2012 Vehicle Technologies Market Report

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Quick Facts

Energy and Economics

- Transportation accounts for 28% of total U.S. energy consumption.
- Dependence on oil costs the U.S. Economy $300 billion in 2010.
- The average price of a new car is just over $25,000.
- Almost 17% of household expenditures are for transportation.
- Over 9 million people are employed in the transportation industry.

Light Vehicles

- The top nine U.S. manufacturers produce only half of the world's vehicles.
- U.S. sales volumes continued to rise in 2011, reversing the downward trend.
- Sales-weighted data on new light vehicles sold show a 119% increase in horsepower and 35% decrease in 0-60 time from 1980 to 2011, with the fuel economy of vehicles improving 19%.
- Nearly 14% of cars sold in 2011 have continuously variable transmissions.
- More than two-thirds of new light vehicles sold in 2011 have transmissions with more than 5 speeds.

Heavy Trucks

- Class 3 truck sales have continued to increase in 2011.
- Sales of class 4-7 trucks were up slightly in 2011, but were 39% below the 2007 level.
- Class 8 truck sales increased drastically in 2011 and rose above 2007 figures.
- Diesel comprised 75% of the class 3-8 trucks sold in 2011, up from 68% in 2007.
- Class 8 combination trucks consume an average of 6.5 gallons per thousand ton-miles.
- Combination trucks are driven an average over 68,000 miles per year.
- Idling a truck-tractor's engine can use a gallon of fuel per hour.

Technologies

- Almost 269,000 hybrid vehicles were sold in 2011.
- At least 27 different models of plug-in vehicles are available or coming soon to market soon.
- Sixty-two flex-fuel vehicle models were offered in model year 2012.
- There are more than 14,500 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.
- There are 93 electrified truck stop sites across the country to reduce truck idling time.

Policy

- Plug-in hybrids and electric vehicle purchasers received a tax credit of $7,500 for select 2011-2013 vehicles.
- Proposed Corporate Average Fuel Economy Standard for cars in 2025 is 56.2 miles per gallon (mpg).
- Proposed Corporate Average Fuel Economy Standard for light trucks in 2025 is 40.3 mpg.
- 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.

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2012 VEHICLE TECHNOLOGIES MARKET REPORT

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Introduction

Welcome to the *2012 Vehicle Technologies Market Report*. This is the fourth 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 32 offer snapshots of major light-duty vehicle brands in the U.S. and Figures 36 through 42 examine the performance and efficiency characteristics of vehicles sold. The discussion of Medium and Heavy Trucks offers information on truck sales (Figures 59 through 61) and fuel use (Figures 64 through 67). The Technology section offers information on alternative fuel vehicles and infrastructure (Figures 69 through 77), and the Policy section concludes with information on recent, current, and near-future Federal policies like the Corporate Average Fuel Economy standard (Figures 89 through 92).

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
Vehicle Technologies Office
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 2011, the transportation sector used 27.1 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.

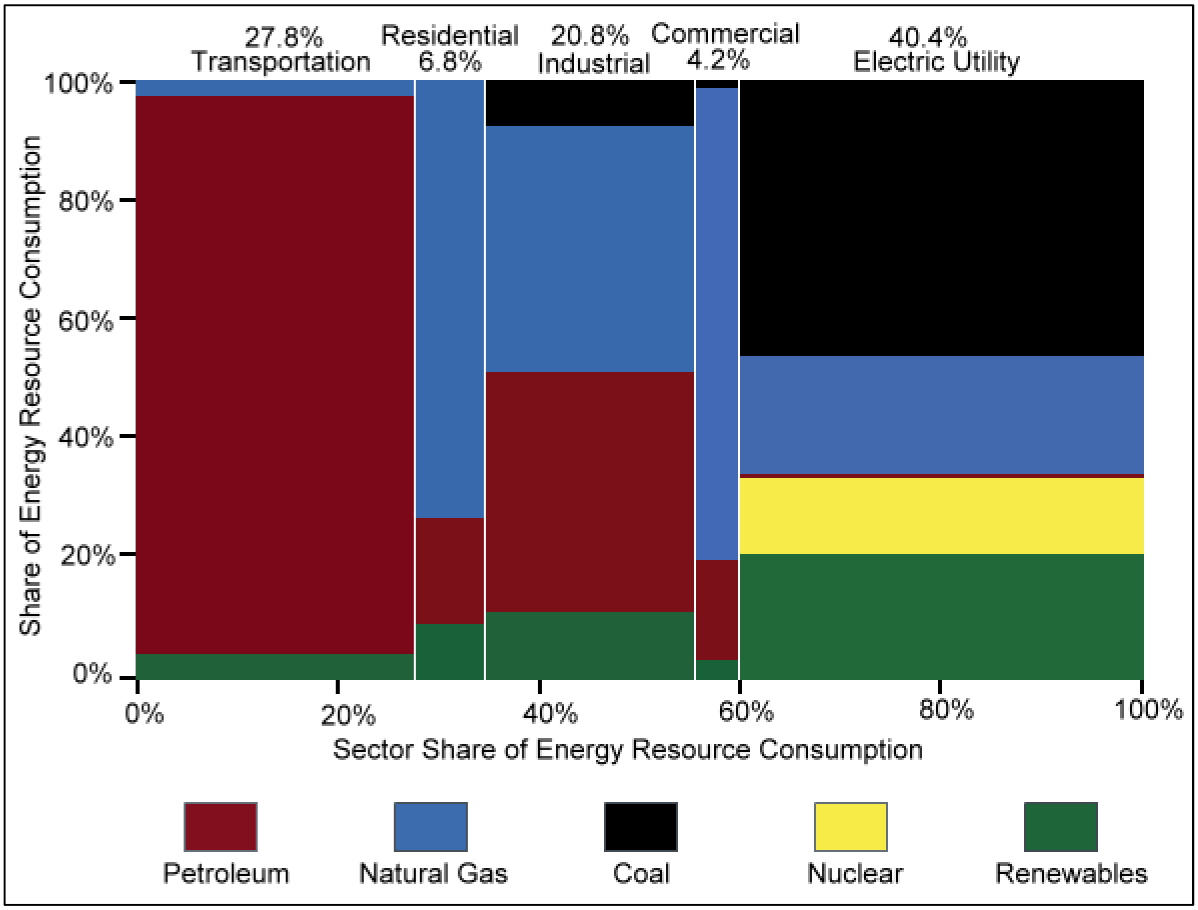


FIGURE 1. U.S. Energy Consumption by Sector and Energy Source, 2011

Sources:

Energy Information Administration, *Monthly Energy Review, September 2012*, 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 2035, transportation petroleum consumption is expected to grow to more than 15 million barrels per day; at that time, the gap between U.S. production and transportation consumption will be about 2.5 million barrels per day when including the non-petroleum sources and 5.5 million barrels per day if using only conventional sources of petroleum fuel.

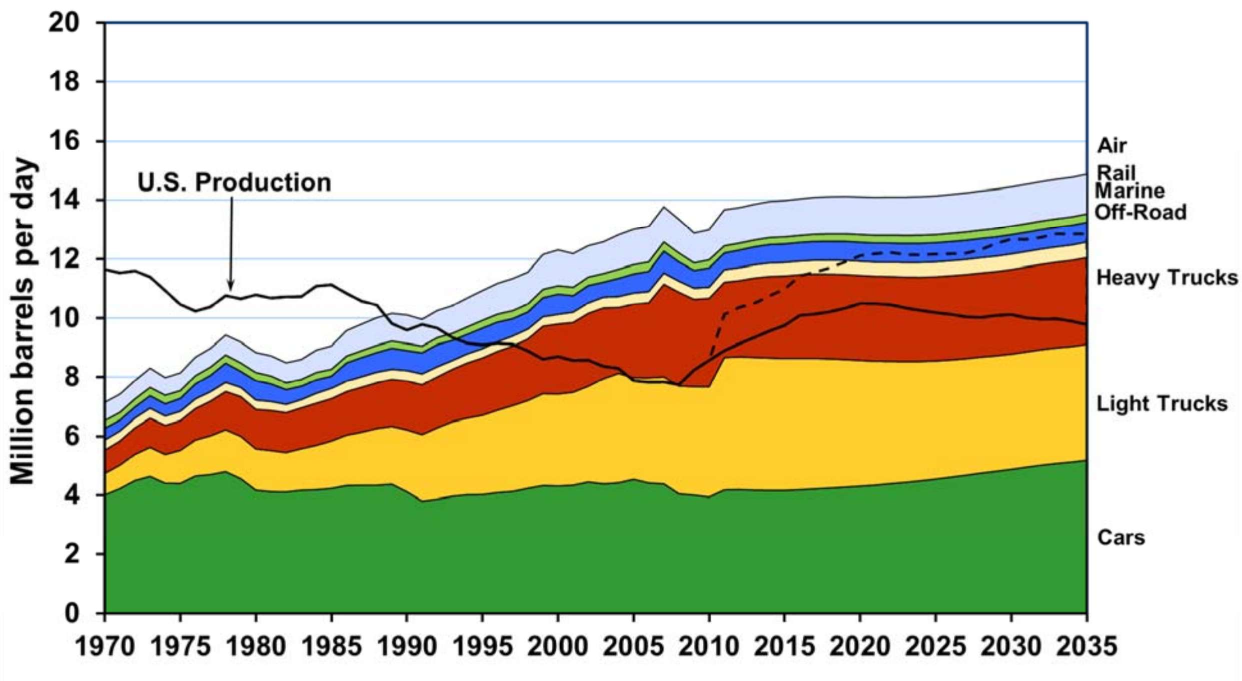


FIGURE 2. Transportation Petroleum Use by Mode and the U.S. Production of Petroleum, 1970-2035

