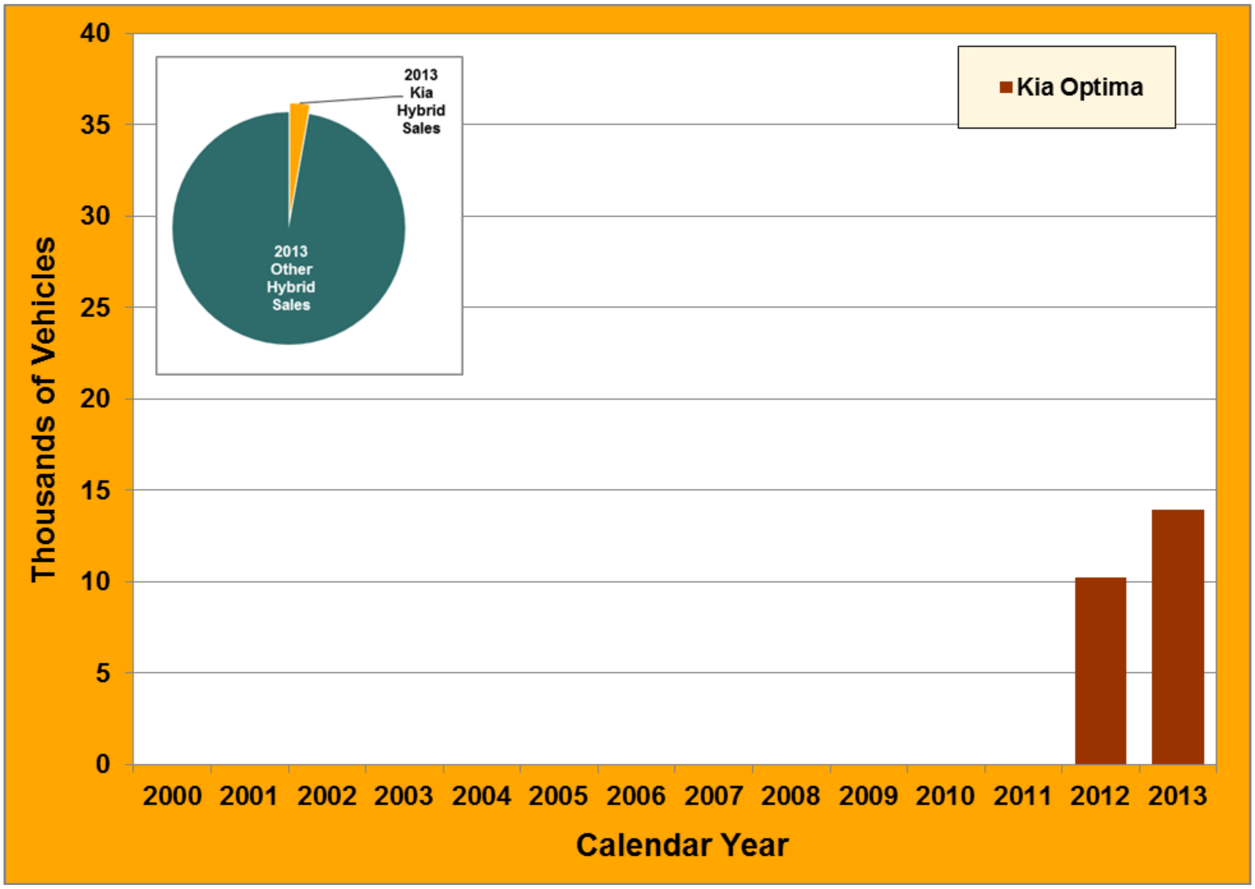


FIGURE 47. Kia Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 36, 40, 44, 48, 52, 56, 64) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Kia Is Owned by Hyundai

TABLE 18. Kia Interrelationships with Other Automotive Manufacturers

Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
Dongfeng		✓				✓	Car-building joint venture in China
Hyundai			✓		✓		Share vehicle platforms, components and some R&D resources
Hyundai	✓						Partial ownership of Kia by Hyundai Motor & Hyundai Capital
Hyundai						✓	Kia builds the Hyundai Santa Fe

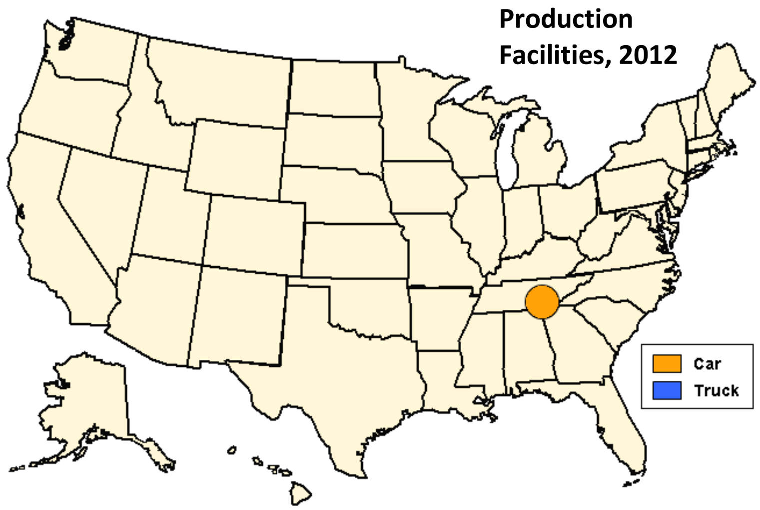
Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

Volkswagen (VW) Company Profile

Corporate Average Fuel Economy, MY 2013	
Domestic Cars	33.3 mpg
Import Cars	33.0 mpg
Light Trucks	25.6 mpg

Average Vehicle Footprint, MY 2013	
Cars	45.5 sq ft
Light Trucks	48.8 sq ft
All	45.9 sq ft

Number of Alternative Fuel Models, MY 2013	
Flex Fuel	6
Natural Gas	0
Propane	0
Hybrid-Electric	3
Plug-In Hybrid-Electric	0
Electric	0



Volkswagen Plants	Type	2012 Production
Chattanooga, TN	Car	152,543

FIGURE 48. VW Company Profile

Fuel Saving Technologies

At the 2013 Los Angeles Auto Show, Volkswagen unveiled the 2015 e-Golf, which is expected to go on sale in the U.S. in selected states by the third quarter of 2014. The e-Golf will be Volkswagen's first all-electric vehicle sold in the U.S. and it is expected to have a range of about 70 to 90 miles. Other all-electric vehicles under development by Volkswagen include the e-Up!, and Audi R8 e-Tron Supercar. Volkswagen has also been developing hybrid systems for passenger vehicles and introduced a gas-electric hybrid Jetta model to the U.S. market in late 2012 as a 2013 model. Following the Jetta hybrid, the Volkswagen Touareg and Audi Q5 became available as hybrids in 2013 as well. Volkswagen is also developing diesel hybrid vehicles to combine the benefits of both diesel and hybrid technologies.

Volkswagen has long been dominant in producing light duty passenger diesel models for the U.S. market and is currently pushing a range of fuel-efficient TDI diesel technologies under the name "BlueMotion". The Volkswagen Jetta uses a self-cleaning diesel emissions filter while the Toureg uses the urea system to control NOx emissions. Volkswagen (including Audi) uses turbo charging and direct injection with both diesel and gasoline engines.

The TSI engines developed by Volkswagen use turbo charging and a supercharger with direct injection which makes it possible to downsize engines while meeting consumer expectations for performance. They are not only more efficient than a traditional port injection engines but also lighter with maximum torque at lower engine speeds. This technology combined with Volkswagen's 7-speed dry dual-clutch automatic transmission offers greater efficiency and uninterrupted torque between the engine and wheels.

VW Has a Variety of Vehicle Types and Vehicle Prices

VW is the parent company of several upscale and luxury brands, so the average MSRP distribution of their models is fairly wide. Most of the models sold by VW are cars in the subcompact, compact, and midsize segments. Although there are no models shown with a combined fuel economy above 30 MPG, it must be noted that high-fuel-economy diesel variants of popular models like the Jetta, Golf, and Passat are not shown separately from their conventional gasoline counterparts.

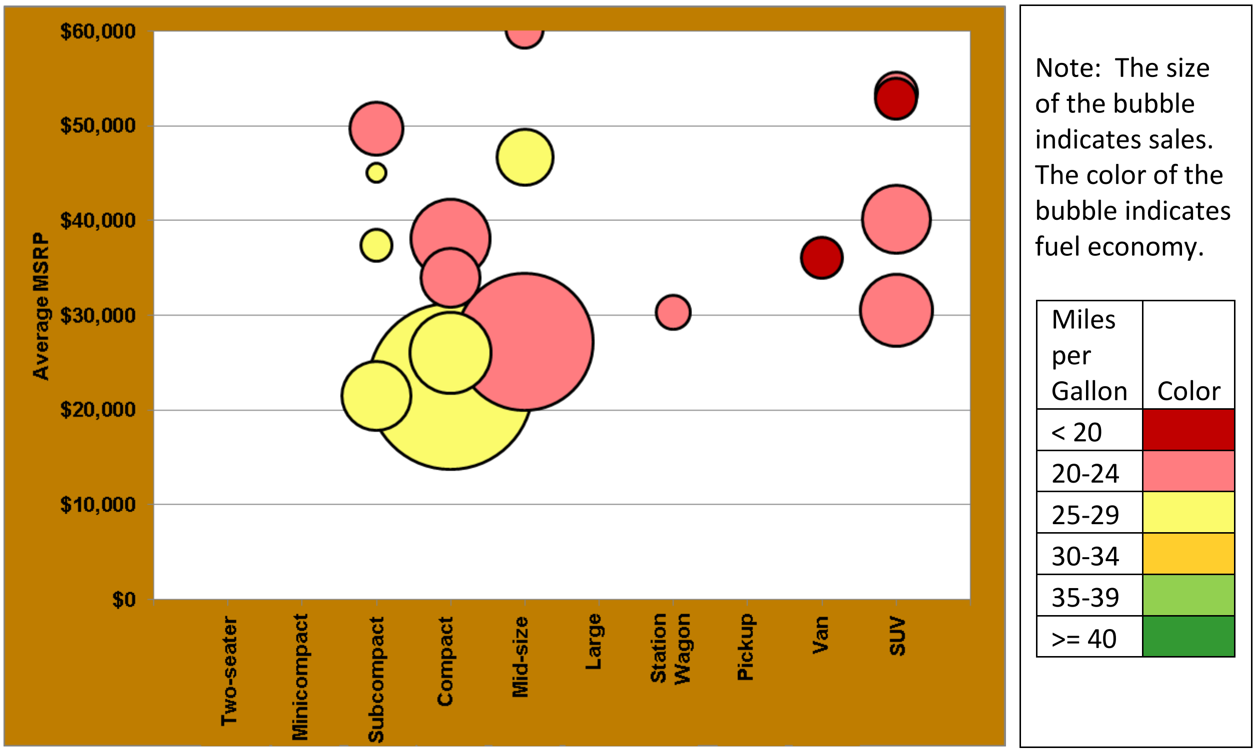


FIGURE 49. VW Sales by Model, MSRP, EPA Size Class, and Fuel Economy, 2012

TABLE 19. VW Models by EPA Size Class, 2012

Two-seater	Mini-compact	Sub-compact	Compact	Mid-size	Large	Station Wagon	Pickup	Van	SUV
R8 Lamborghini		A5/S5 TT Eos Beetle	A4/S4 CC Rabbit/Golf Jetta	A8/S8 A7 A6/S6 Passat	Bentley	A3		Routan	Touareg-Hybrid Q7 Touareg Q5 Tiguan

Note: Models with average MSRP over $60,000 are not shown on the chart above, but are included in the table. Includes VW, Audi, Lamborghini, and Bentley.

VW Has Three Hybrid Models

VW began hybrid sales in 2011 with the VW Touareg Hybrid. By 2012, VW had two additional hybrid models available – the Audi Q5 Hybrid and the VW Jetta Hybrid – with combined sales for all three models less than 1,000 units that year. In 2013, sales for the VW Jetta Hybrid grew substantially to more than 5,000 units.

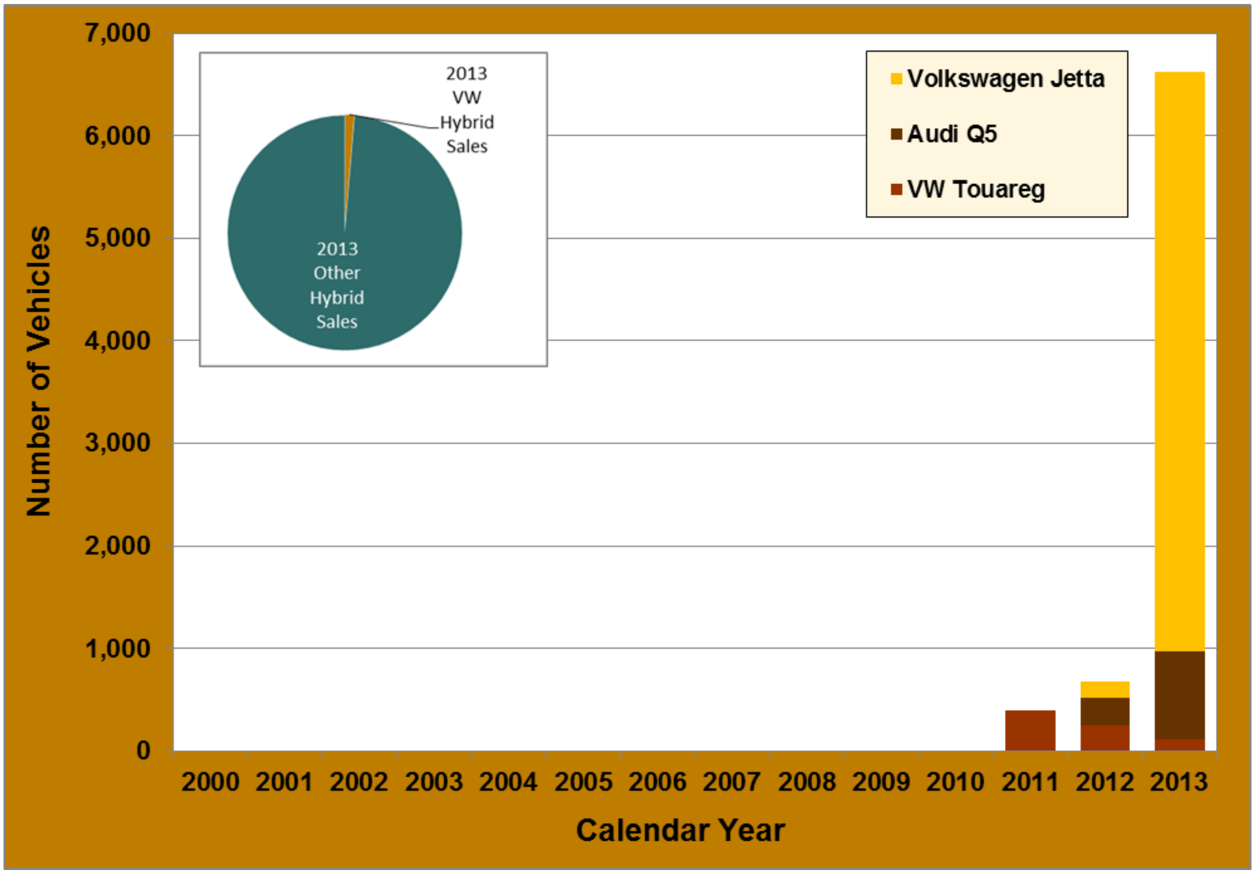


FIGURE 50. VW Hybrid-Electric Vehicle Sales, 2000-2013

Note: Due to the wide variation of hybrid sales among manufacturers, other manufacturers' hybrid sales charts (pp. 32, 36, 40, 44, 48, 52, 56, 60) will have different vertical axis scales.

Source:
Data provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

As One of the Largest Manufacturers in the World, VW has Few Interrelationships

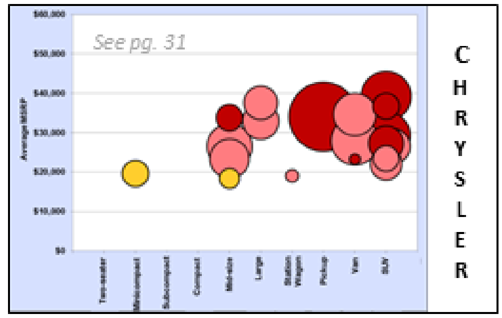
TABLE 20. VW Interrelationships with Other Automotive Manufacturers

Company	Equity Arrangement	Joint Venture	Supplies/ Buys Major Components	Marketing/Distribution Arrangement	Technology/ Design Arrangement	Manufacturing/ Assembly Agreement	Description
BMW, Ford Daimler, GM, Honda, Toyota, VW					✓		Partners in Clean Energy Partnership
Daimler					✓		VW & Mercedes co-designed a commercial vehicle sold as Mercedes Sprinter & VW Crafter
First Auto Works		✓				✓	Joint car-producing venture in Changchun, China
GAZ						✓	VW & Skoda models are produced in Nizhny, Novogorod (Russia)
Shanghai Automotive		✓				✓	Joint venture in Shanghai, China producing Skoda and VW vehicles & engines
Suzuki	✓						VW holds a stake in Suzuki

Source:
Wards AutoInfoBank, *Interrelationships Among the World's Major Auto Makers*, January 2014.

Summary Comparison of Manufacturers' Markets

A comparison of each manufacturers' sales chart shows that GM and Toyota have the most models. Toyota has more fuel efficient models; Hyundai's market is mainly in cars; and Chrysler's market is mainly light trucks.



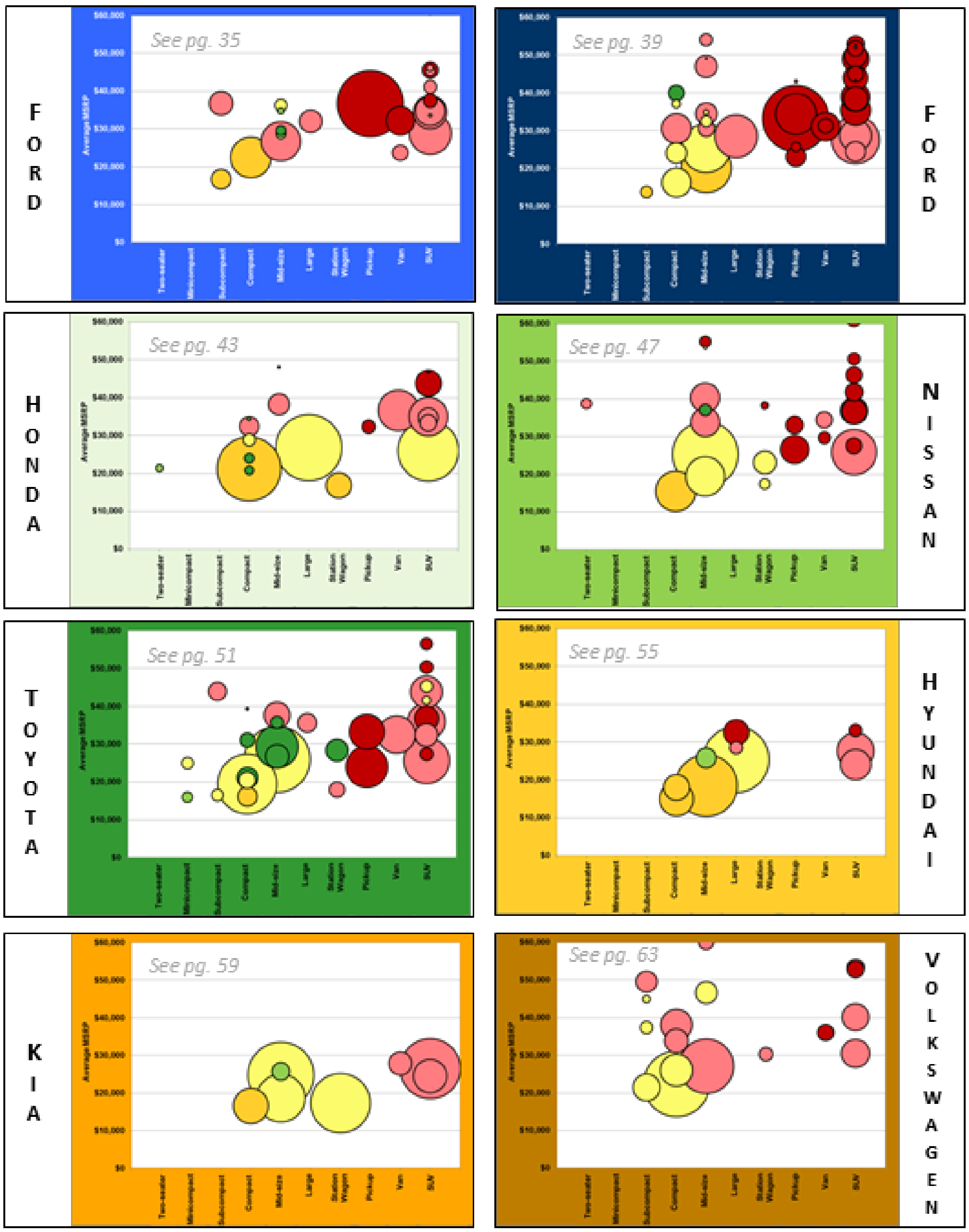


FIGURE 51. Summary Comparison of Manufacturers' Markets, 2012

Top Nine Manufacturers Selling Vehicles in the U.S. Produce Only Half of World's Vehicles

The companies that made 91% of all vehicles produced in the United States in 2012 are together responsible for a little more than half of the vehicles produced worldwide. Volkswagen, which did not produce vehicles in the United States until 2011, held 8% of World production in 2012. Hyundai produced 7% of the World's vehicles and only 5% of U.S. vehicles. Toyota produced 11% in the World as well as 11% in the United States. Many companies, like recent upstarts in China and India, comprise the other 49% of world production. The U.S. produces about 12% of the world's vehicles.

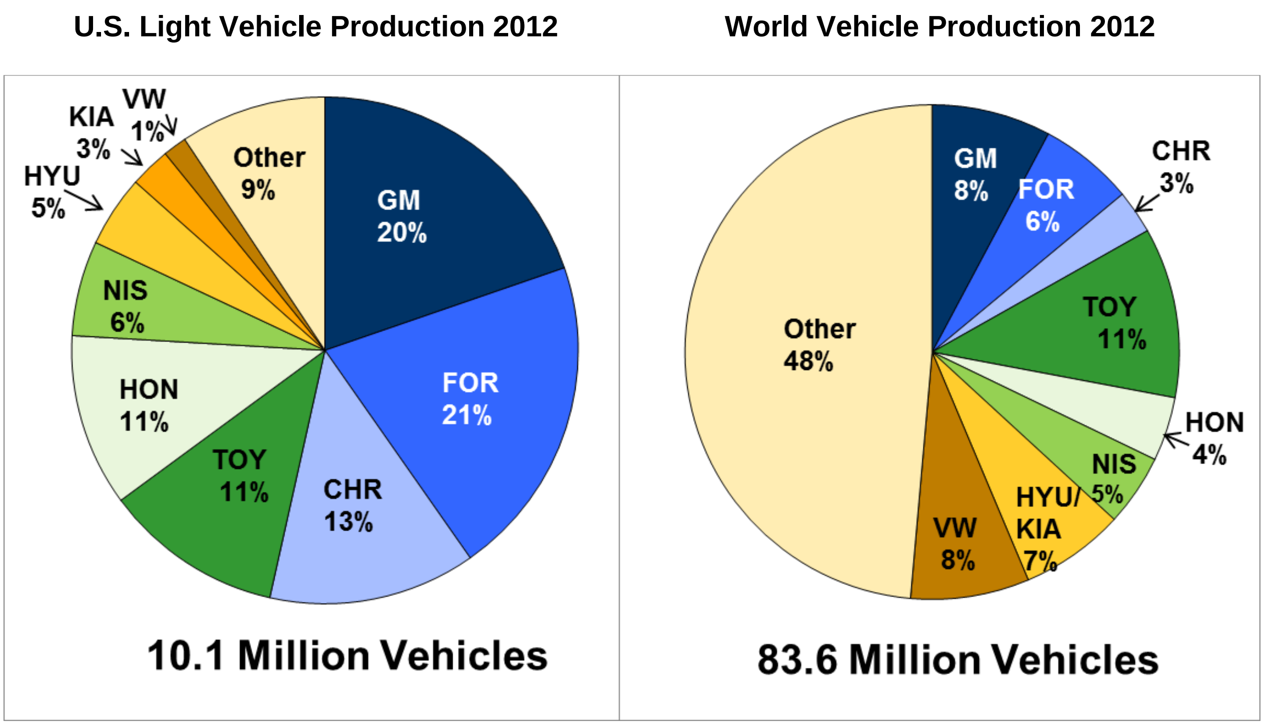


FIGURE 52. Production of U.S. and World Vehicles in 2012 by Manufacturer

Notes: World production includes heavy vehicles, which are a small share of total production. Shanghai AIC, which is included in the "Other" category on the World chart above, is the only other automotive company to hold more than 5% of World production; it had a 5.5% share in 2012.

Source:
Wards AutoInfoBank.

U.S. Sales Volumes Continued to Rise in 2012

Overall sales volumes rose from 2008 to 2012 for both cars and light trucks. Not all manufacturers saw gains though. Car sales from GM, Honda and Toyota declined while truck sales declined for GM and Hyundai. However, all manufacturers sold more in 2012 than the low point in 2009.

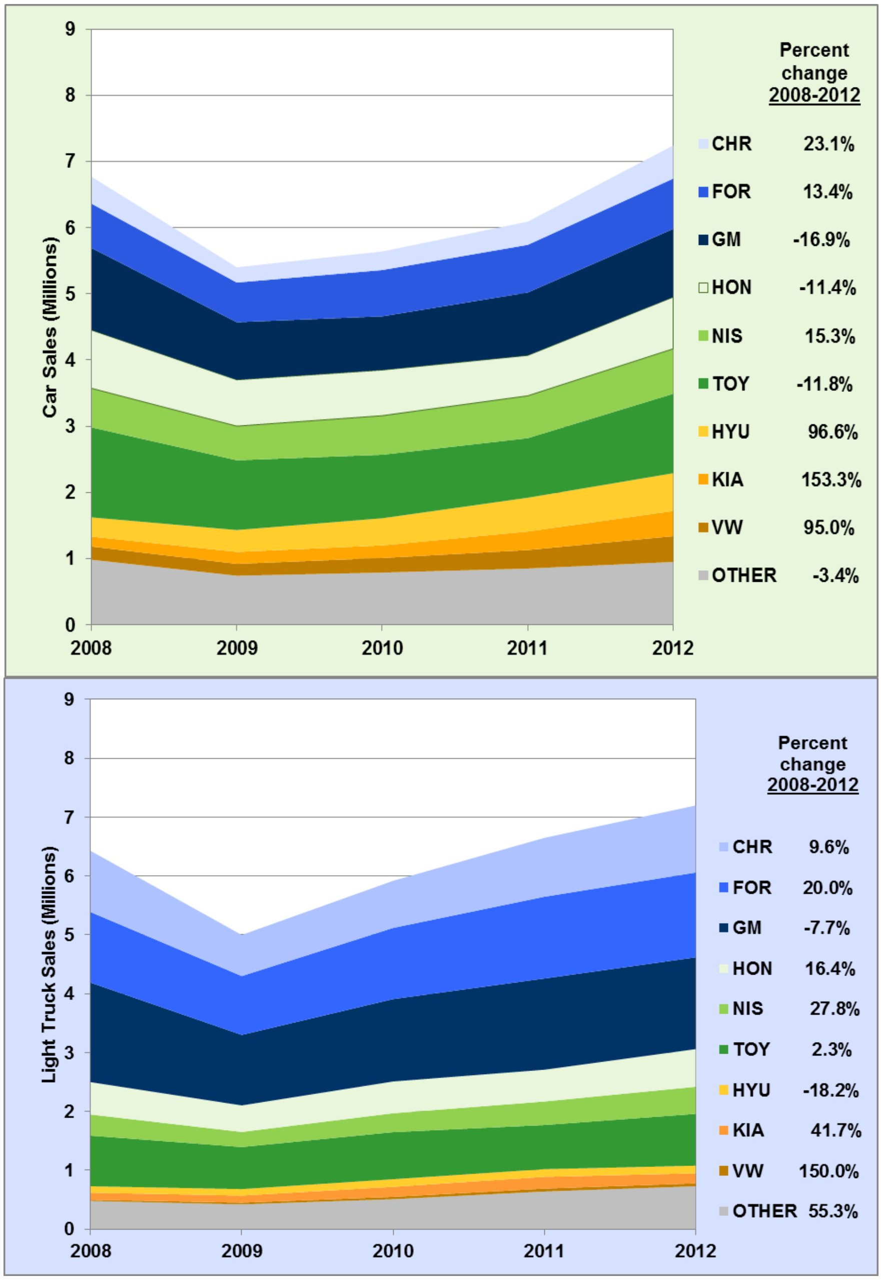


FIGURE 53. New Light Vehicle Sales by Manufacturer, 2008-2012

Source:
Wards AutoInfoBank.

Market Share Shifted Among Manufacturers

Hyundai and Volkswagen nearly doubled their car market share from 2008 to 2012 and Kia more than doubled. Nissan and Ford experienced slight gains in car market share in the five-year period. The three domestic manufacturers accounted for about 60% of the light truck market share in 2008 and 2012.

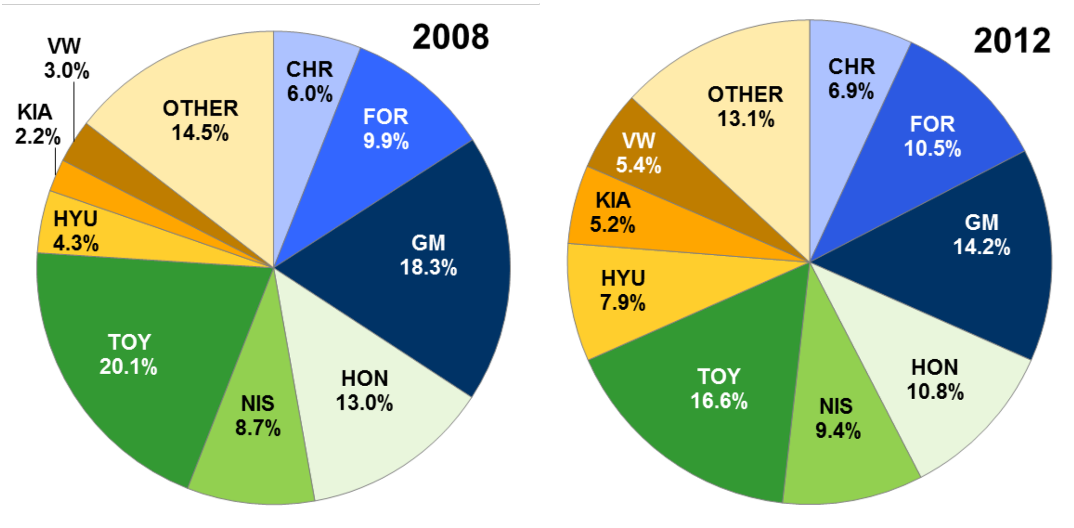


FIGURE 54. New Car Market Share by Manufacturer, 2008 and 2012

Source:
Ward's AutoInfoBank

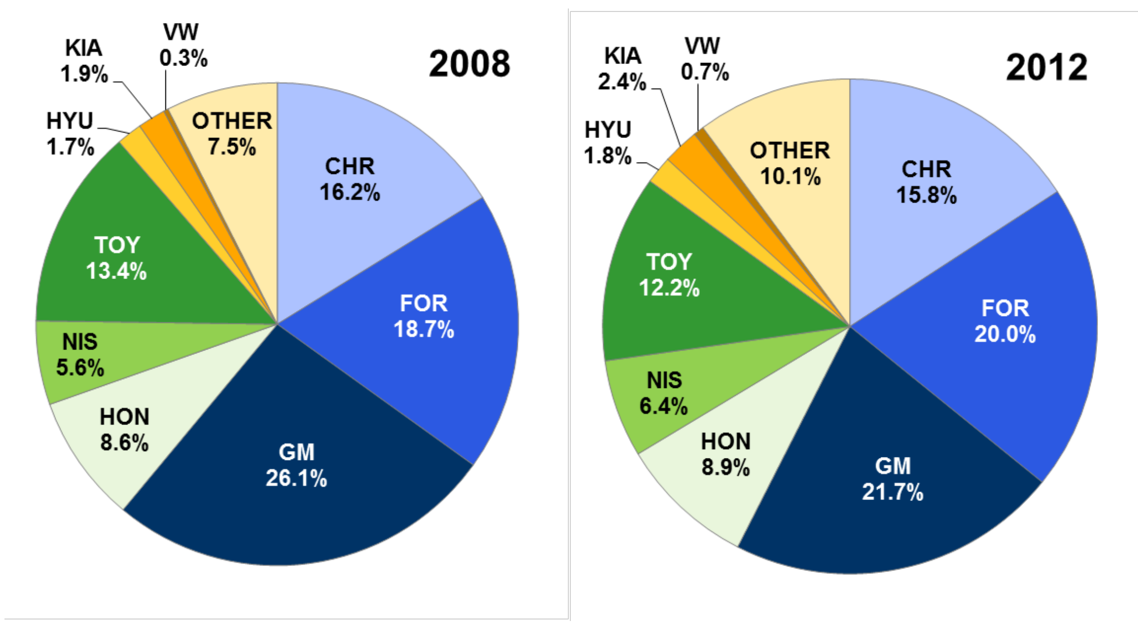


FIGURE 55. New Light Truck Market Share by Manufacturer, 2008 and 2012

Source:
Ward's AutoInfoBank.

Engine Size Has Been Fairly Stable

Average sales-weighted engine size for cars and light trucks did not vary significantly for many of the manufacturers over the past five years, though light trucks showed more variation than cars. In general, Ford, General Motors, and Chrysler have larger engines than the other major manufacturers. Yearly fluctuations are typically a result of the introduction or elimination of a model.

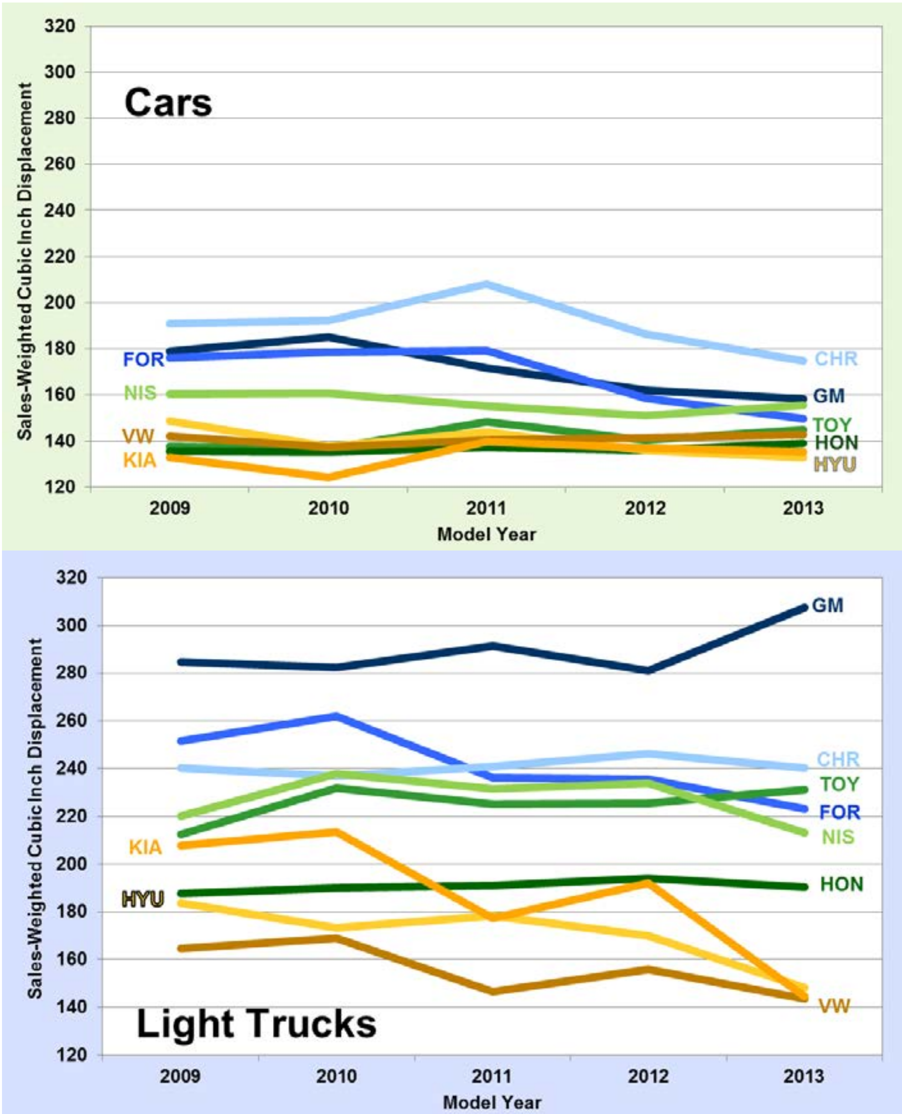


FIGURE 56. Car and Light Truck Engine Size by Manufacturer, 2009-2013

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13- 002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Light Truck Horsepower Is Up in 2013

Advancements in engine design and overall engine technology can increase horsepower without increasing the engine size. Chrysler, General Motors, and Ford, which produce the most trucks, have increased average sales-weighted horsepower in 2013 model year light trucks. Nissan and Volkswagen had a slight decline in light truck horsepower between 2009 and 2013. The noticeable drop in Kia's light truck horsepower in 2013 is likely due to the discontinuation of the Sedona minivan. Average horsepower for cars has not significantly changed over the five-year time period.

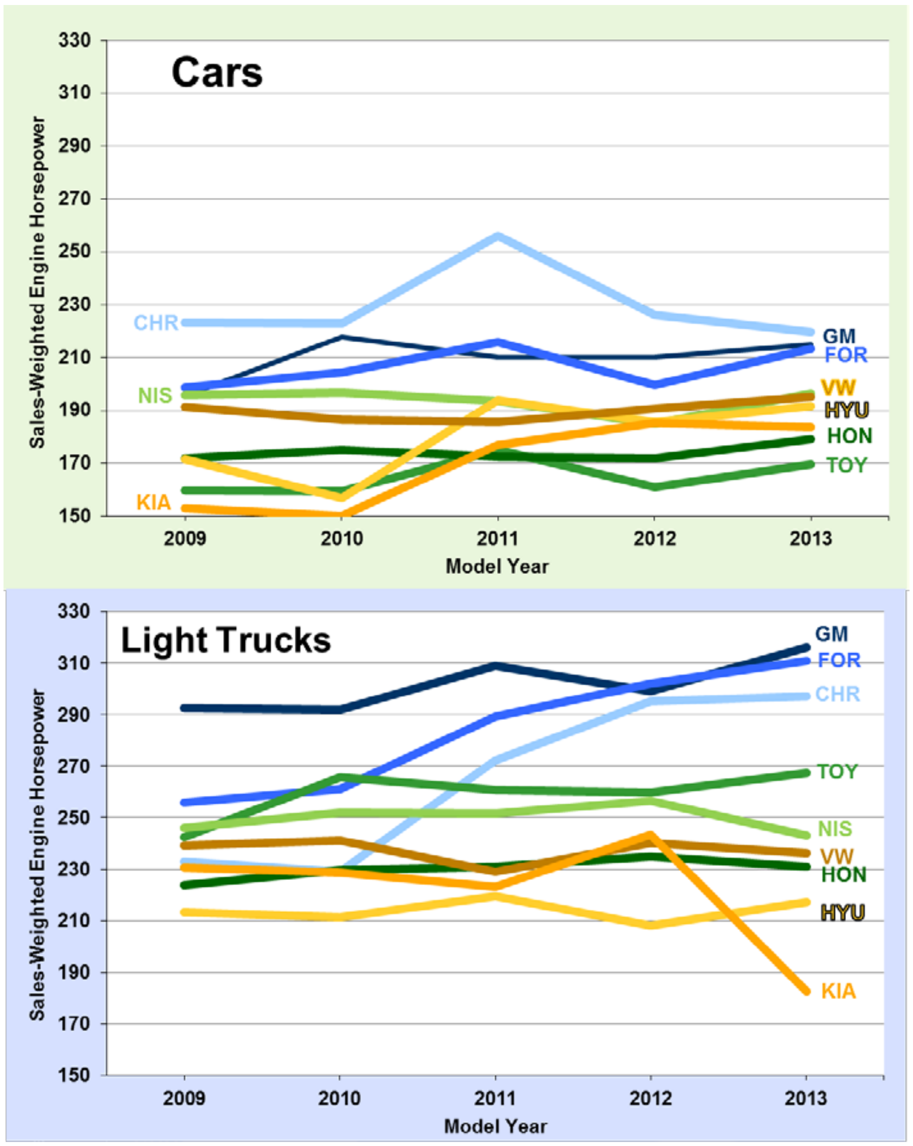


FIGURE 57. Car and Light Truck Horsepower by Manufacturer, 2009-2013

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Technology Has Improved Performance More Than Fuel Economy

Despite a 121% increase in horsepower and 35% decrease in 0-60 time from 1980 to 2013, the fuel economy of vehicles improved 25%. All of these data series are sales-weighted averages. The weight of the vehicle appears to have an inverse relationship with fuel economy.