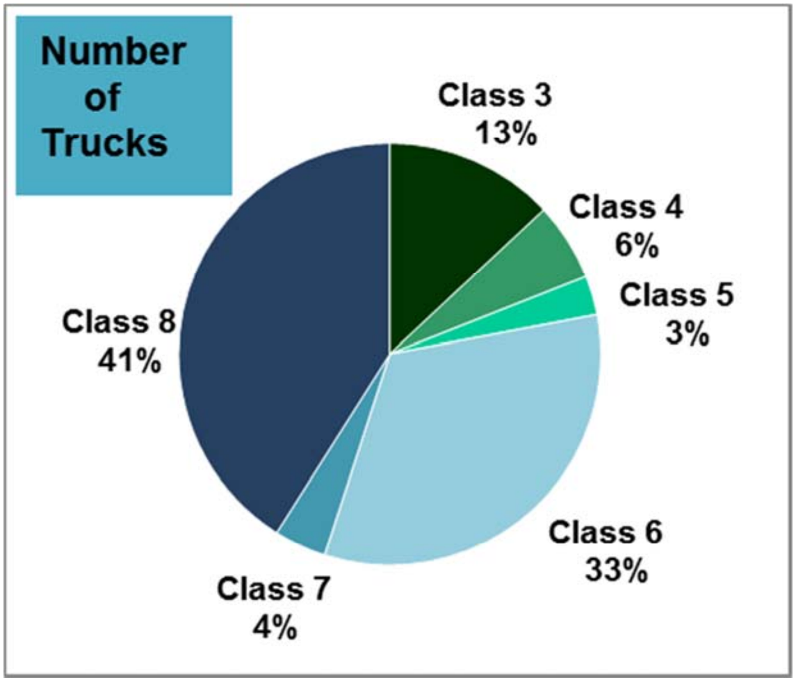
Note: The U.S. production has two lines after 2010. The solid line is conventional sources of petroleum, including crude oil, natural gas plant liquids, and refinery gains. The dashed line adds in other non-petroleum sources, including ethanol, biomass, liquids from coal, other blending components, other hydrocarbons, and ethers. The sharp increase in values between 2010 and 2011 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 31*, Oak Ridge, TN, 2012. http://cta.ornl.gov/data

2010-2035: Energy Information Administration, *Annual Energy Outlook 2012*, DOE/EIA-0383(2012), Washington, DC, 2012. 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 67 for truck class definitions. Data for 2002 are the latest available.

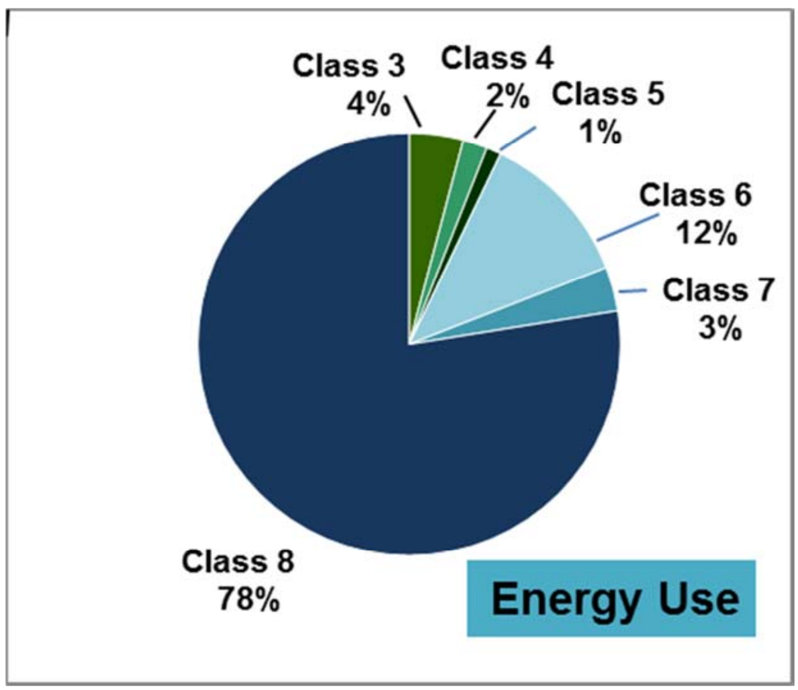


FIGURE 3. Medium and Heavy Truck Fleet Composition and Energy Usage, 2002

Source:

Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 31*, Oak Ridge, TN, 2012. 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.

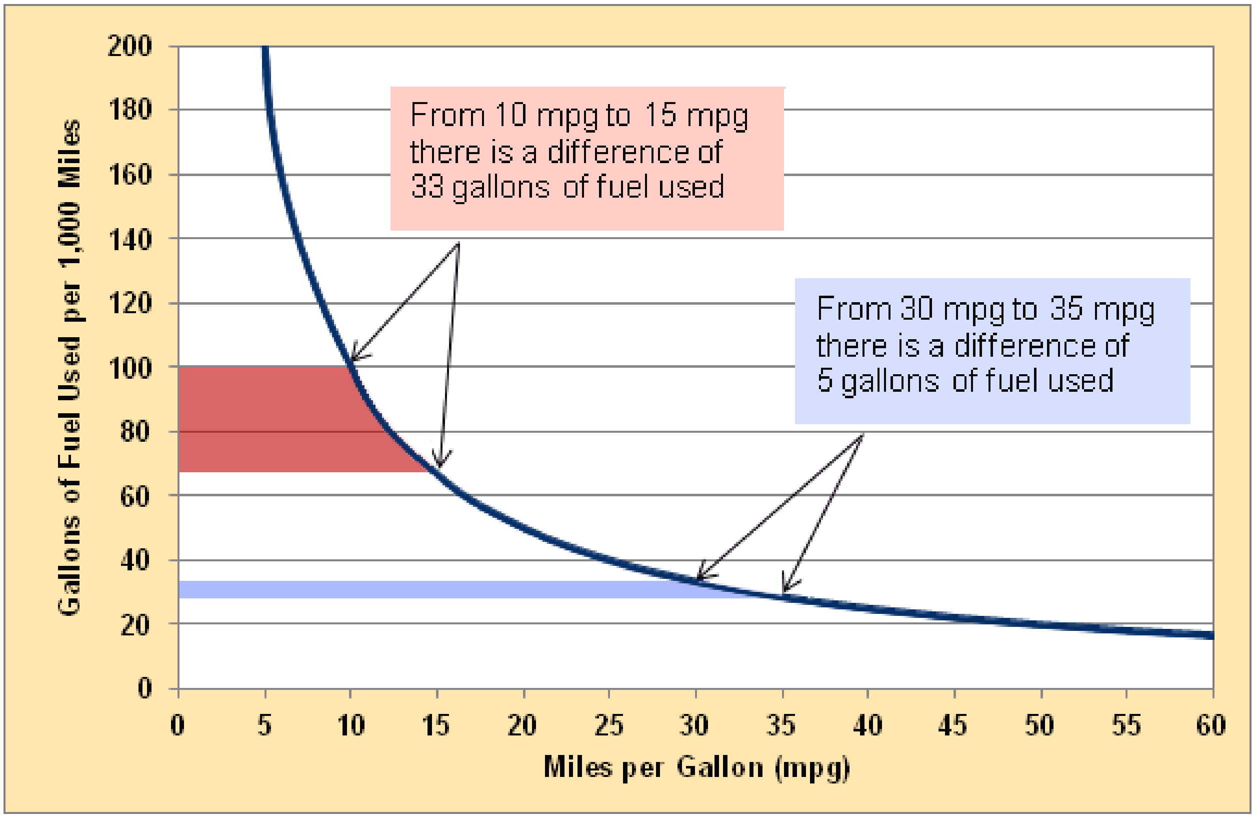


FIGURE 4. Fuel Use Versus Fuel Economy

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 2004

Carbon dioxide (CO_2) emissions decreased by 11% from a high of 1,966 million metric tons (mmt) in 2004 to 1,750 mmt in 2010. 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.