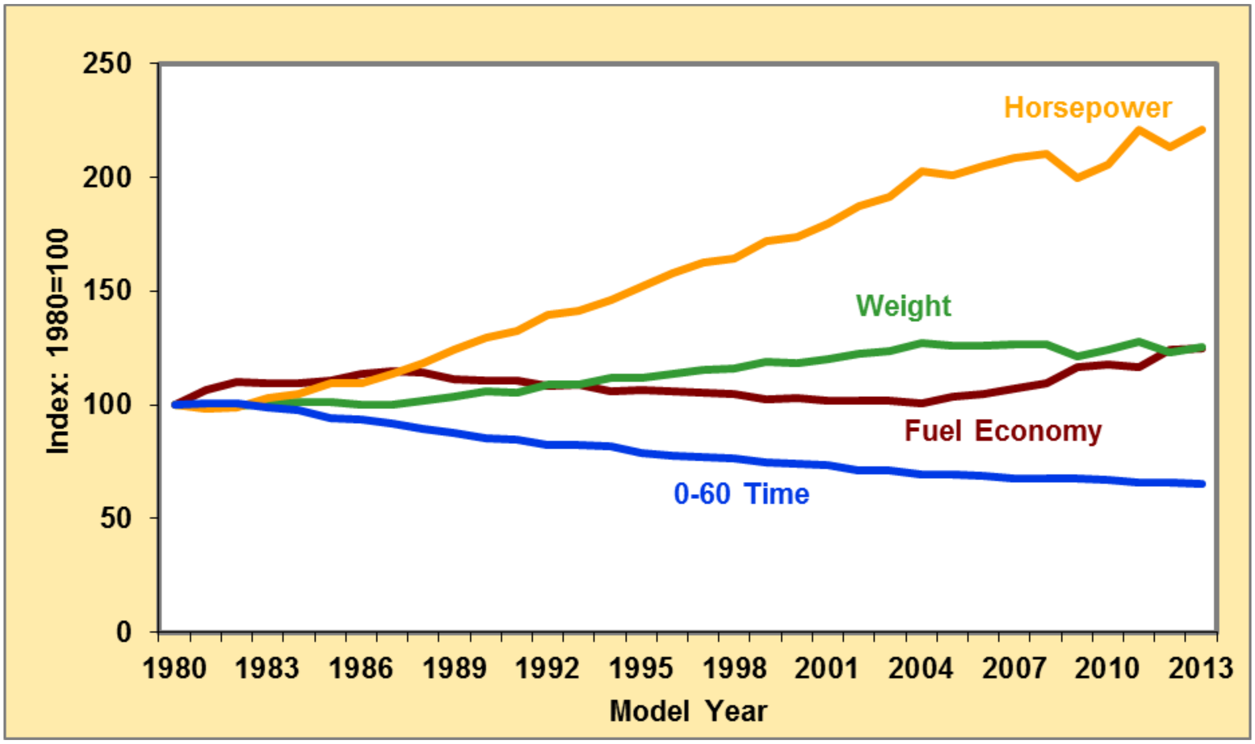
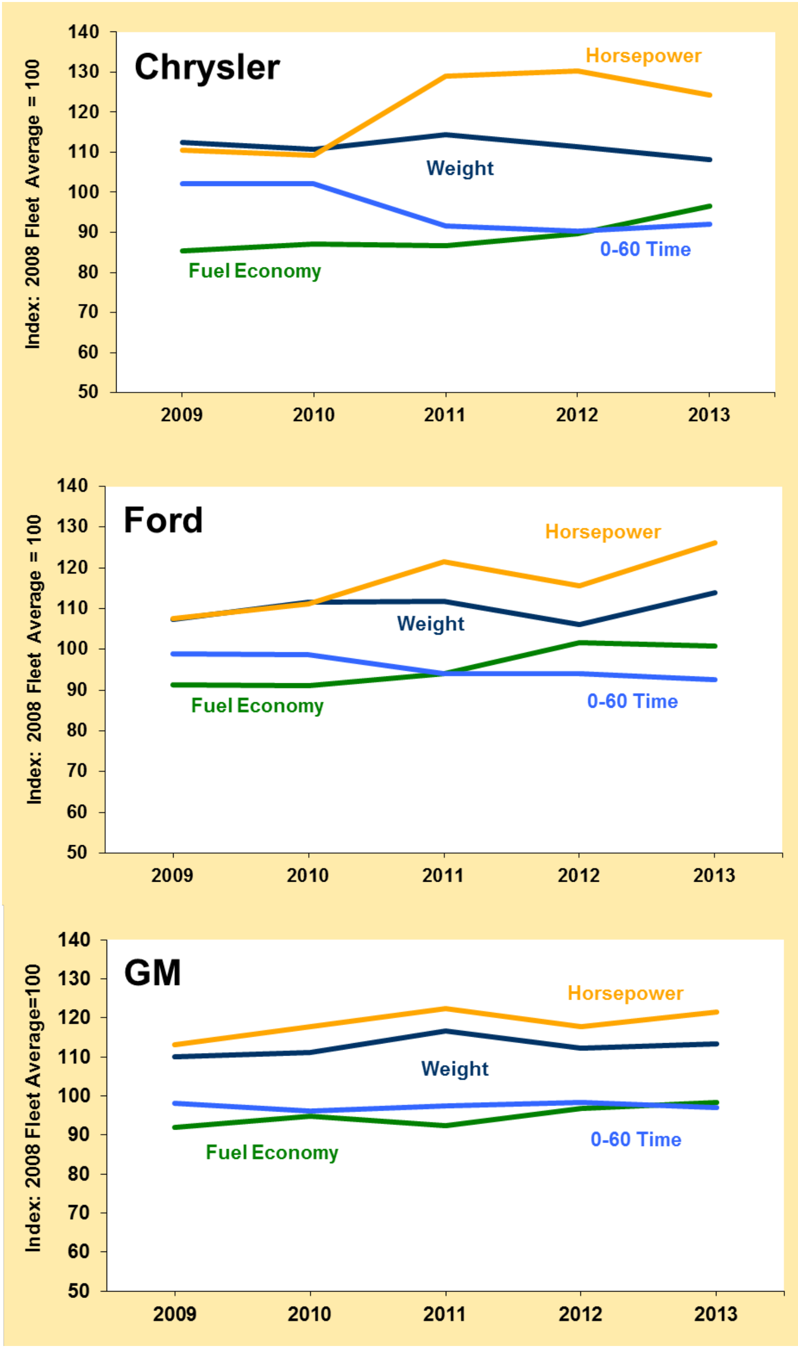


FIGURE 58. Characteristics of Light Vehicles Sold, 1980-2013

Note: Data are sales-weighted.

Source:
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Horsepower Above Fleet Average and Fuel Economy Near Fleet Average for Detroit 3 Manufacturers



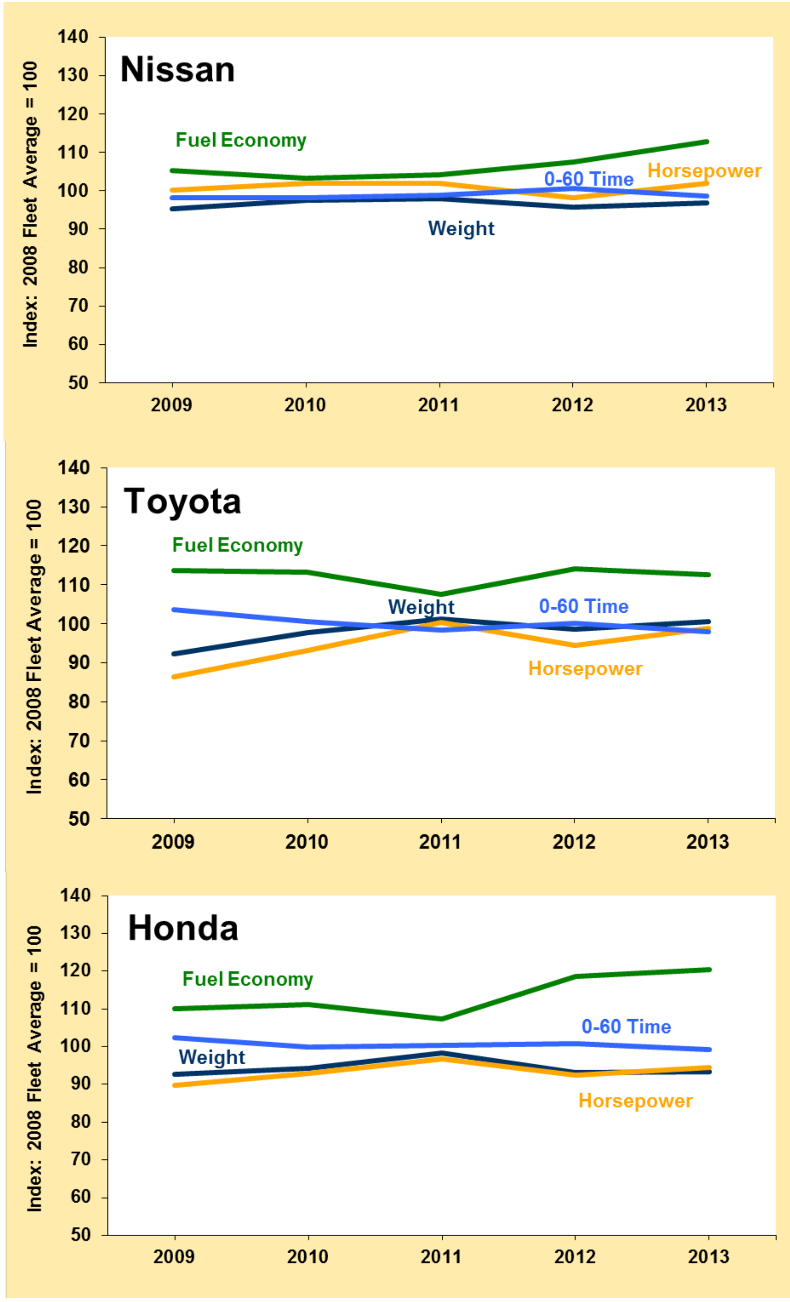
These sales-weighted averages show that all of the Detroit 3 manufacturers have increased the horsepower and decreased the 0-60 times of the light vehicles they sell. Vehicle weight for all three has fluctuated slightly up and down as they try to use more lightweight materials while adding additional features on the vehicles. Chrysler made the biggest improvement in fuel economy over the five year period – a 13% improvement from 2009 to 2013. In the same time frame, Ford had a 10% and General Motors (GM) a 7% improvement. Fuel economy in 2013 was below the fleet average (below 100 on the graph) for all three manufacturers.

FIGURE 59. Characteristics of Detroit 3 Light Vehicles Sold, 2009-2013

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Fuel Economy Above Fleet Average and Weight Below or Equal to Fleet Average for Toyota, Honda and Nissan



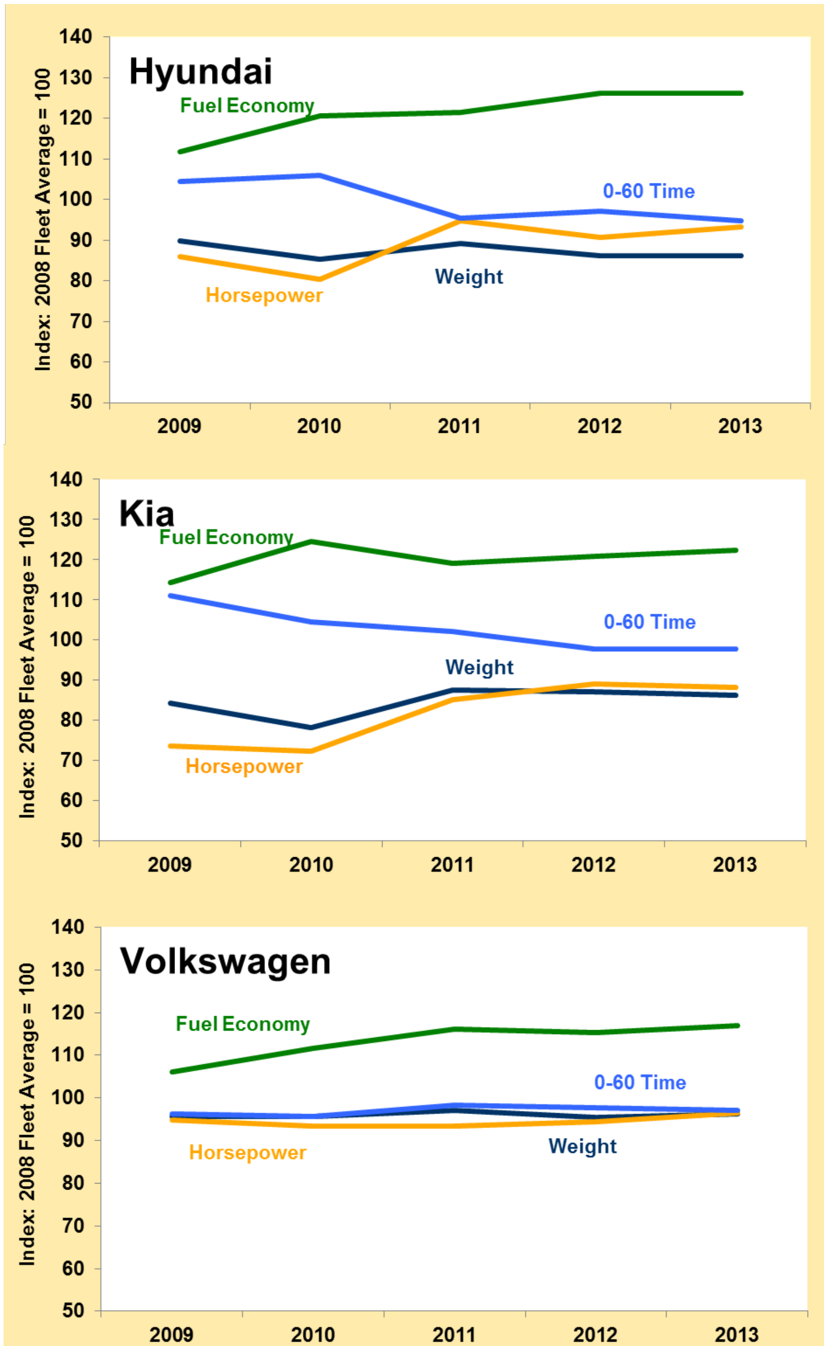
These sales-weighted averages show that the fuel economy of Toyota, Honda and Nissan has been equal to or above the fleet average (above 100 on the graph) over the last five years. Honda had the greatest fuel economy improvement of the three Japanese manufacturers – 10% over the five year period – followed by Nissan with 7% improvement. While Toyota's fuel economy remained relatively flat, their horsepower increased by 14% in this period. Weight for all three manufacturers was equal to or below fleet average.

FIGURE 60. Characteristics of Japanese Light Vehicles Sold, 2009-2013

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Fuel Economy Above Fleet Average and Horsepower Below Fleet Average for Hyundai, Kia and Volkswagen



These sales-weighted averages show that Hyundai, Kia and Volkswagen have greatly improved fuel economy since 2009. The fuel economy for all three companies' light vehicles in 2009 was higher than the fleet average (higher than 100 on the graph). Hyundai decreased 0-60 time by 9% from 2009 to 2013, while horsepower increased by 8%. Kia decreased 0-60 time over the period while also decreasing horsepower. Horsepower and weight were below the fleet averages for all three manufacturers.

FIGURE 61. Characteristics of Light Vehicles Sold by Other Large Manufacturers, 2009-2013

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Nearly 17% of Cars Sold Have Continuously Variable Transmissions

Continuously variable transmissions (CVT) offer an infinite number of gear ratios that allow the engine to operate at peak efficiency throughout the entire range of vehicle speeds which improves fuel efficiency. Though CVT technology has been around for many years, the sales of vehicles with CVTs began slowly and have climbed to 16.8% of car and 9.5% of light truck market share with a total share of 14.2% for all light vehicles. Nissan sold more than half of the cars and the light trucks in 2012 that were equipped with CVT.

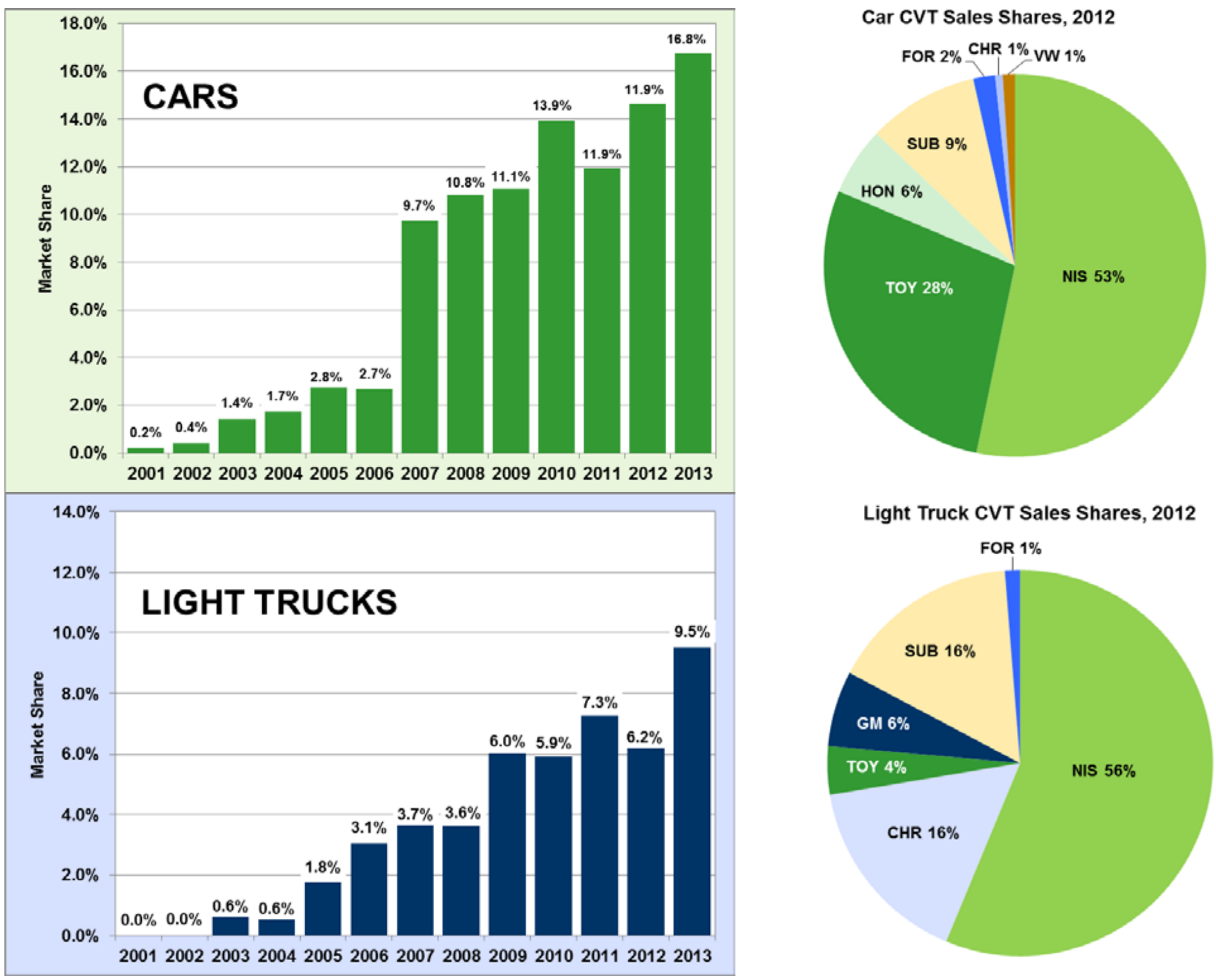


FIGURE 62. CVT Market Share, 2001-2013 and CVT Manufacturer's Share, 2012

Note: SUB = Subaru

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

The Number of Transmission Speeds Has Been Increasing

The number of transmission speeds in new light vehicles has been growing. A greater number of gears improve fuel economy and performance by more closely matching the wheel speed to the optimum engine speed. Four-speed transmissions were the norm for cars and light trucks until the mid-2000's when transmissions of five speeds or more began dominating the market. The market share grew for 6-, 7-, and 8-speed cars and light trucks in 2013. Continuously variable transmissions (CVT) are also making their way into the market.

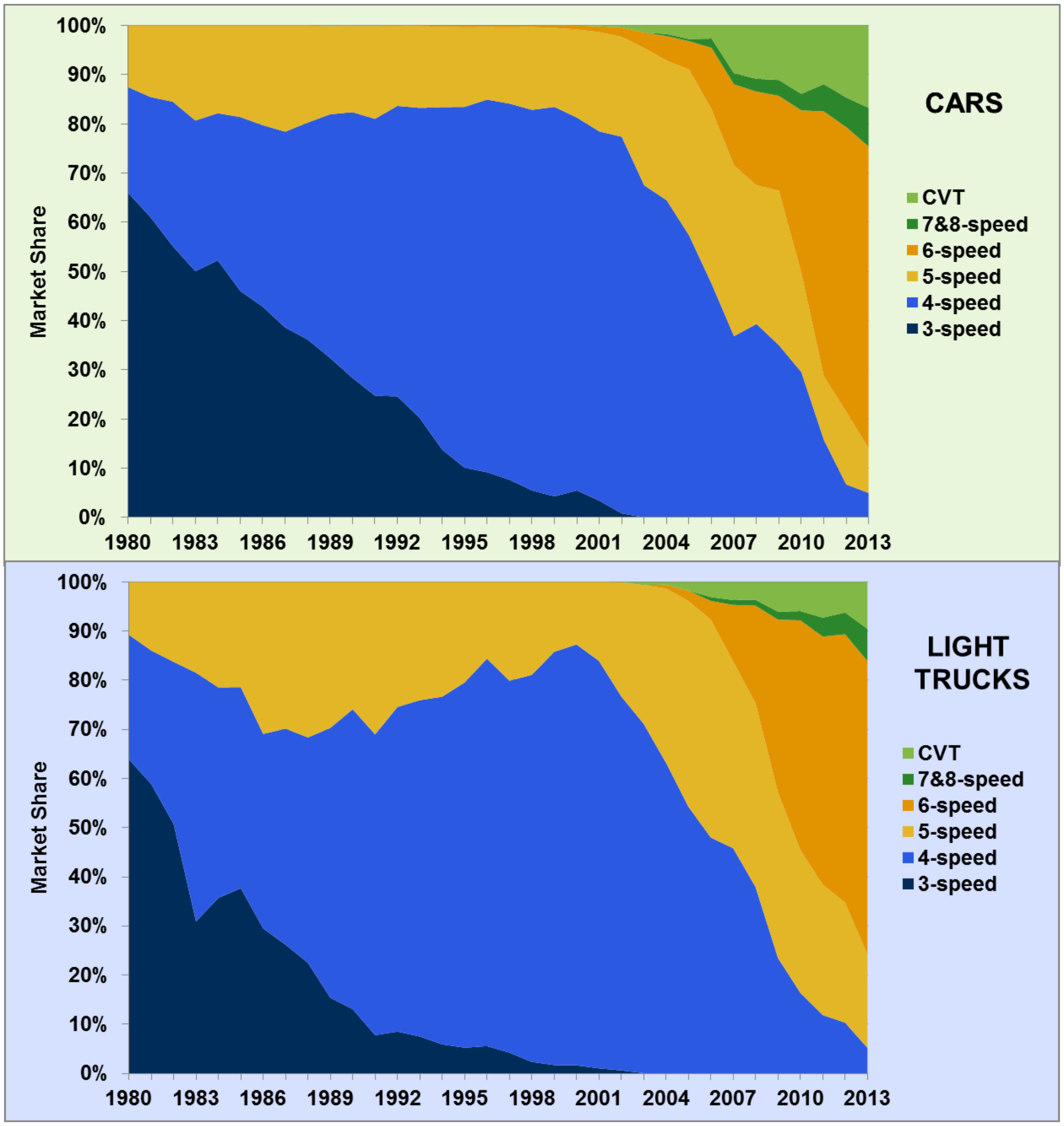


FIGURE 63. Market Share of Transmission Speeds, 1980-2013

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Nearly 40% of Light Vehicles Sold Have Gasoline Direct Injection

Gasoline direct injection (GDI) began market penetration in cars in 2007 and in light trucks in 2008. By 2013, the market share for GDI was 37.8% for cars and 18% for light trucks.

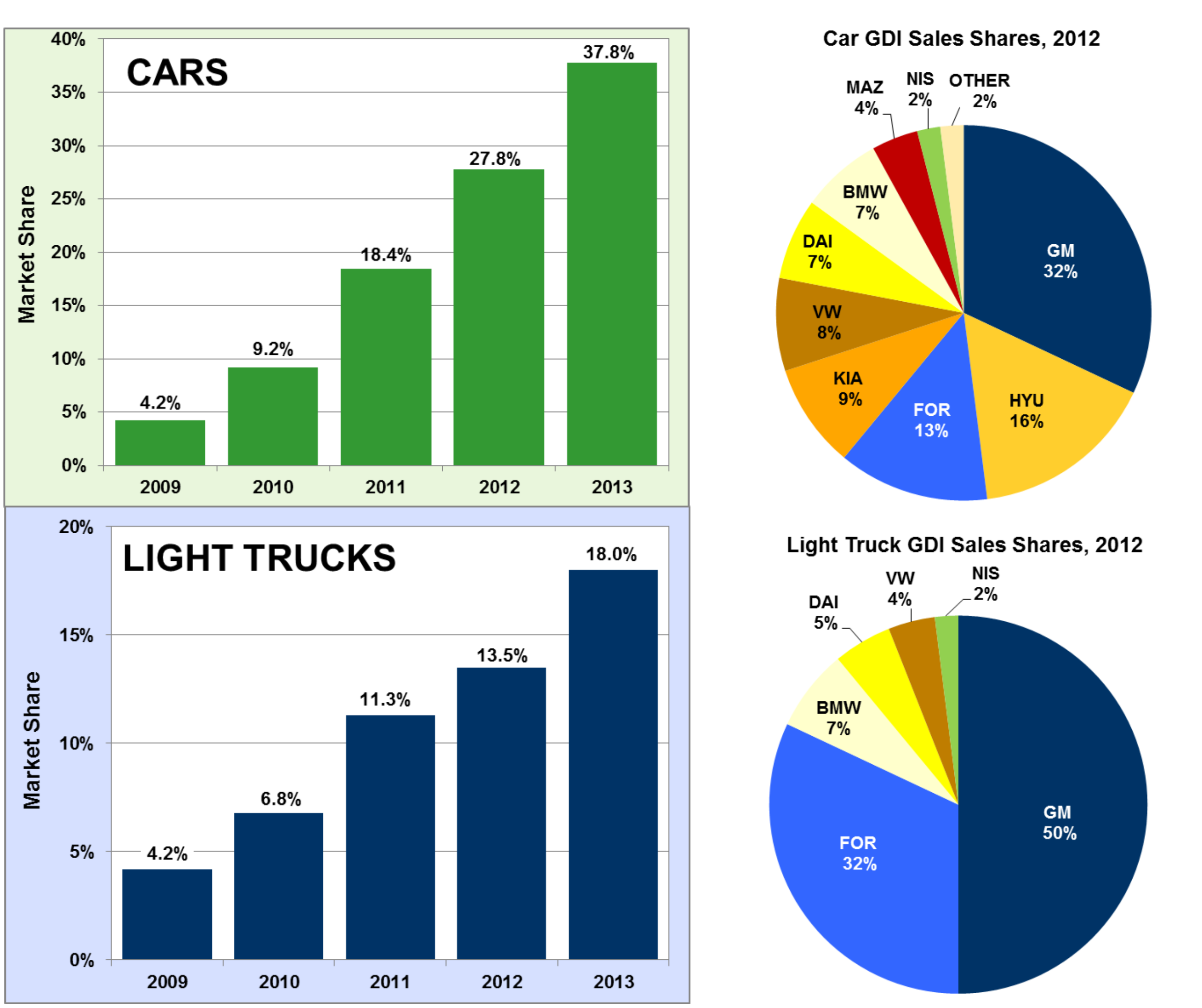


FIGURE 64. GDI Market Share, 2009-2013 and GDI Manufacturer's Share, 2012

Note: Light trucks include pickups, sport utility vehicles, and vans. MAZ = Mazda, DAI = Daimler.

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Number of Light Vehicle Diesel Models Has Increased Since 2000

In the early 1980's gas prices were high, the economy was in a downturn, and the cost of a gallon of diesel fuel was much less than that of a gallon of gasoline. Many manufacturers at that time produced diesel cars and light trucks. In model year (MY) 1984, there were 101 different models of light vehicles with diesel engines, including many common models like the Chevrolet Chevette, Ford Escort, Buick Regal, and Toyota Camry. Diesel engines in light vehicles, however, were not widely embraced by American consumers, with many finding them noisy, dirty, and hard to start in cold weather. By MY 2000, Volkswagen was the only manufacturer selling diesel light vehicles. Recently, advanced diesel technologies, combined with a nationwide switch to ultra-low-sulfur diesel fuel, have given light vehicle manufacturers new impetus to invest in diesel models. In MY 2013, four different manufacturers has 15 light vehicle models for sale with clean diesel engines that meet current emission standards.

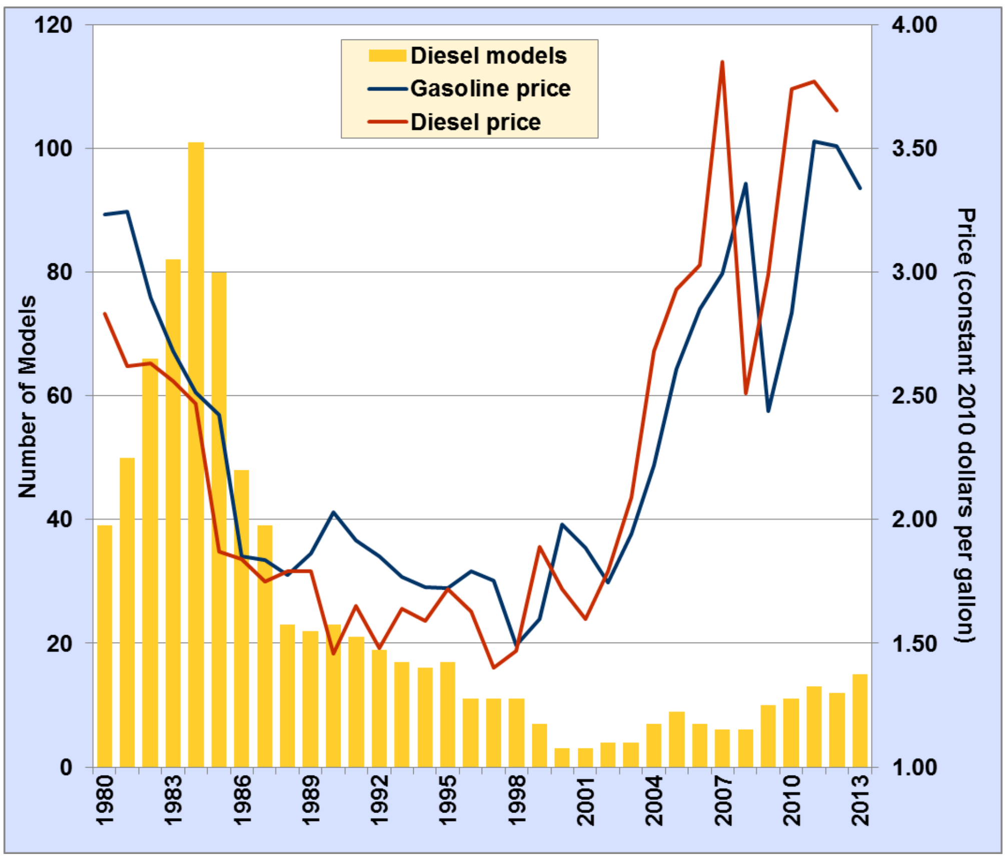


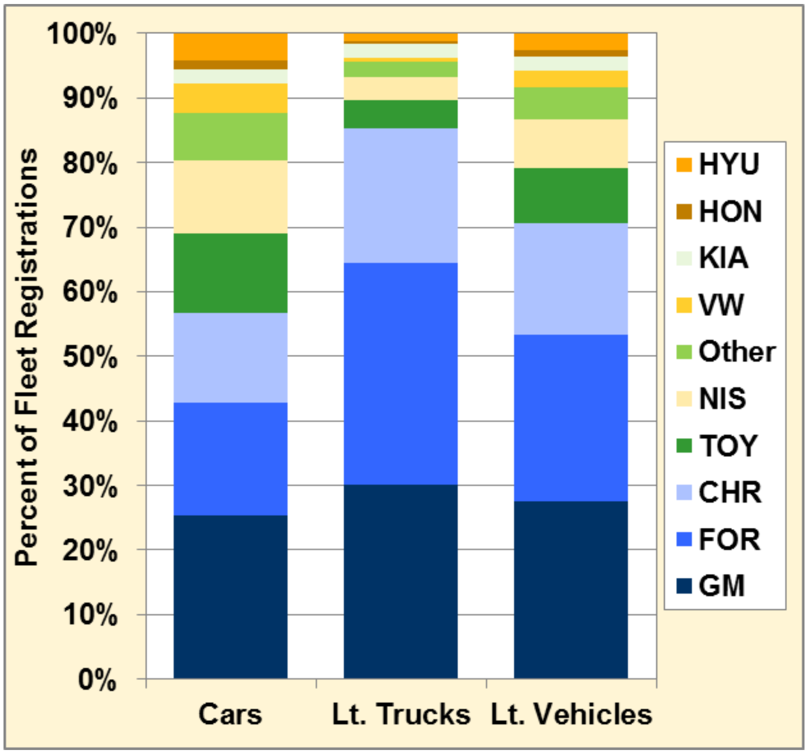
FIGURE 65. Number of Diesel Models and the Price of a Gallon of Gasoline and Diesel, 1980-2013

Sources:

U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy Guide website, October 2013. http://www.fueleconomy.gov

Energy Information Administration, "Petroleum and Other Liquids Data Tool." http://www.eia.gov/petroleum

Detroit 3 Dominate New Fleet Registrations in 2012



Ford, General Motors, and Chrysler together accounted for 57% of new fleet car registrations and 85% of the new fleet light truck registrations in 2012. New registrations are often used as a proxy for sales. Of the top nine manufacturers, Honda had the smallest share of new fleet registrations and Ford had the largest share.

Though Ford and General Motors had more new fleet registrations in 2012 than Chrysler, Chrysler had the largest proportion of fleet vehicles vs. total – total being the sum of fleet vehicles and retail vehicles. Over 36% of the new Chrysler cars registered in 2012 were registered to fleets. Honda had only 1.6% of total new vehicles registered to fleets.

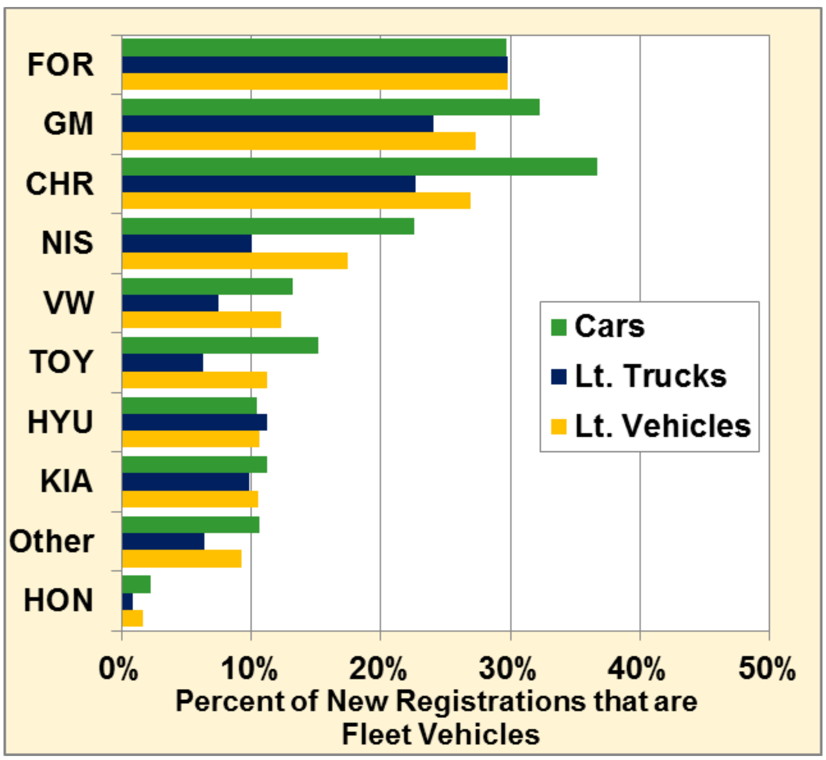


FIGURE 66. New Fleet Registration Data by Manufacturer, 2012

Source:

Bobit Publishing Company, *Automotive Fleet Factbook 2013*. http://www.automotive-fleet.com/statistics

Chevrolet Impala Was the Top New Fleet Car in 2012

The Chevrolet Impala topped the list of new cars which were registered to fleets in 2012. New registrations are often used as a proxy for sales. Over 78% of the new Impalas registered in 2012 were fleet vehicles, most of them in rental fleets. The Dodge Charger was the top model for government fleets, likely due to law enforcement. The Ford Fusion was the model with the most new registrations in commercial fleets, possibly due to the high fuel economy of the Fusion.

TABLE 21. Top 25 New Registrations of Cars in Fleets in 2012

Make	Model	Commercial	Government	Rental	Total Fleet	Total Retail	Total	% Fleet vs Total
Chevrolet	Impala	13,356	8,365	115,880	137,601	38,104	175,705	78.3%
Chevrolet	Malibu	10,579	5,176	63,403	79,158	133,069	212,227	37.3%
Nissan	Altima	7,205	117	69,011	76,333	221,437	297,770	25.6%
Ford	Fusion	23,715	3,605	46,197	73,517	157,074	230,591	31.9%
Toyota	Corolla	4,491	206	59,578	64,275	222,429	286,704	22.4%
Ford	Focus	10,873	4,725	48,069	63,667	183,185	246,852	25.8%
Chevrolet	Cruze	2,233	416	58,487	61,136	174,108	235,244	26.0%
Toyota	Camry	4,155	281	52,768	57,204	298,996	356,200	16.1%
Dodge	Avenger	1,067	872	53,304	55,243	40,714	95,957	57.6%
Chrysler	200	2,428	305	44,019	46,752	78,012	124,764	37.5%
Ford	Taurus	16,125	7,871	20,534	44,530	36,167	80,697	55.2%
Dodge	Charger	10,963	10,109	19,311	40,383	48,055	88,438	45.7%
Nissan	Versa	5,248	287	27,876	33,411	78,072	111,483	30.0%
Chrysler	300	901	115	26,728	27,744	40,803	68,547	40.5%
Volkswagen	Jetta	1,380	48	24,273	25,701	137,611	163,312	15.7%
Mazda	3	301	35	22,495	22,831	98,921	121,752	18.8%
Hyundai	Elantra Sedan	1,270	404	19,260	20,934	146,970	167,904	12.5%
Hyundai	Sonata	1,198	45	19,442	20,685	188,258	208,943	9.9%
Volkswagen	Passat	1,748	57	18,571	20,376	88,183	108,559	18.8%
Ford	Mustang	385	38	19,295	19,718	62,051	81,769	24.1%
Nissan	Sentra	1,246	20	17,349	18,615	87,079	105,694	17.6%
Toyota	Yaris	347	9	16,268	16,624	14,070	30,694	54.2%
KIA	Optima	189	18	16,380	16,587	124,200	140,787	11.8%
Mazda	6	159	10	16,165	16,334	15,117	31,451	51.9%
Toyota	Prius	3,666	766	9,144	13,576	135,404	148,980	9.1%

Source:
Bobit Publishing Company, *Automotive Fleet Factbook 2013*. http://www.automotive-fleet.com/statistics

Ford F-Series Was the Top New Fleet Truck in 2012

The Ford F-series topped the list of new light trucks which were registered to fleets in 2012. New registrations are often used as a proxy for sales. Almost 26% percent of the new F-Series trucks registered in 2012 were fleet vehicles, the majority of them in commercial fleets. The F-Series was also the top vehicle model for government fleets. The Dodge Caravan and the Ford Escape were the models with the most new registrations in rental fleets.

TABLE 22. Top 25 New Registrations of Trucks in Fleets in 2012

Make	Model	Commercial	Government	Rental	Total Fleet	Total Retail	Total	% Fleet vs Total
Ford	F-Series	93,108	26,310	41,326	160,744	462,853	623,597	25.8%
Dodge	Caravan	18,708	8,107	64,644	91,459	53,425	144,884	63.1%
Chevrolet	Silverado	50,065	9,929	22,839	82,833	339,745	422,578	19.6%
Ford	Econoline	32,043	7,097	40,555	79,695	26,295	105,990	75.2%
Ford	Escape	22,699	2,275	45,924	70,898	186,808	257,706	27.5%
Chevrolet	Express	26,072	6,547	19,896	52,515	20,746	73,261	71.7%
Ford	Explorer	16,422	8,666	20,403	45,491	125,650	171,141	26.6%
Ram	Truck	19,515	4,922	18,172	42,609	241	283,406	15.0%
Chrysler	Town & Country	558	34	38,672	39,264	71,347	110,611	35.5%
Chevrolet	Captiva	679	45	35,738	36,462	118	36,580	99.7%
Chevrolet	Equinox	11,253	1,393	20,875	33,521	184,431	217,952	15.4%
Chevrolet	Tahoe	11,633	10,141	10,836	32,610	44,054	76,664	42.5%
Ford	Edge	4,955	175	21,237	26,367	101,137	127,504	20.7%
Dodge	Journey	2,750	291	18,105	21,146	57,613	78,759	26.8%
Chevrolet	Suburban	2,425	1,388	16,942	20,755	27,508	48,263	43.0%
Jeep	Liberty	1,825	1,017	17,660	20,502	56,111	76,613	26.8%
Ford	Transit Connect Van	13,311	1,198	3,932	18,441	18,059	36,500	50.5%
Chevrolet	Traverse	2,340	337	15,211	17,888	66,946	84,834	21.1%
Chevrolet	Colorado	9,944	2,838	4,590	17,372	21,224	38,596	45.0%
Toyota	Sienna	5,396	449	10,670	16,515	94,878	111,393	14.8%
GMC	Sierra	11,451	2,703	1,438	15,592	141,247	156,839	9.9%
GMC	Terrain	1,524	150	13,860	15,534	80,388	95,922	16.2%
Jeep	Grand Cherokee	3,198	864	9,959	14,021	140,831	154,852	9.1%
GMC	Savana	3,823	504	8,498	12,825	4,305	17,130	74.9%
Ford	Expedition	3,093	1,866	7,177	12,136	27,187	39,323	30.9%

Source:
Bobit Publishing Company, *Automotive Fleet Factbook 2013*. http://www.automotive-fleet.com/statistics

Fleet Management Companies Remarket Vehicles On-Line

The top ten fleet management companies owned or managed over 3.3 million vehicles in 2013. They remarketed 12% of those vehicles during the year. Remarketing is often done by auctioning the vehicles through established auction houses. However, remarketing vehicles on-line is becoming more common. Twenty-five percent of the vehicles remarketed in 2012 by the top ten fleet management companies were remarketed on-line. Donlan and Emkay remarketed over 80% of their vehicles on-line.

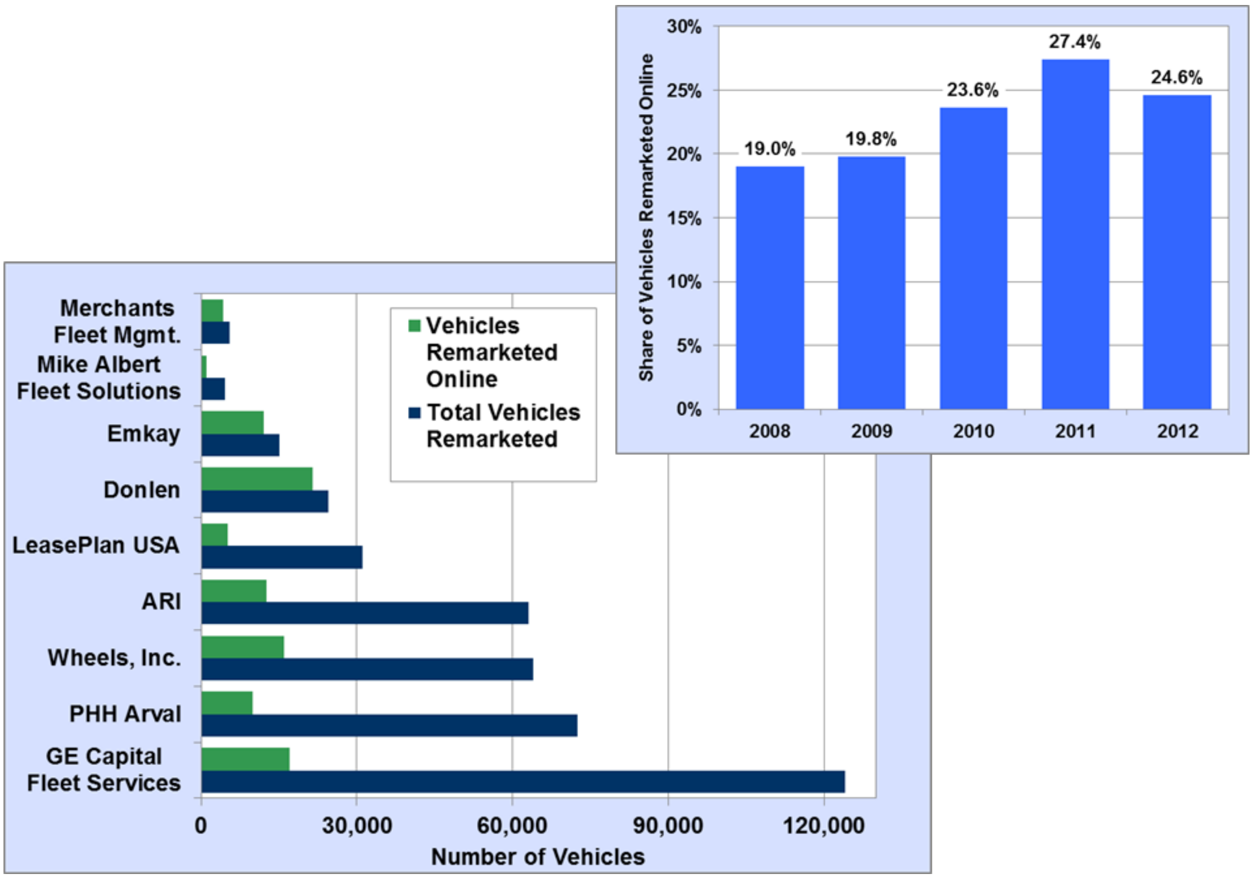
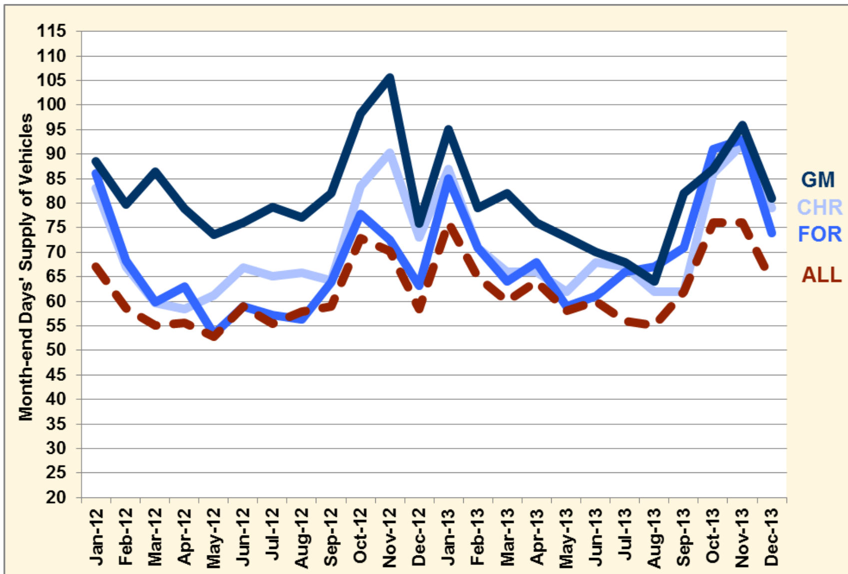


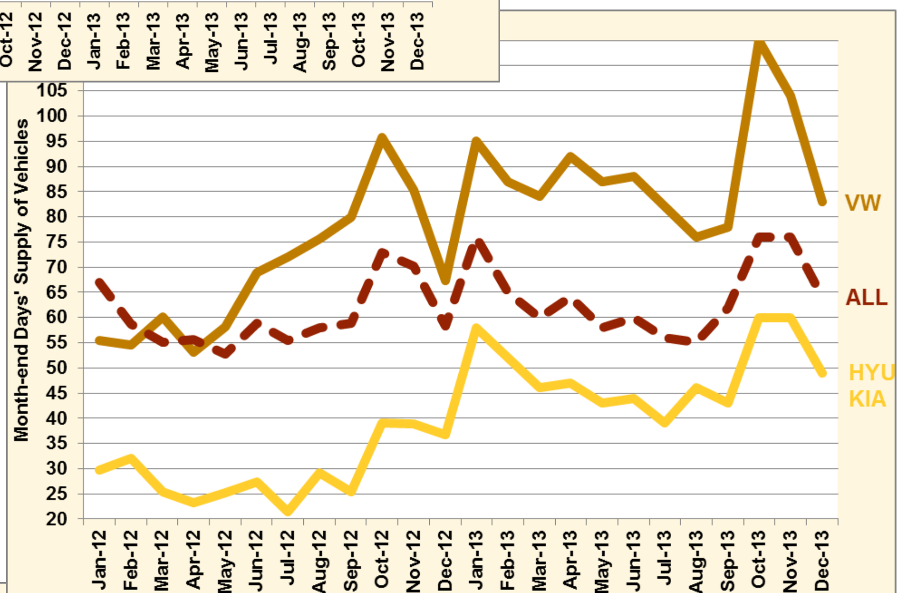
FIGURE 67. Vehicles Remarketed by the Top Ten Fleet Management Companies, 2013, and Share of Vehicles Remarketed On-Line, 2008-2012

Source:
Bobit Publishing Company, *Automotive Fleet Factbook 2013*. http://www.automotive-fleet.com/statistics

Light Vehicle Inventory Supplies Change Rapidly



Light vehicle inventories change quickly throughout the year because they are affected by so many different variables: Dealer or manufacturer financial incentives, economic news, supply disruptions.