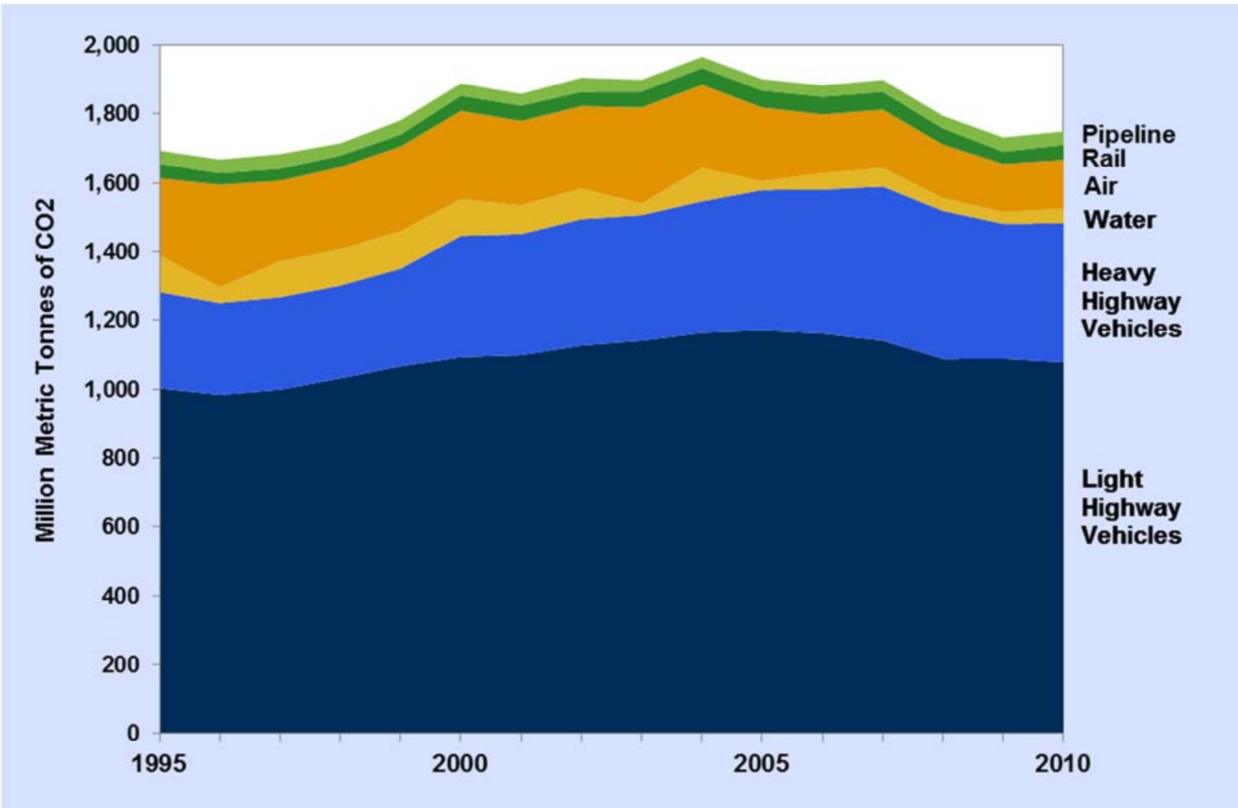


FIGURE 5. Transportation Carbon Dioxide Emissions, 1995-2010

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 2012. 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) 2012 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 and Volkswagen Jetta had the greatest increase in interior volume while still reducing CO_2 emissions.

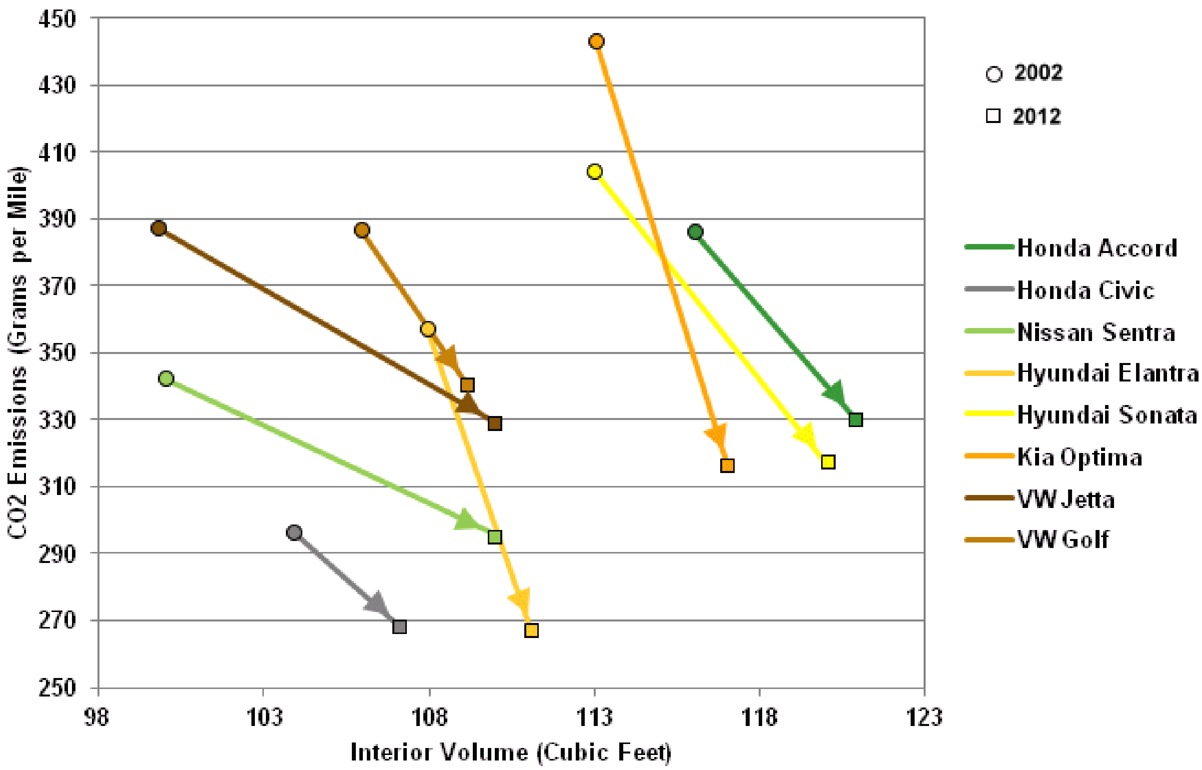


FIGURE 6. Carbon Dioxide Emissions Versus Interior Volume for Selected MY 2012 Cars

Source:

U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy website, October 2012. 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) 2011 the sales-weighted average of CO_2 emitted by cars was 7.2 tons annually per car. For light trucks, the average was 9.9 tons annually per truck.