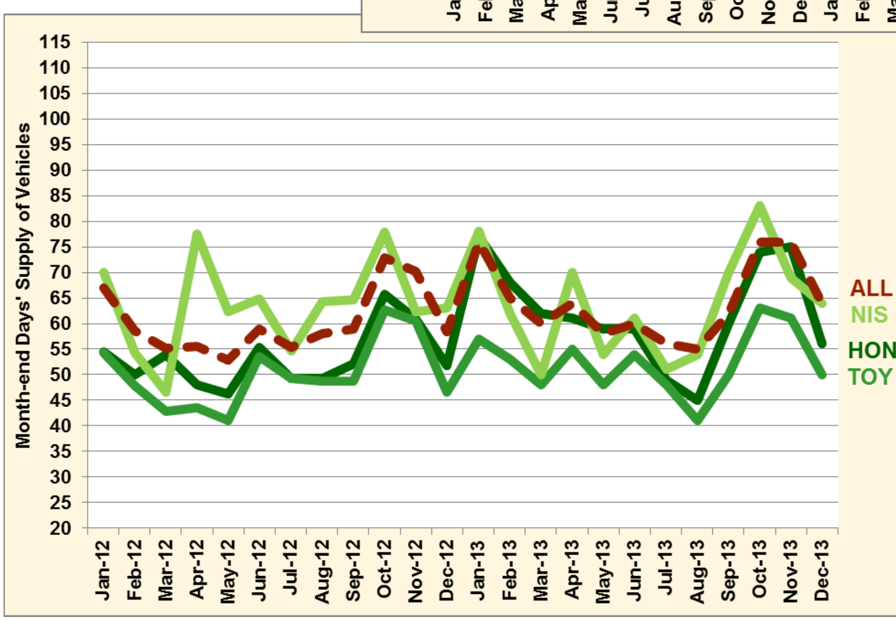


FIGURE 68. Monthly Inventory Supplies by Manufacturer, 2012-2013

Note: ALL = Average of all manufacturers.

Source:
Ward's Autoinfobank.
http://wardsauto.com

Days to Turn Trend by Vehicle Class

"Days to turn" is an automotive industry term that refers to the number of days that vehicles stay in dealer inventories before they are sold (i.e., the time a vehicle stays on the dealer's lot). There are many factors that influence this number including fuel prices, the economy, and supply disruptions. The figure below shows that the days to turn by vehicle class were closer together in November 2010 when light vehicle sales were depressed across all classes and fuel prices were under $3 per gallon. As light vehicle sales recovered, there was greater variability in the pace of sales among the different vehicle classes. By October 2013, subcompact cars, large trucks, and sport utility vehicles (SUVs) stayed on the lot more than 70 days, on average, while the compact and large cars stayed about 60 days. The sharp decline for compact and subcompact cars in 2011 probably reflects the earthquake and tsunami that struck Japan which constrained supplies, limited dealer inventories and shortened days to turn, particularly among the smaller cars produced in Japan.

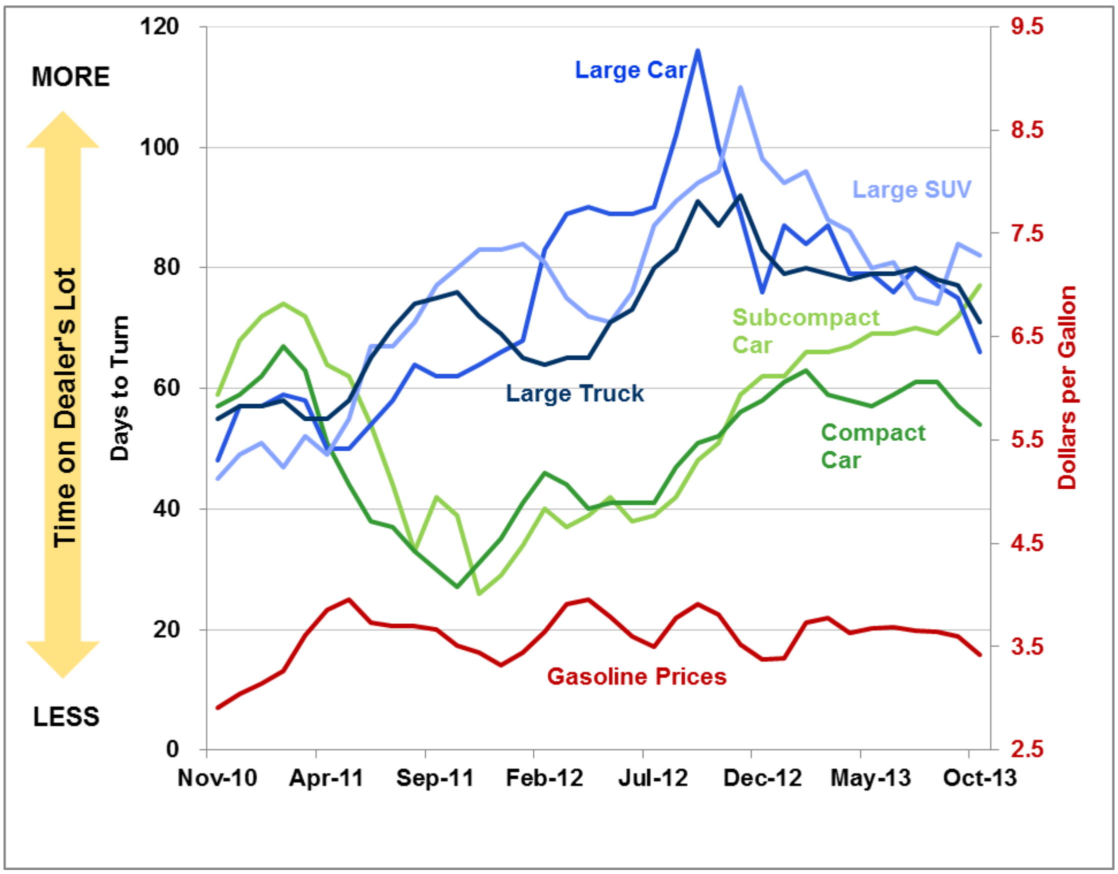


FIGURE 69. Days to Turn Trend by Vehicle Class, 2010-2013

Sources:
Edmunds website data, www.Edmunds.com; U.S. Department of Energy, Energy Information Administration, International Statistics website, November 2013.

Many Tier 1 Suppliers Sell More in Europe and Asia Than in North America

In the automotive industry, a Tier 1 supplier is a company that sells directly to the original equipment manufacturer (OEM). Globally, Robert Bosch GmbH is the top supplier with over $36 billion in parts sales to OEMs in 2012. Within the top ten suppliers, only one – Magna International, Inc. – has the majority (53%) of its sales to North America. The other companies in the top ten sell to North America, but sell more in Europe or Asia.

TABLE 23. List of Top Ten Tier 1 Global Suppliers, 2012

			Market Share				
Rank	**Company**	**Company Headquarters**	**North America**	**Europe**	**Asia**	**Rest of World**	**Total**
1	Robert Bosch GMbH	Germany	17%	52%	27%	4%	100%
2	Denso Corp.	Japan	16%	11%	71%	2%	100%
3	Continental AG	Germany	21%	50%	25%	4%	100%
4	Magna International, Inc.	Canada	53%	40%	0%	7%	100%
5	Aisin Seiki Co., Ltd.	Japan	14%	10%	76%	0%	100%
6	Johnson Controls, Inc.	United States	41%	47%	12%	0%	100%
7	Faurecia	France	27%	56%	10%	7%	100%
8	Hyundai Motors	Korea	22%	11%	67%	0%	100%
9	ZF Friedrichshafen AG	Germany	19%	58%	18%	5%	100%
10	Yazaki Corp.	Japan	22%	[a]	[a]	[a]	100%

[a] Unknown

Note: Rank based on total global OEM automotive parts sales in 2012.

Source:
Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2013. http://www.autonews.com/

Top U.S.-Based Tier 1 Suppliers Sell Globally

There are 11 U.S.-based companies in the top 50 automotive global suppliers. Of these companies, only two have more than half of their sales in North America.

TABLE 24. U.S.-Based Tier 1 Suppliers in the Top 50, 2012

Rank	Company	Percent North America Sales	Products
6	Johnson Controls, Inc	41%	Seating, overhead systems, door & instrument panels, center & overhead consoles, interior electronics, lead-acid & hybrid vehicle batteries
11	Lear Corp.	39%	Seating & electrical power management systems
12	Delphi Automotive PLC	34%	Mobile electronics; powertrain, safety, thermal, controls & security systems; electrical/electronic architecture; in-car entertainment technologies
13	TRW Automotive Holdings Corp.	36%	Steering, suspension, braking & engine components; fasteners, occupant-restraint systems, electronic safety & security systems
20	Cummins, Inc.	53%	Diesel & natural gas engines
26	Dana Holding Corp.	43%	Axles, driveshafts, sealing & thermal management products, tire management products
29	BorgWarner, Inc.	29%	Turbochargers, engine valve-timing systems, ignition systems, emissions systems, thermal systems, transmission-clutch systems, transmission-control systems & AWD systems
32	Visteon Corp.	18%	Climate-control systems, electronics, interiors
36	Tenneco, Inc.	49%	Emission control systems, manifolds, catalytic converters, diesel aftertreatment systems, catalytic reduction mufflers, shock absorbers, struts, electronic suspension products & systems
49	Flex-N-Gate Corp.	91%	Plastic & steel bumpers, fascias, stamping, mechanical assemblies, running boards, prototype sheet metal, interior & exterior plastic, towing hitches, body-in-white stampings, roll forming, lighting
50	Federal-Mogul Corp.	34%	Pistons, rings, cylinder liners, piston pins, ignition & spark plugs, bearings, valve seats & guides, gaskets, seals, heat shields, brake friction materials/products, systems protection products, lighting products, wipers, fuel pumps

Note: Rank based on total global OEM automotive parts sales in 2012.

Source:
Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2013. http://www.autonews.com/

U.S.-Based Tier 1 Suppliers Have Been Diversifying Globally over the Past Five Years

There are nine U.S. automotive parts suppliers that sold more than $5 billion in parts to original equipment manufacturers in 2012. Most of these companies have been diversifying their customer base over the last five years; eight of them increased their share of sales to Asia and seven decreased their share of sales to Europe from 2008 to 2012. Five companies increased their North American market share during this period.

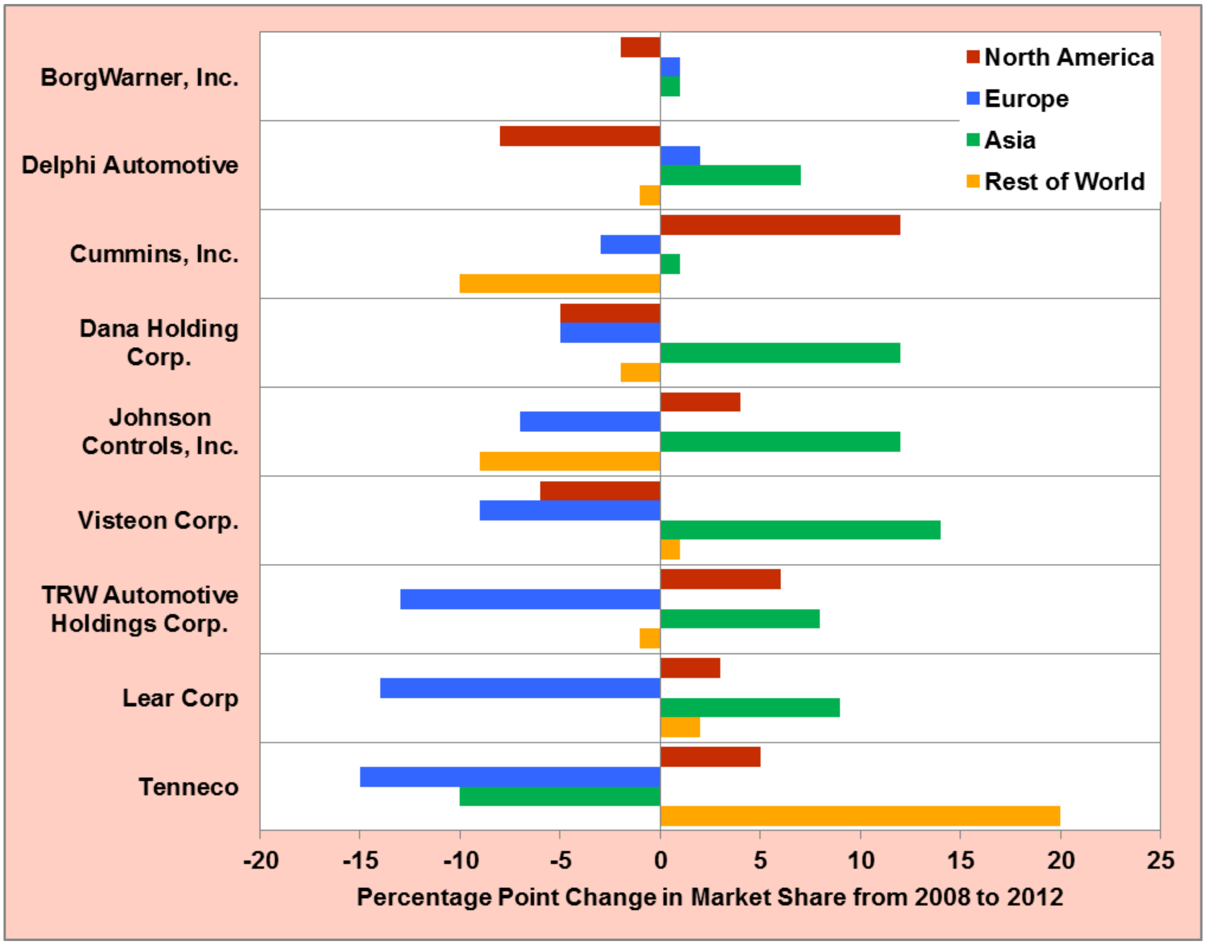


FIGURE 70. Change in Market Share of Top U.S.-Based Tier 1 Suppliers, 2008-2012

Source:

Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2013 and June 2009. http://www.autonews.com/

Chapter 3.

HEAVY TRUCKS

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What Types of Trucks Are in Each Truck Class?

There are eight truck classes, categorized by the gross vehicle weight rating that the vehicle is assigned when it is manufactured. The pictures below show examples of some of the different types of trucks that would be included in each class.

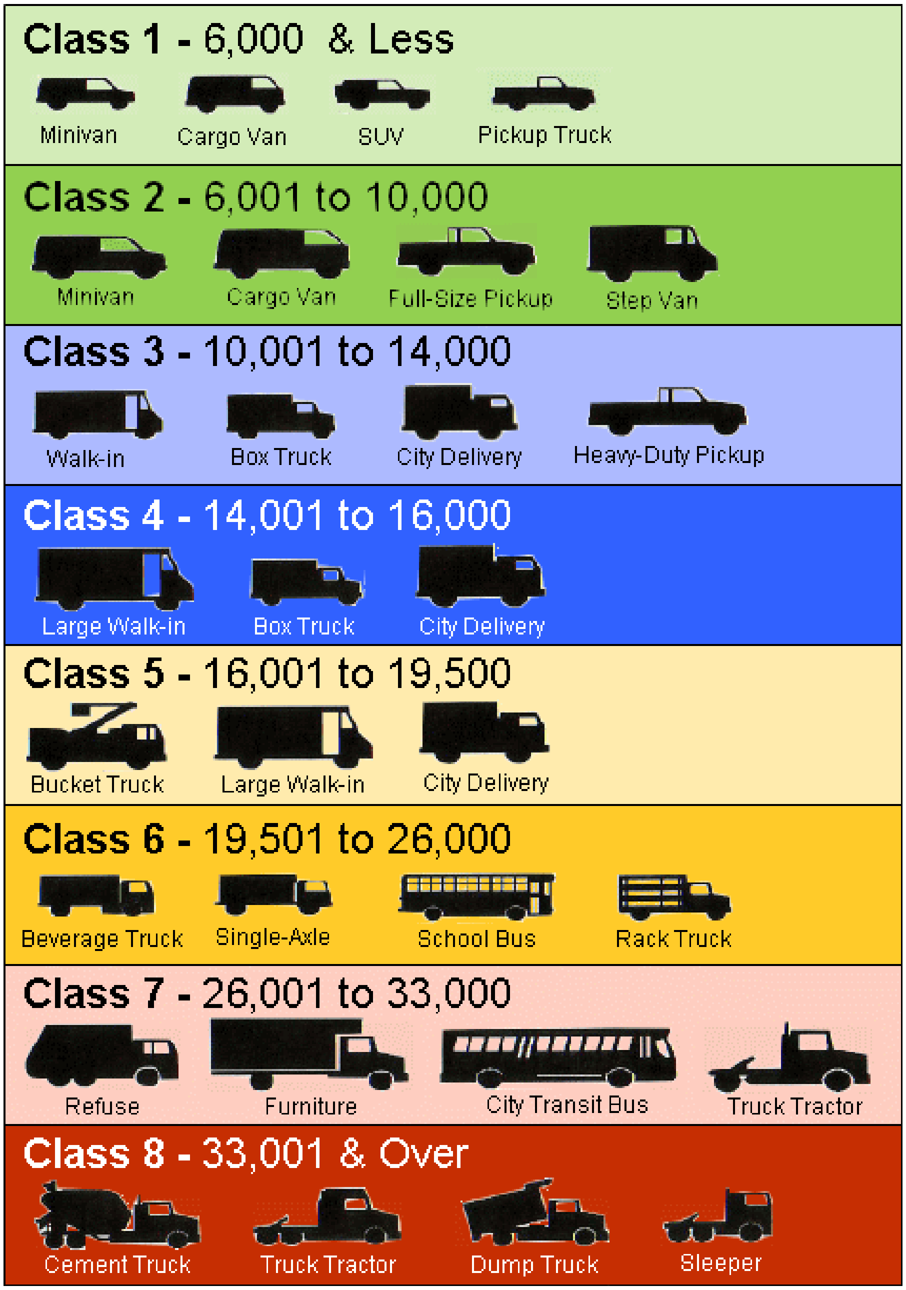

FIGURE 71. Examples of Trucks in Each Truck Class

Source:

Oak Ridge National Laboratory, Center for Transportation Analysis, Oak Ridge, TN. Weight category definitions from 49CFR565.6 (2000)

Heaviest Trucks Consume an Average of 6.5 Gallons per Thousand Ton-Miles

There are eight truck classes, categorized by the gross vehicle weight rating (GVWR) that the vehicle is assigned when it is manufactured. Cars and small pickups, vans, and sport-utility vehicles (SUVs) are shown here for comparison. Two truck classes are further subdivided into "a" and "b" designations. Class 2a and 2b are subdivided based on GVWR. Class 8a and 8b are subdivided based on the truck design (straight truck vs. combination truck).

TABLE 25. Typical Weights and Fuel Use by Truck Class

Class	Applications	Gross Weight Range (lbs.)	Empty Weight Range (lbs.)	Typical Payload Capacity Max (lbs.)	Typical Fuel Economy Range in 2007 (mpg)	Typical Fuel Consumed (gallons per thousand ton-miles)
1c	Cars *only*	3,200 - 6,000	2,400 - 5,000	250 - 1,000	25-33	69.0
1t	Minivans, Small SUVs, Small Pickups	4,000 - 6,000	3,200 - 4,500	250 - 1,500	20-25	58.8
2a	Large SUVs, Standard Pickups	6,001 - 8,500	4,500 - 6,000	250 - 2,500	20-21	38.5
2b	Large Pickups, Utility Van, Multi-Purpose, Mini-Bus, Step Van	8,501 - 10,000	5,000 - 6,300	3,700	10-15	38.5
3	Utility Van, Multi-Purpose, Mini-Bus, Step Van	10,001 - 14,000	7,650 - 8,750	5,250	8-13	33.3
4	City Delivery, Parcel Delivery, Large Walk-In, Bucket, Landscaping	14,001 - 16,000	7,650 - 8,750	7,250	7-12	23.8
5	City Delivery, Parcel Delivery, Large Walk-In, Bucket, Landscaping	16,001 - 19,500	9,500 - 10,800	8,700	6-12	25.6
6	City Delivery, School Bus, Large Walk-In, Bucket	19,501 - 26,000	11,500 - 14,500	11,500	5-12	20.4
7	City Bus, Furniture, Refrigerated, Refuse, Fuel Tanker, Dump, Tow, Concrete, Fire Engine, Tractor-Trailer	26,001 - 33,000	11,500 - 14,500	18,500	4-8	18.2
8a	Straight Trucks, e.g., Dump, Refuse, Concrete, Furniture, City Bus, Tow, Fire Engine	33,001 - 80,000	20,000 - 34,000	20,000 - 50,000	2.5-6	8.7
8b	Combination Trucks, e.g., Tractor-Trailer: Van, Refrigerated, Bulk Tanker, Flat Bed	33,001 - 80,000	23,500 - 34,000	40,000 - 54,000	4-7.5	6.5

Source:

The National Academies, *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*, 2010. http://www.nap.edu/catalog.php?record_id=12845

Medium and Heavy Truck Assembly Plants Are Located Throughout the United States

There are seven major manufacturers of class 7 and 8 trucks in the United States – Freightliner/Western Star, Hino, International, Kenworth, Mac, Peterbilt and Volvo. Two of those, Freightliner and International, also manufacture medium trucks (classes 3-6), along with Isuzu.

TABLE 26. Production of Medium and Heavy Trucks by Manufacturer, 2012

Freightliner & Western Star	Hino	International	Kenworth	Mack	Peterbilt	Volvo	Isuzu
56.9	8.2	41.0	32.7	25.0	29.4	26.1	2.6

Note: Production not available by plant site. Production not available for NEOPLAN, Sprinter, and Thomas.

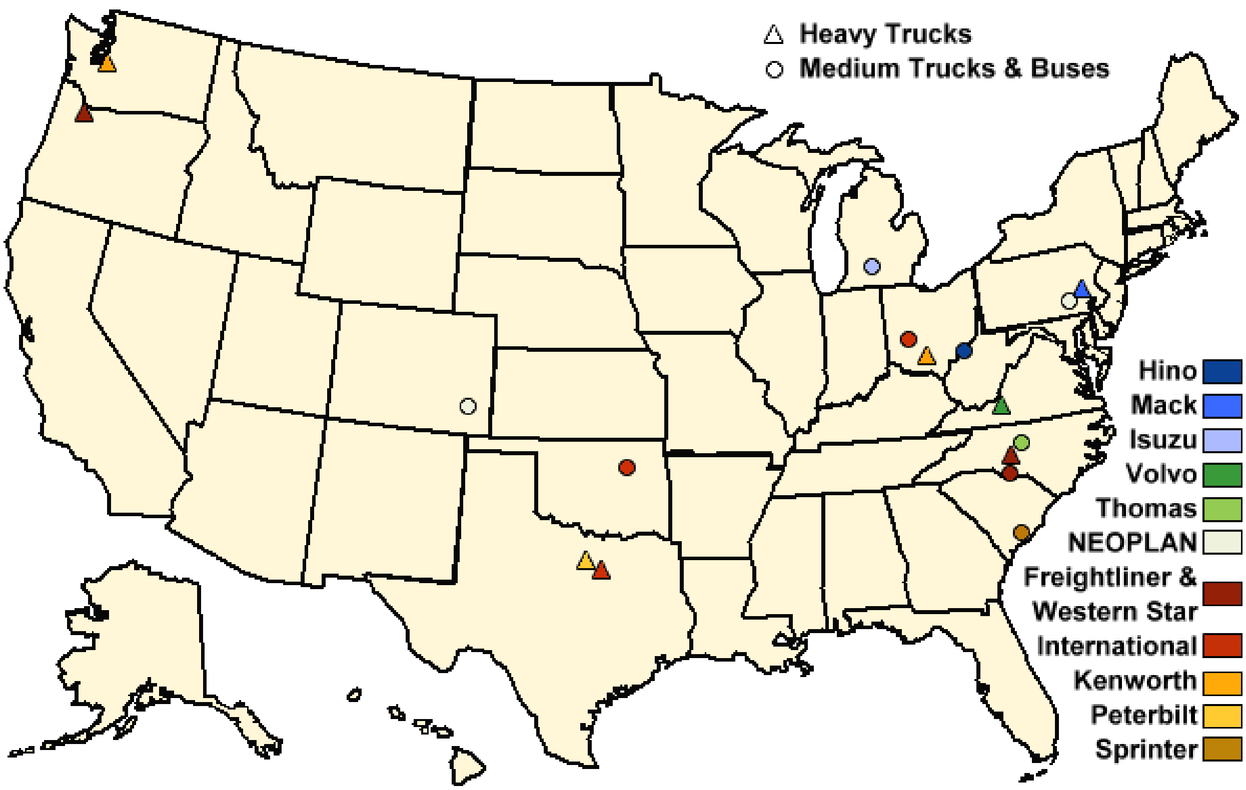

FIGURE 72. Heavy Truck Manufacturing Plants by Location, 2013

Source:
Ward's Autodata. http://wardsauto.com

Class 3 Truck Sales Are Up in 2012

Class 3 truck sales fell with the economy in 2008 and 2009, but recovered in 2010 through 2012. In fact, 2012 sales were 19% above 2008 sales. Chrysler, Ford, and General Motors continue to dominate the class 3 market.

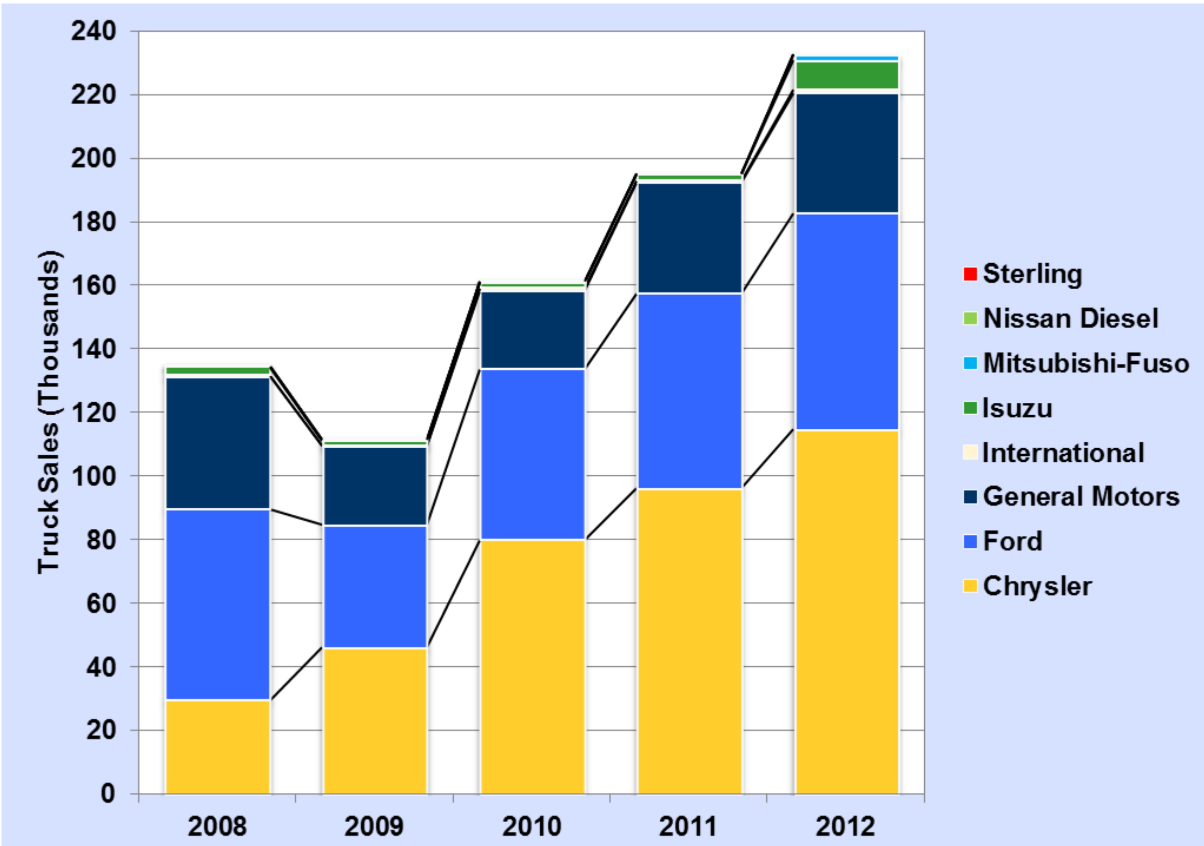

FIGURE 73. Class 3 Truck Sales by Manufacturer, 2008-2012

Source:

Ward's Automotive Group, *Motor Vehicle Facts and Figures 2013*, Southfield, MI, 2013.
http://wardsauto.com

Class 4-7 Truck Sales Still Below 2008 Level

Though the sales of class 4-7 trucks continued to increase in 2012, they were still 5% below the 2008 level. However, most companies kept their market share of the significantly lower market, with General Motors (GM) being the notable exception. In 2008 GM sold almost 25,000 class 4-7 trucks, while in 2012 they sold none. Freightliner, Hino, Isuzu, Peterbilt, Ford, and Kenworth all gained one to three percent of the market share after GM's decline. Chrysler gained seven percent from 2008 to 2012.

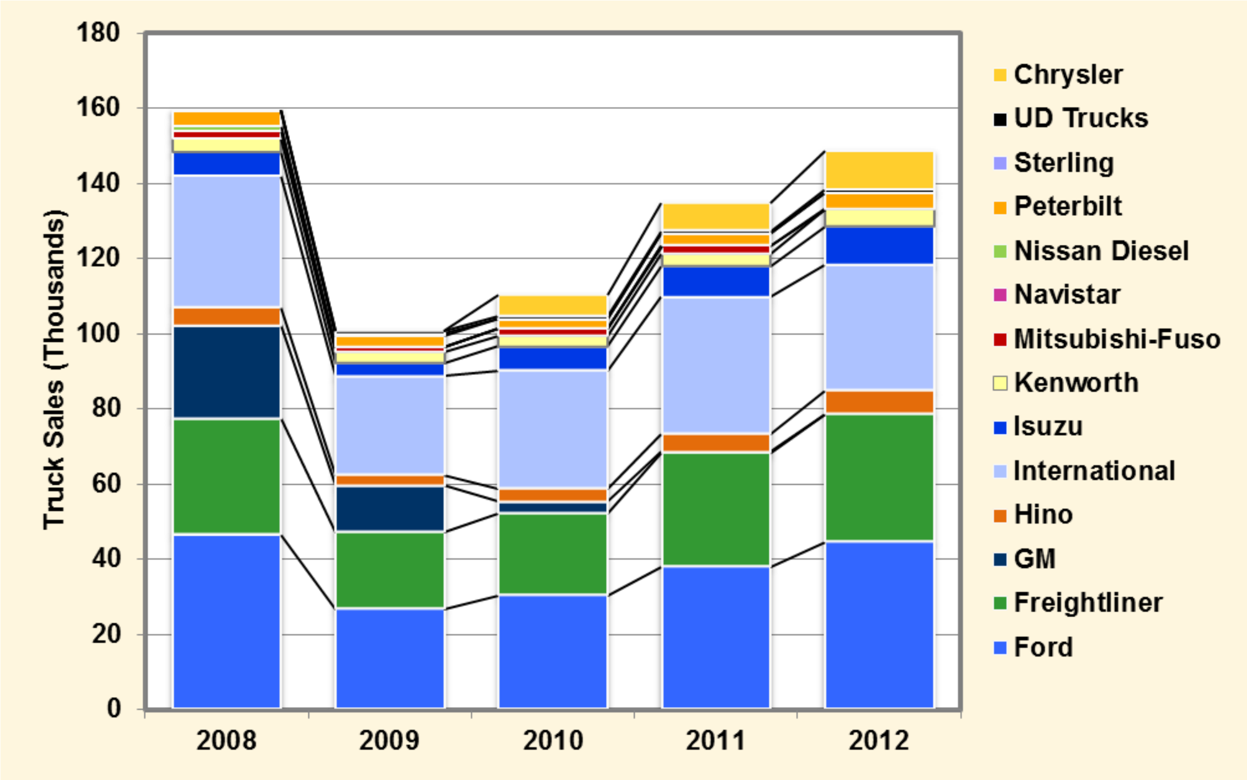

FIGURE 74. Class 4-7 Truck Sales by Manufacturer, 2008-2012

Note: Nissan Diesel was renamed UD Trucks at the end of 2009.

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2013*, Southfield, MI, 2013. http://wardsauto.com

Class 8 Truck Sales Continue to Grow

Class 8 truck sales in 2012 were more than double that of 2009. There was not a large shift in market share among the manufacturers over the last five years. Freightliner had 34% of the market in 2012 and International had 18%. All other companies listed have less than a 15% share of the market.

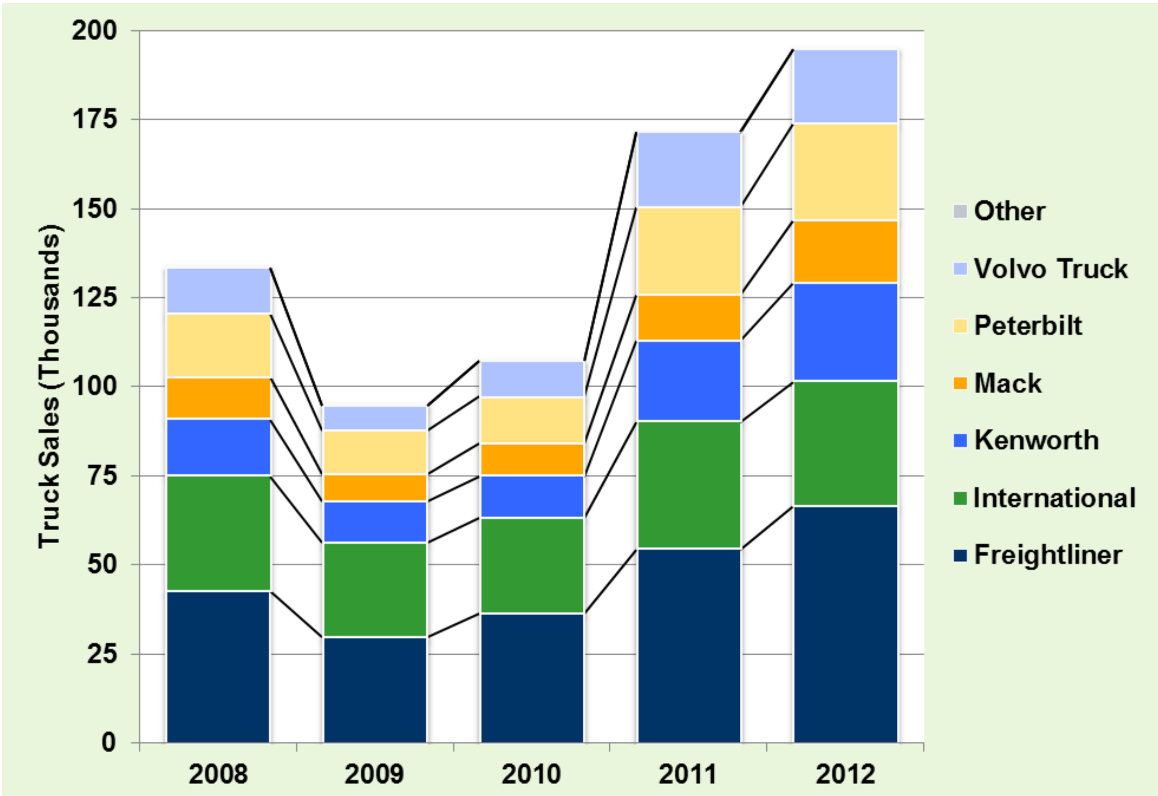

FIGURE 75. Class 8 Truck Sales by Manufacturer, 2008-2012

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2013*, Southfield, MI, 2013.
http://wardsauto.com

Diesel Engine Use Declines for Class 4 Trucks

In 2008, over half of class 6 trucks sold were diesel; in 2012, nearly all of class 6 trucks sold were diesel. Class 4 trucks were predominately diesel in 2008, but in 2012 were predominately gasoline. Classes 3 and 5 trucks also showed a decline in diesel share. However, class 6 trucks reversed the trend. Class 8 trucks have always been near 100% diesel and that has not changed. Overall, diesel comprised 74% of the class 3-8 trucks sold in 2012, up from 72% in 2008.

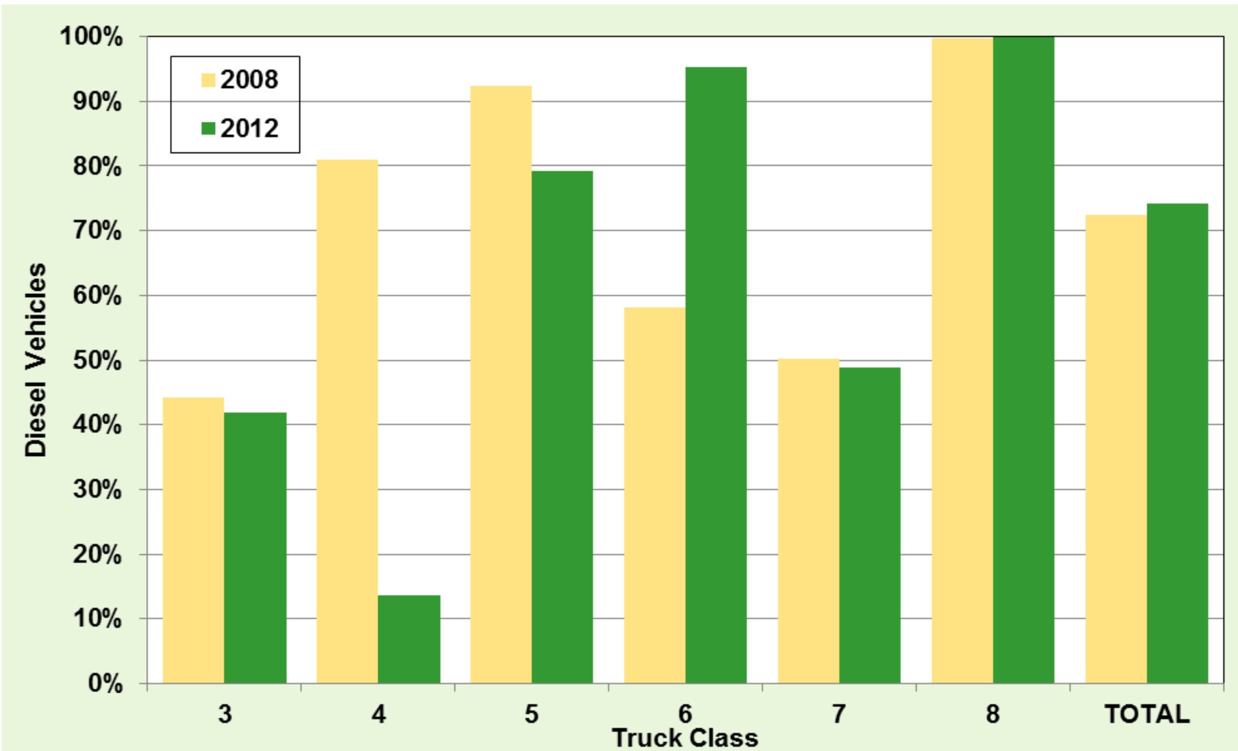

FIGURE 76. Share of Diesel Truck Sales by Class, 2008 and 2012

Note: These shares were derived using factory sales of trucks.

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2013*, Southfield, MI, 2013.
http://wardsauto.com

Cummins Supplies Diesel Engines for Many Manufacturers

Though some medium and heavy truck manufacturers also manufacture their own engines, others purchase engines from engine manufacturers. Cummins supplies diesel engines for Freightliner, International, Kenworth, Peterbilt, Volvo, and Western Star. Hino and Mack build their own diesel engines.

TABLE 27. Diesel Engine Suppliers by Manufacturer, 2012

Make	Engine Manufacturer	Share
Freightliner	Cummins	60.3%
	Detroit Diesel	38.8%
	Mercedes Benz	0.9%
	Total	**100.0%**
Hino	Hino	100.0%
International	Cummins	2.2%
	Navistar	97.8%
	Total	**100.0%**
Kenworth	Cummins	78.1%
	PACCAR	21.9%
	Total	**100.0%**
Mack	Mack	100.0%
Peterbilt	Cummins	75.4%
	PACCAR	24.6%
	Total	**100.0%**
Volvo	Cummins	22.9%
	Volvo	77.1%
	Total	**100.0%**
Western Star	Caterpillar	0.2%
	Cummins	25.5%
	Detroit Diesel	74.3%
	Total	**100.0%**
Other	Cummins	100%

Note: International's parent company is Navistar.

Source:
Ward's Automotive Group. http://wardsauto.com

Cummins Leads Heavy Truck Diesel Engine Market

In 2008, Navistar held a 65% share of the heavy truck diesel engine market. By 2012, Navistar's share had declined to 17% and Cummins held the largest share of the market (42%).

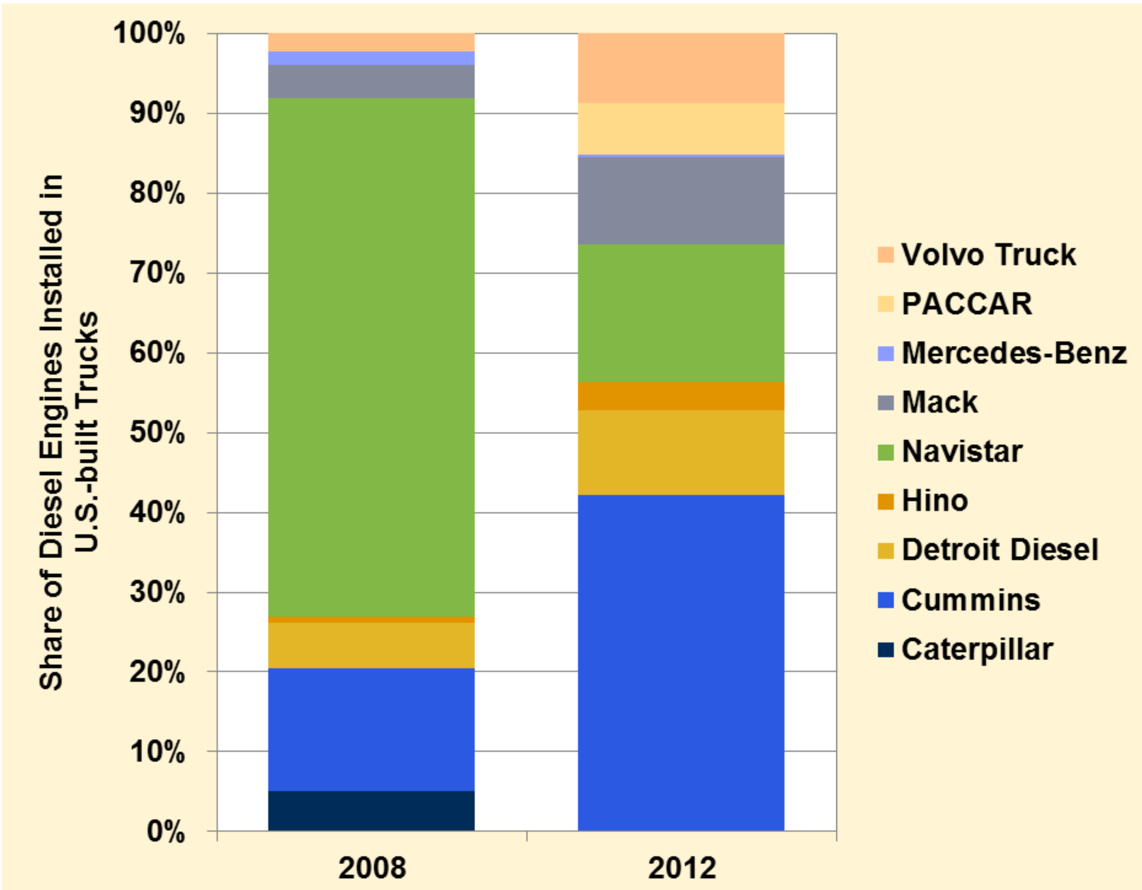

FIGURE 77. Diesel Engine Manufacturers Market Share, 2008 and 2012

Source:
Ward's Automotive Group. http://wardsauto.com

Combination Trucks Average Over 66,000 Miles per Year

According to the latest Federal Highway Administration estimates, the average miles traveled per truck was over 66,000 miles for a combination truck in 2011, up from over 64,000 miles in 2009. Because heavy truck duty-cycles vary, these averages have large standard deviations. Heavy single-unit trucks (above 10,000 lbs. and having at least six tires) were driven significantly fewer miles, because they are typically driven locally. The average fuel economy of single-unit trucks was 7.3 miles per gallon (mpg) in 2011 while the combination truck fuel economy was 5.8 mpg. The combination trucks typically have larger engines to carry heavier loads than the single-unit trucks.

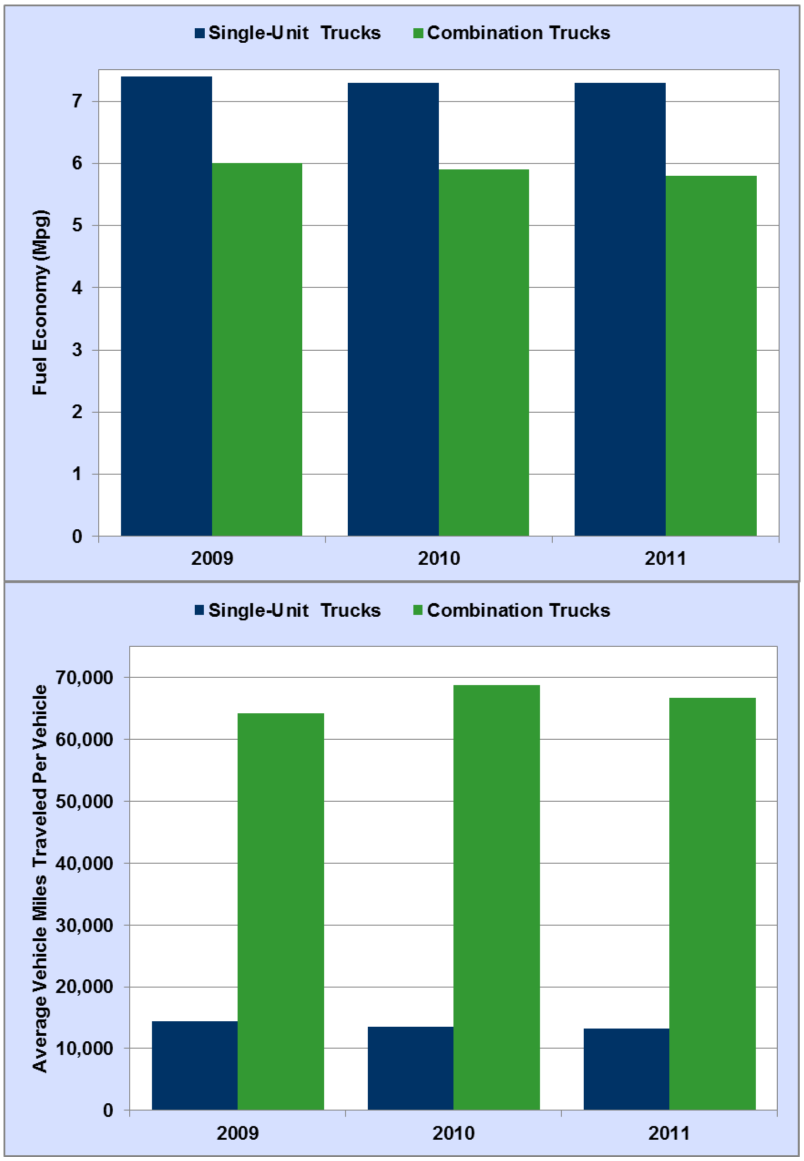

FIGURE 78. Vehicle-Miles of Travel and Fuel Economy for Heavy Trucks, 2009-2011

Source:

U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2011*, Table VM-1, March 2013. http://www.fhwa.dot.gov/policyinformation/statistics/2011/vm1.cfm

Study Conducted of Heavy Trucks at Steady Speed on Flat Terrain

A study conducted by Oak Ridge National Laboratory outfitted Class 8 trucks with monitoring equipment which tracked the weight, speed, and fuel efficiency of the truck along with the global position of the truck. Using only data where the roadway grade was 1% to -1% grade (flat terrain) the study showed the difference in fuel efficiency for different truck weights at the speed of 65 miles per hour (mph).

TABLE 28. Fuel Efficiency of Class 8 Trucks by Vehicle Weight Range on Flat Terrain

Weight Range (Pounds)	Average Weight (Pounds)	Distance Traveled (Miles)	Fuel Consumed (Gallons)	Fuel Efficiency (Miles per Gallon)	Fuel Efficiency (Ton-miles per Gallon)	Average Speed (mph)
20,000-30,000	21,222	51.4	5.4	9.5	101	65.0
30,000-40,000	34,285	505.9	53.0	9.5	164	65.0
40,000-50,000	44,911	537.8	58.7	9.2	206	65.0
50,000-60,000	55,468	541.2	63.3	8.6	237	64.9
60,000-70,000	66,558	1,356.9	171.9	7.9	263	65.0
70,000-80,000	73,248	1,363.1	172.3	7.9	290	65.0

Note: Ton-miles per gallon calculated as average weight multiplied by miles per gallon.

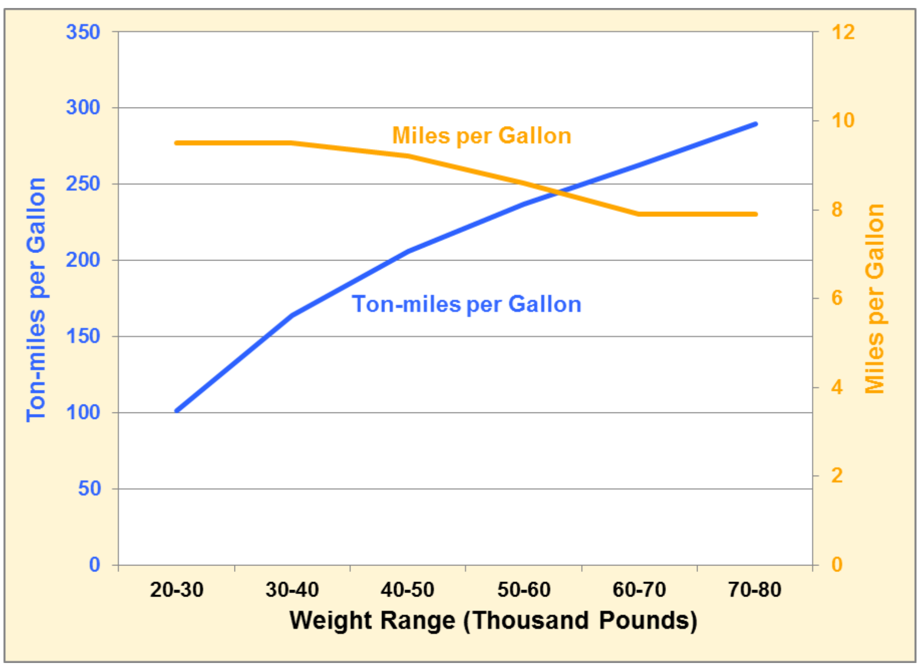

FIGURE 79. Fuel Efficiency of Class 8 Trucks by Vehicle Weight Range on Flat Terrain

Source:

Franzese, Oscar, *Effect of Weight and Roadway Grade on the Fuel Economy of Class-8 Freight Trucks*, Oak Ridge National Laboratory, ORNL/TM-2011/471, October 2011. http://cta.ornl.gov/cta/Publications/Reports/ORNL_TM_2011_471.pdf

Roadway Grade Affects Fuel Economy of Class 8 Trucks

A study conducted by Oak Ridge National Laboratory outfitted Class 8 trucks with monitoring equipment which tracked the weight, speed, and fuel efficiency of the truck along with the global position of the truck. The average for all trucks in the study at all speeds on flat terrain was 7.3 miles per gallon (mpg). However, the fuel economy of those same vehicles on different roadway grades was significantly different. On average, trucks on a severe downslope gained 221% of their fuel economy, while trucks on a severe upslope lost 60% of their fuel economy.

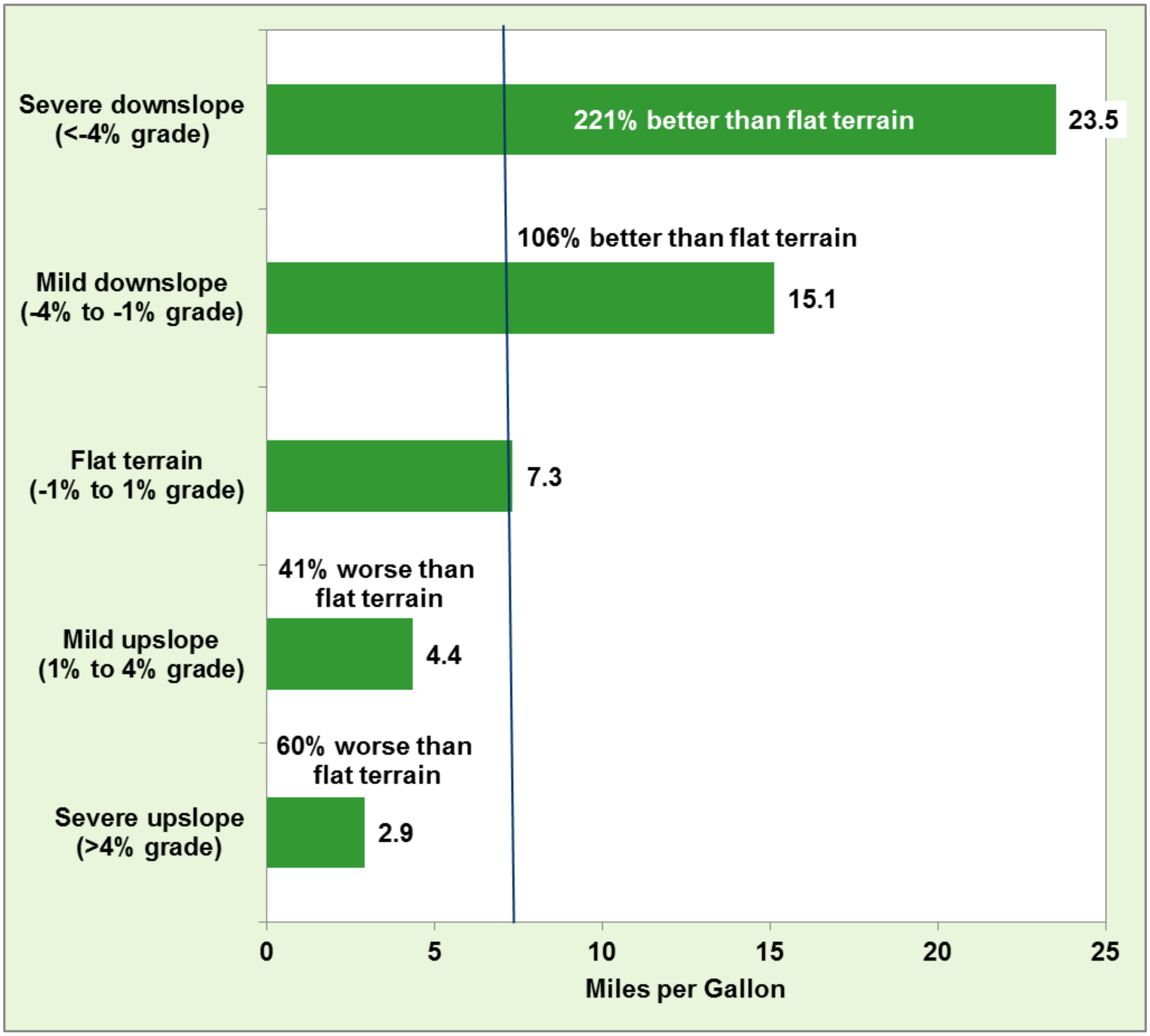

FIGURE 80. Fuel Efficiency of Class 8 Trucks by Roadway Grade

Source:

Franzese, Oscar, *Effect of Weight and Roadway Grade on the Fuel Economy of Class-8 Freight Trucks*, Oak Ridge National Laboratory, ORNL/TM-2011/471, October 2011. http://cta.ornl.gov/cta/Publications/Reports/ORNL_TM_2011_471.pdf

Idling a Truck-Tractor's Engine Can Use a Gallon of Fuel per Hour

Drivers of truck-tractors often idle the engine to provide heating, cooling, or electric power during Federally-mandated breaks. Estimates show that an engine at 1,200-rpm without the use of air conditioning (AC) uses 1.03 gallons of fuel per hour. Having the AC on even half of the time makes a difference. The graph below shows the fuel used when idling the engine for one hour with different engine idle speed (rpm) and air conditioning scenarios. Newer tractors can idle at 800-900 rpm, but older tractors are smoother at higher idle speeds.

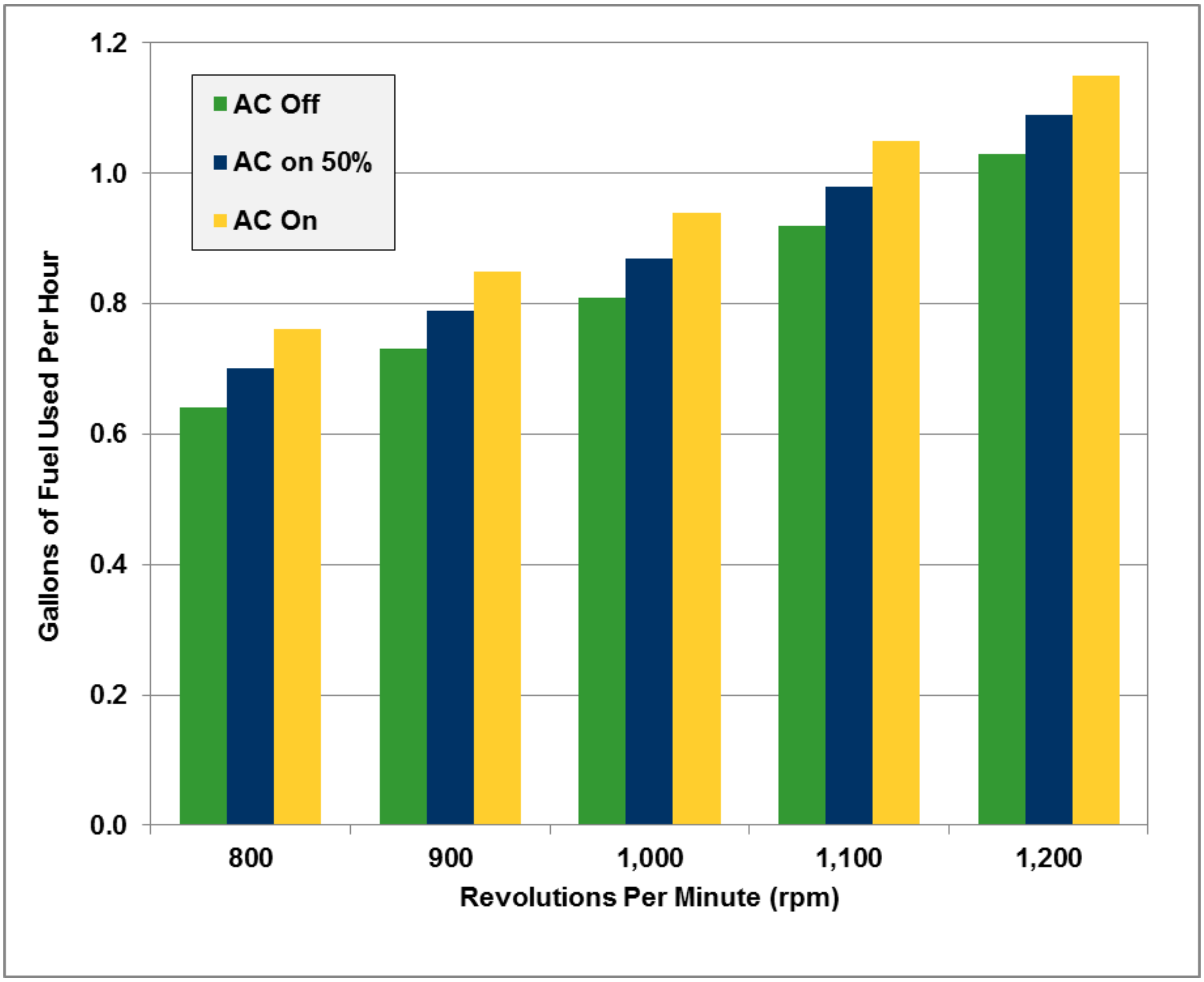

FIGURE 81. Average Amount of Fuel Used for Idling a Truck-Tractor

Source:
Argonne National Laboratory, "How Much Could You Save by Idling Less?"
http://www.transportation.anl.gov/pdfs/TA/361.pdf

Truck Stop Electrification Reduces Idle Fuel Consumption

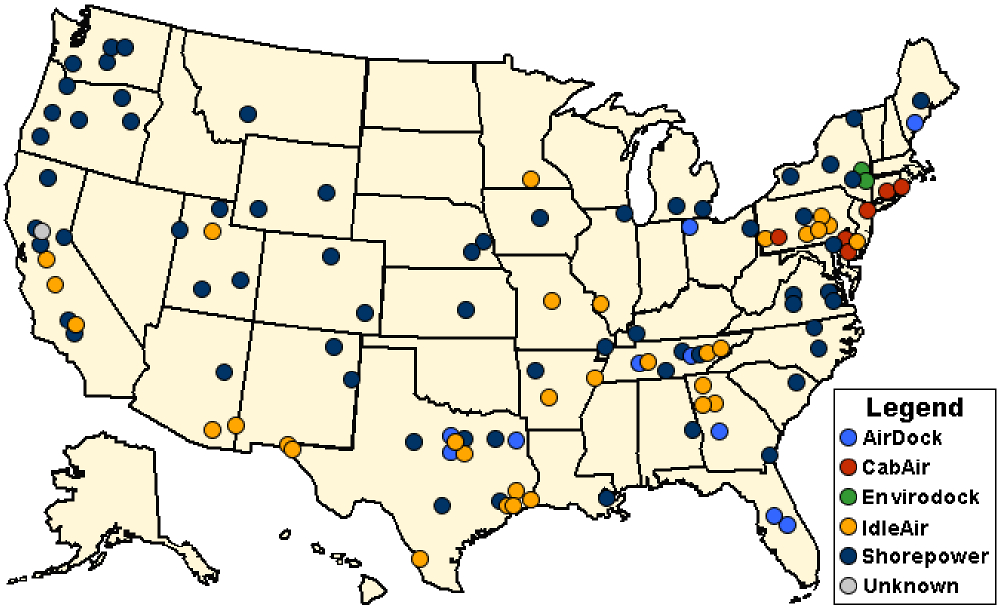

FIGURE 82. Map of Truck Stop Electrification Sites, 2013

TABLE 29. Number of Truck Stop Electrification Sites by State, 2013

State	Number of Sites	State	Number of Sites
Alabama	1	Missouri	2
Arizona	3	Montana	1
Arkansas	3	Nebraska	2
California	10	New Jersey	2
Colorado	2	New Mexico	2
Connecticut	2	New York	6
Delaware	2	North Carolina	2
Florida	2	Ohio	2
Georgia	5	Oregon	6
Illinois	2	Pennsylvania	7
Iowa	1	South Carolina	1
Kansas	1	Tennessee	9
Louisiana	1	Texas	18
Maryland	1	Utah	5
Maine	2	Virginia	4
Michigan	2	Washington	4
Minnesota	1	Wyoming	2
Total	**116**		

The U.S. Department of Transportation mandates that truckers rest for 10 hours after driving for 11 hours, during which time they often park at truck stops idling the engines to provide heating, cooling and use of electrical appliances. Electrification at truck stops allows truckers to “plug-in” vehicles to operate the necessary systems without idling the engine. There are currently 116 publicly accessible electrification sites across the nation. Some of these sites require special equipment to be installed on the truck and others do not. Presently, five companies equip electrification sites: Shorepower, CabAire, EnviroDock, AireDock, and IdleAir.

Source:

Alternative Fuels and Advanced Vehicles Data Center. (Data through 1/28/14).
http://www.afdc.energy.gov/afdc/tse_locator

SuperTruck Project Achieves 10.7 Miles per Gallon

The U.S. Department of Energy partnered with industry to explore fuel economy improvements for class 8 trucks. In February 2014, the Cummins/Peterbilt team announced that their fully-loaded class 8 truck achieved a fuel economy of 10.7 miles per gallon, which was a 75% increase in fuel economy, a 43% reduction in greenhouse gas (GHG) emissions and an 86% gain in freight efficiency in testing against a 2009 baseline truck.

FIGURE 83. Change in GHG Emissions, Fuel Economy, and Freight Efficiency for the SuperTruck Project, February 2014

Source:
Cummins Social Media News Hub, accessed February 24, 2014.
http://social.cummins.com/cummins-peterbilt-supertruck-passes-important-milestone/

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Chapter 4.

TECHNOLOGIES

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Hybrid Sales Strong in 2012 and 2013

In 1999, the Honda Insight debuted as the first hybrid-electric vehicle (HEV) on the market, followed closely by the Toyota Prius in 2000. Since that time, many other manufacturers have entered the hybrid market. From 2008 to 2011, sales of hybrid vehicles declined. In 2012, however, sales of hybrids grew substantially and in 2013 sales were almost 500,000 vehicles.

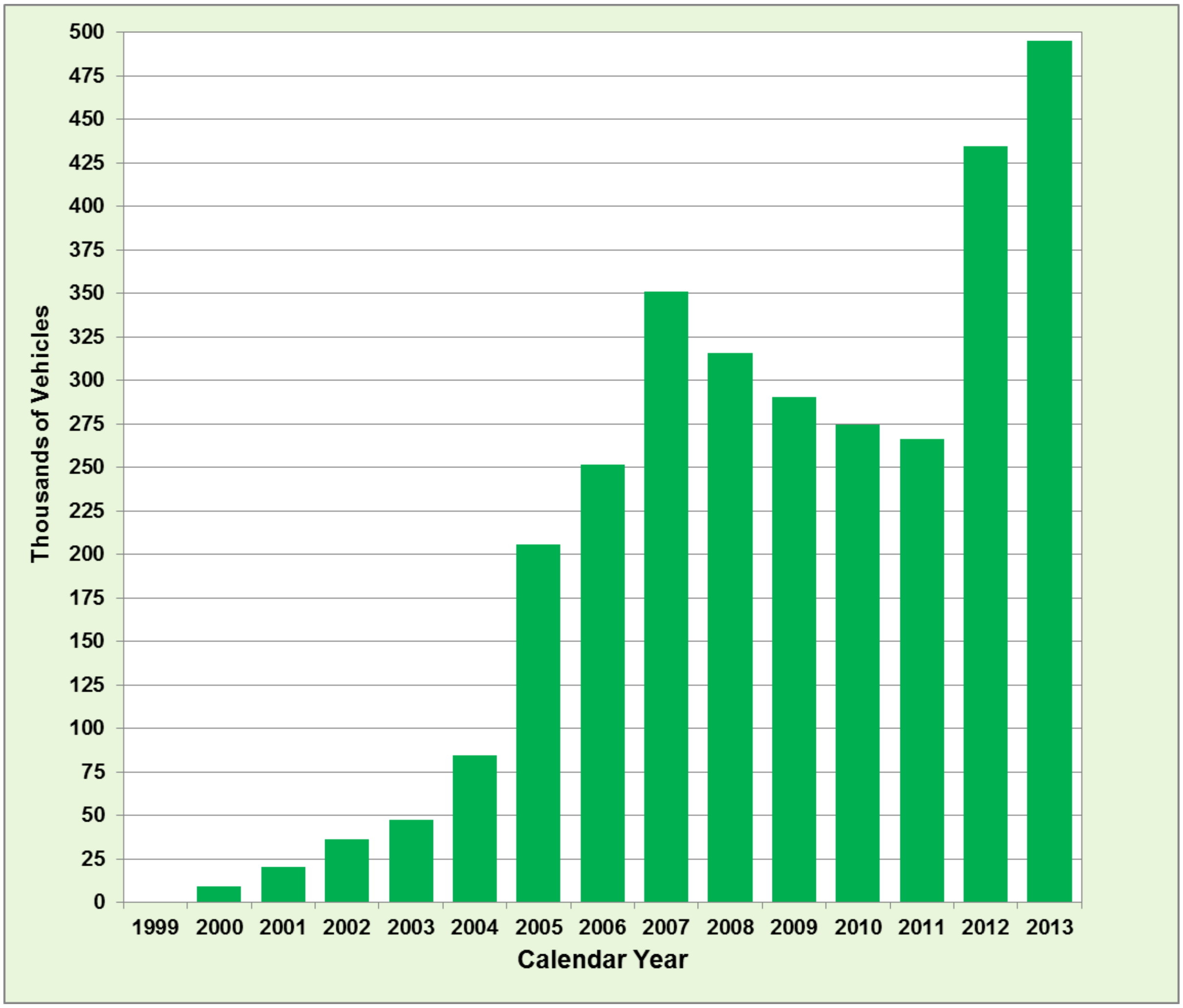


FIGURE 84. Hybrid-Electric Vehicle Sales, 1999-2013

Source:
Provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Toyota Reigns as Leader of U.S. Hybrid-Electric Vehicle Market Share

Though Honda was the first manufacturer of hybrid-electric vehicles (HEV), Toyota has held more than 50% of the market share since 2000. Ford entered the HEV market in 2004 with an Escape HEV; Lexus began selling the RX400h a year later. Mercury, Nissan, and Saturn joined the other manufacturers selling HEVs in 2007. Thereafter, many more manufacturers began selling HEVs, though some are sold in small volumes.

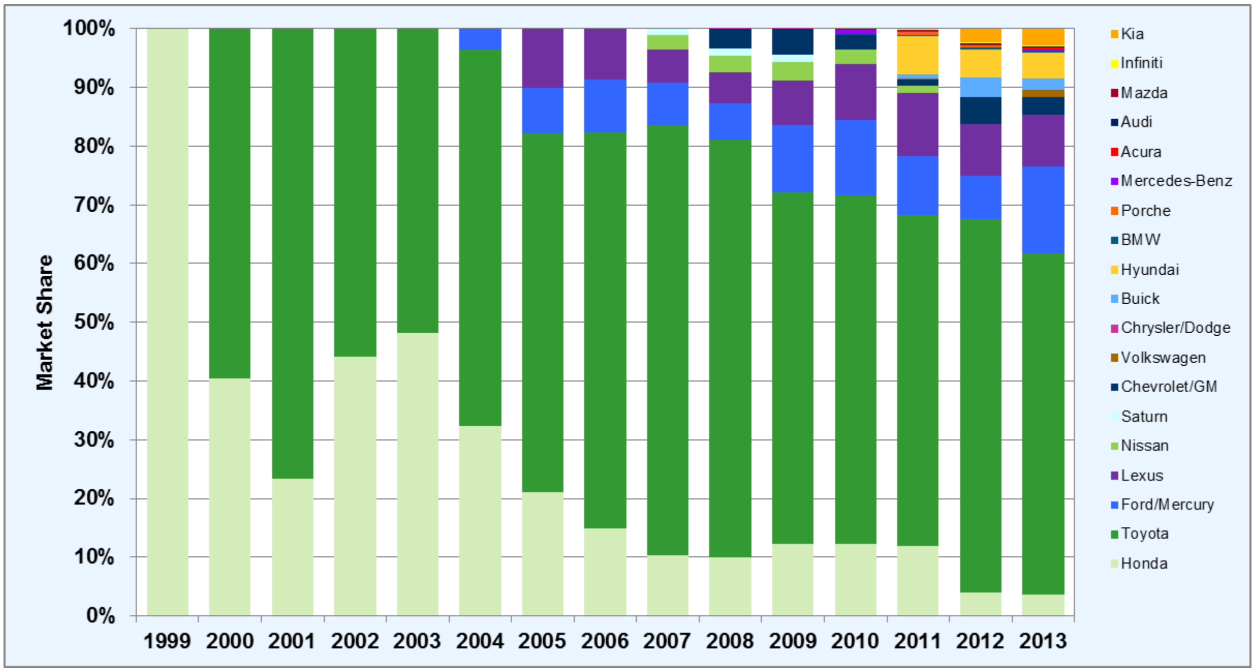


FIGURE 85. Hybrid-Electric Vehicle Market Share, 1999-2013

Source:
U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/data/#tab/fuels-infrastructure/data_set/1030

Sales from Introduction: Some Plug-In Vehicles Beat Hybrid-Electric Sales

The Toyota Prius hybrid-electric vehicle (HEV) was first released in the U.S. market in January 2000 and 324 were sold in the first month. The Chevrolet Volt, a hybrid-electric plug-in, and the Nissan Leaf, an all-electric plug-in vehicle, were first released in December 2010. The Prius plug-in hybrid-electric vehicle (PHEV) began sales in April 2012. The chart below shows a comparison of the sales of the Prius HEV from when it was first introduced, to the sales of the Volt, the Leaf, the Prius PHEV, and the Tesla Model S when they were first introduced.

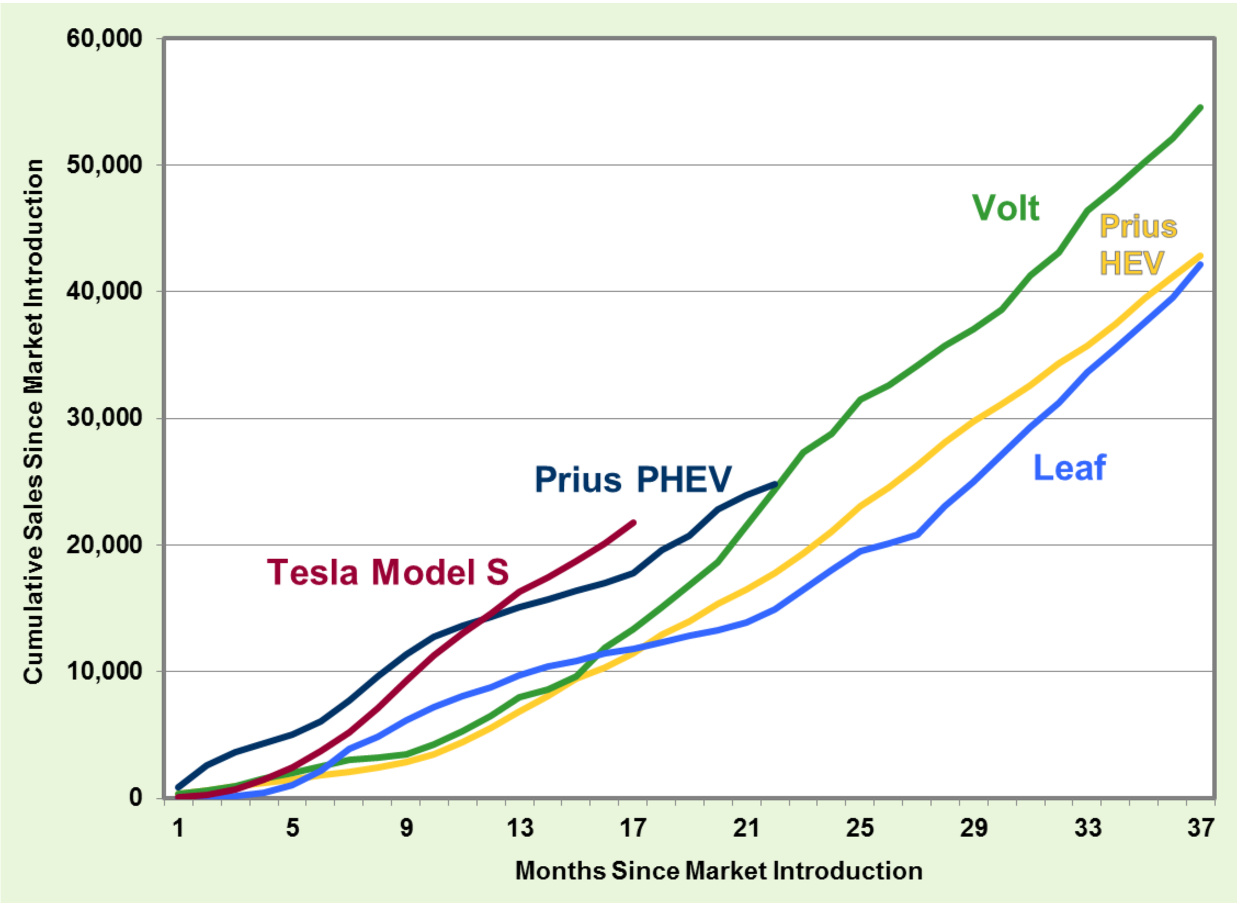


FIGURE 86. Monthly Sales since Market Introduction for Hybrid Vehicles and Plug-In Vehicles

Notes: The Prius HEV was first released in the U.S. market in January 2000.
The Prius PHEV was first released in the U.S. market in April 2012.
The Volt and Leaf were first released in the U.S. market in December 2010.
The Tesla Model S was first released in the U.S. market in June 2012.

Source:
Provided by Argonne National Laboratory,
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Plug-In Vehicle Sales Total Nearly 100,000 Units in 2013

The number of plug-in vehicles sold in the U.S. in 2013 grew to 97,000, up from 53,000 the year before. Nissan and Chevrolet had the best sellers in 2011 with the Leaf and the Volt, but were joined by several other manufacturers in 2012. There were 16 different plug-in models available in 2013, many selling less than 5,000 units. The biggest plug-in sellers in 2013 were the Chevrolet Volt, Nissan Leaf, Tesla Model S, and Toyota Prius PHEV.

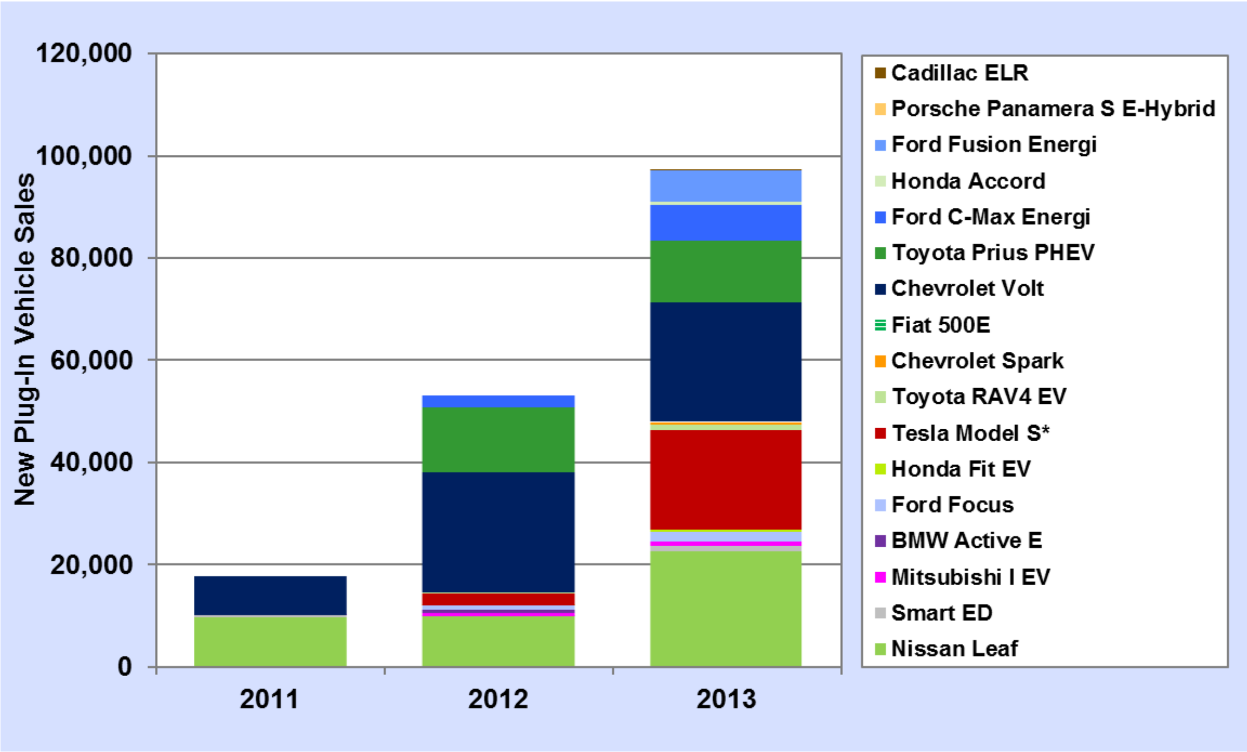


FIGURE 87. Plug-In Vehicle Sales, 2011-2013

Source:

Data provided by Yan (Joann) Zhou, Argonne National Laboratory.

http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Plug-In Vehicles Available from Eleven Manufacturers

There are already 16 vehicles from 11 different manufacturers that plug into electrical outlets to get all or part of their fuel. The Tesla Model S has the longest all-electric range at 265 miles with the 85 kW-hr battery pack. Among plug-in hybrid-electric models, the Chevrolet Volt has the longest all-electric range at 38 miles, with an additional 342-mile range on gasoline, for a total range of 380 miles.

TABLE 30. Available Plug-In Vehicles

Manufacturer	Model	All-Electric Range	Total Range	Specifications
All- Electric Plug-In Vehicles				
Tesla	Model S	265/208 miles	265/208 miles	85/60 kW-hr Li-Ion battery, 270 kW AC induction motor
Toyota	Rav4 EV	103 miles	103 miles	41.8 kW-hr Li-Ion battery, 115 kW AC induction motor
BMW	i3	90+ miles	90+ miles	22 kW-hr Li-ion battery, 170 hp electric motor
Fiat	500e	87 miles	87 miles	24 kW-hr Li-Ion battery, 82 kW AC induction motor
Nissan	Leaf	84 miles	84 miles	24 kW-hr Li-Ion battery, 80 kW permanent magnet motor
Chevrolet	Spark EV	82 miles	82 miles	21 kW-hr, Li-Ion, 104 kW AC induction motor
Honda	Fit EV	82 miles	82 miles	20 kW-hr Li-Ion battery, 92 kW DC permanent magnet motor
Ford	Focus Electric	76 miles	76 miles	23 kW-hr Li-Ion battery, 107 kW AC permanent magnet motor
Smart	ED	68 miles	68 miles	17.6 kW-hr Li-Ion battery, 55 kW electric motor
Mitsubishi	i-MiEV	62 miles	62 miles	16 kW-hr Li-Ion battery, 49 kW permanent magnet motor
Hybrid-Electric Plug-In Vehicles				
Chevrolet	Volt Plug-In Hybrid	38 miles	380 miles	16.5 kW-hr battery, 1.4 liter 4 cylinder gasoline engine
Cadillac	ELR Plug-in Hybrid	37 miles	340 miles	16.5 kW-hr Li-ion battery, 1.4-liter gasoline engine
Ford	C-Max Energi Plug-in Hybrid	21 miles	620 miles	7.6 kW-hr Li-ion battery, 2.0 liter 4 cylinder, gasoline engine
Ford	Fusion Energi Plug-In Hybrid	21 miles	620 miles	7.6 kW-hr Li-ion battery, 2.0 liter 4 cylinder, gasoline engine
Honda	Accord Plug-in Hybrid	13 miles	570 miles	6.7 kW-hr Li-ion battery, 124 kW electric motor
Toyota	Prius Plug-in Hybrid	11 miles	540 miles	4.4 kW-hr battery, 1.8-liter 4 cylinder engine

Sources:
Fuel Economy website www.fueleconomy.gov and Plugincars.com, www.plugincars.com

New Plug-In Vehicles Are on the Horizon

There are eight new plug-in vehicles expected in model years 2014 and 2015: four all-electric and four hybrid-electric. The expected ranges of the all-electric vehicles go from 230 miles with the Tesla Model X to 80+ miles with the Kia Soul. The hybrid-electrics, which also use gasoline, have expected electric ranges of 22-30 miles.

TABLE 31. Upcoming Plug-In Vehicles

Manufacturer	Model	Availability	All-Electric Range	Specifications
All-electric Plug-In Vehicles				
Tesla	Model X	2015	230 miles	60-85 kWh battery
Mercedes-Benz	B-Class ED	2014	100 miles	28 kW battery, 100 kW electric motor
Volkswagen	E-Golf	2014	93 miles	24.2 kWh battery, 85 kW - 114 hp electric motor
Kia	Soul EV	2014	80+ miles	27 kW-hr Lithium polymer battery, 109 hp electric motor
Hybrid-Electric Plug-In Vehicles				
Audi	A3 eTron Hybrid	2015	30 miles	63 kW Li-ion battery, 102 hp electric motor
BMW	i8 Hybrid	2014	30 miles	10.8 kWh lithium-ion battery
Mitsubishi	Outlander Plug-in Hybrid	2015	30 miles	12 kW-hr Li-ion battery, 1.6-liter 4 cylinder gasoline engine
Porsche	Panamera S E-hybrid	2014	22 miles	9.4 kW battery, 95 hp electric motor

Note: Since these vehicles are not currently for sale, the all-electric ranges are company estimates and not the result of the Environmental Protection Agency tests.