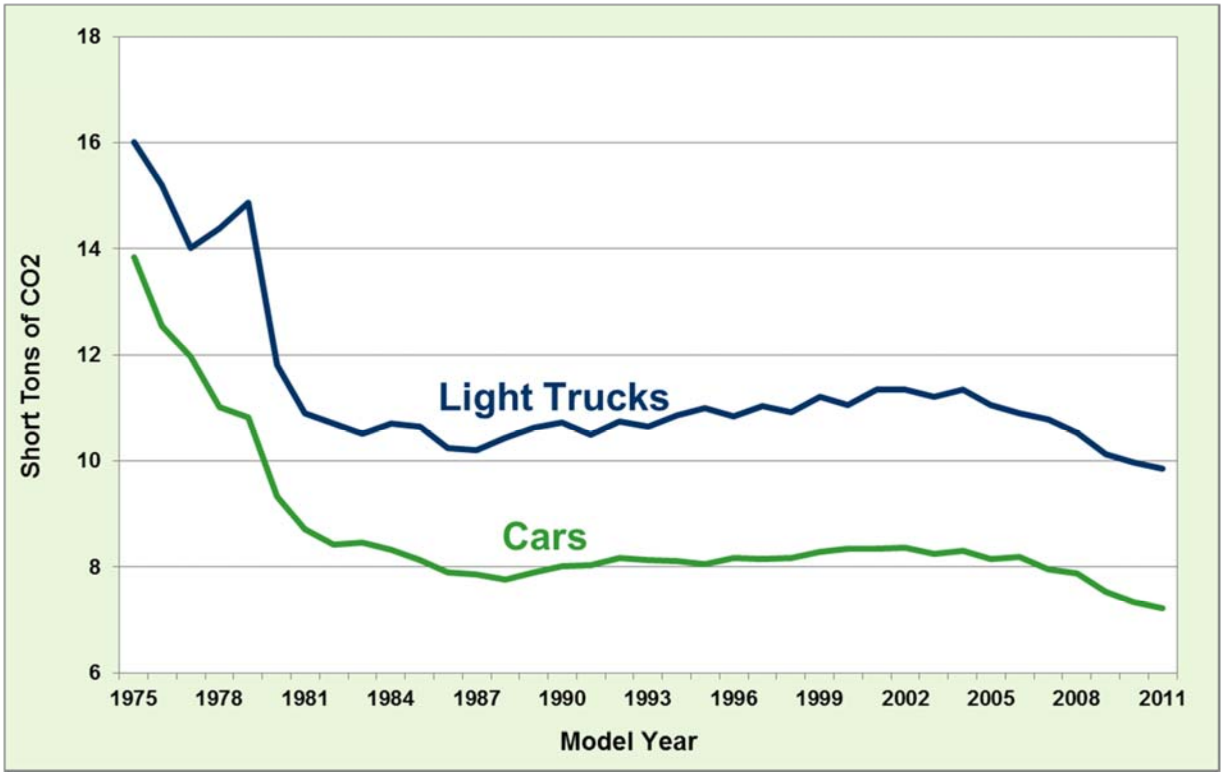


FIGURE 7. Average Carbon Footprint for Cars and Light Trucks Sold, 1975-2011

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

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

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 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Total Transportation Pollutants Decline over Last Two Decades

Due to improvements in fuels and vehicle technologies, the total amount of pollutants emitted from the transportation sector has declined. Over the last two decades 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 1990 to 2012, carbon monoxide (CO) emissions declined by 72%; volatile organic compound (VOC) emissions declined by 70%; particulate matter emissions less than 10 microns (PM-10) declined 33%; and nitrogen oxide (NOx) emissions declined by 44%.

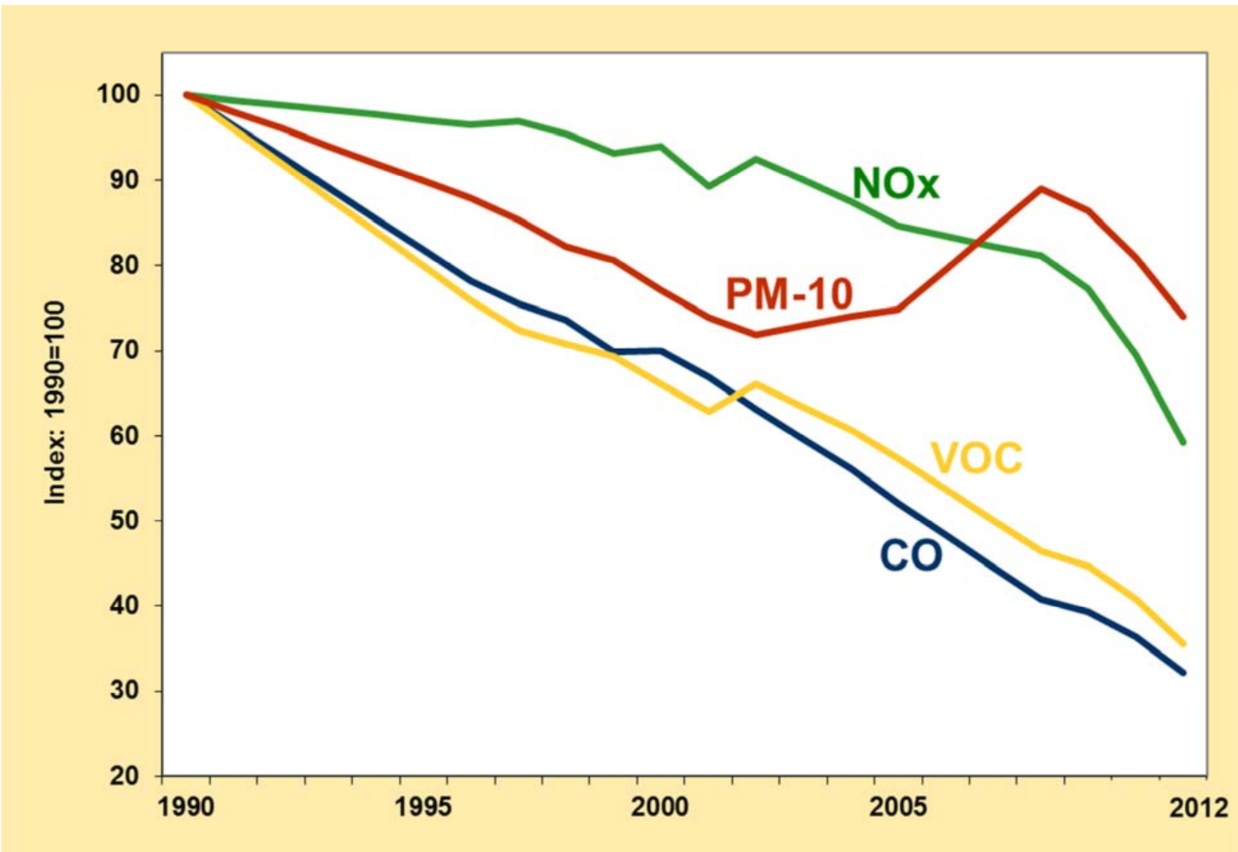


FIGURE 8. Total Transportation Pollutant Emissions, 1990-2012

Note: Includes highway, air, water, rail, and other nonroad vehicles and equipment.
For 2006-on, the highway vehicle emissions estimates were changed to reflect the results of the Environmental Protection Agency MOVES estimation model. Previous estimates used the results of the MOBILE6 model. This resulted in changes to the total transportation pollutant emissions. Particularly, a new methodology for particulate matter estimates is used in the MOVES model.

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 70% of carbon monoxide (CO) emissions from the transportation sector in 1990 were from highway vehicles; by 2012 that fell to 38%. The share of transportation's nitrogen oxide (NOx) emissions from highway vehicles experienced a decline from 38% in 1990 to 34% in 2012. (A model change by the Environmental Protection Agency is likely the cause of the increase in 2009.) The highway share of volatile organic compound (VOC) emissions declined by 26% during this same period.