Sources:
Plugincars.Com. http://www.plugincars.com/cars and the Fuel Economy website www.fueleconomy.gov

Primearth EV Energy Supplied the Most Batteries by Number but Panasonic Supplied the Most Battery Capacity for Model Year 2013

Primearth EV Energy supplied a majority of the batteries for hybrid vehicles in 2013. While hybrid vehicle sales far outnumber plug-in vehicle sales, the capacity of hybrid batteries average only about 1.3 kW-hrs per battery. Panasonic, while supplying fewer batteries, produced them for plug-in vehicles that have much larger batteries so they supplied the greatest amount battery capacity. For model year 2013, the battery capacity for a plug-in vehicle could be as high as 85 kW-hrs – a battery offering for the Tesla Model S. AESC and LG Chem also produced a substantial amount of battery capacity for plug-in vehicles in that year.

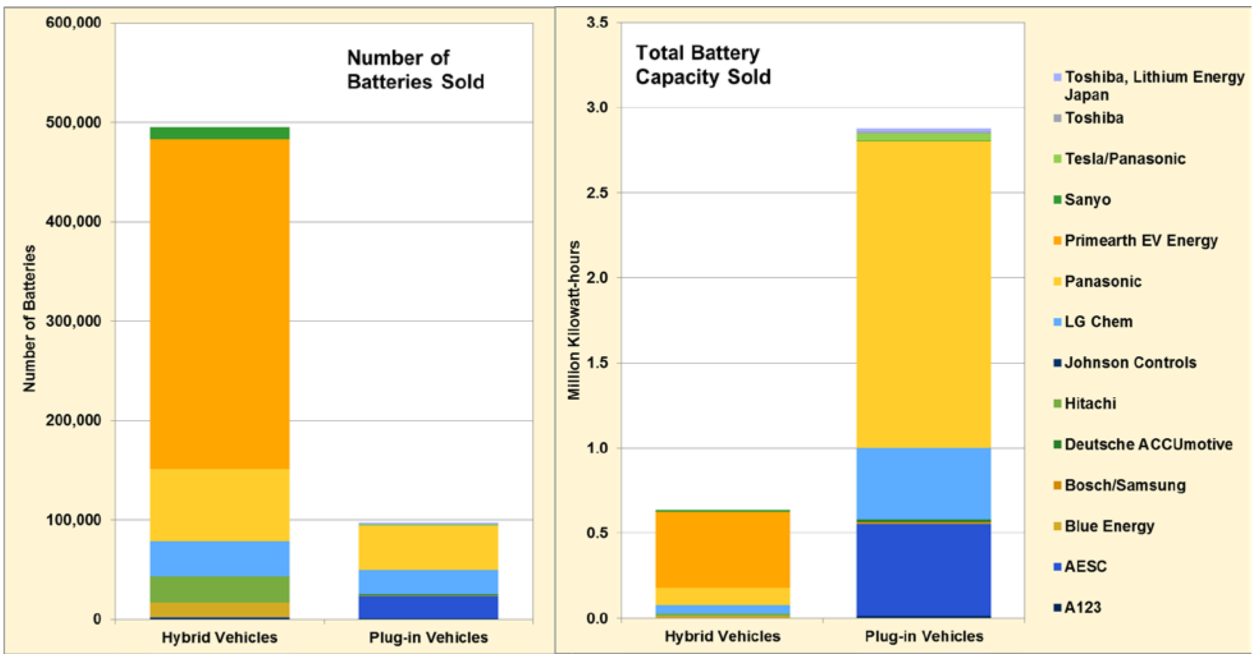


FIGURE 88. Battery Sales Estimates for Hybrid and Plug-In Vehicles, 2013

Sources:

Estimated using hybrid and plug-in sales data along with information on battery suppliers.

Vehicle Sales Data – Provided by Yan (Joann) Zhou, Argonne National Laboratory.
http://www.transportation.anl.gov/technology_analysis/edrive_vehicle_monthly_sales.html

Battery Suppliers – Compiled from public sources by Josh Pihl, Oak Ridge National Laboratory, January 2014.

Battery Capacity Varies Widely for Plug-In Vehicles

The all-electric plug-in vehicles have capacities ranging from 12 kW-hrs in the Scion iQ EV to 85 kW-hrs in the Tesla Model S (and Model X). Plug-in hybrid-electric vehicles typically have smaller battery capacities than all-electric vehicles because their range is extended with a gasoline engine. All plug-in vehicles currently have lithium-ion (Li-ion) batteries.

TABLE 32. Batteries for Selected Available and Upcoming Plug-in Vehicles, Model Years 2013-2015

Vehicle	Model Year	Battery Capacity (kW-hrs)	Battery Type	Supplier
All-Electric Vehicles				
BMW i3	2014	22	Li-ion	Samsung SDI
Chevrolet Spark EV	2014	21	Li-ion	A123
Fiat 500e	2014	24	Li-ion	Bosch/Samsung
Ford Focus Electric	2013	23	Li-ion	LG Chem
Honda Fit-EV	2013	20	Li-ion	Toshiba
Kia Soul EV	2015	27	Li-ion	SK Innovation
Mercedes-Benz B-Class EV	2014	28	Li-ion	Tesla/Panasonic
Mitsubishi iMiEV	2014	16	Li-ion	Toshiba, Lithium Energy Japan
Nissan Leaf	2013	24	Li-ion	AESC
Scion iQ EV	2014	12	Li-ion	Panasonic
Smart For Two Electric Drive	2013	17.6	Li-ion	Deutsche ACCUmotive
Tesla Model S	2013	60 or 85	Li-ion	Panasonic
Tesla Model X	2015	60 or 85	Li-ion	Panasonic
Toyota RAV 4 EV	2013	41.8	Li-ion	Tesla/Panasonic
Volkswagen e-Golf	2014	24.2	Li-ion	Sanyo
Wheego LiFe	2013	30	Li-ion	Flux Power
Plug-In Hybrid-Electric Vehicles				
BMW i8	2014	7.1	Li-ion	Samsung SDI
Cadillac ELR	2014	16.5	Li-ion	LG Chem
Chevrolet Volt	2014	16.5	Li-ion	LG Chem
Ford C-Max Energi	2014	7.6	Li-ion	Panasonic
Ford Fusion Energi	2014	7.6	Li-ion	Panasonic
Honda Accord Plug-In	2014	6.7	Li-ion	Blue Energy
Mitsubishi Outlander	2015	12	Li-ion	Lithium Energy Japan
Porsche Panamera S E-Hybrid	2014	9.4	Li-ion	Sanyo
Toyota Prius Plug-In	2013	4.4	Li-ion	Panasonic

Notes: Automotive Energy Supply Corporation (AESC) is a joint venture between NEC and Nissan. Deutche ACCUmotive is a joint venture between Daimler and Evonik Industries AG. Sanyo is a wholly-owned subsidiary of Panasonic. Tesla has supplied EV batteries built from Panasonic cells to Toyota and Mercedes Benz. Blue Energy is a joint venture between GS Yuasa and Honda. Lithium Energy Japan is a joint venture between GS Yuasa and Mitsubishi.

Source:
Compiled from public sources by Josh Pihl, Oak Ridge National Laboratory, January 2014.

Hybrid-Electric Vehicles Use Batteries with Capacities Up to 2 Kilowatt-Hours

Battery capacities for hybrid-electric vehicles range from 0.5 to 1.9 kilowatt-hours. Some manufacturers have moved to lithium-ion (Li-ion) or lithium-polymer batteries, while others continue with the nickel-metal hydride (NiMH) batteries.

TABLE 33. Batteries for Selected Hybrid-Electric Vehicles, Model Years 2013-2014

Vehicle	Model Year	Battery Capacity (kW-hrs)	Battery Type	Supplier
Acura ILX	2014	0.7	Li-ion	Blue Energy
Audi Q5 Hybrid	2014	1.3	Li-ion	Sanyo
BMW ActiveHybrid 3	2014	1.4	Li-ion	A123
BMW ActiveHybrid 5	2014	1.4	Li-ion	A123
BMW ActiveHybrid 7	2014	1.4	Li-ion	A123
Buick LaCrosse eAssist	2014	0.5	Li-ion	Hitachi
Buick Regal eAssist	2014	0.5	Li-ion	Hitachi
Chevrolet Impala ECO	2014	0.5	Li-ion	Hitachi
Ford C-Max Hybrid	2014	1.4	Li-ion	Panasonic
Ford Fusion Hybrid	2014	1.4	Li-ion	Panasonic
Honda Accord Hybrid	2014	1.3	Li-ion	Blue Energy
Honda Civic Hybrid	2013	0.7	Li-ion	Blue Energy
Honda CR-Z Hybrid	2014	0.7	Li-ion	Blue Energy
Honda Insight Hybrid	2014	0.6	NiMH	Sanyo
Hyundai Sonata Hybrid	2013	1.4	Li polymer	LG Chem
Infiniti M Hybrid	2014	1.4	Li-ion	AESC
Infiniti Q50 Hybrid	2014	1.4	Li-ion	AESC
Infiniti QX60 Hybrid	2014	0.7	Li-ion	Hitachi
Kia Optima	2013	1.4	Li polymer	LG Chem
Lexus CT 200h	2014	1.3	NiMH	Primearth EV Energy
Lexus ES 300h	2014	1.6	NiMH	Primearth EV Energy
Lexus GS 450h	2014	1.9	NiMH	Primearth EV Energy
Lexus LS 600h L	2014	1.9	NiMH	Primearth EV Energy
Lexus RX 450h	2014	1.9	NiMH	Primearth EV Energy
Lincoln MKZ Hybrid	2014	1.4	Li-ion	Panasonic
Mercedes-Benz E400 Hybrid	2014	0.8	Li-ion	Johnson Controls
Nissan Pathfinder Hybrid	2014	0.7	Li-ion	Hitachi
Porsche Cayenne S Hybrid	2013	1.7	NiMH	Sanyo
Toyota Avalon Hybrid	2014	1.6	NiMH	Primearth EV Energy
Toyota Camry Hybrid	2014	1.6	NiMH	Primearth EV Energy
Toyota Highlander Hybrid	2014	1.9	NiMH	Primearth EV Energy
Toyota Prius	2014	1.3	NiMH	Primearth EV Energy
Toyota Prius c	2014	0.9	NiMH	Primearth EV Energy
Toyota Prius v	2014	1.3	NiMH	Primearth EV Energy
Volkswagen Jetta Hybrid	2014	1.1	Li-ion	Sanyo
Volkswagen Touareg Hybrid	2014	1.7	NiMH	Sanyo

Notes: Automotive Energy Supply Corporation (AESC) is a joint venture between NEC and Nissan. Primearth EV Energy, formerly Panasonic EV Energy, is a joint venture between Panasonic and Toyota. Sanyo is a wholly-owned subsidiary of Panasonic. Blue Energy is a joint venture between GS Yuasa and Honda.

Source:
Compiled from public sources by Josh Pihl, Oak Ridge National Laboratory, January 2014.

Hybrid and Electric Cargo Trucks Are on the Market

The first line production of commercial diesel-electric hybrid trucks was the International DuraStar Hybrid which began production in 2007. There are currently numerous models of hybrid cargo trucks on the market. Two of those, Ford and Navistar, also manufacture fully electric trucks, along with Modec and Smith Electric Vehicles. Most of the hybrid trucks available are diesel-fueled and are used for a variety of purposes, ranging from delivery vehicles to long-haul trucks.

TABLE 34. Hybrid and Electric Cargo Trucks on the Market

Make	Model	Body Type/Application	GVW Class
Gasoline Hybrid			
Ford	E450	Step Van, Shuttle Bus	3
GM	TC5500	Utility	5
Via Motors	VTRUX	Van, Pickup, Sport Utility Vehicle	2, 3
Diesel Hybrid			
Freightliner	Business Class M2e Hybrid	City Delivery, Utility, Delivery Tractor	7, 8
Freightliner CCC	MT-45, MT-55	Walk-in Van	
Kenworth	T270	Delivery, Utility	6
Kenworth	T370	Delivery, Utility	7
Mack/Volvo	TerraPro Hybrid	Refuse	8
Navistar, Inc.	DuraStar Hybrid (Truck)	Beverage, Box Van, Refrigeration, Landscape Dump, Utility, Crane, Tree Trimmer, Recovery Towing, Armored Vehicle, Stake Flat, Grapple, Road Patch Truck, Refined Fuels, Propane Tank	6, 7
Navistar, Inc.	4300	Utility, Digger Derrick, Air Compressor	6, 7, 8
Navistar, Inc.	DuraStar Hybrid (4x2) Tractor	Beverage Diminishing Load	7
Navistar, Inc.	WorkStar Hybrid (Truck)	4x4 Utility, Landscape Dump, Snowplow, Digger Derrick, Utility, Crane, Stake Flat, Box Van, Recovery Towing, Refined Fuels, Propane Tank	6, 7
Peterbilt	320 Hybrid (Hydraulic Launch Assist)	Refuse	8
Peterbilt	330 Hybrid	Delivery van	6
Peterbilt	337 Hybrid	City Delivery, Fire & Rescue, Beverage, Municipal, Refuse, Utility	6, 7
Peterbilt	348 Hybrid	Municipal, Service, Utility	7, 8
Peterbilt	386 Hybrid	Long Haul	8
Full Electric			
Ford	Transit Connect	Cargo Van	1
Modec	Chassis Cab, Dropside & Box Van	Chassis Cab, Dropside, Box Van, Refrigerated Box Van, Tail Lift, Tipper	3
Navistar, Inc.	eStar	Delivery Van	3
Smith Electric Vehicles	Newton	Food Distribution, Parcel Delivery, Chilled Food Distribution, Short Haul, Utility, Airport Operations, Public Sector	5, 6, 7

Source:

Environmental Defense Fund, Innovation Exchange. http://business.edf.org/projects/fleet-vehicles/hybrid-trucks-financial-incentives-guide/available-models-medium-heavy-duty-

Flex-Fuel Vehicle Offerings Expand for Model Year 2013

In the last five years, GM, Ford and Chrysler have been the front-runners in the number of flex-fuel models offered to the public (includes cars and light trucks). Nissan and Toyota have offered flex-fuel models each of the last five years, too. Other manufacturers, like Mercedes-Benz and Volkswagen expanded their flex-fuel offerings in 2012, and in 2013 there were 82 different flex-fuel vehicle models available. The manufacturers receive credits in the Corporate Average Fuel Economy program for producing flex-fuel vehicles, which run on E-85 and/or gasoline.

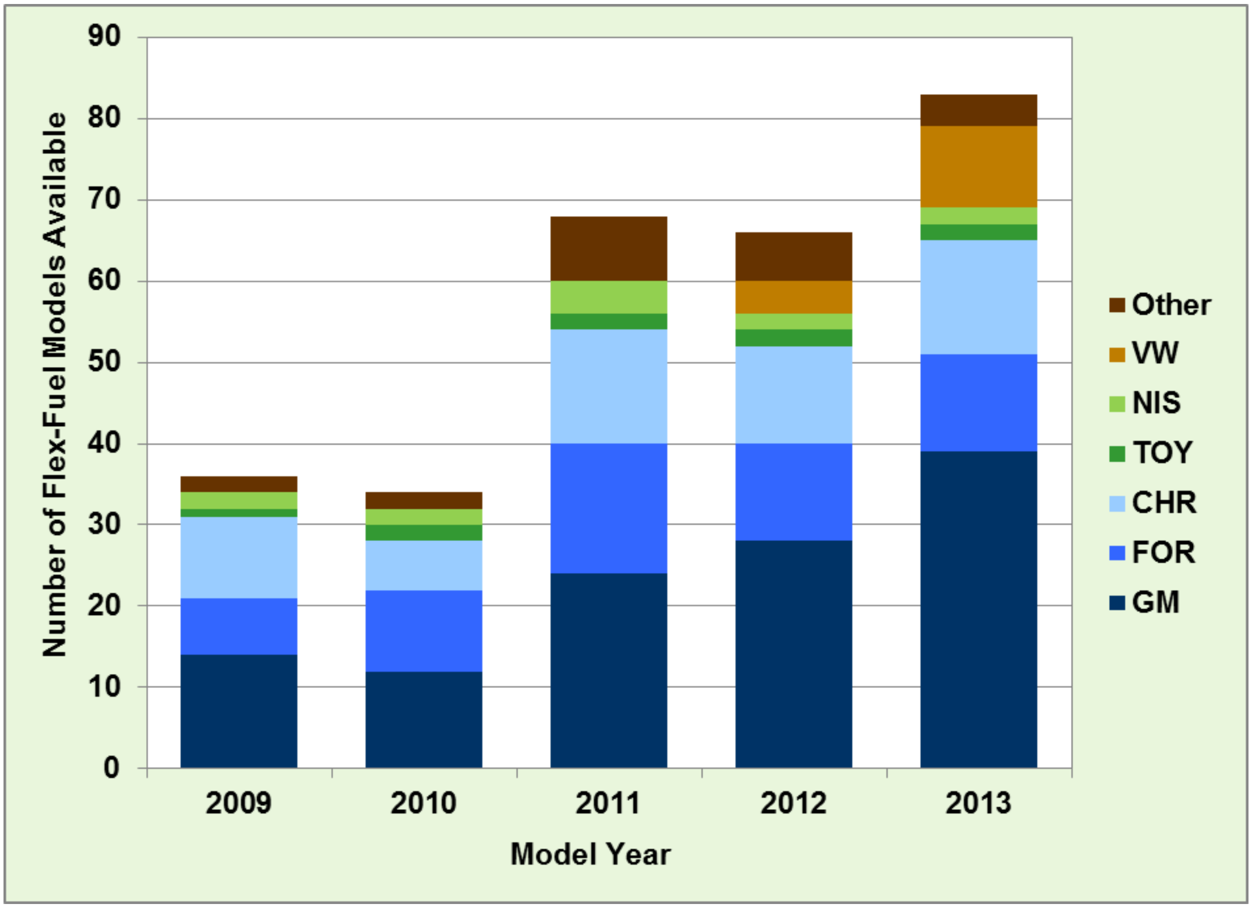
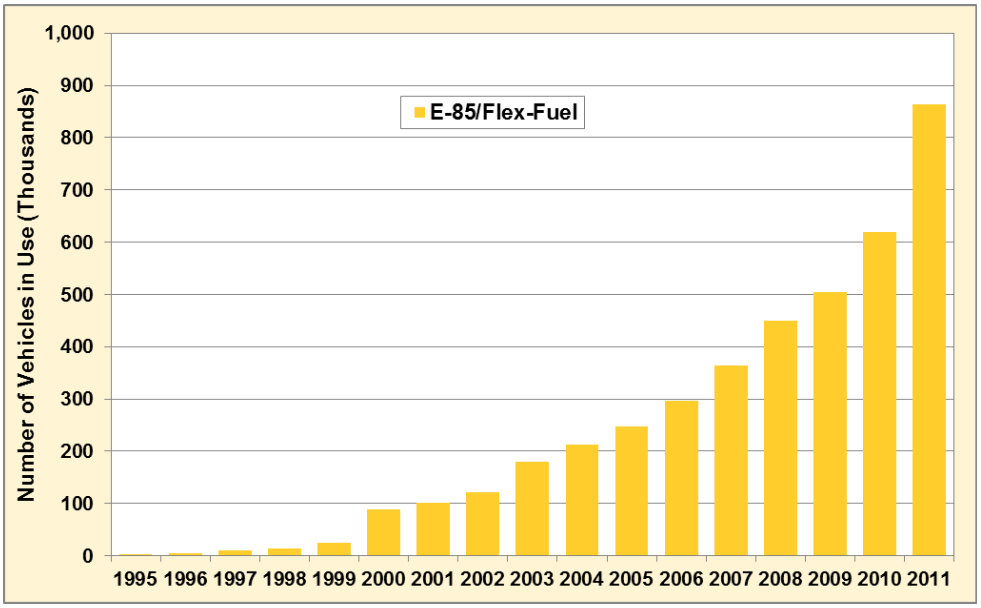


FIGURE 89. Number of Flex-Fuel Models Available, 2009-2013

Source:
U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/afdc/vehicles/search/light

Alternative Fuel Vehicles in Use Are Mostly Flex-Fuel Vehicles

There are over 800 thousand vehicles in use that run on E-85, often called flex-fuel vehicles. This includes only those vehicles believed to be using E-85, which are primarily fleet-operated vehicles. The number of vehicles using liquefied petroleum gas (LPG) has declined each year since 2003, while plug-in electric vehicles (including low-speed electric vehicles) have increased.



Note: Includes only those vehicles believed to be using E-85.

Note: Electricity includes only vehicles that plug into an outlet, including low-speed vehicles. LPG = Liquefied petroleum gas. CNG = Compressed natural gas. LNG = Liquefied natural gas.

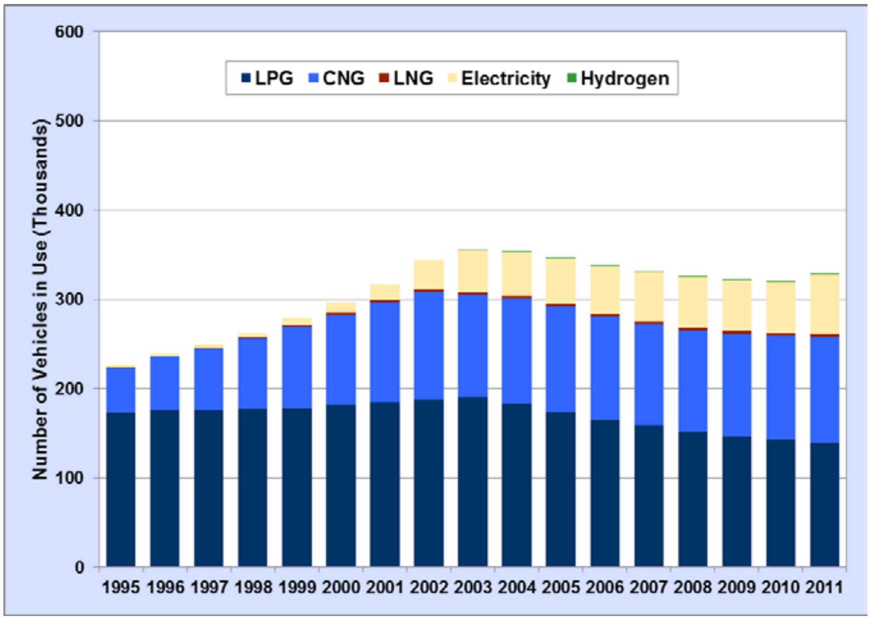


FIGURE 90. Number of Alternative Fuel Vehicles in Use, 1995-2011

Source:
U.S. Department of Energy, Energy Information Administration. www.eia.gov/renewable/afv/users.cfm

Biofuel Stations Spread Beyond the Midwest

E-85, which is nominally 85% ethanol and 15% gasoline, is sold at 2,669 stations nationwide. Many stations are located in the Midwest where the majority of ethanol feedstock is grown, but E-85 stations are found throughout the nation. B-20, which is 20% biodiesel, is sold at 814 stations across the country, with the predominance of stations in the Southeast. Data are as of February 3, 2014.

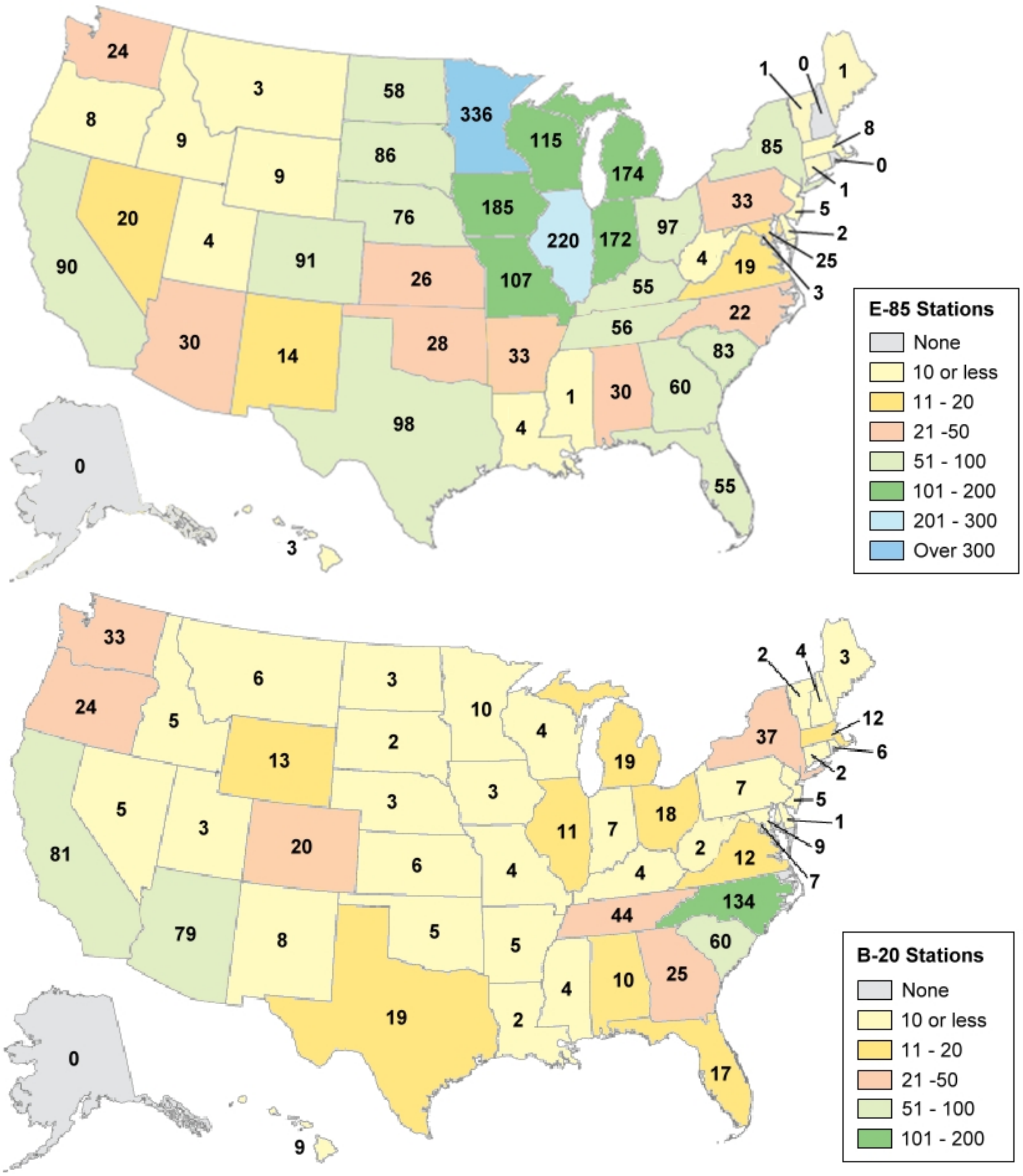


FIGURE 91. Number of E-85 (top) and B-20 Stations by State, 2014

Source:
U.S. Department of Energy, Alternative Fuel and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/afdc/fuels/stations_counts.html

Most States Have Stations with Propane and Natural Gas

There is a wide distribution of the 2,982 propane stations across the country. Texas and California together comprise 24% of the propane stations. Natural gas, compressed or liquefied, is not as widely available as many other alternative fuels. There are 1,321 stations nationwide. New York and California have the most natural gas stations. Data are as of February 3, 2014.

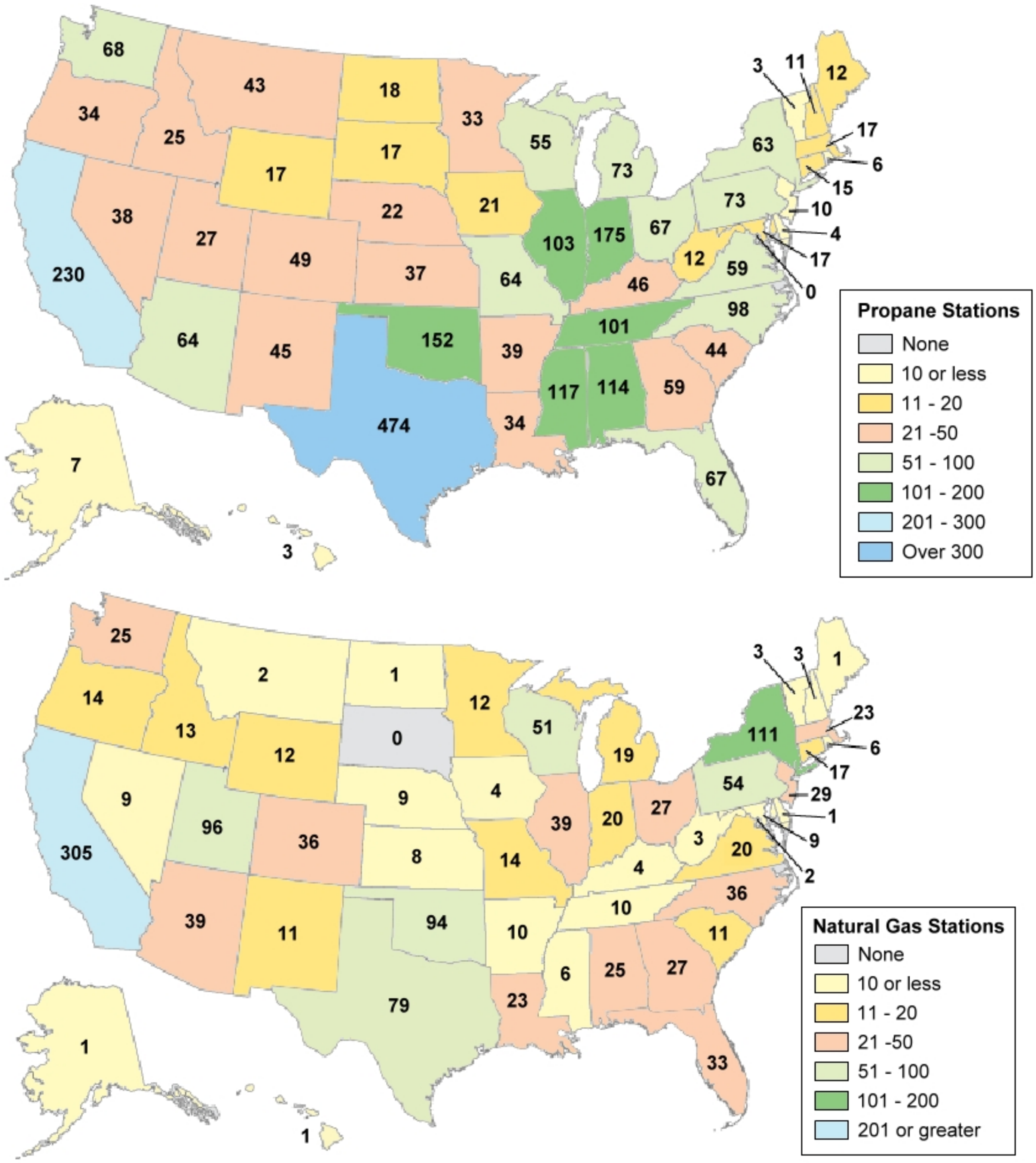


FIGURE 92. Number of Propane (top) and Natural Gas Stations by State, 2014

Source:

U.S. Department of Energy, Alternative Fuel and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/afdc/fuels/stations_counts.html

Number of Electric and Hydrogen Stations Increasing

In January of 2014, Tesla completed their first coast-to-coast Supercharger route, making electric vehicle travel from Los Angeles to New York practical for the first time. There are now more electric stations than any other alternative fuel (20,835 stations). Hydrogen stations are mainly located in California and New York, where research and development is on-going for this fuel. Data are as of Februrary 3, 2014.

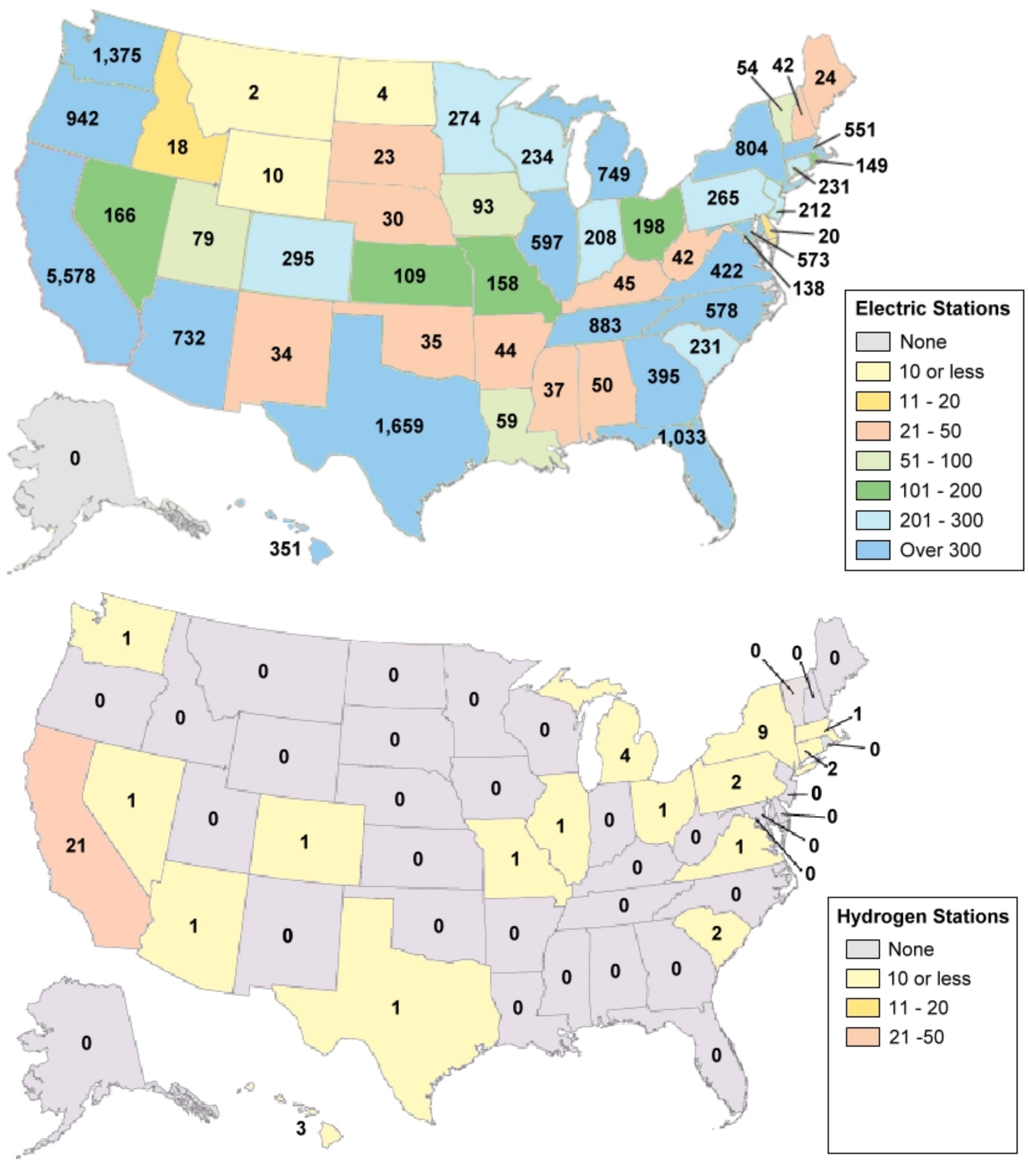


FIGURE 93. Number of Electric (top) and Hydrogen Stations by State, 2014

Source:
U.S. Department of Energy, Alternative Fuel and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/afdc/fuels/stations_counts.html

Federal Government Uses Alternative Fuel

The Federal Government is a large user of alternative fuel. Over 18 million gasoline-equivalent gallons (GGEs) of biofuels (E-85 and biodiesel) were used in 2012. Federal use of other alternative fuels has been less than one million GGEs combined in 2009-2012. Note the large difference in the scales of the two graphs.

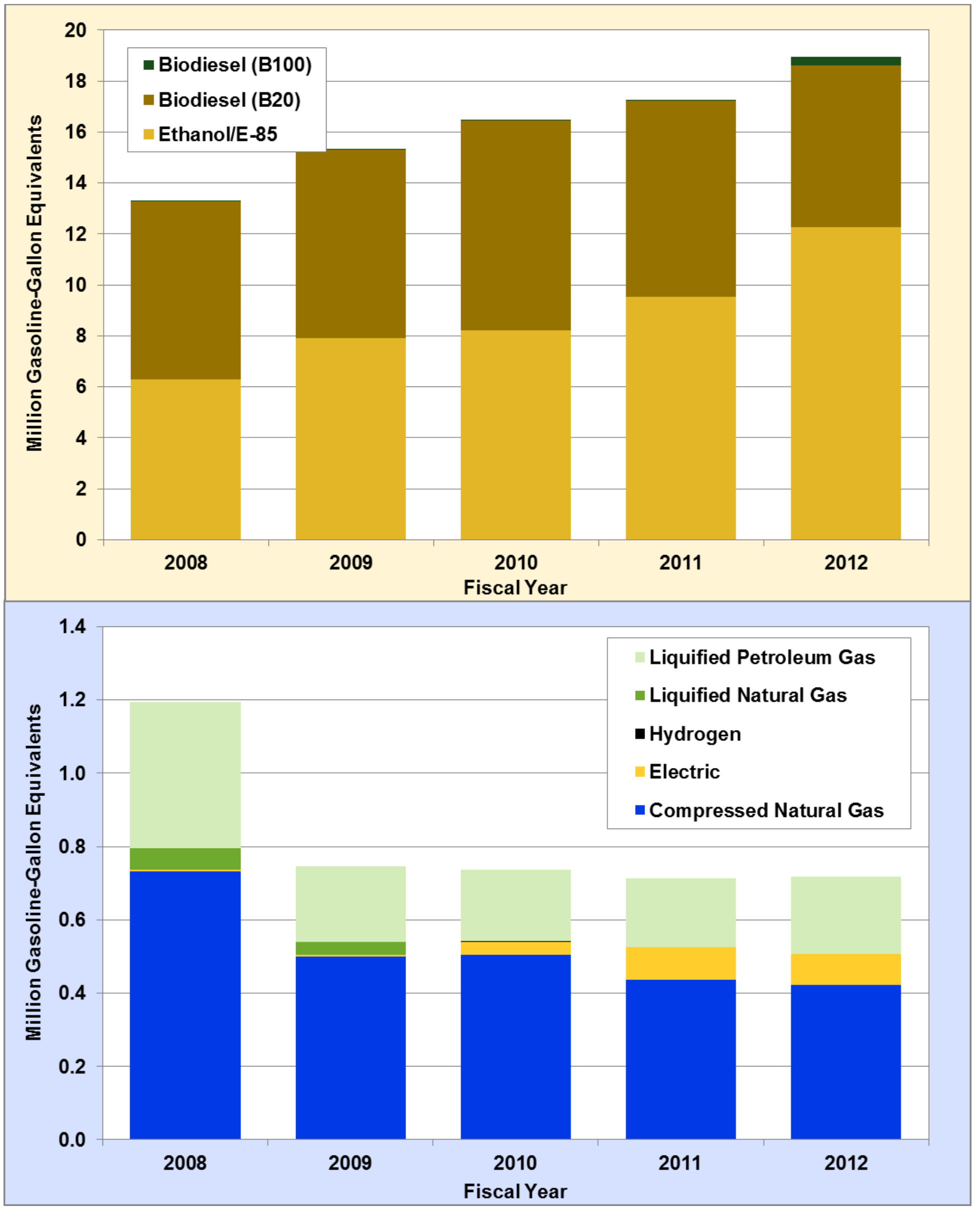


FIGURE 94. Alternative Fuel Use by the Federal Government, 2008-2012

Source:

U.S. General Services Administration, *FY 2012 Federal Fleet Report*, Washington, DC, 2013. http://www.gsa.gov/portal/content/102943#top

E-85 Vehicles Top Diesels in the Federal Government Fleet

Though gasoline vehicles are the most prevalent in the Federal Government fleet, there are more E-85 vehicles than diesels in the inventory. The number of gasoline hybrid vehicles and electric vehicles both rose substantially between 2008 and 2012.

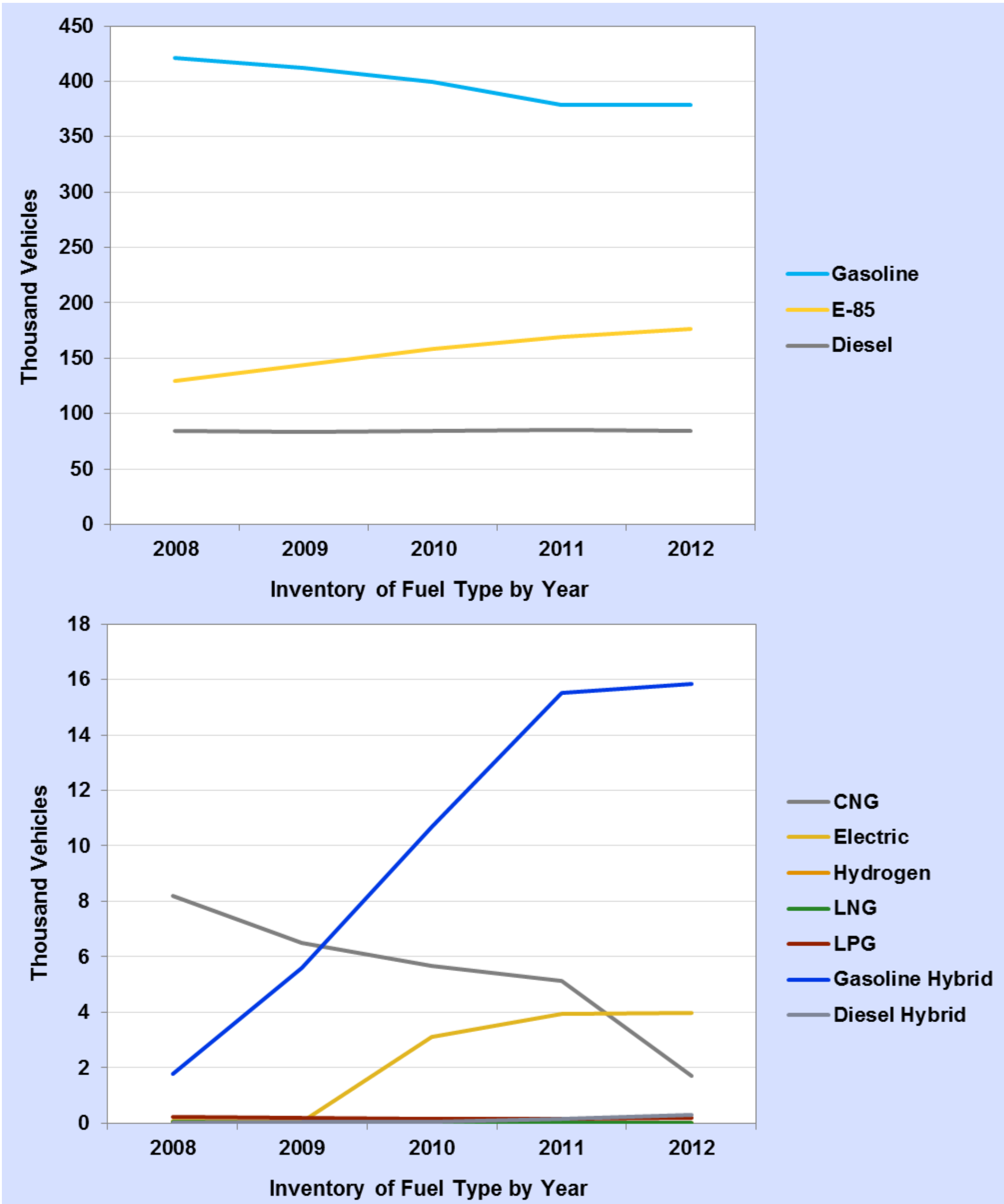


FIGURE 95. Federal Government Vehicles by Fuel Type, 2008-2012

Source:

U.S. General Services Administration, *FY 2012 Federal Fleet Report*, Washington, DC, 2013. http://www.gsa.gov/portal/content/102943

Commercial Fleets Use Alternative Fuel and Advanced Technology Vehicles

Some commercial fleet owners are realizing the advantages of using alternative fuels and advanced technology vehicles. A list of the top "green" fleets compiled by Bobit Publishing shows that United Parcel Service uses more than 12,000 alternative fuel vehicles, most of them biodiesel. Eighty-four percent of Schwan's Home Service vehicles run on propane.

TABLE 35. Top 25 Commercial Fleets Using Alternative Fuel and Advanced Technology Vehicles, 2013

	Company	Total Alt Fuel	CNG*	Propane*	Flex-Fuel	Biodiesel	Hybrid/ Electric*	Total Vehicles	Percent Alt Fuel	Percent Hybrid/Electric
1	United Parcel Service (UPS)	12,331	933	10	0	11,000	388	92,614	13%	0%
2	Comcast Corp.	7,085	0	0	6,800	0	285	36,175	20%	1%
3	Verizon	6,821	514	0	3,500	1,500	1,307	32,695	21%	4%
4	GE Healthcare	6,045	0	0	6,005	0	40	6,045	100%	1%
5	Waste Management	5,568	1,144	20	2,100	2,300	4	5,309	105%	0%
6	State Farm Mutual Auto Insurance Co.	5,692	0	0	4,857	1	834	12,208	47%	7%
7	AT&T	5,196	3,466	0	85	0	1,645	66,977	8%	2%
8	Merck & Co., Inc.	5,190	0	0	5,000	0	190	8,710	60%	2%
9	Schwan's Home Service, Inc.	4,800	0	4,800	0	0	0	5,700	84%	0%
10	Chesapeake Energy	4,773	1,563	0	3,210	0	0	4,457	107%	0%
11	Cox Enterprises	4,591	2	0	4,328	0	261	12,098	38%	2%
12	Monsanto Co.	2,800	0	0	2,800	0	0	3,351	84%	0%
13	Liberty Mutual Insurance	2,647	0	0	2,647	0	0	2,755	96%	0%
14	Honeywell International Inc.	2,460	0	0	2,460	0	0	4,003	61%	0%
15	Public Service Enterprise Group (PSE&G)	2,331	60	0	0	1,741	530	4,060	57%	13%
16	Johnson & Johnson Services, Inc.	2,269	0	0	0	0	2,269	7,700	29%	29%
17	Florida Power & Light	2,249	0	39	0	1,776	434	1,736	130%	25%
18	PepsiCo, Inc.	2,235	88	120	0	0	2,027	22,685	10%	9%
19	Xerox Corp.	2,030	0	0	2,000	0	30	5,499	37%	1%
20	Delta Airlines	2,013	30	151	0	0	1,832	1,827	110%	100%
21	Kellogg's	2,002	0	0	2,000	0	2	1,207	166%	0%
22	Consolidated Edison Company of New York	1,962	149	149	0	1,450	214	4,561	43%	5%
23	Xcel Energy	1,939	59	0	1,500	368	12	2,925	66%	0%
24	Bristol-Myers Squibb Co.	1,925	0	0	1,875	0	50	2,735	70%	2%
25	Novartis Pharmaceuticals	1,889	0	0	915	278	696	6,643	28%	10%

Note: Total Alt Fuel and Percent Alt Fuel columns include hybrid/electric vehicles.

Source:
Bobit Publishing, *Automotive Fleet 500*, "Top 50 Green Fleets," 2013.
http://www.fleet-central.com/TopFleets/pdf/FLT500top50green.pdf

*Includes dedicated and bi-fuel vehicles.

Use of Lightweight Materials Is On the Rise

As automakers strive to improve fuel economy, they have turned increasingly to lightweight materials to reduce overall vehicle weight. For example, most light vehicle engine blocks are now made of aluminum rather than cast iron, and in many cases, aluminum wheels have replaced heavier steel wheels as standard equipment. Use of regular steel has declined by 200 pounds per vehicle from 1995 to 2011 while the use of high and medium strength steels has increased by 284 lbs. per vehicle. The increased use of high and medium strength steel is significant because it allows manufacturers to improve the structural integrity of vehicles while keeping the overall vehicle weight to a minimum. The use of plastics and composites has also increased by 57% and lightweight magnesium castings have seen greater use in dashboards and other interior applications such as seat components, replacing the heavier steel components that were previously used.

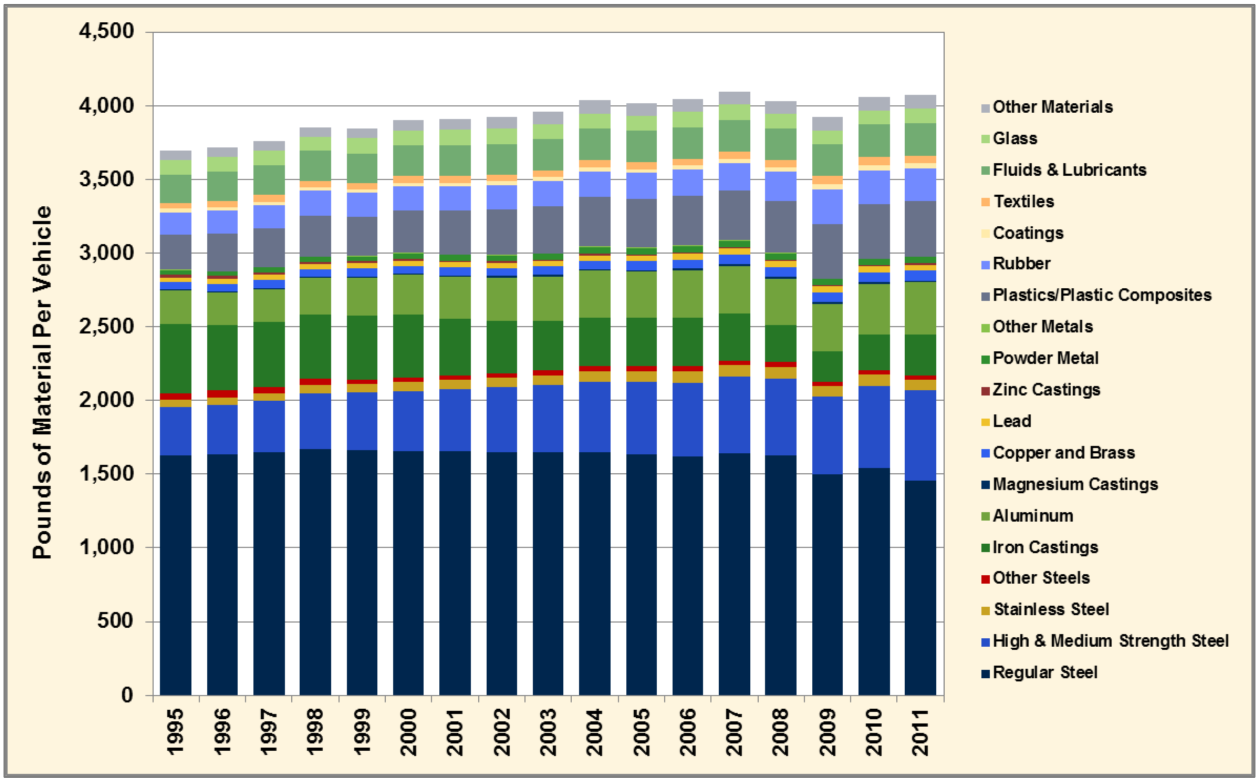


FIGURE 96. Average Materials Content of Light Vehicles, 1995-2011

Source:
Ward's AutoInfoBank. http://wardsauto.com

Hybridization and Other Engine Technologies Show the Most Promise for Improving Fuel Economy of Medium and Heavy Trucks

As a precursor to the Federal heavy truck fuel economy standards recently finalized, the National Academy of Sciences produced a study of the technologies and approaches to reducing fuel consumption (FC) in medium and heavy trucks. They determined that the most effective technologies in terms of fuel consumption reduction are: hybridization; replacement of gasoline engines with diesel engines; improvement in diesel engine thermal efficiency; improvement in gasoline engine thermal efficiency; aerodynamics, especially on tractor-trailers; reduced rolling resistance; and weight reduction. Hybridization and other engine technologies show the most promise for improving fuel economy of medium and heavy trucks.

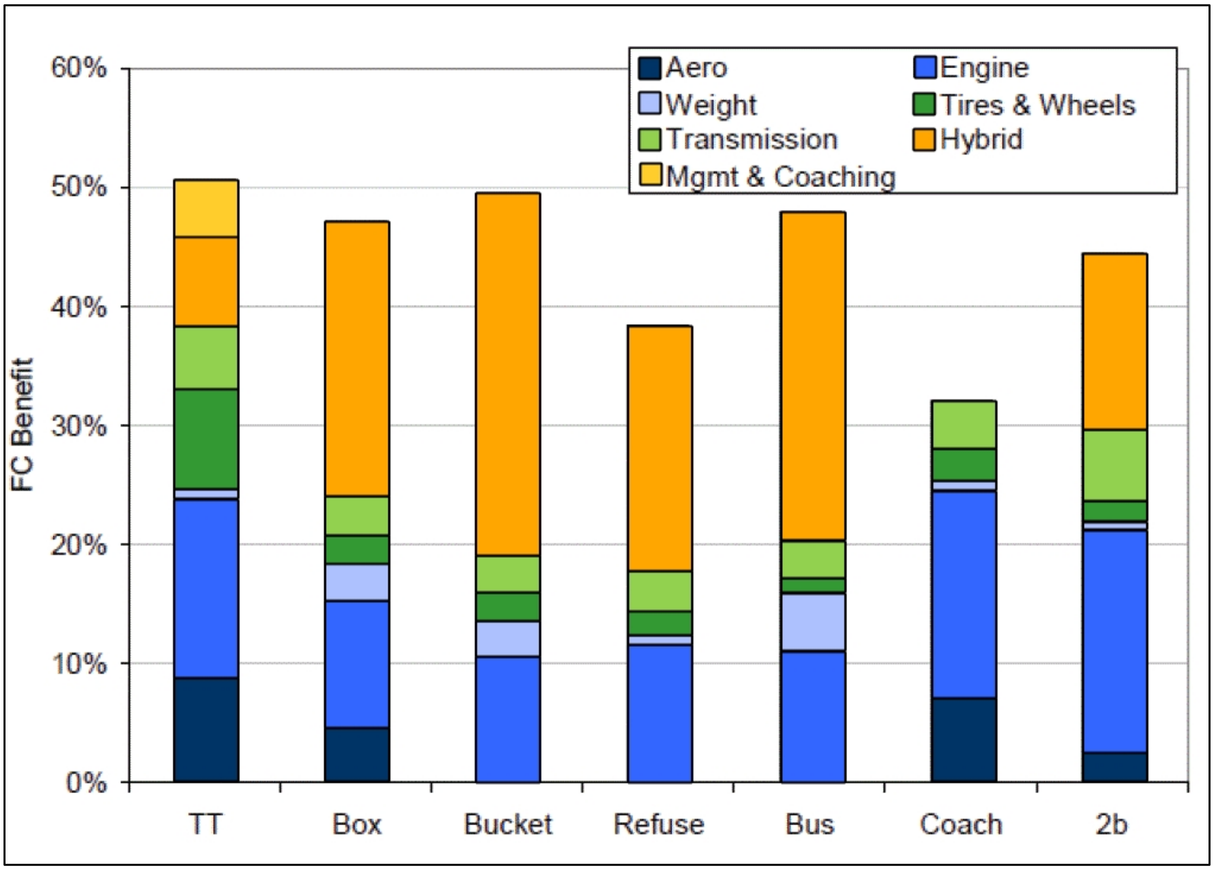


FIGURE 97. Comparison of 2015-2020 New Vehicle Potential Fuel Saving Technologies

Note: FC Benefit = fuel consumption benefit; TT = tractor-trailer; Box = Class 3-6 box truck; Bucket = Class 3-6 bucket truck; Refuse = Class 8 refuse truck; Bus = transit bus; Coach = motor coach; 2b = Class 2b pickups and vans; Areo = aerodynamics; Mgmt = management.

Source:
TIAX, LLC. As shown in the National Research Council and Transportation Research Board, *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*, 2010. http://www.nap.edu/catalog.php?record_id=12845

SmartWay Technology Program Encourages Heavy Truck Efficiencies

An EPA-certified SmartWay **tractor** is characterized by a model year 2007 or later engine; integrated sleeper-cab high roof fairing; tractor-mounted side fairing gap reducers; tractor fuel-tank side fairings; aerodynamic bumper and mirrors; options for reducing periods of extended engine idling (auxiliary power units, generator sets, direct-fired heaters, battery-powered HVAC system, and automatic engine start/stop system); and options for low-rolling resistance tires (single wide or dual) mounted on aluminum wheels.

As part of SmartWay Transport Partnership, begun in 2004, the U.S. Environmental Protection Agency (EPA) certifies tractors and trailers that incorporate efficient technologies. When manufacturers equip tractors and trailers with certified SmartWay specifications and equipment, theyare given a SmartWay designation.

An EPA-certified SmartWay **trailer** is characterized by side skirts; weight-saving technologies; gap reducer on the front or trailer tails (either extenders or boat tails); and options for low-rolling resistance tires (single wide or dual) mounted on aluminum wheels.

TABLE 36. SmartWay Certified Manufacturers

Tractors	Trailers	Low Rolling Resistance Tires		
Daimler	Great Dane Trailers	Advance	Falken	Regul
Kenworth	Hyundai Translead	Aeolus	Fargo	Roadlux
Mack	Manac Inc.	Akuret	Firestone	Roadmaster (Cooper)
Navistar	Stoughton Trailers, LLC	Aosen	General	Roadone
Peterbilt	Strick Trailers, LLC	Arisun	Geostar	Roadpro
Volvo	Utility Trailer Manufacturing Company	Atlas	Gladiator	Sailun
	Vanguard National Trailer Corporation	Aurora	Goodride	Samson
	Wabash National Corporation	Barkley	Goodyear	Sumitomo
	Wilson Trailer Co.	Benchmark	GT Radial	Sunny
		BF Goodrich	Hankook	Super Cargo
		Blacklion	Hercules	Synergy
		Boristar	Hilo	TBB
		BOTO	Hunter	Topstar
		Bridgestone	Ironman	Toyo Tires
		Briway	Jinyu	Triangle
		Continental	Kumho	Westlake
		Diamondback	Leao	Yokohama
		Dongfeng	Linglong	Wanli
		Double Coin	Long March	Wind Power
		Doublestar	Michelin	Zeetex
		Dunlop Tire	Milestar	
`		ECED	Milever	

Source:
U.S. Environmental Protection Agency, SmartWay Technology Program.
http://www.epa.gov/smartway/forpartners/technology.htm

Some New Engine Technologies Can Improve Fuel Economy and Reduce Emissions

The table below shows some of the notable technologies that have been adopted by manufacturers, as well as those still under development that show promise for further improvements to performance and efficiency.

TABLE 37. Fuel Saving Engine Technologies

Engine Technologies Currently Being Used	
Variable Valve Timing and Lift (VVT&L)	Unlike gasoline engines that use a fixed valve lift, where the valve lift does not change with the speed and load of the engine, VVT&L allows the period of valve opening to vary based on need, which reduces pumping losses and valve train frictional loss. It also increases the compression ratio and reduces idle speed.
Cylinder Deactivation	Cylinder deactivation allows the engine to shut down some of its cylinders during light load operation for greater fuel efficiency.
Down-speeding	This is a strategy that is widely used in the light vehicle market where the transmission and differential are matched to the engine so that the engine turns at the lowest possible speed (RPM) for any given highway speed.
Turbocharging and Supercharging	Turbochargers and superchargers both use small impellers to force compressed air into the cylinders to improve combustion and boost power. Turbochargers are powered by the exhaust while superchargers are powered as an accessory through a mechanical connection to the engine.
Turbo Compounding	Used in heavy vehicle sectors, turbo compounding recovers waste heat energy from the exhaust stream and converts it into usable energy. Mechanical turbo compounding converts waste heat energy into kinetic energy and electric turbo compounding converts the waste heat energy into electrical energy.
Bottoming Cycle Waste Heat Recovery	Bottoming cycle waste heat recovery systems like the Organic Rankin Cycle (ORC) use a fluid that is heated by waste engine heat which then expands to generate electricity and supplement the engine. It is used in heavy trucks.
Direct Injection (with Turbocharging)	Direct fuel injection allows fuel to be injected directly into the cylinder so the timing and shape of the fuel mist can be controlled more precisely. This uses fuel more efficiently because of the higher compression ratios. The combination of direct injection and turbocharging has allowed manufacturers to downsize engines without compromising performance.
Dual Port Injection	Rather than a single injector per port, a dual injector arrangement improves combustion and increases performance and fuel economy.
Variable Displacement Oil Pump	Rather than pump oil through the engine at a constant rate and pressure, the intensity and rate of pumping can be varied to meet the needs of the engine at different load levels.
Variable Speed Water Pump	Variable speed water pumps improve efficiency by limiting the output during low load periods rather than running at a fixed rate.
Active Grille Shutters	Active grille shutters on the front of vehicles close off a portion of the front grille which limits the amount of air entering the engine compartment. This reduced flow of air into the engine compartment improves the aerodynamics of the vehicle while still allowing enough airflow to cool the engine.
Selective Catalytic Reduction (SCR)	Though an emission control technology used for diesel engines, SCR saves fuel over other types of emission control systems because it allows the engine combustion to occur unhindered while treating the exhaust with urea to control NOX after combustion. Other systems compromise the combustion process to limit the formation of NOX or use fuel to maintain the filters resulting in a greater loss in fuel economy. Most heavy duty engine manufacturers have adopted SCR and it has been adopted by some light passenger vehicle manufacturers as well.

TABLE 37. Fuel Saving Engine Technologies (continued)

Engine Technologies Under Development	
Homogenous Charge Compression Ignition (HCCI)	Homogenous Charge Compression Ignition is a combustion strategy that applies diesel technology to gasoline engines. A very lean mixture of gasoline and air are thoroughly mixed and compressed in the cylinder until auto-ignition occurs without the need for a spark. This achieves many of the benefits of a diesel engine such as high efficiency and torque without the emissions drawbacks associated with diesel.
Camless Valve Actuation	Rather than opening and closing the valves mechanically with a cam shaft, there are efforts to reduce these mechanical losses by opening and closing the valves electronically.
Variable Compression Ratio	In standard engines, the compression ratio is fixed across all operating conditions based on cylinder geometry. Variable compression ratio increases efficiency by altering the cylinder compression ratio. New engine designs can mechanically vary cylinder geometry. This allows for engines that can operate at a high-compression ratio under partial or light-load conditions and at a lower compression ratio under heavy-load conditions.
Advanced Corona Ignition System (ACIS)	As fuel mixtures become increasingly lean in gasoline engines, the importance of achieving maximum combustion efficiency is critical. In contrast to the traditional spark plug that produces a small, localized spark at the top of the combustion chamber, the ACIS provides a plasma burst throughout the combustion chamber, igniting the fuel air mixture more quickly and evenly. This not only improves fuel economy but could also reduce maintenance costs because the ACIS does not suffer from electrode erosion like a traditional sparkplug.

Source:
Compiled from published sources by Bob Boundy, Roltek, Inc., Clinton, TN, 2012.

Hybrid Technologies and Transmission Technologies Can Improve Fuel Economy

There are many different implementations of hybrid technology but most fall within the basic classifications shown in the table below. Similarly, there are many different strategies for improving transmission efficiency and performance. Shown are the more prevalent technologies and strategies.

TABLE 38. Drivetrain Technologies

Hybrid Technologies	
Integrated Starter/Generator	Often referred to as "Stop-Start" or "Mild Hybridization", this system shuts off the engine during deceleration and when stopped but instantly restarts the engine when the break is released or the accelerator is depressed. This type of system can be integrated with regenerative breaking. General Motors has been marketing this system under the name eAssist beginning with 2011 Buick models. Other manufacturers including Ford and Kia are also offering Stop-Start options.
Parallel Hybrid	A parallel hybrid system is one where the wheels of the vehicle can be turned by either the gasoline engine or an electric motor or both at the same time. The Toyota Prius is an example of a parallel hybrid.
Series Hybrid	A series hybrid is only propelled by a single source, typically an electric motor while electricity is supplied by an engine that acts as a generator. The Chevrolet Volt functions primarily as a series hybrid when the gasoline engine is required.
Dual Mode Hybrid	A Dual Mode or Two Mode hybrid can operate in either parallel or series hybrid configuration depending on the circumstances. The dual mode hybrid is well suited to heavy applications like busses and light vehicles where towing is a consideration.
Plug-in Hybrid	A plug-in hybrid is often referred to as an extended range electric vehicle because of its ability to charge from a wall outlet and run entirely on electricity until the battery pack is depleted. Then an internal combustion engine is used to power the vehicle.
Hydraulic Hybrid	Hydraulic hybrid technology is still in the demonstration phase and is well suited to heavy duty vehicles in urban settings with frequent stops like refuse trucks and city buses. Due to the heavy weight of these vehicles, a tremendous amount of energy is lost during frequent starts and stops. A hydraulic system can recapture large amounts of energy very quickly and efficiently.
Transmission Technologies	
Continuously Variable Transmission (CVT)	Continuously variable transmissions control the ratio between engine speed and wheel speed, using a pair of variable-diameter pulleys connected by a belt or a chain that can produce an infinite number of engine and wheel speed ratios.
eCVT	The eCVT transmissions are designed for hybrid vehicles that require multiple combinations of inputs to drive the wheels whether an electric motor, gasoline engine or both. The eCVT transmission uses a combination of gears to provide variable gear ratios rather than a belt and cones or pulleys used in standard CVT transmissions.
Automated Manual Transmission (AMT)	Automated manual transmissions operate like a manual transmission but without a clutch pedal. The shifting can be entirely computer controlled or allow driver input through shifter paddles or buttons mounted on the steering wheel. AMT transmissions are increasingly used on heavy trucks in urban settings and are also found in light duty vehicles as well.
Dual Clutch Transmission	A dual clutch transmission is an automated manual transmission that uses two clutches to select gears. One clutch selects the odd gears (1, 3, & 5) while the other selects the even gears (2, 4, & 6). The advantage of this arrangement is that gears are preselected by the alternate clutch allowing for instantaneous shifts that maintain torque to the wheels at all times. Eliminating the power interruption between shifts that occurs with a single clutch improves both performance and efficiency.
Increased Number of Gears	More gears allow the engine to remain closer to its optimal speed as the vehicle accelerates and decelerates. To maintain an optimal engine speed and improve fuel economy and performance, manufacturers have been increasing the number of gears in both manual and automatic transmissions. Manual transmissions now commonly have 6 speeds while conventional automatic transmissions have reached 9 speeds and manufacturers continue to develop transmissions with even more gear ratios.

Source:
Compiled from published sources by Bob Boundy, Roltek, Inc., Clinton, TN, 2012.

Heavy Vehicles Use Hybrid Technologies in Different Ways

FIGURE 98. Hybrid Bucket Truck

Hybridization of medium and heavy trucks can lead to significant gains in efficiency but optimum configuration of the hybrid system and potential gains in efficiency are highly dependent on the application. Bucket trucks that spend much of their time in a stationary position but running the engine to power the boom could benefit greatly from separating driving power requirements from stationary operation requirements. Engine run time could be drastically reduced through the electrification of auxiliary equipment.

Other heavy vehicles that operate at low speed and with frequent stops like a city bus or refuse truck may benefit more from a hydraulic hybrid system. Still in the prototype phase of development, the EPA claims a potential decrease in fuel consumption by as much as 50%. The hydraulic hybrid system is particularly well suited to heavy truck applications because the hydraulic system can recapture about 70% of the kinetic energy while the storage system is very efficient. This favors a duty cycle that involves a high degree of regenerative breaking but lower sustained power requirements.

FIGURE 99. Hybrid Bus

FIGURE 100. Tractor-Trailer

Long-haul class 8 tractor-trailers have a unique set of requirements that favors a different approach to hybridization. The duty cycle involves long periods of sustained work followed by long periods at rest. While driving, tractor trailers can benefit from the electrification of engine driven devices like air conditioning, power steering, water pumps and fans that are normally belt driven. Accessories which are connected to the engine by a belt create a parasitic loss on the engine while it is running. Electrically-powered accessories only draw power when in use, which can provide fuel savings, especially for devices with intermittent use.

When stopped overnight, trucks are often left to idle in order to power the cabin accessories while the driver is at rest. This consumes up to one gallon of diesel per hour. Some truck stops have begun providing external power services in an attempt to reduce overnight idling. Another approach is to integrate smaller heating and cooling systems into the truck that use considerably less fuel than the regular engine.

Source:

National Research Council and Transportation Research Board*, Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*, 2010.

(Pictures from the National Renewable Energy Laboratory.)

Most Highway Operational Energy Losses for Class 8 Trucks Are From Aerodynamics

For class 8 long-haul tractor trailers, the engine accounts for more than half of the energy losses, whether the truck is traveling over the highway or in the city. Operational losses, however, are vastly different depending on whether the truck is on the highway or in the city. Overcoming aerodynamic drag is the greatest burden from an energy loss standpoint on the highway, followed by rolling resistance. In city driving, the braking (loss of inertia) plays a much bigger role in energy losses.

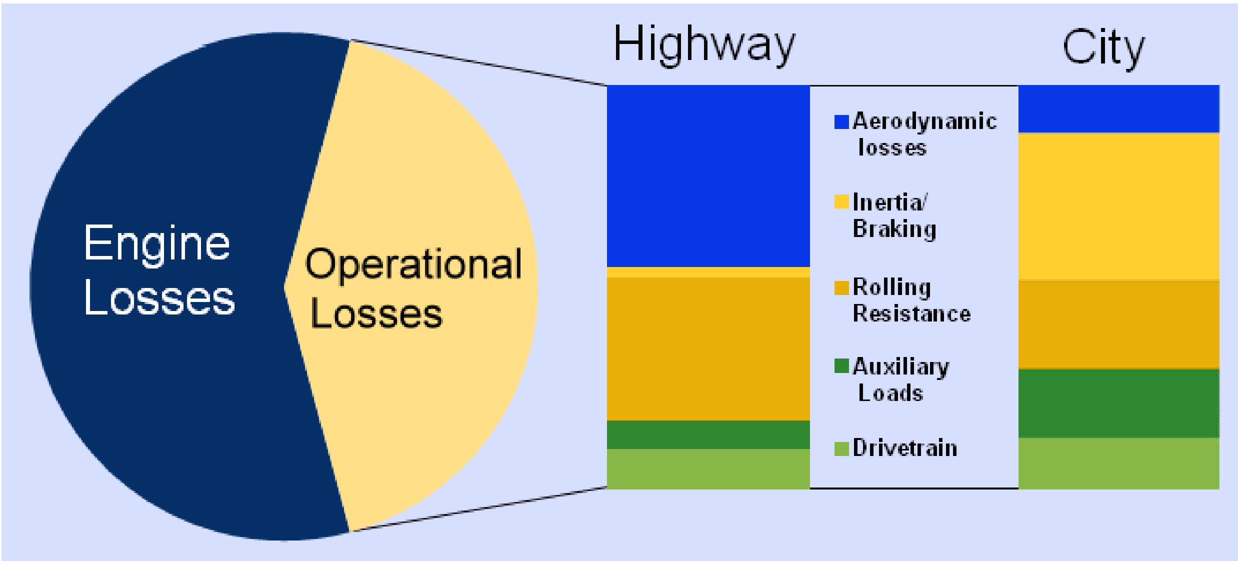


FIGURE 101. Class 8 Truck-Tractor Energy Losses

Note: Applies to Class 8 tractor with sleeper cab and van-type trailer at 65 miles per hour with a gross vehicle weight of 80,000 pounds.

Source:

National Research Council and Transportation Research Board, *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*, 2010. http://www.nap.edu/catalog.php?record_id=12845

Some Aerodynamic Technologies Are Widely Adopted

Aerodynamic drag is a large energy loss point for Class 8 tractor-trailers. Aerodynamic devices like cab fairings that do not hinder performance and are usually free from accidental damage have been widely adopted. Other devices like chassis skirts that are more prone to road damage or gap reducers that reduce the gap between the cab and trailer to improve aerodynamics but prevent tight turns have not been adopted as widely. Boat tails that are fitted on the back of a trailer reduce drag but increase the length of the trailer, which can have practical or regulatory implications.

Technology	Approximate Cost	Industry Adoption Rate
Day Cab Roof Deflector	$1,000-1,300	Most
Sleeper Roof Fairing	$500-1,000	Standard equipment
Chassis Skirt	$1,500-2,000	50-60%
Cab Extender	$300-500	80-90%
Next-Generation Package	$2,750	2012 Introduction

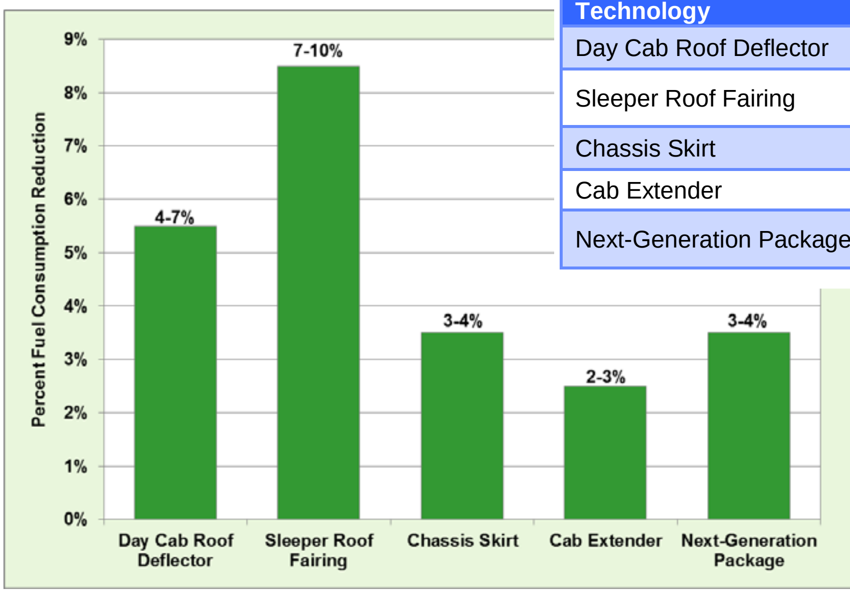


FIGURE 102. Fuel Consumption Reduction Rate, Approximate Cost, and Industry Adoption Rate for Aerodynamic Technologies

Though there are potential savings with improved aerodynamics, there are challenges as well. Adding aerodynamic devices to trailers such as skirts or trailer bogies can be challenging; because the trailer and tractor are often owned separately and the fuel savings are realized by the owner of the tractor, there is often little incentive for the trailer owner to invest in fuel saving devices. Also, trailers outnumber tractors and tend to log fewer annual miles than tractors. This extends the payback period for investment in aerodynamic improvements to trailers. Additionally, for every 1,000 lbs. of weight added, there is a 0.5% penalty in fuel consumption. Trailer skirts alone can add more than 200 lbs. to the weight of a standard 53-foot trailer.

Note: Next-generation package= features designed and optimized for long-haul tractors in 2012.

Source:
National Research Council and Transportation Research Board, *Technologies and Approaches to Reducing the Fuel Consumption of Medium- and Heavy-Duty Vehicles*, 2010. http://www.nap.edu/catalog.php?record_id=12845

Single Wide Tires Improve Fuel Economy of Class 8 Trucks

A study done by Oak Ridge National Laboratory outfitted Class 8 trucks with monitoring equipment which measured the fuel economy of the vehicle along with many other variables. During the study period, the truck-tractors sometimes had standard dual tires and at other times used single very wide tires on the same roads with similar loads. The results of the study show fuel economy improvements due to single wide tires average 7.1% on flat terrain, but can be as much as 16% improvement on severe downslopes.

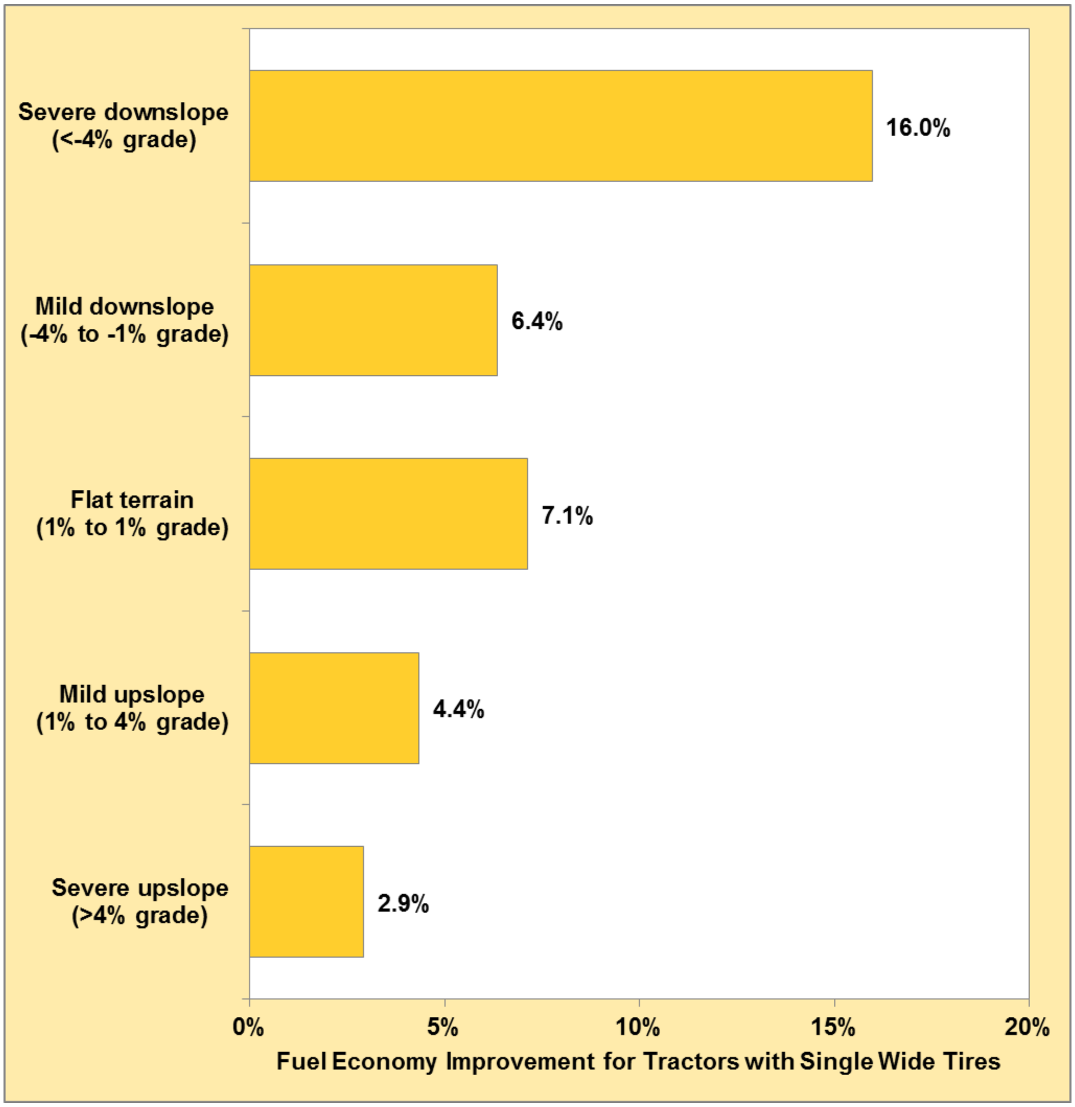


FIGURE 103. Fuel Economy Improvement for Class 8 Tractors with Single Wide Tires

Source:

Franzese, Oscar, *Effect of Weight and Roadway Grade on the Fuel Economy of Class-8 Freight Trucks*, Oak Ridge National Laboratory, ORNL/TM-2011/471, October 2011. http://cta.ornl.gov/cta/Publications/Reports/ORNL_TM_2011_471.pdf

Chapter 5.

POLICY

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Federal Tax Credits Encourage the Purchase of Advanced Technology Vehicles

The Federal Government encourages the use of different transportation fuels by allowing tax credits on vehicle purchases. Between 2005 and 2010, those who purchased hybrid vehicles or vehicles that ran on alternative fuels, such as natural gas, methanol, and hydrogen, received Federal tax credits. Now, electric vehicles and plug-in hybrid-electric vehicles are the only ones for which a Federal tax credit is available – up to $7,500. There are eight plug-in hybrid-electric vehicle models that currently qualify for a credit, and 21 electric vehicle models that qualify. Because the maximum credit amount depends on the capacity of the battery, the Toyota Prius Plug-in Hybrid and the Honda Accord Plug-In Hybrid have lower maximums than the other vehicles.

TABLE 39. Federal Government Tax Incentives for Advanced Technology Vehicles

Vehicle Type	Calendar Year in which the Vehicle was Purchased	Maximum Credit Amounti	Vehicles Currently Eligible for a Tax Credit
Plug-In Hybrid-Electric Vehicles	2010 - on	$2,500	2012-2014 Toyota Prius Plug-In Hybrid
		$3,626	2014 Honda Accord Plug-In Hybrid
		$4,007	2013-2014 Ford C-Max Energi 2013-2014 Ford Fusion Energi
		$4,752	2014 Porsche Panamera S E Hybrid
		$7,500	2011-2014 Chevrolet Volt 2012 Fisker Karma Sedan 2014 BMW i3 w/ Range Extender
Electric Vehicles	2010 - on	$7,500	2012 AMP GCE Electric Vehicle 2012 AMP MLE Electric Vehicle 2014 BMW i3 Sedan 2012 BYD e6 Electric Vehicle 2010-2012 CODA Sedan 2010 Electric Mobile Cars E36 Wagon 2010 Electric Mobile Cars E36t Pickup Truck 2010 Electric Mobile Cars E36v Utility Van 2013 Fiat 500e 2012-2014 Ford Focus EV 2012-2012 Ford/Azure Dynamics Transit Connect EV 2014 Chevrolet Spark EV 2012 Mitsubishi i-MiEV 2011-2013 Nissan Leaf 2011 Smart ForTwo EV 2013 Smart Coupe/Cabriolet EV 2012-2013 Tesla Model S 2008-2011 Tesla Roadster 2011 Think City EV 2012-2014 Toyota RAV4 EV 2011 Wheego LiFe

Source:

U.S. Department of Energy and U.S. Environmental Protection Agency, www.fueleconomy.gov website, February 2014. http://www.fueleconomy.gov/feg/taxcenter.shtml

EPA and NHTSA Redesigned Window Stickers Beginning With Model Year 2013

In May 2011, the U.S. Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA) unveiled the most dramatic overhaul to fuel economy labels since they were introduced 35 years ago. The new labels address many of the challenges presented by a growing number of drivetrains and fuel types. The new labels also provide consumers with new information including:

- New ways to compare energy use and cost between vehicles with diverse fuel types.
- An estimate of how much fuel or electricity it takes to drive 100 miles.
- Information on driving range and charging times for electric vehicles.
- An estimate of how much consumers will spend or save over a five year period on fuel versus the average vehicle.
- Tailpipe emission ratings for pollutants and greenhouse gas emissions expressed in grams per mile.
- A QR code that allows users with smartphones to quickly access online information about the vehicle.

These new labels are mandatory for the 2013 model year (MY) and beyond.

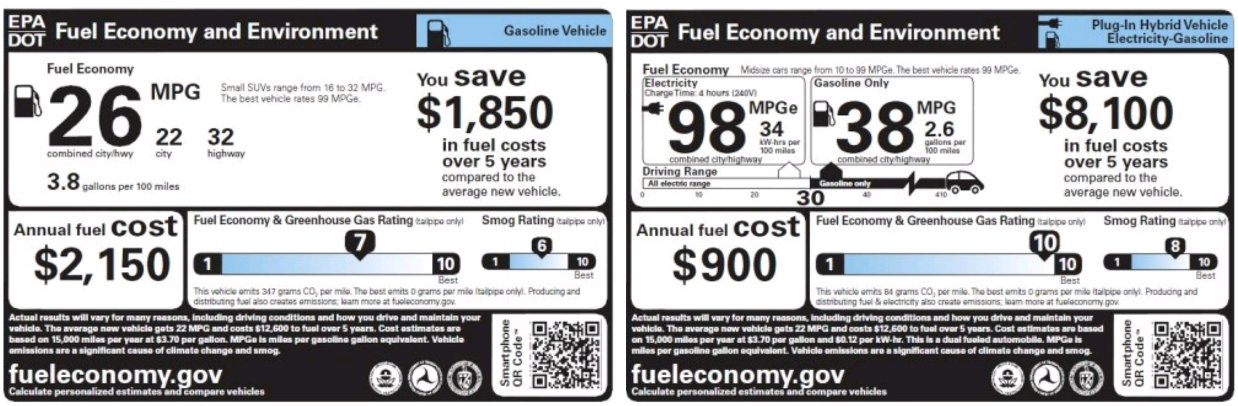


FIGURE 104. Current Window Stickers for Cars and Light Trucks

Note: There are different labels for each fuel type. Above are two examples of the new labels: one for a conventional gasoline vehicle and one for a plug-in hybrid vehicle. The plug-in hybrid label above shows the efficiency in electric mode only expressed in miles per gallon equivalent and also in gasoline mode. Labels for vehicles with fuel types that provide significantly less range than conventionally fueled vehicles have range bars showing consumers the range that they can expect.

Sources:

U.S. Environmental Protection Agency, *A New Generation of Labels for a New Generation of Vehicles,* September 2011. http://www.epa.gov/carlabel/basicinformation.htm

U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy Guide website, *Learn About the New Label*, September 2011. http://www.fueleconomy.gov/feg/label/

DOE and EPA Create Used Vehicle Window Sticker

The U.S. Department of Energy and the Environmental Protection Agency (EPA) created a window sticker that features EPA fuel economy and carbon dioxide emission estimates for those selling used vehicles. The label is created electronically by selecting vehicle specifications on the FuelEconomy.gov website. The graphic can be downloaded and included in online advertisements or printed and affixed to the vehicle's window. The original EPA fuel economy estimate is the best indicator of a used vehicle's average gas mileage because a vehicle's fuel economy changes very little over a typical 15-year life with proper maintenance.

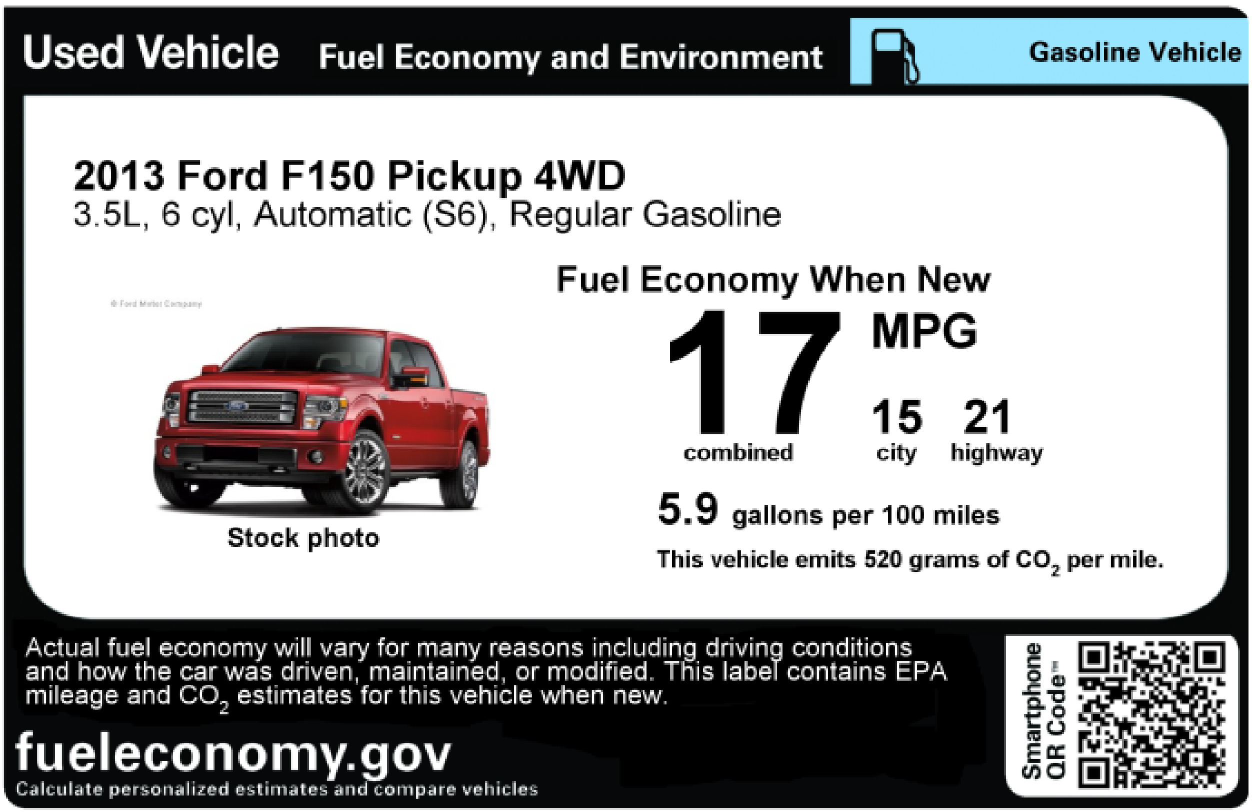


FIGURE 105. Used Vehicle Fuel Economy Window Sticker

Note: Labels for plug-in hybrids and electric vehicles are not available. Labels for vehicles before model year 1984 are not available.