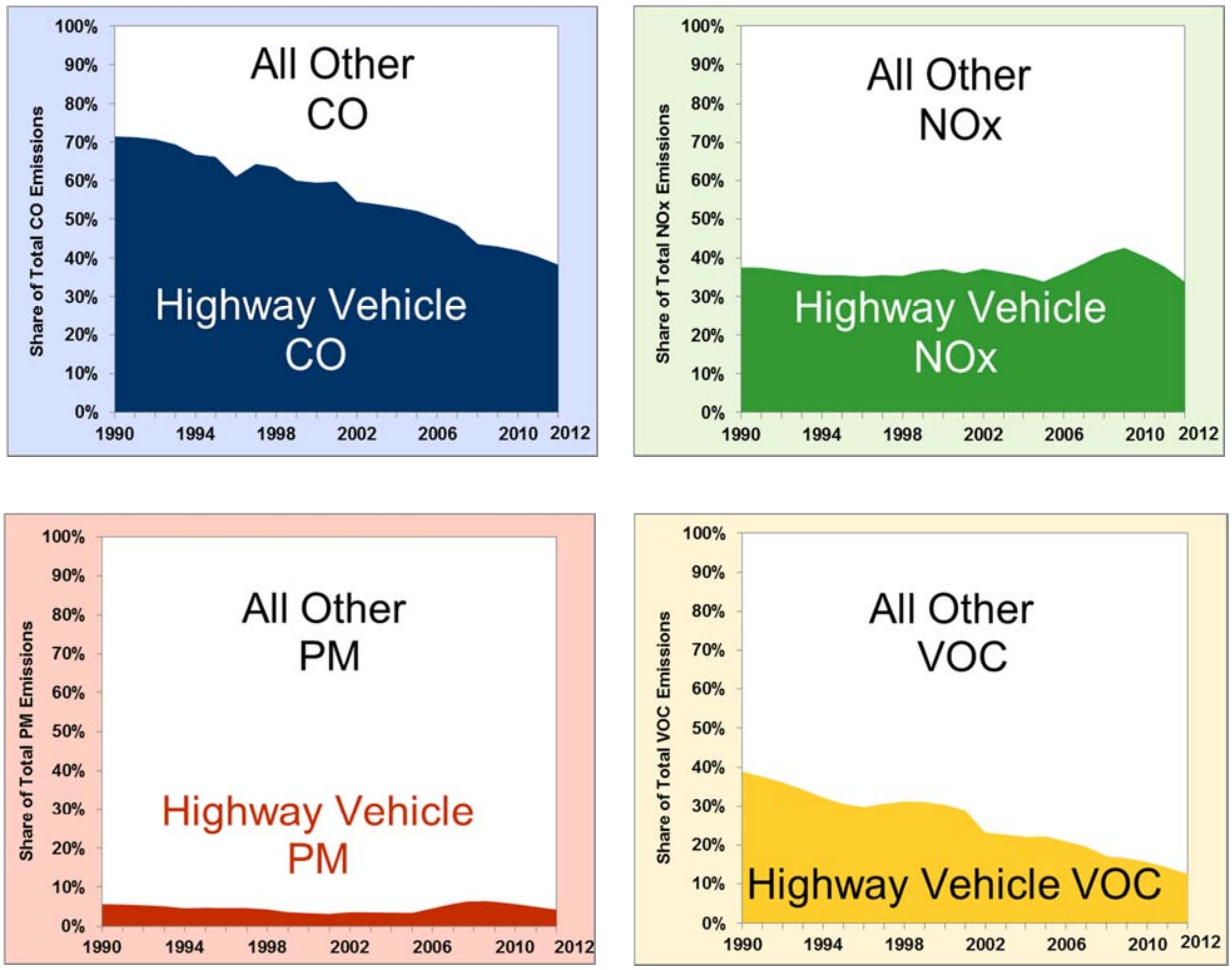


FIGURE 9. Highway and Nonhighway Share of Transportation Pollutant Emissions, 1990-2012

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 2010.

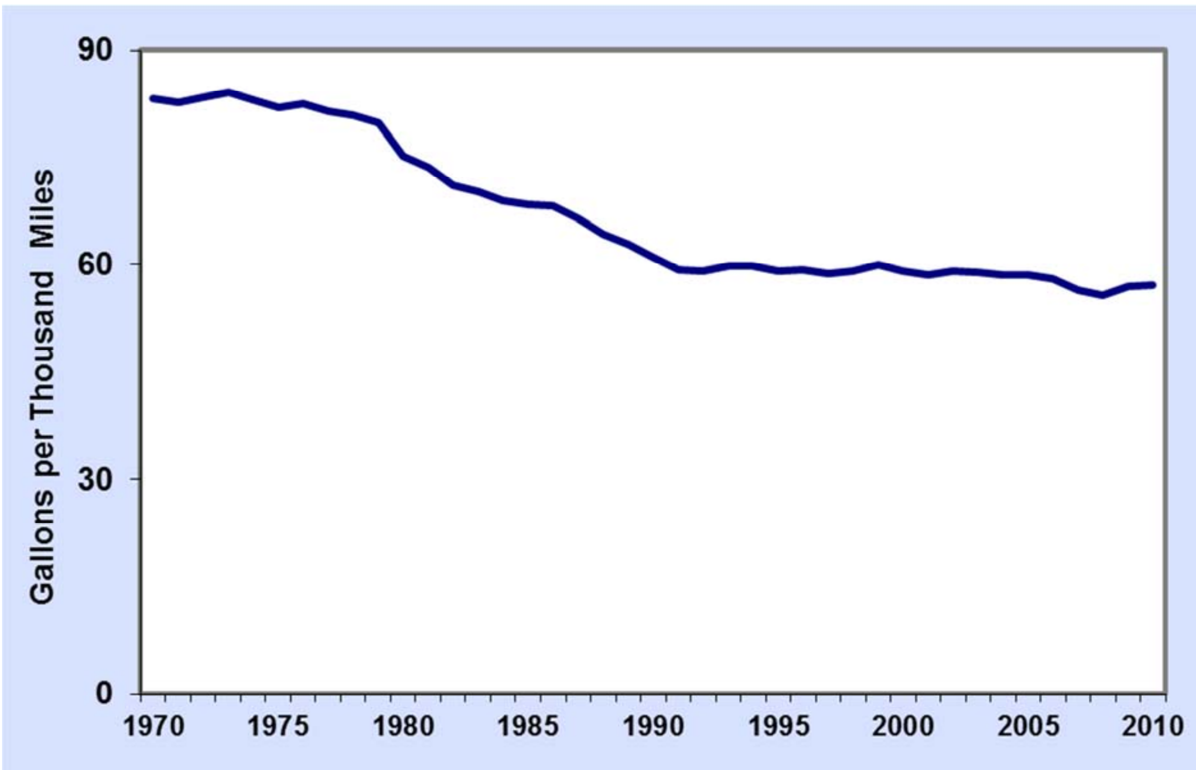


FIGURE 10. Fuel Use per Thousand Miles on the Highways, 1970-2010

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

Sources:
Federal Highway Administration, *Highway Statistics 2010*, Table VM-1 and previous annual editions.
http://www.fhwa.dot.gov/policyinformation/statistics/2010

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.

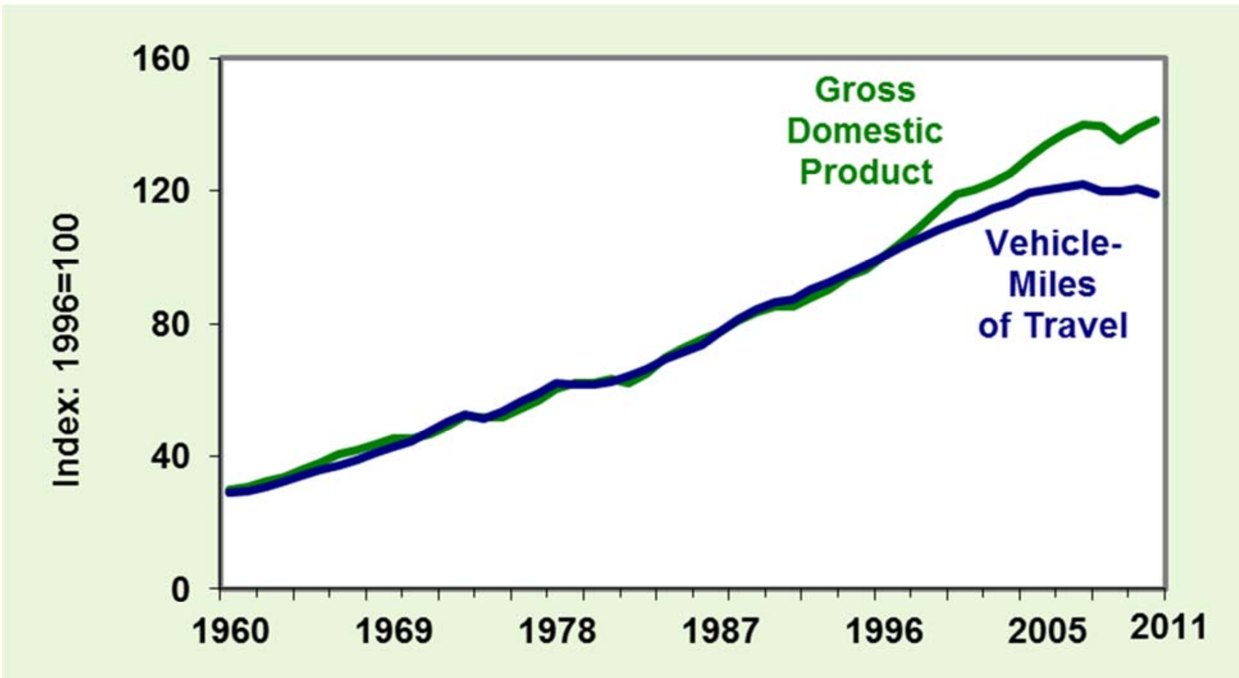


FIGURE 11. Relationship of VMT and GDP, 1960-2011

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 2010*, Table VM-1 and previous annual editions.
http://www.fhwa.dot.gov/policyinformation/statistics/2010

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, uprisings in Egypt and Libya have caused uncertainty in the oil markets and the price of oil has been affected.