Source:
U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy Guide website, *Selling Your Vehicle? Advertise Its Fuel Economy!* Accessed February 19, 2014. https://www.fueleconomy.gov/feg/UsedCarLabel.jsp

Corporate Average Fuel Economy: Historical Standards and Values

The Corporate Average Fuel Economy (CAFE) is the sales-weighted harmonic mean fuel economy of a manufacturer's fleet of new cars or light trucks in a certain model year (MY). First enacted by Congress in 1975, the standards for cars began in MY 1978 and for light trucks in MY 1979. In general, the average of all cars and all light trucks has met or exceeded the standards each year. However, standards must be met on a manufacturer level – some manufacturers fall short of the standards while others exceed them. Legislation passed in December 2007 raised the CAFE standards beginning in MY 2011 – for cars, this was the first increase since 1990.

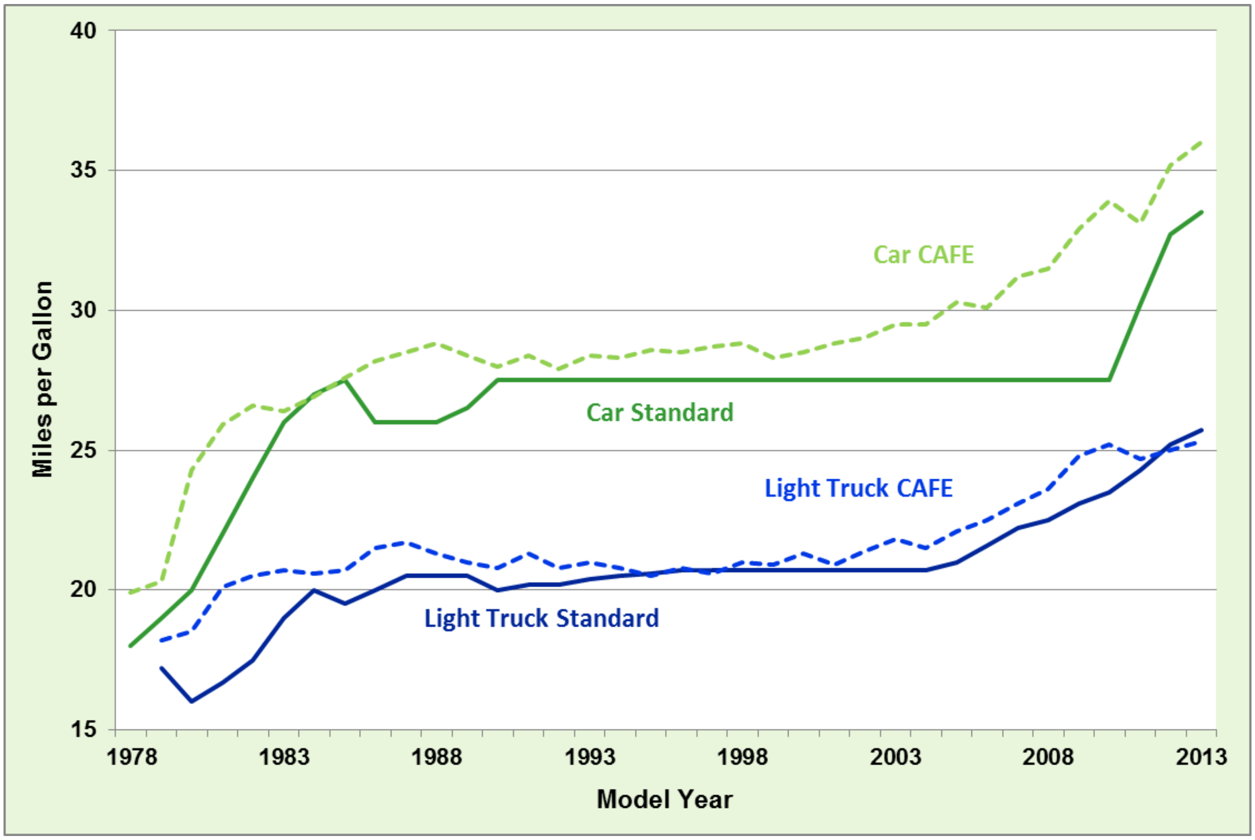


FIGURE 106. CAFE for Cars and Light Trucks, 1978-2013

Note: Light truck standards for MY 2008-2010 are based on "unreformed" standards. MY 2012 and 2013 data are estimates based on product plans.

Source:
National Highway Traffic Safety Administration, "Summary of Fuel Economy Performance," April 2013.
http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/April_2013_Summary_Report.pdf

Corporate Average Fuel Economy Improves for All Manufacturers

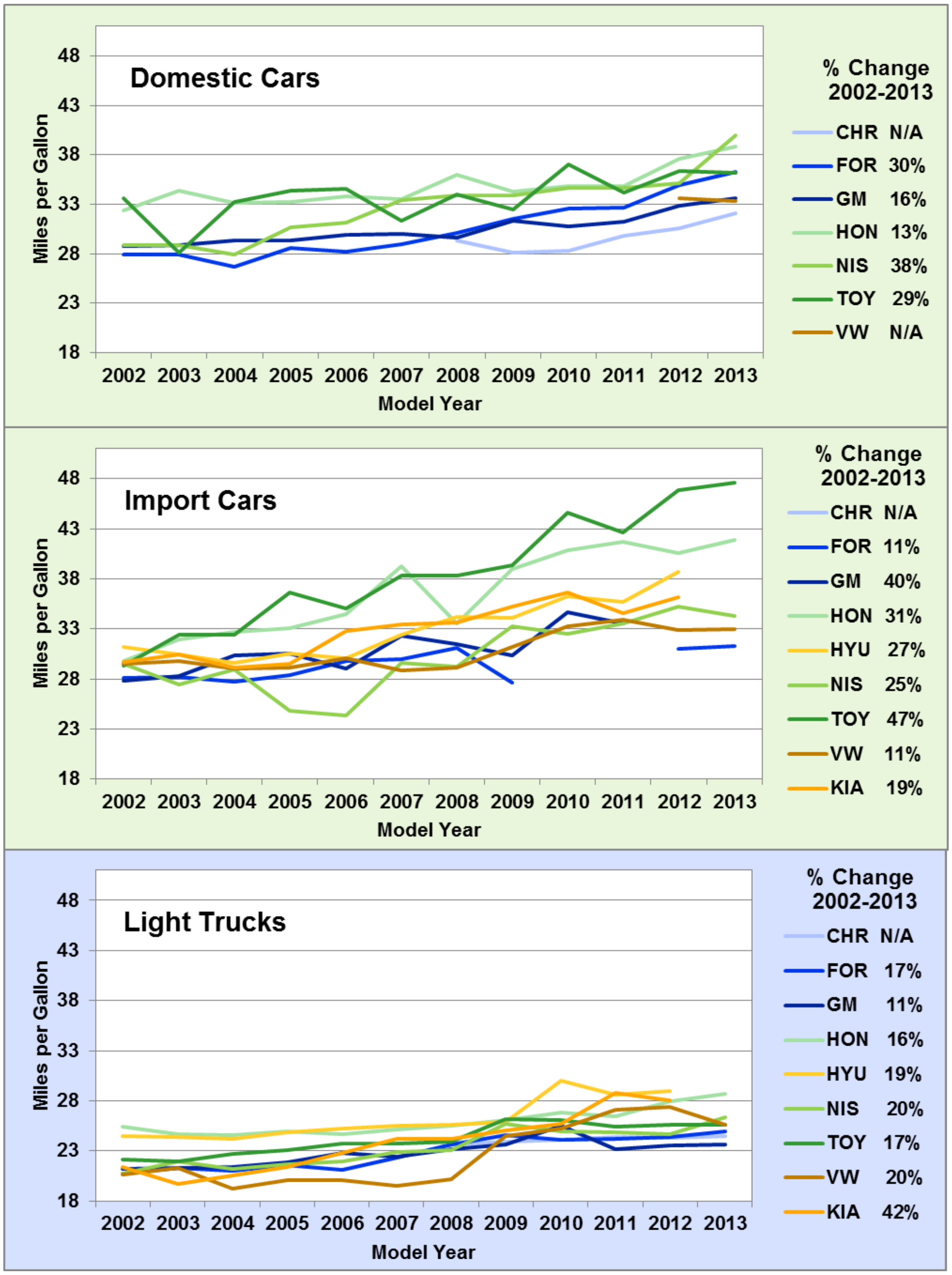


FIGURE 107. CAFE for Domestic and Import Cars and Light Trucks by Manufacturer, 2002-2013

Note: Data for Chrysler begin in 2008 after the merger with Daimler ended. Ford had no import cars in 2010 and 2011. General Motors had no import cars in 2012. Volkswagen domestic cars begin in 2012. No 2013 data available for Hyundai and Kia.

Source:

National Highway Traffic Safety Administration, "Summary of Fuel Economy Performance," April 2013. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/April_2013_Summary_Report.pdf

Corporate Average Fuel Economy Credits

The rulemaking which established the Corporate Average Fuel Economy (CAFE) standards included a plan for the manufacturers to receive credits for the purpose of applying those credits to other model years or trading credits with other manufacturers. Beginning with model year 2008, a manufacturer whose fleet achieves an average fuel economy better than the standard generates credits; a manufacturer whose fleet does not meet the standard fuel economy incurs a debit, or shortfall. There are very specific rules for the trading of credits found in 49 CFR 536. Credits are tracked by the model year in which they are earned and must be used within five years. One credit is equal to 1/10 of a mile per gallon above the fuel economy standard per one vehicle within a compliance category.

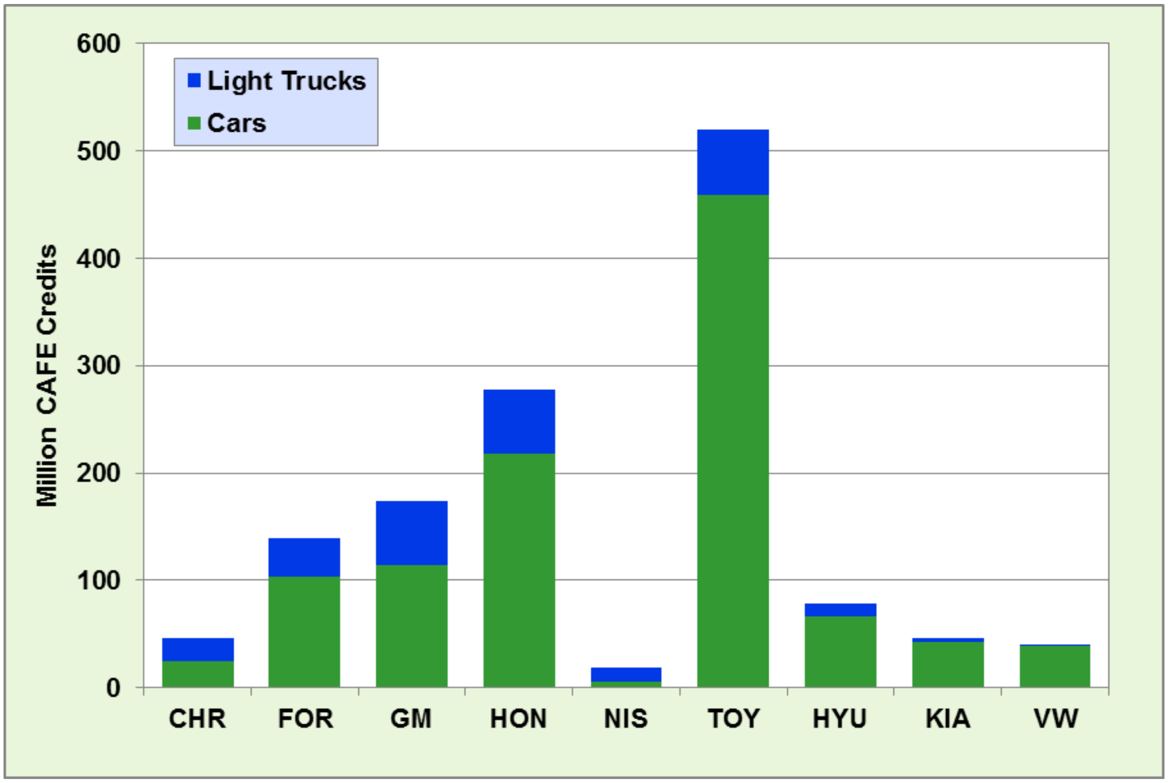


FIGURE 108. CAFE Credit Status by Manufacturer at the End of Model Year 2011

Note: Air-conditioning credits, flexible-fuel credits, and alternative fuel vehicle credits are different types of credits and are not included in these data.

Source:
U.S. Department of Transportation, National Highway Traffic Safety Administration, http://www.nhtsa.gov/Laws+&+Regulations/CAFE+-+Fuel+Economy/CAFE_credit_status

Corporate Average Fuel Economy: Average Fleet-Wide Fuel Economies for Future Cars and Light Trucks

The average fleet-wide fuel economies required to meet the Corporate Average Fuel Economy (CAFE) standards are shown below. In May 2010, the final standards were set for model years (MY) 2012 through 2016. In August 2012, the National Highway Traffic Safety Administration (NHTSA) issued final standards for MY 2017 through 2021 and proposed standards for MY 2022 through 2025. These standards apply to cars and pickup trucks less than 8,500 lbs. gross vehicle weight rating (GVWR), and sport utility vehicles and passenger vans less than 10,000 lbs. GVWR.

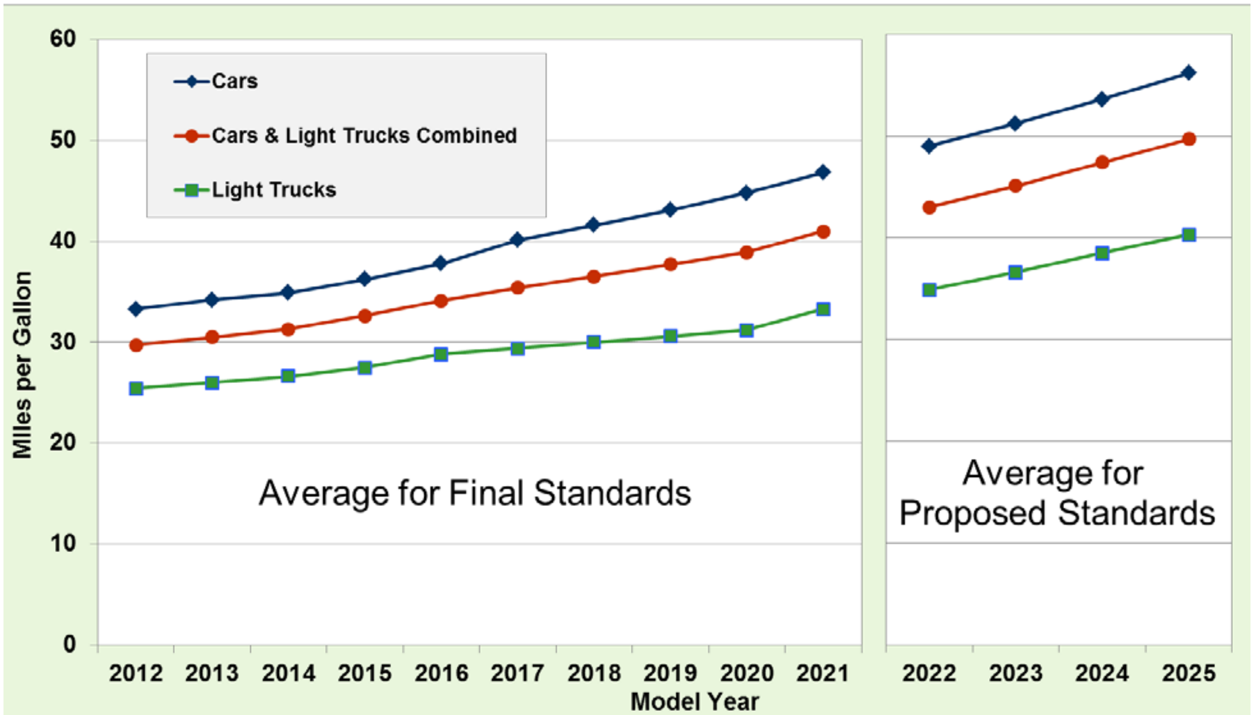


FIGURE 109. Average CAFE Standards for MY 2012-2025

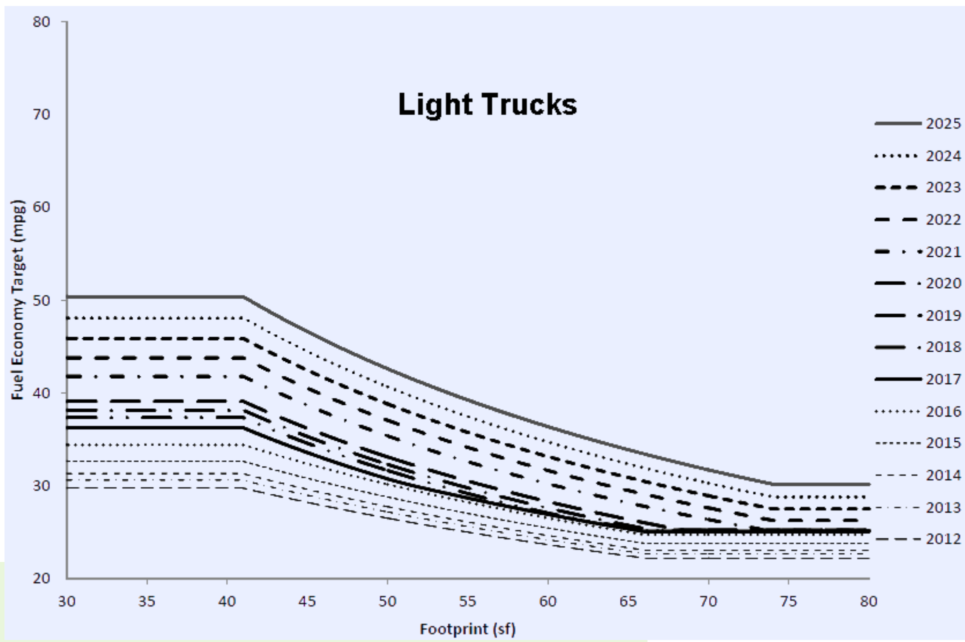
Notes: A MY 2008 baseline was used for MY 2017-2025.
The presented rates of increase in stringency for NHTSA CAFE standards are lower than the Environmental Protection Agency (EPA) rates of increase in stringency for greenhouse gas (GHG) standards. One major difference is that NHTSA's standards, unlike EPA's, do not reflect the inclusion of air conditioning system refrigerant and leakage improvements, but EPA's standards would allow consideration of such improvements which reduce GHGs but generally do not affect fuel economy. The 2025 EPA GHG standard of 163 grams/mile would be equivalent to 54.5 mpg, if the vehicles were to meet this level all through fuel economy improvements. The agencies expect, however, that a portion of these improvements will be made through reductions in air conditioning leakage, which would not contribute to fuel economy.

Sources:
Federal Register, Vol. 75, No. 88, May 7, 2010, pp. 25324-25728.
Final Rule, Docket No. NHTSA-2010-0131, August 28, 2012.

Corporate Average Fuel Economy: Sliding Scale Standards for New Cars and Light Trucks

Beginning in 2012, the Corporate Average Fuel Economy (CAFE) standards are based on a vehicle's footprint, where each vehicle has a different fuel economy target depending on its footprint. The footprint is calculated as the vehicle's track width times the wheelbase (i.e., the distance between the wheels [width] multiplied by the distance between the axles [length]). In general, as the vehicle footprint increases, the fuel economy standard the vehicle has to meet decreases. Footprint-based standards help to distribute the burden of compliance across all vehicles and manufacturers.

Note:
Standards from 2022 to 2025 are proposed standards.



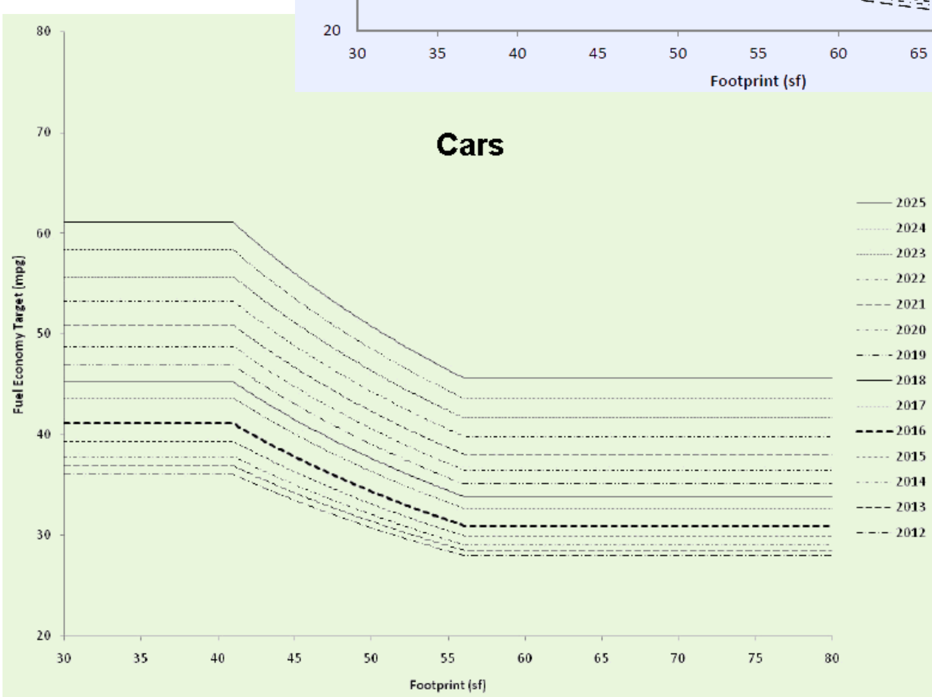


FIGURE 110. CAFE Standards for Cars and Light Trucks, MY 2012-2025

Source:
Final Rule, Docket No. NHTSA-2010-0131, August 28, 2012.

Vehicle Footprints Are Used for Corporate Average Fuel Economy

The vehicle footprint is the area defined by the four points where the tires touch the ground. It is calculated as the product of the wheelbase and the average track width of the vehicle. The upcoming Corporate Average Fuel Economy Standards have fuel economy targets based on the vehicle footprint. The average footprint for all cars sold in model year (MY) 2013 was 45.9 square feet (sq. ft.), up just 0.8 sq. ft. from MY 2009. The average footprint for light trucks was higher – 54.9 in 2013. The table shows selected vehicles and their MY 2012 footprint.

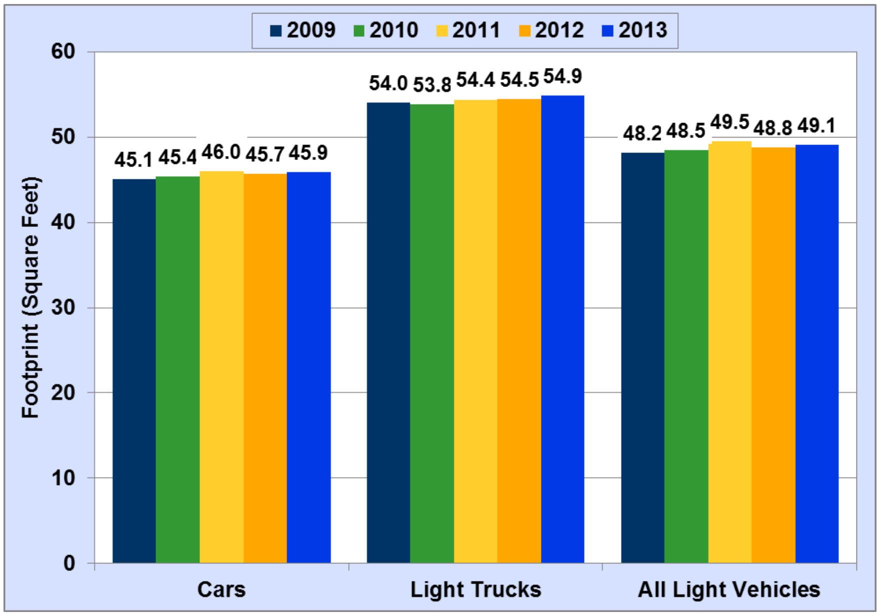


FIGURE 111. Average Vehicle Footprint, MY 2009-2013

TABLE 40. Vehicle Footprint and Fuel Economy Target, MY 2025

Vehicle Type	Example Model (MY 2012 Vehicles)	Footprint (Sq. Ft.)	MY 2025 Fuel Economy Target (mpg)
Cars			
Compact	Honda Fit	40	61.1
Midsize	Ford Fusion	46	54.9
Full-size	Chrysler 300	53	48.0
Light Trucks			
Small Sport Utility	Ford Escape 4WD	43	47.5
Midsize Crossover	Nissan Murano	49	43.4
Minivan	Toyota Sienna	56	39.2
Large Pickup Truck	Chevrolet Silverado	67	33.0

Sources:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Final Rule, Docket No. NHTSA-2010-0131, August 28, 2012.

Chrysler Has the Highest Car Footprint and General Motors Has the Highest Light Truck Footprint

The Corporate Average Fuel Economy (CAFE) standards are based on the vehicle's footprint beginning in model year (MY) 2012. In MY 2013, Chrysler had the highest sales-weighted average car footprint, thus would have the least stringent standards to meet according to the new CAFE methodology. General Motors has the highest sales-weighted average light truck footprint.

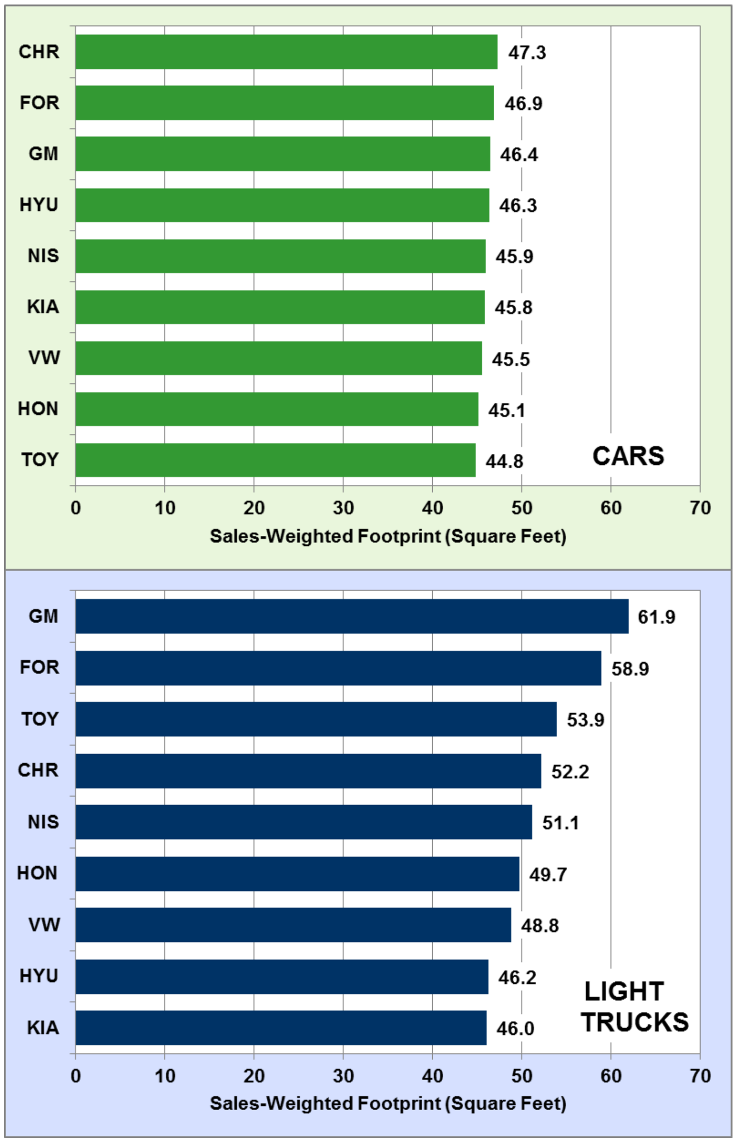


FIGURE 112. Car and Light Truck Footprint by Manufacturer, 2013

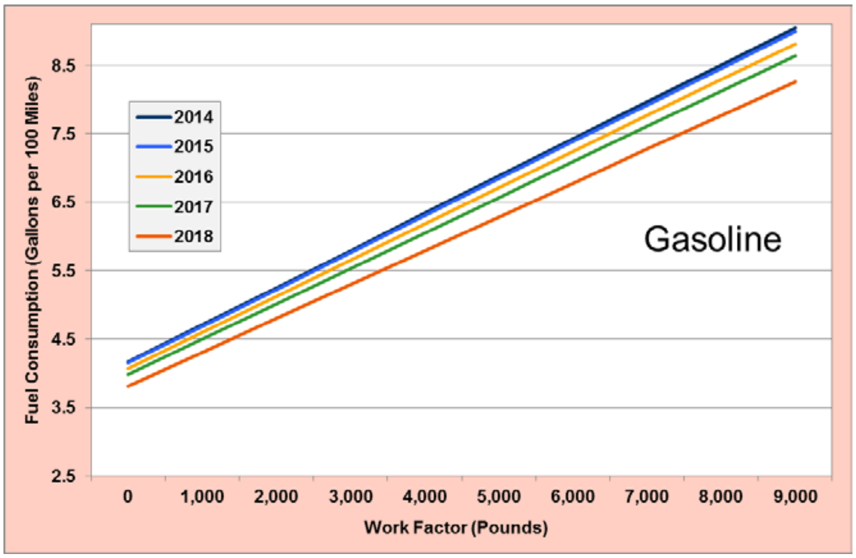
Sources:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2013*, EPA-420-S-13-002, December 2013. http://www.epa.gov/otaq/fetrends.htm

Final Rule, Docket No. NHTSA-2010-0131, August 28, 2012.

Fuel Consumption Standards Set for Heavy Pickups and Vans

In September 2011 the National Highway Traffic Safety Administration issued the final rule to set standards regulating the fuel use of new vehicles heavier than 8,500 lbs. gross vehicle weight. Included in the new standards are pickup trucks over 8,500 lbs., cargo trucks over 8,500 lbs., and passenger vans over 10,000 lbs. Standards were set separately for gasoline and diesel vehicles, on a scale that depends on a "work factor." The work factor, which is expressed in pounds, takes into account the vehicle's payload capacity, towing capacity, and whether or not the vehicle is four-wheel drive (see note below for work factor details). Standards for model years 2014 and 2015 are voluntary, but standards are mandatory thereafter.



Note: Work factor is a weighted average of 25% towing capacity and 75% payload capacity. An additional 500 lbs. is added to payload capacity when the vehicle is four-wheel drive.

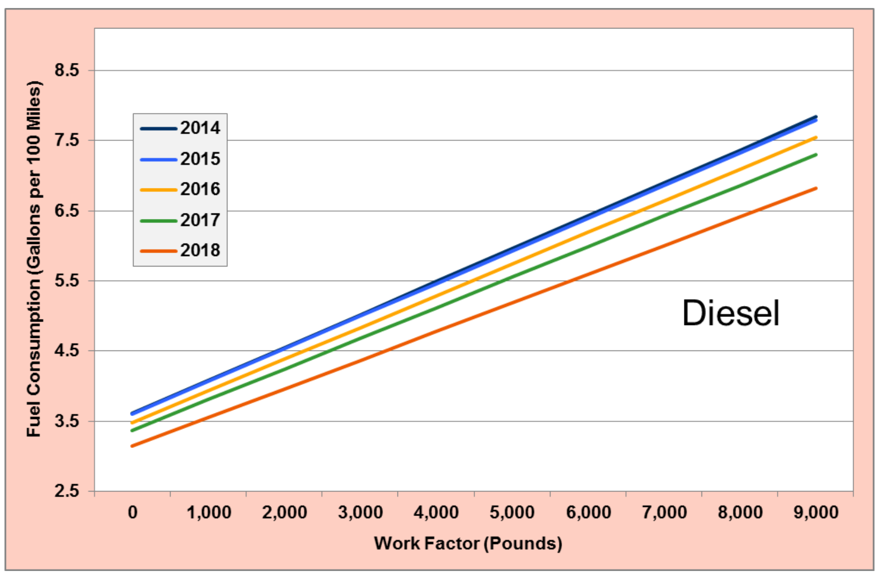


FIGURE 113. Fuel Consumption Target Standards for Gasoline and Diesel Heavy Pickups and Vans, MY 2014-2018

Source:
Federal Register, Vol. 76, No. 179, September 15, 2011, pp. 57105 - 57513.

Fuel Consumption Standards Set for Combination Tractors

The National Highway Traffic Safety Administration published a final rule setting fuel consumption standards for heavy trucks in September 2011. For tractor-trailers, the standards focus on the gallons of fuel per thousand ton-miles. Ton-miles are equal to the weight of a shipment transported multiplied by the distance hauled. Because differences in the tractors create differences in the fuel used, standards were set for varying roof height (low, mid, and high), gross vehicle weight rating (class 7 and 8), and types of tractor (day cab, sleeper cab).

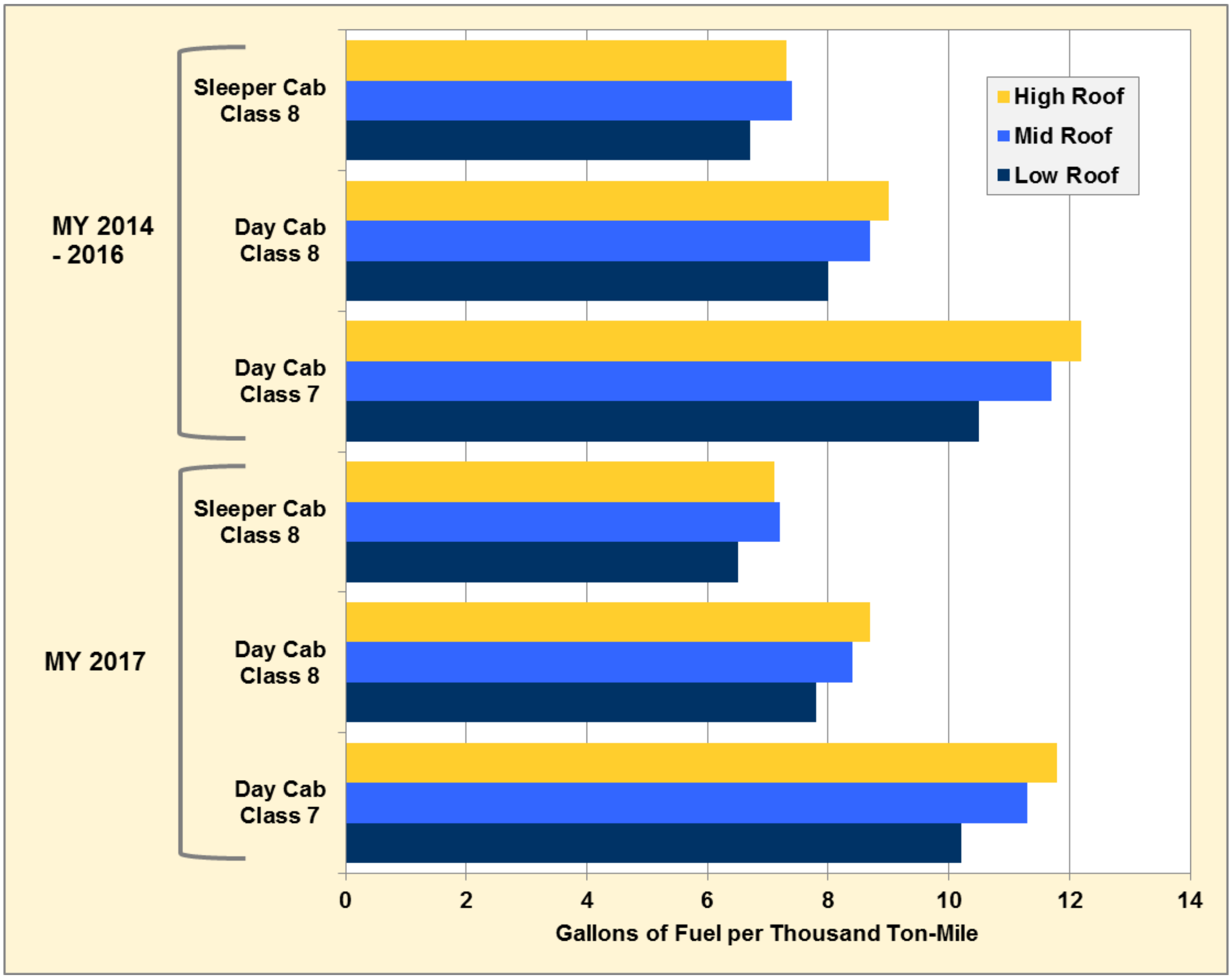


FIGURE 114. Fuel Consumption Standards for Combination Tractors, MY 2014-2017

Note: The standards for 2014 and 2015 are voluntary. Class 7 trucks have a gross vehicle weight rating between 26,000 and 33,000 lbs. Class 8 trucks have a gross vehicle weight rating over 33,000 lbs.

Source:
Federal Register, Vol. 76, No. 179, September 15, 2011, pp. 57105 - 57513.

Fuel Consumption Standards Set for Vocational Vehicles

The National Highway Traffic Safety Administration (NHTSA) recently published final fuel consumption standards for heavy vehicles called "vocational" vehicles. A vocational vehicle is generally a single-unit work vehicle over 8,500 lbs. gross vehicle weight rating (GVWR) or a passenger vehicle over 10,000 lbs. GVWR. These vehicles vary in size, and include smaller and larger van trucks, utility ''bucket'' trucks, tank trucks, refuse trucks, urban and over-the-road buses, fire trucks, flat-bed trucks, dump trucks, and others. Often, these trucks are built as a chassis with an installed engine purchased from one manufacturer and an installed transmission purchased from another manufacturer. The chassis is typically then sent to a body manufacturer, which completes the vehicle by installing the appropriate feature—such as dump bed, delivery box, or utility bucket—onto the chassis. Because of the complexities associated with the wide variety of body styles, NHTSA decided to finalize a set of standards beginning in 2016 for the chassis manufacturers of vocational vehicles (but not the body builders).

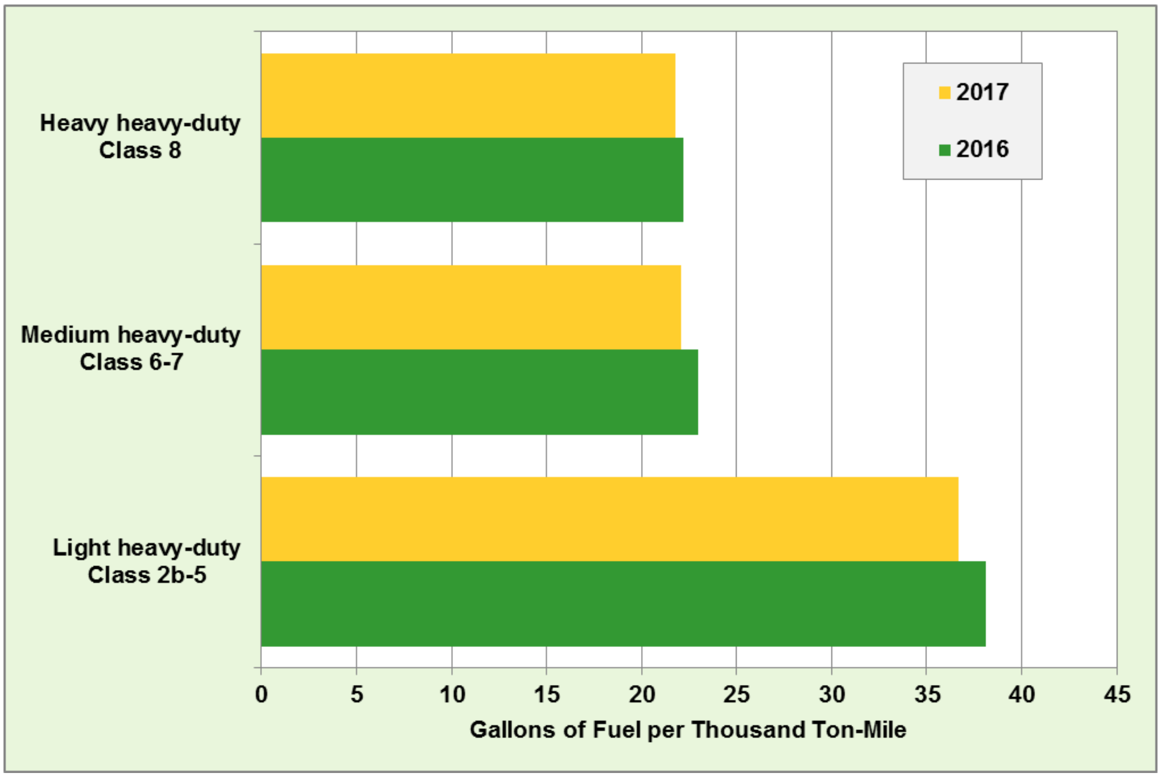


FIGURE 115. Vocational Vehicle Fuel Consumption Standards, MY 2016 and 2017

Note: Vehicles in classes 2b – 5 are between 8,500 and 19,500 lbs. GVWR. Vehicles in class 6-7 are between 19,500 and 33,000 lbs. GVWR. Vehicles in class 8 are above 33,000 lbs. GVWR. A ton-mile is a measure of shipment weight multiplied by distance traveled.

Source:
Federal Register, Vol. 76, No. 179, September 15, 2011, pp. 57105 - 57513.

Diesel Engine Fuel Consumption Standards Are Set

In addition to the combination truck and vocational truck fuel consumption standards, the National Highway Traffic Safety Administration set fuel consumption standards for diesel engines installed in truck-tractors and vocational vehicles. The standards are set in gallons of fuel used per brake-horsepower hour, which is a measure of an engine's horsepower before the loss in power caused by the gearbox, alternator, differential, water pump, and other auxiliary components for one hour. These standards are voluntary from 2014 through 2016 and mandatory thereafter.