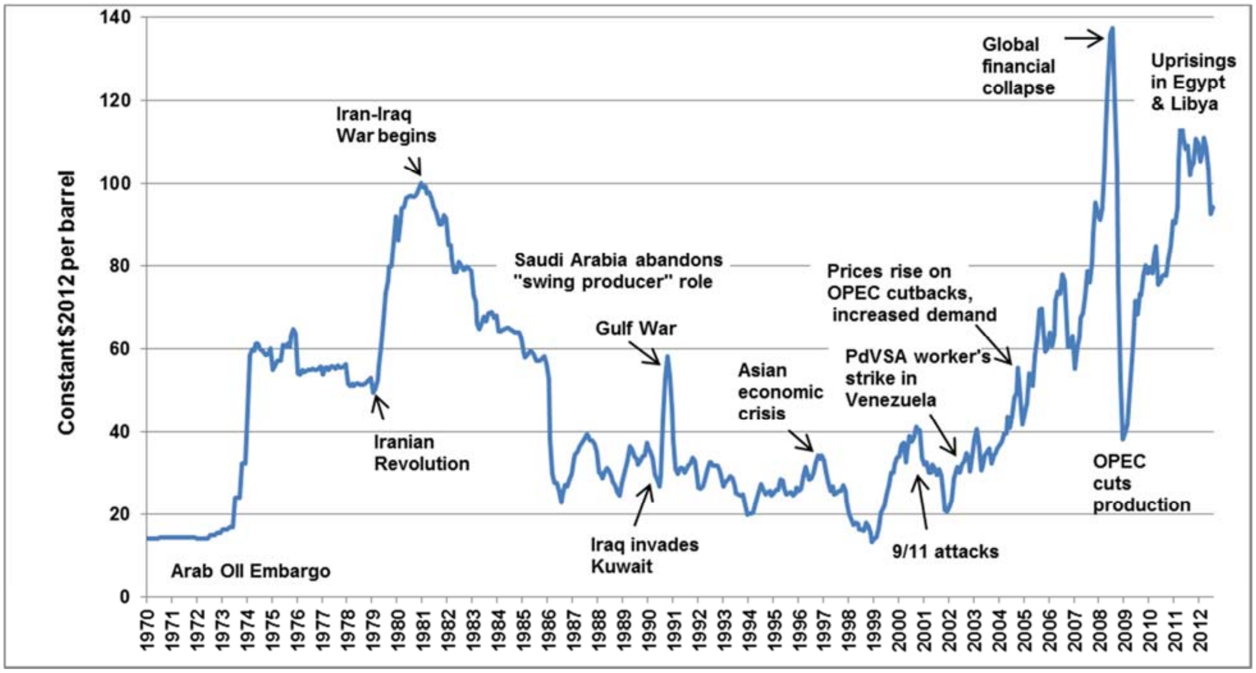


FIGURE 12. World Crude Oil Price and Associated Events, 1970-2012

Note: Refiner acquisition cost of imported crude oil.

Sources:

Energy Information Administration, "What Drives Crude Oil Prices?" September 2012. 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.

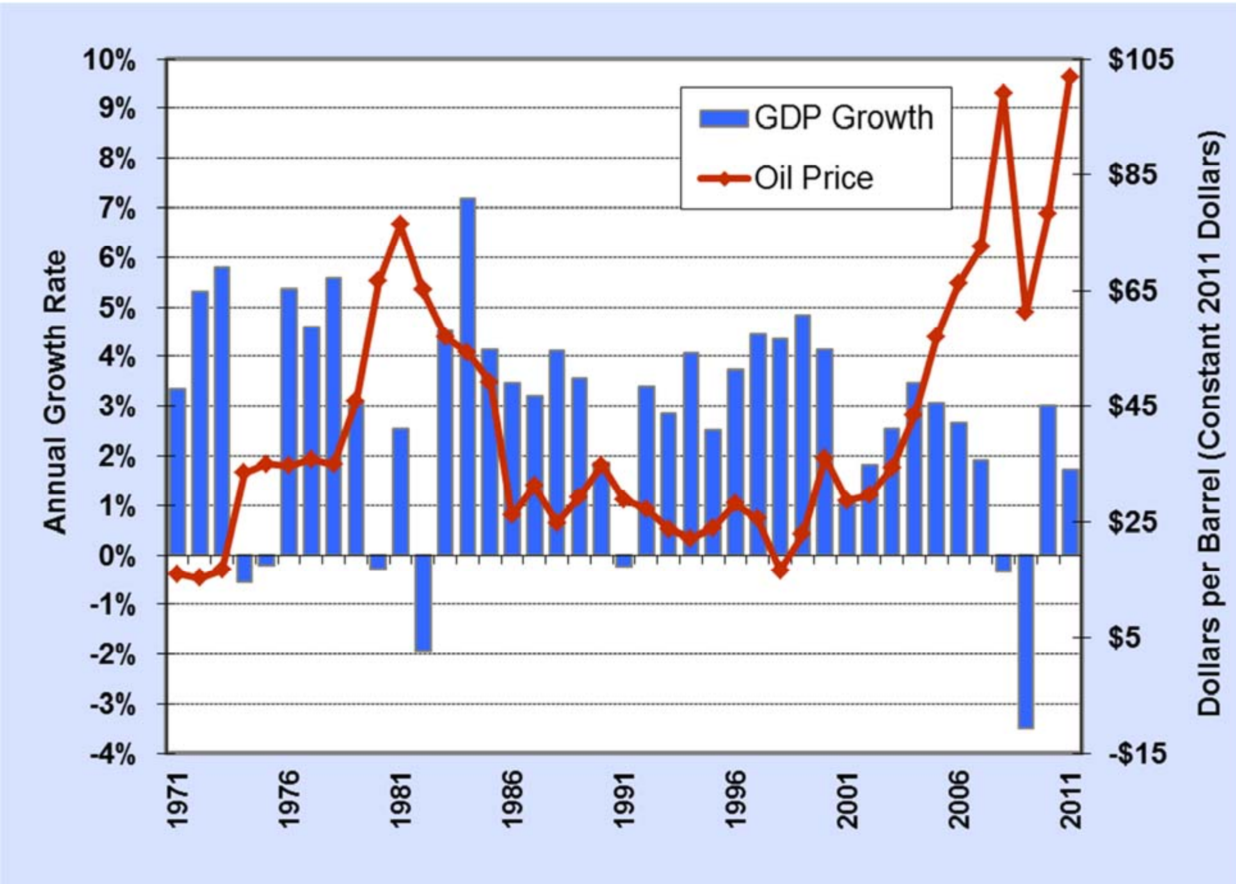


FIGURE 13. The Price of Crude Oil and Economic Growth, 1971-2011

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, 2012. http://cta.ornl.gov/data

Dependence on Oil Costs the U.S. Economy $300 Billion in 2010

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 approximately 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 4.5% of GDP in 1980, but were under 3.5% 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. This one-time study has not been updated past 2010.

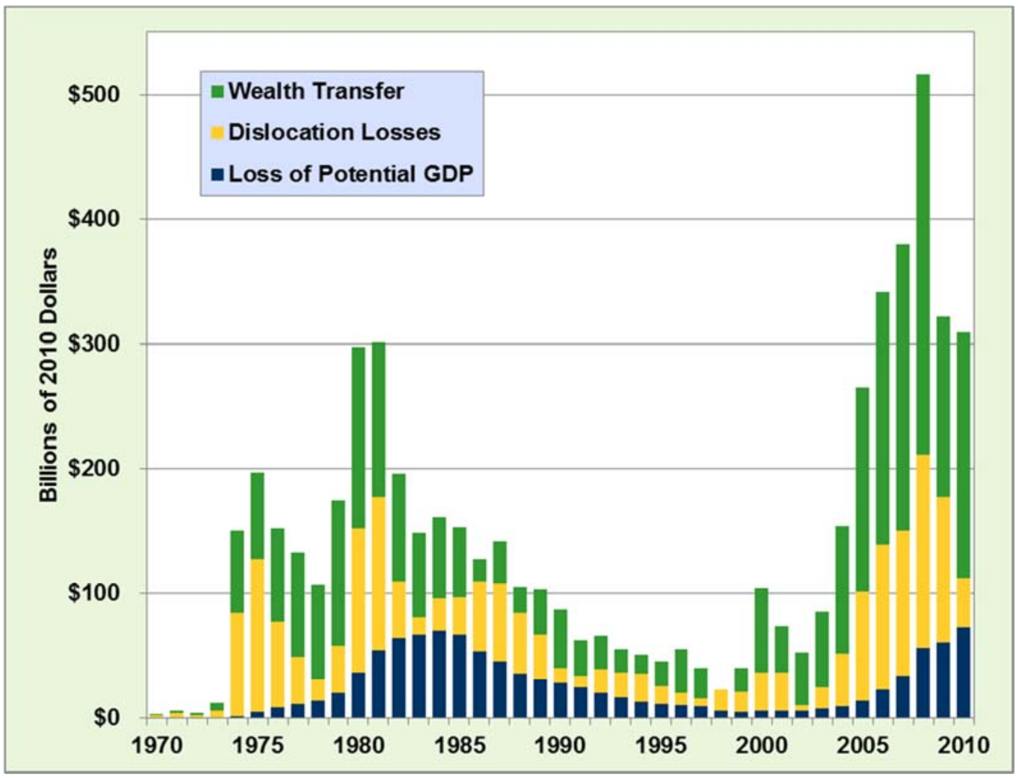


FIGURE 14. Costs of Oil Dependence to the U.S. Economy, 1970-2010

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.