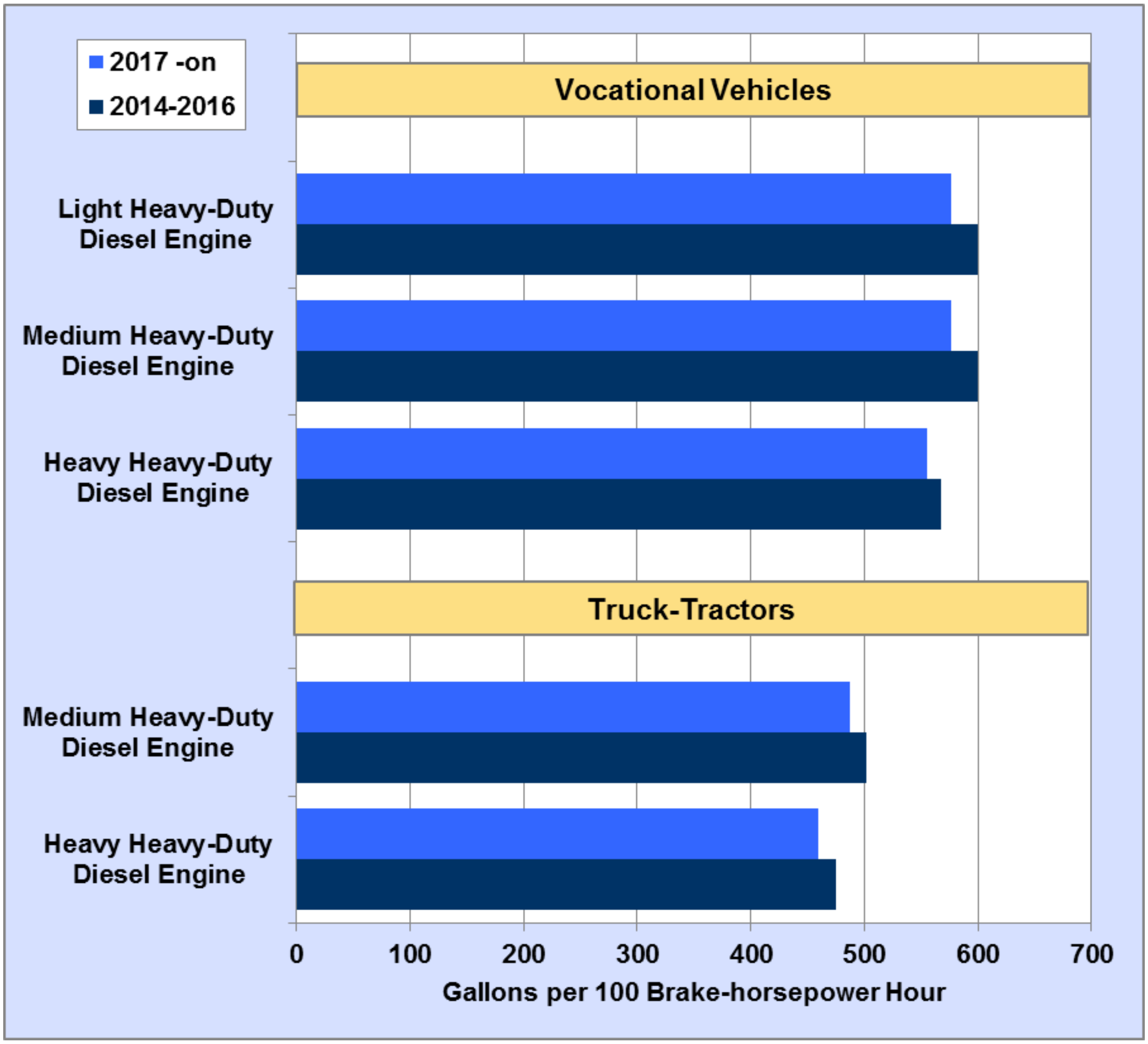


FIGURE 116. Fuel Standards for New Diesel Engines, MY 2014-On

Note: Light Heavy-Duty (Class 2b–5); Medium Heavy-Duty (Class 6–7); and Heavy Heavy-Duty (Class 8).

Source:
Federal Register, Vol. 76, No. 179, September 15, 2011, pp. 57105 - 57513.

Energy Policy Act Encourages Idle Reduction Technologies

In order to encourage the use of idling reduction devices in large trucks, the Energy Policy Act of 2005 allowed for a weight exemption for the additional weight of idling reduction technology. States were given the discretion of adopting this exemption without being subjected to penalty.

Since then, most states have passed laws which allow trucks to exceed the maximum gross vehicle weight limit by an additional 400lbs. (green) or 550 lbs. (dark green). Other States have a 400-lb. weight allowance which is granted by enforcement personnel (light green). Five states plus the District of Columbia have not adopted the weight exemption (gold).

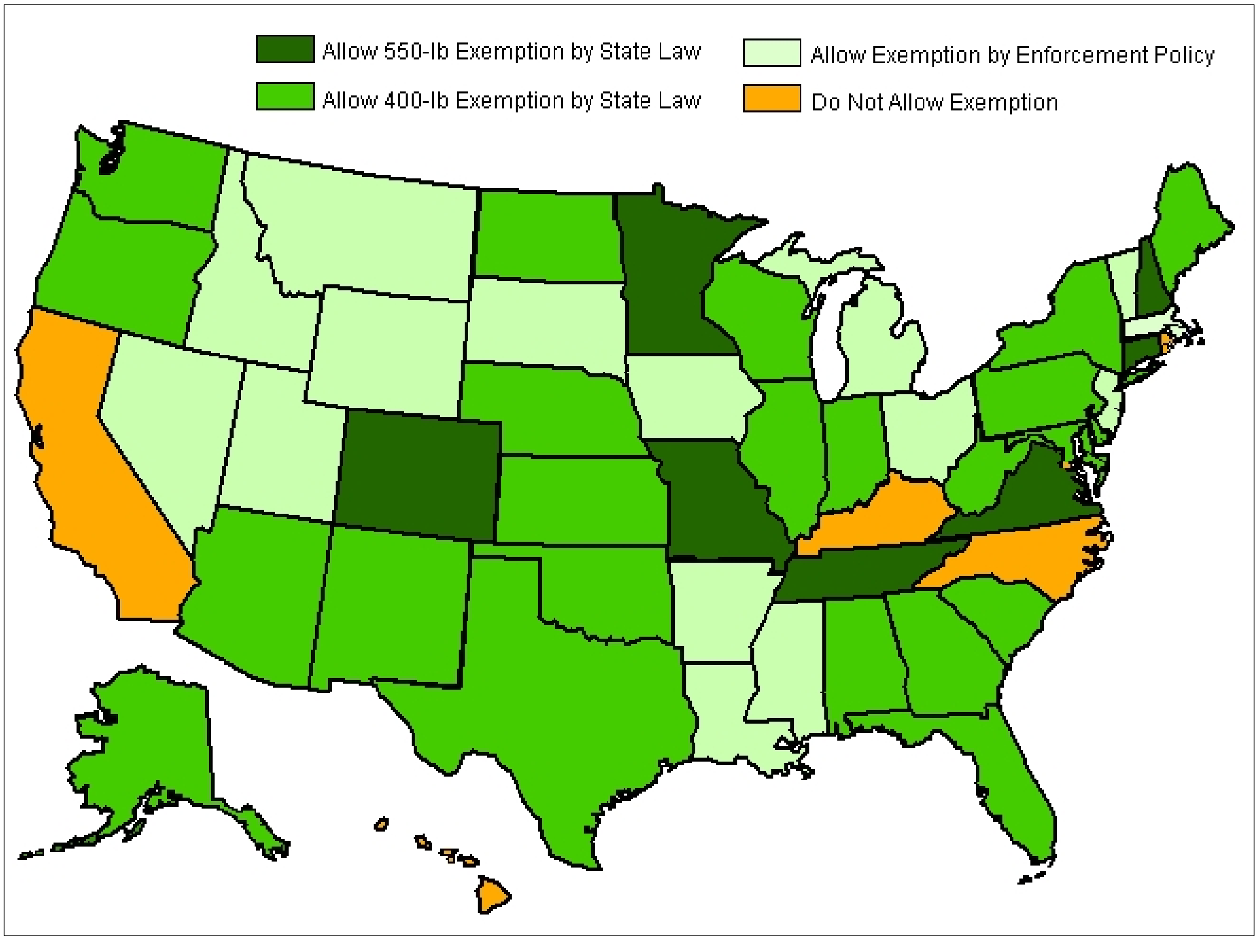


FIGURE 117. States Adopting Weight Exemptions for Idling Reduction Devices, 2013

Source:

U.S. Department of Energy, Energy Efficiency & Renewable Energy, *National Idling Reduction News*, December 2013. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/idling_news/dec13_network_news.pdf

Idle Reduction Technologies Excluded From Federal Excise Taxes

With the passage of the Energy Improvement and Extension Act of 2008, certain idling reduction devices are excluded from Federal excise taxes. The Environmental Protection Agency (EPA) certifies products that are eligible for the exemption. The exemption is only available for EPA-certified idling reduction devices installed on truck tractors. The companies that have devices certified with the EPA are shown below.

Auxiliary Power Units/ Generator Sets

- ACEMCO Power Systems, LLC
- Airworks Compressors Corp
- Big Rig Products
- Carrier Transicold
- Cantramatic
- Diamond Power Systems
- Dunamis Power Systems
- Hodyon LP
- Kohler
- Life Force
- Mantis Metalworks, LLC
- McMillan Electric Company
- Midwest Power Generators
- Navistar
- Parks Industries, LLC
- Pony Pack, Inc.
- Power Technology Southeast
- RigMaster Power by Mobile Thermo Systems
- Star Class
- Thermo King Corp
- TRIDAKO Energy Systems
- Volvo
- Willis Power Systems

Fuel Operated Heaters

- Automotive Climate Control
- Espar
- Teleflex
- Volvo
- Webasto

Battery Air Conditioning/ Heating Systems

- All Around
- AuraGen
- Bergstrom, Inc.
- Cool Moves
- Crosspoint Solutions
- DC Power Solutions APU
- Diamond Power Systems
- Dometic Corporation
- Driver Comfort System
- EnergyXtreme
- Freightliner
- Hammond Air Conditioning, LTD
- Indel B Sleeping Well
- Idle Free Systems
- NAS, LLC
- Navistar
- Paddock Solar
- Peterbilt
- Safer Corporation
- Sobo, Inc.
- Sun Power Technologies
- Thermo King
- Volvo

Shore Connection Systems

- Comfort
- Freightliner
- Phillips and Temro Industries
- Shurepower, LLC
- Volvo
- Xantrex Technology

Thermal Storage Systems

- Autotherm Division Enthal Sys, Inc.
- Webasto

FIGURE 118. Idle Reduction Technologies Which Are Granted Exemption from Federal Excise Taxes

Source:

U.S. Environmental Protection Agency, SmartWay Technology Program. February 2014.
http://www.epa.gov/smartway/forpartners/technology.htm

Longer Combination Trucks Are Only Permitted on Some Routes

Although all states allow the conventional combinations consisting of a 28-foot semi-trailer and a 28-foot trailer, only 14 states and six state turnpike authorities allow longer combination vehicles (LCVs) on at least some parts of their road networks. LCVs are tractors pulling a semi-trailer and trailer, with at least one of them – the semi-trailer, the trailer, or both – longer than 28 feet. The routes that these LCVs can travel are shown in the map below.

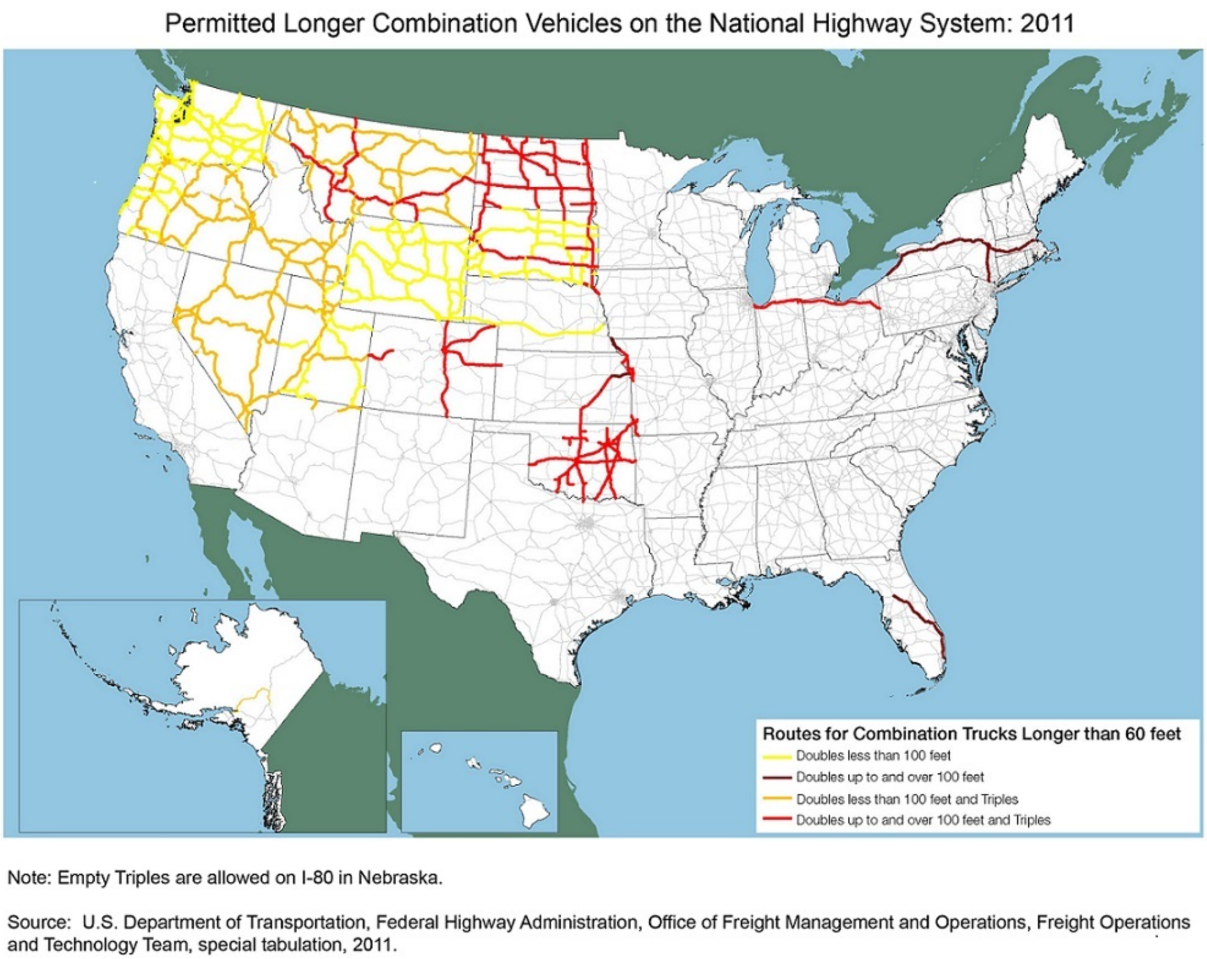


FIGURE 119. Routes where Longer Combination Vehicles Are Permitted, 2011

Source:

U.S. Department of Transportation, Federal Highway Administration, *Freight Facts and Figures 2012,* FHWA-HOP-13-001, November 2012. http://ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/11factsfigures

Heavy Truck Speed Limits Are Inconsistent

Ranging from a speed limit of 55 miles per hour (mph) to 85 mph, the maximum speed limit for trucks varies from state-to-state and sometimes from year to year. Currently, California and Oregon have the most conservative maximum speed limit for trucks – 55 mph. At the other end of the spectrum, Texas has some roads where the truck speed limit is 85 mph. Because of the varying limits, there is not one common highway speed at which trucks travel. This precludes truck manufacturers from engineering truck engines that peak in efficiency after reaching the speed at which the vehicles most commonly travel. Instead, manufacturers design the vehicle to perform well over the entire range of speeds, which in turn limits engine efficiency.

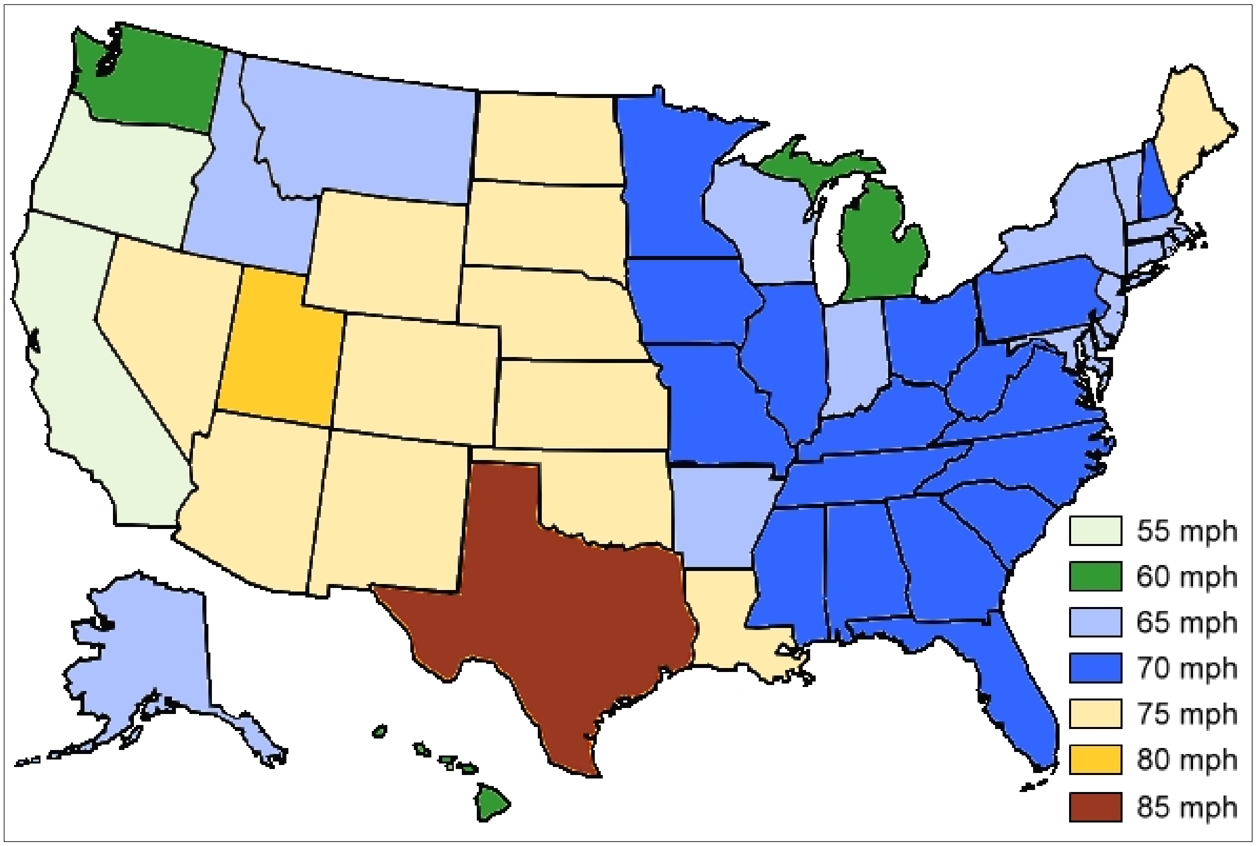


FIGURE 120. Maximum Daytime Truck Speed Limits by State, 2014

Source:
Insurance Institute for Highway Safety, Highway Loss Data Institute, February 2014.
http://www.iihs.org/laws/speedlimits.aspx

EPA Finalizes Stricter Standards for Gasoline

Sulfur naturally occurs in gasoline and diesel fuel, contributing to pollution when the fuel is burned and reducing the effectiveness of vehicle emission controls. Beginning in 2004, standards were set on the amount of sulfur in gasoline (Tier 2 standards). Separate standards were set for different entities, such as large refiners, small refiners, importers, downstream wholesalers, etc. In March 2014, Tier 3 standards were finalized by the Environmental Protection Agency (EPA). Tier 3 standards take effect in 2017. Large refinery standards are shown below, both the maximum and average per gallon. See the Environmental Protection Agency website for additional details on sulfur standards.

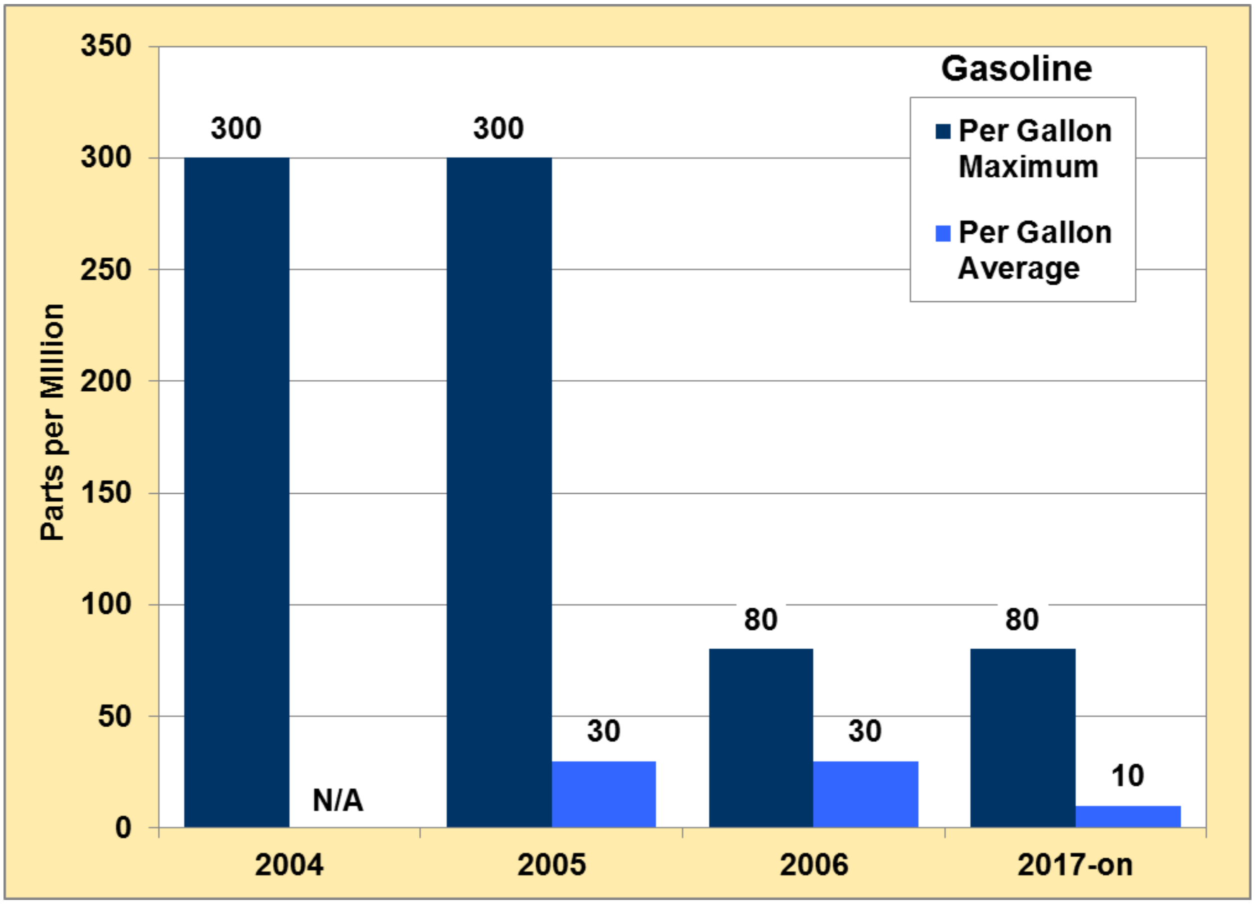


FIGURE 121. Gasoline Sulfur Standards, 2004-On

Note: N/A = not applicable.

Source:
U.S. Environmental Protection Agency, http://www.epa.gov/otaq/fuels/gasolinefuels/tier2/index.htm and http://www.epa.gov/otaq/tier3.htm.

Diesel Sulfur Standards Set at 15 Parts per Million

Sulfur naturally occurs in diesel fuel, contributing to pollution when the fuel is burned and reducing the effectiveness of vehicle emission controls. Low-sulfur diesel (500 parts per million (ppm)) began in 1993 as a result of the 1990 Clean Air Act Amendments. By October 2006, 80% of the diesel fuel produced was ultra-low sulfur diesel (ULSD) which is 15 ppm. By 2010, all diesel fuel produced was ULSD. Separate standards were created for highway and non-highway diesel fuel. The standards for highway diesel from large refineries are shown here; see the Environmental Protection Agency website for additional details on sulfur standards.

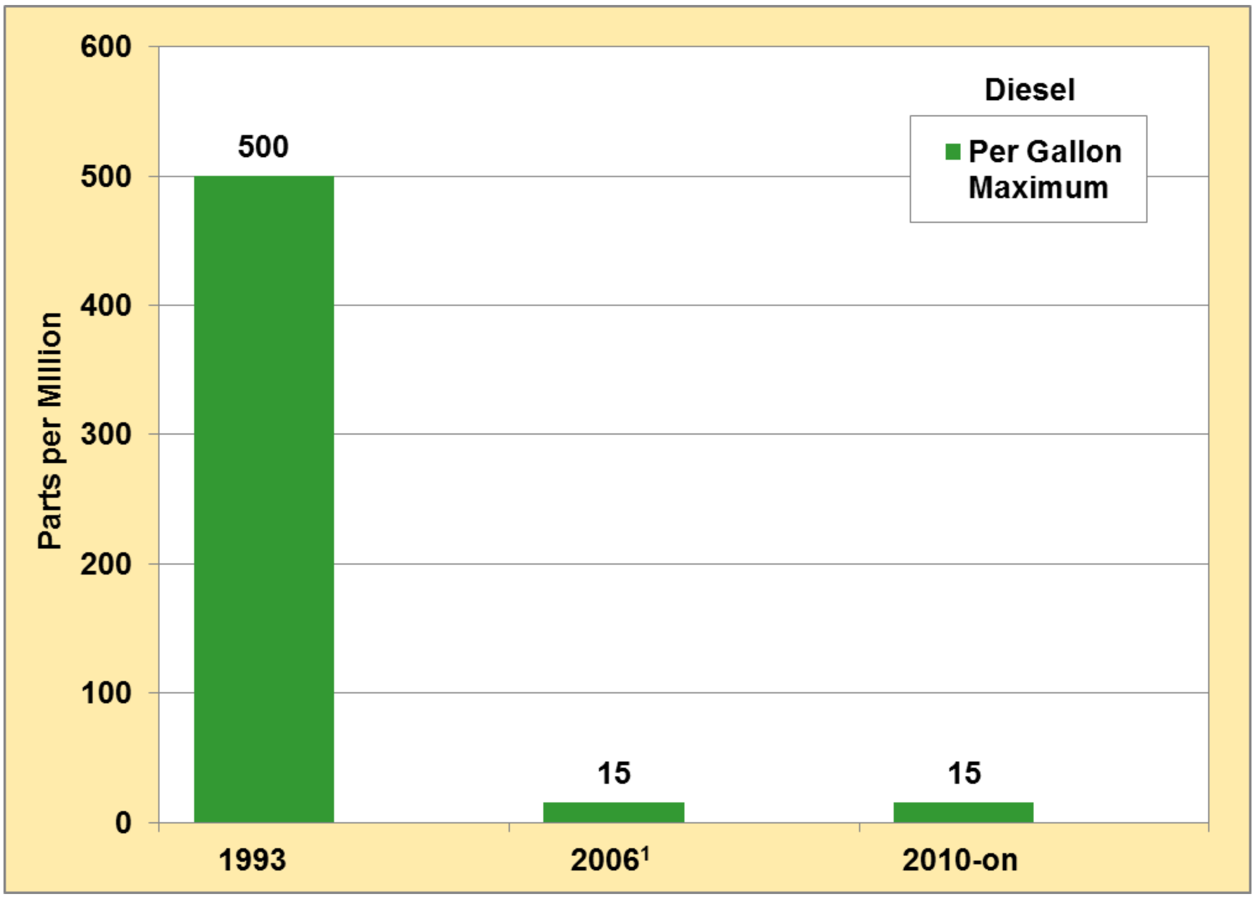


FIGURE 122. Diesel Sulfur Standards, 1993-On

[1] By October 2006 80% of the diesel fuel produced was required to be 15 ppm. In 2010, 100% produced was required to be 15 ppm.

Source:
U.S. Environmental Protection Agency, http://www.epa.gov/otaq/highway-diesel/regs/2007-heavy-duty-highway.htm.

Tier 3 Sets New Light Gasoline Vehicle Emission Standards for NMOG+NOx

The Environmental Protection Agency finalized Tier 3 emission standards in a rule issued in March 2014. One effect of the rule is a decrease in the combined amount of non-methane organic gases (NMOG) and nitrogen oxides (NOx) that new light vehicles with gasoline engines are allowed to produce from 2017 to 2025. These standards apply to a corporate average, meaning that some vehicles produced in those model years will emit more than the standard, while others will emit less.

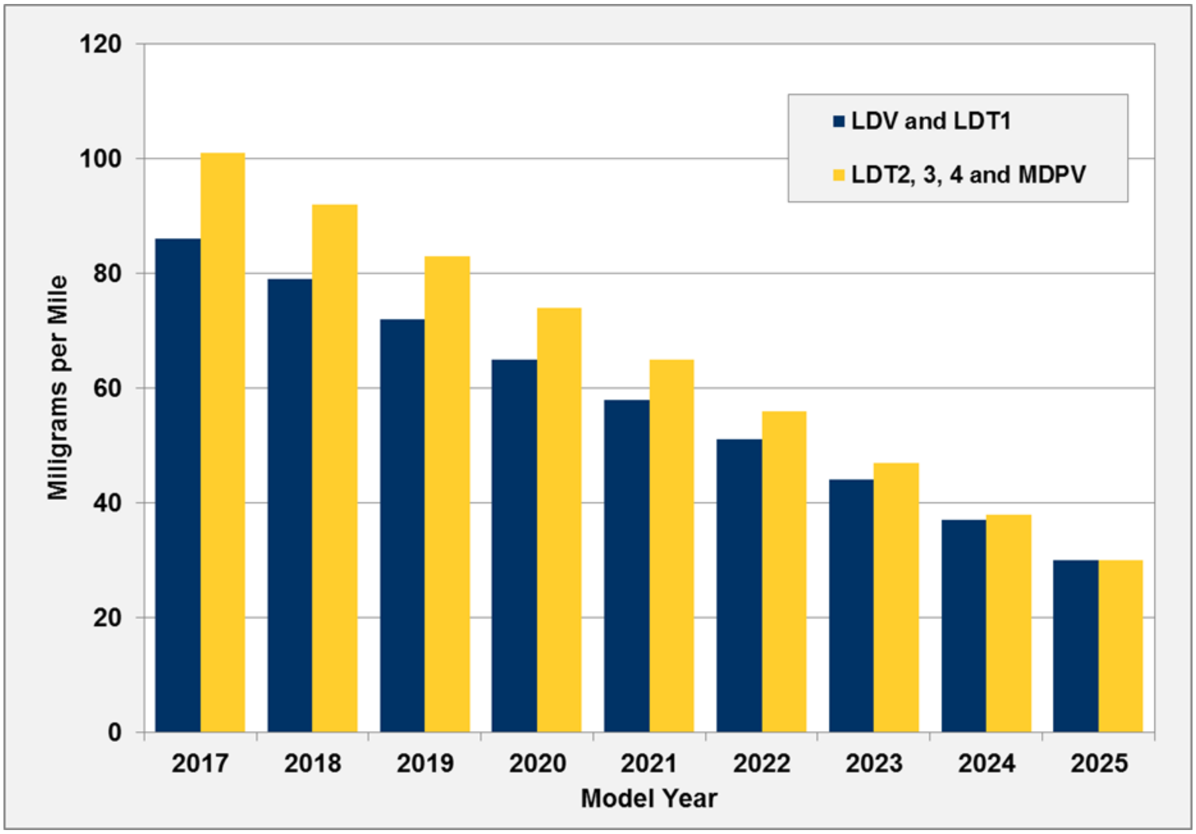


FIGURE 123. Tier 3 NMOG+NOx Emission Standards for Light Gasoline Vehicles, MY 2017-2025

Notes: Standards shown are for the Federal Test Procedure. Different standards apply to the Supplemental Federal Test Procedure. For vehicles over 6,000 lbs. gross vehicle weight rating (GVWR), the standards apply beginning in MY 2018.
LDV = Light-duty vehicles.
LDT1 = Light trucks less than 6,000 lbs. GVWR and less than 3,750 lbs. loaded vehicle weight (LVW).
LDT2, 3, 4 = Light trucks less than 8,500 lbs. GVWR and more than 3, 750 lbs. LVW.
MDPV = Medium-duty passenger vehicles.

Source: U.S. Environmental Protection Agency, http://www.epa.gov/otaq/tier3.htm

Tier 3 Particulate Emission Standards for Light Gasoline Vehicles Are Phased In Over Six Years

The Environmental Protection Agency finalized Tier 3 emission standards in a rule issued in March 2014. One effect of the rule is a decrease in the amount of particulate matter (PM) that new light vehicles with gasoline engines are allowed to emit from 2017-on. These standards are to be phased in over a six-year period. The first year, only 20% of U.S. sales are mandated to meet the standard. The PM standards are on a "per vehicle" basis, so by 2021, all vehicles sold (100%) must comply with the standards. Both the certification standards and the in-use standards are shown.

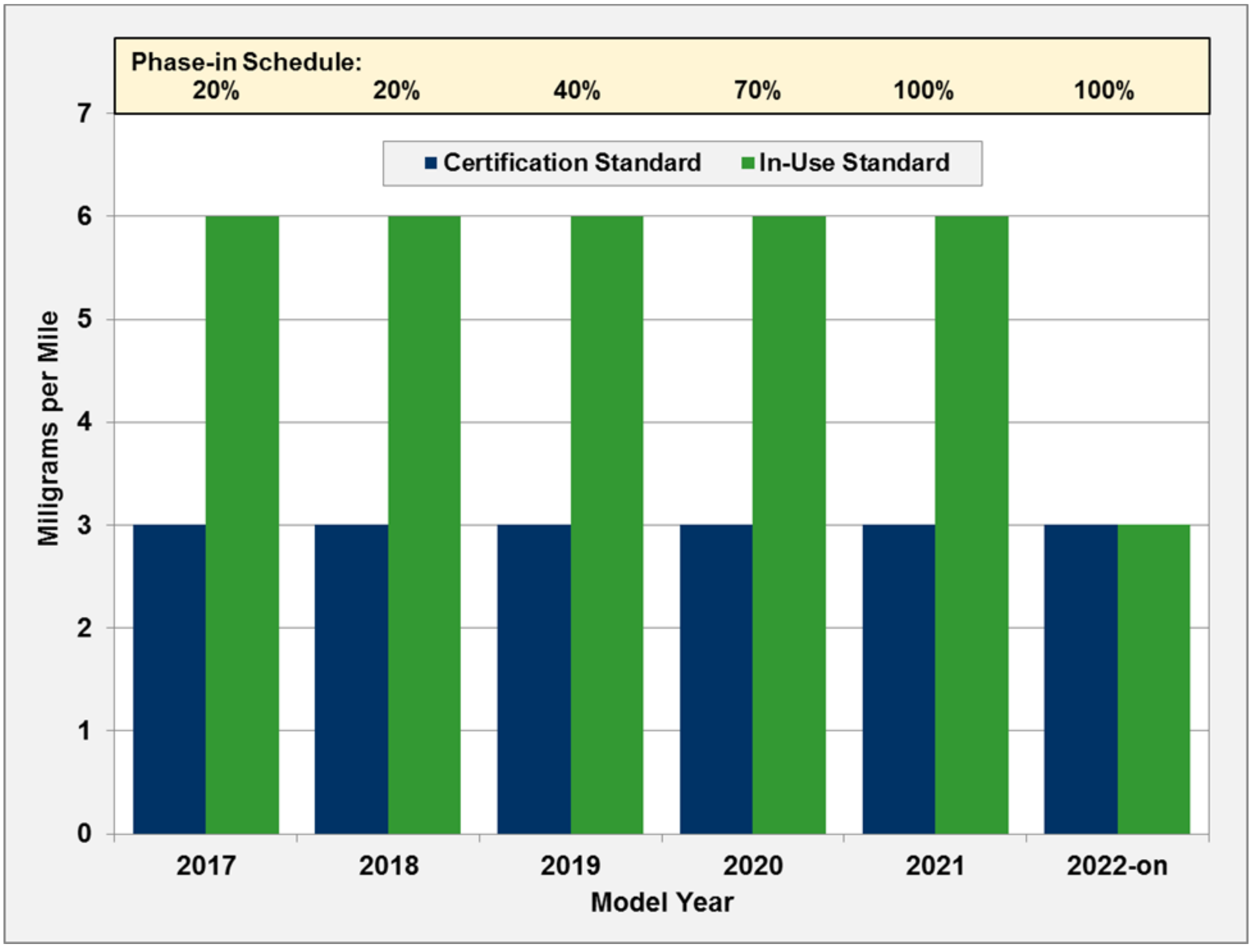


FIGURE 124. Tier 3 Particulate Matter Emission Standards for Light Gasoline Vehicles, MY 2017 and Beyond

Note: Standards shown are for the Federal Test Procedure. The standards apply to all light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles. For vehicles over 6,000 lbs. gross vehicle weight rating, the standards apply beginning in MY 2018.

Source: U.S. Environmental Protection Agency, http://www.epa.gov/otaq/tier3.htm

Emission Standards on Diesel Engines Are More Strict

In 1994, the emission standards for new heavy-duty highway diesel vehicles was five grams per horsepower-hour (g/HP-hr) of nitrogen oxides (NOx) and 0.1 g/HP-hr of particulate matter (PM). The units of measure, g/HP-hr, describes the grams of the pollutant as a result of the use of the energy equivalent to 1 horsepower for one hour. Since 1994, the standards for NOx have been reduced four times, in 1998, 2002, 2007, and 2010. By 2010, the NOx standard was reduced to 0.2 g/HP-hr. For PM, the standards changed from 0.1 g/HP-hr in 2002 to 0.01 g/HP-hr in 2007 and beyond. New medium and heavy trucks are meeting these standards by using technologies such as selective catalytic reduction and exhaust gas recirculation in combination with diesel particulate filters.

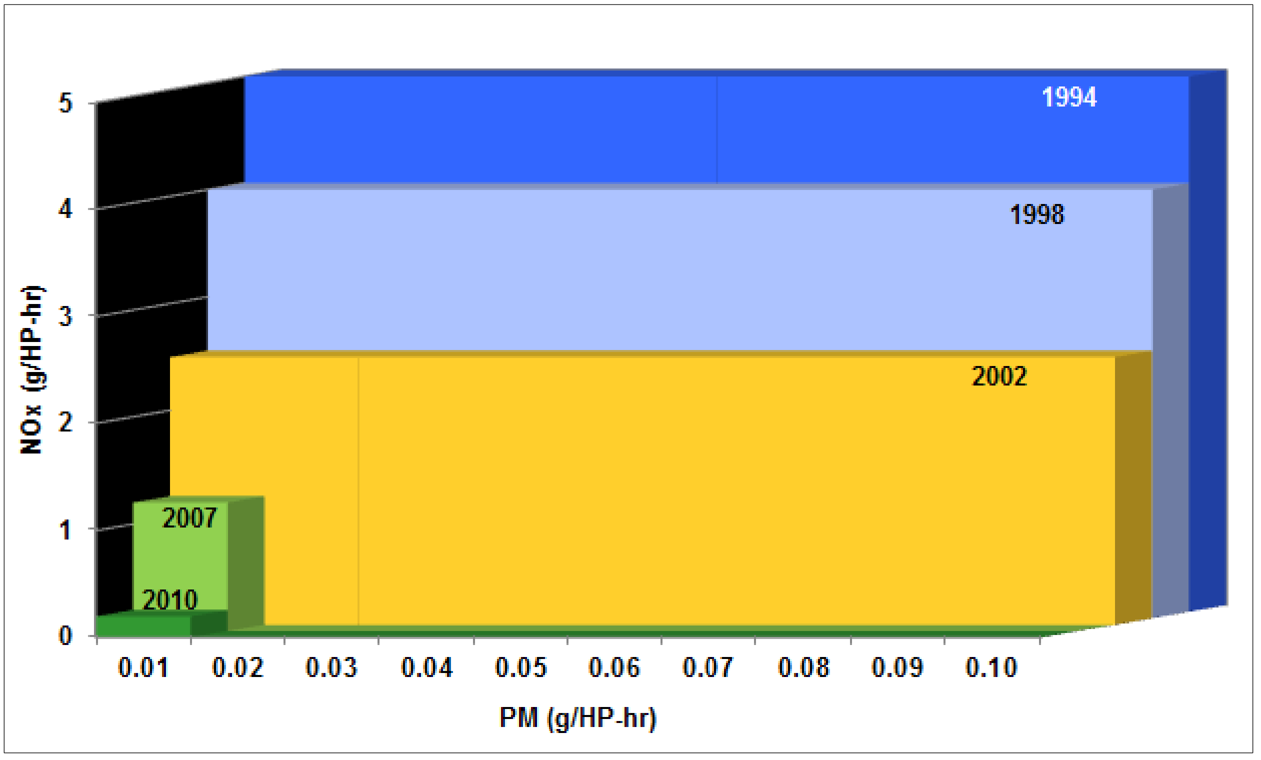


FIGURE 125. Diesel Emission Standards, 1994-2010

Note: All standards apply to vehicle model years, not calendar years.

Source:
U.S. Environmental Protection Agency, http://www.epa.gov/otaq/hd-hwy.htm.

Effect of Emission Standards on Heavy Truck Sales

It is often thought that stricter emission standards on diesel engines largely affect the sales of heavy trucks. Companies may purchase a greater amount of new heavy trucks just before the stricter emission standard takes effect, thus avoiding the added expense of new engines which meet the regulations. Though this purchase pattern is surely true for many companies, the overall annual sales patterns do not reflect this trend, likely due to the fact that the economy's impact on truck sales dwarfs the effect from emission standards. Also, the calendar year sales may not show the effects of regulations that apply to model years.

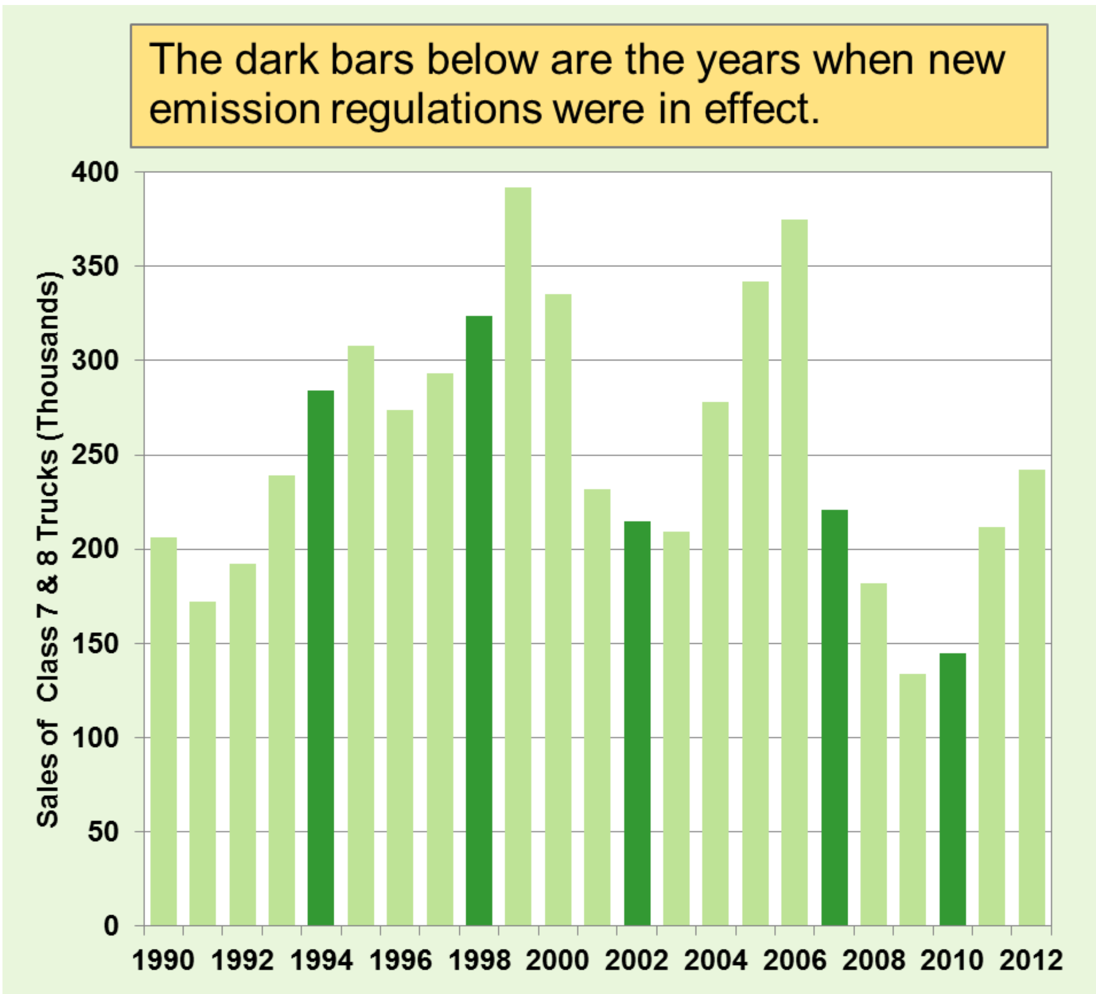


FIGURE 126. Class 7 and 8 Truck Sales, 1990-2012

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2013*, Southfield, MI, 2013.
http://wardsauto.comISE