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 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.

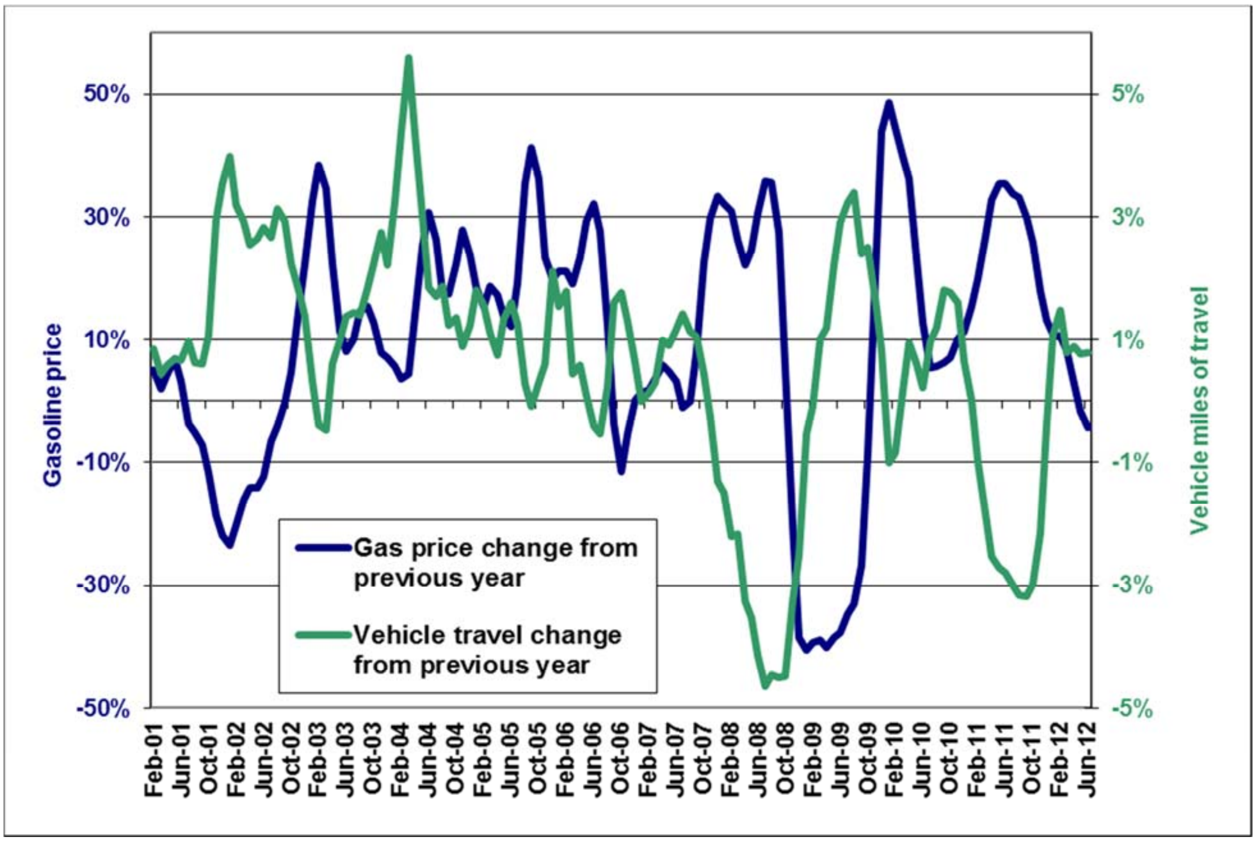


FIGURE 15. Relationship of Vehicle-Miles of Travel and the Price of Gasoline, 2001-2012

Sources:

Federal Highway Administration, *July 2012 Traffic Volume Trends,* and previous monthly editions.
http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Energy Information Administration, *Monthly Energy Review, September 2012*, 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 2011 was $25,233, about the same as the 2010 average (constant 2011 dollars). That price is down, however, from a high of $28,102 in 1998, mainly driven by the high price of import cars. The price of imports peaked in 1998 at $40,867. Until 1982, domestic cars were more expensive than imports.

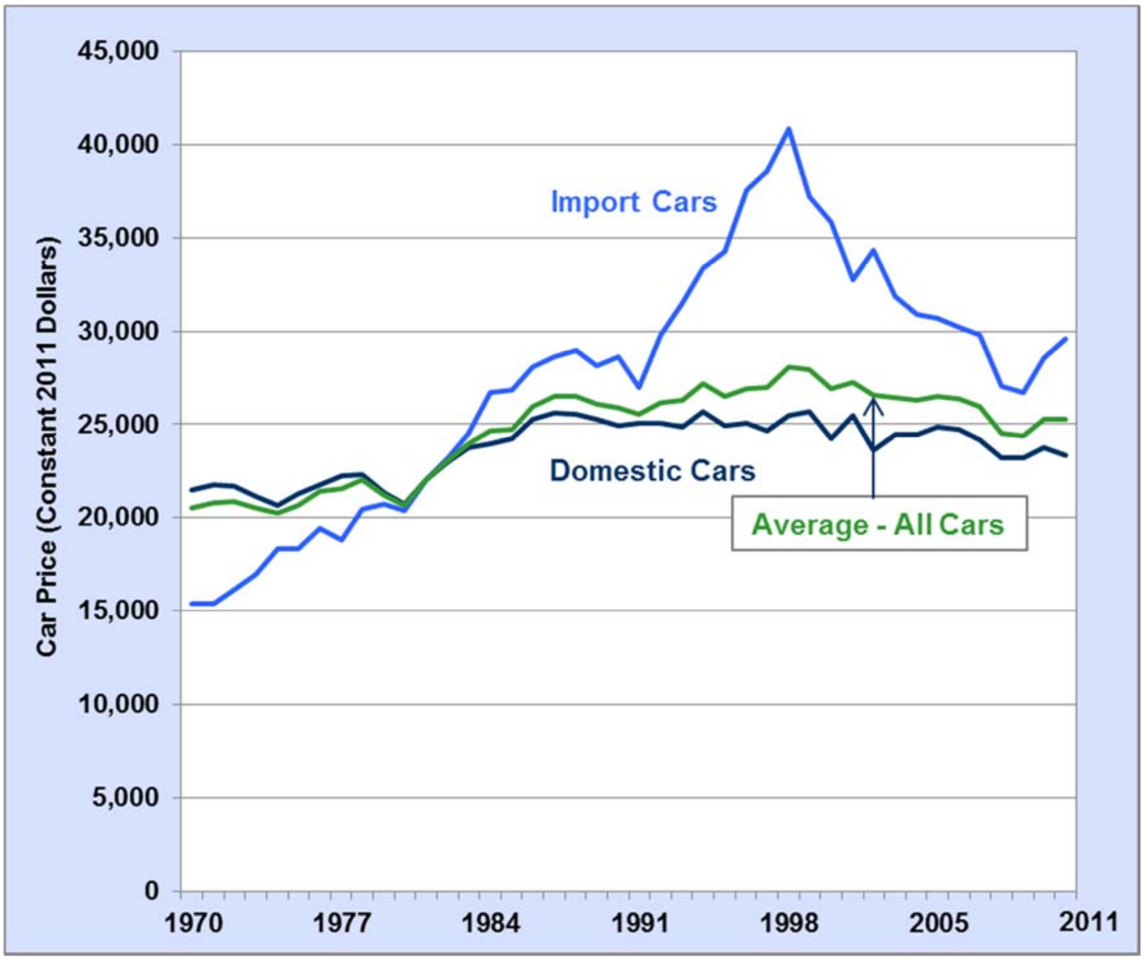


FIGURE 16. Average Price of a New Car, 1970-2011

Sources:

U.S. Department of Commerce, Bureau of Economic Analysis, *National Income and Product Accounts*, underlying detail estimates for Motor Vehicle Output, Washington, DC 2012.

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

A 2012 survey 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.

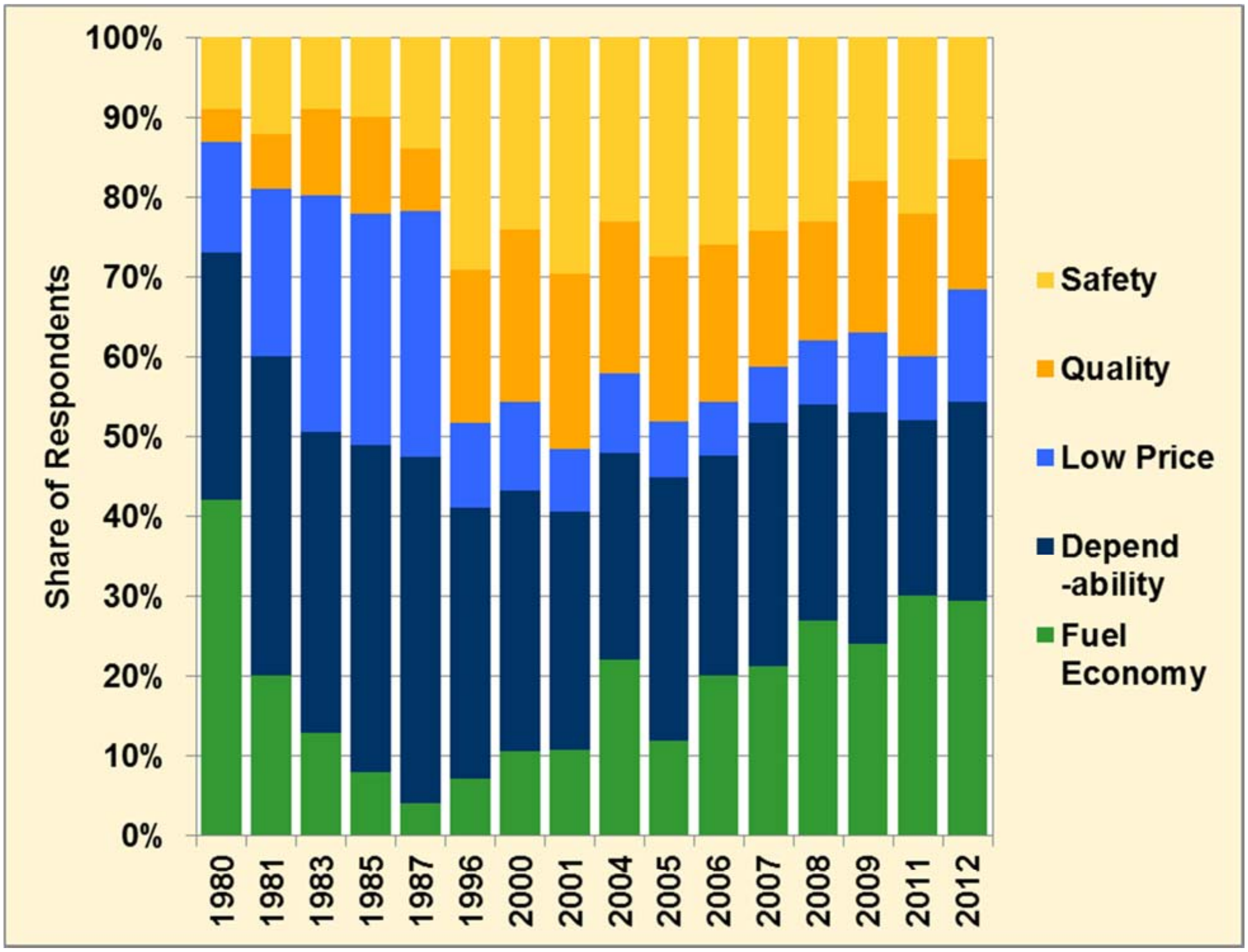


FIGURE 17. Most Important Vehicle Attribute, 1980-2012

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).

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.

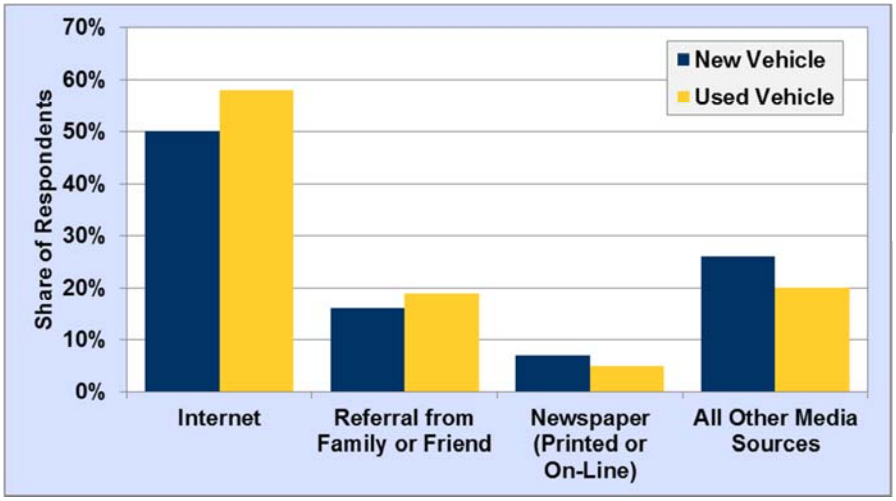


FIGURE 18. Media Which Led a Consumer to the Vehicle Dealer, 2011

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 17% of Household Expenditures Are for Transportation

Except for housing, transportation was the largest single expenditure for the average American household in 2011. 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 17% and 20% over time. In 2009, however, the transportation share reached a low of 15.6%.

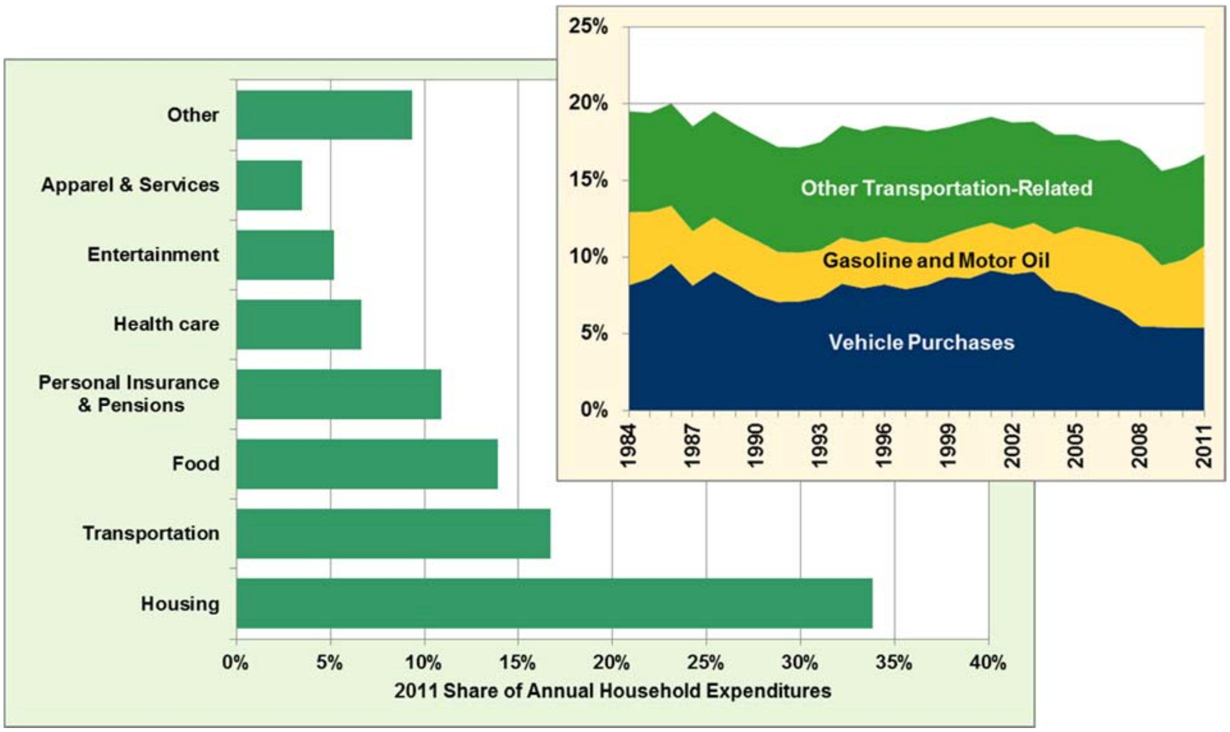


FIGURE 20. Share of Household Expenditures by Category, 2011, and Transportation Share of Household Expenditures, 1984-2011

Sources:

U.S. Department of Labor, *Consumer Expenditure Survey 2011*, Table 2, Washington, DC, 2012, 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, 9.5 million people are employed in transportation-related jobs. These transportation-related jobs account for 7.2% 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.

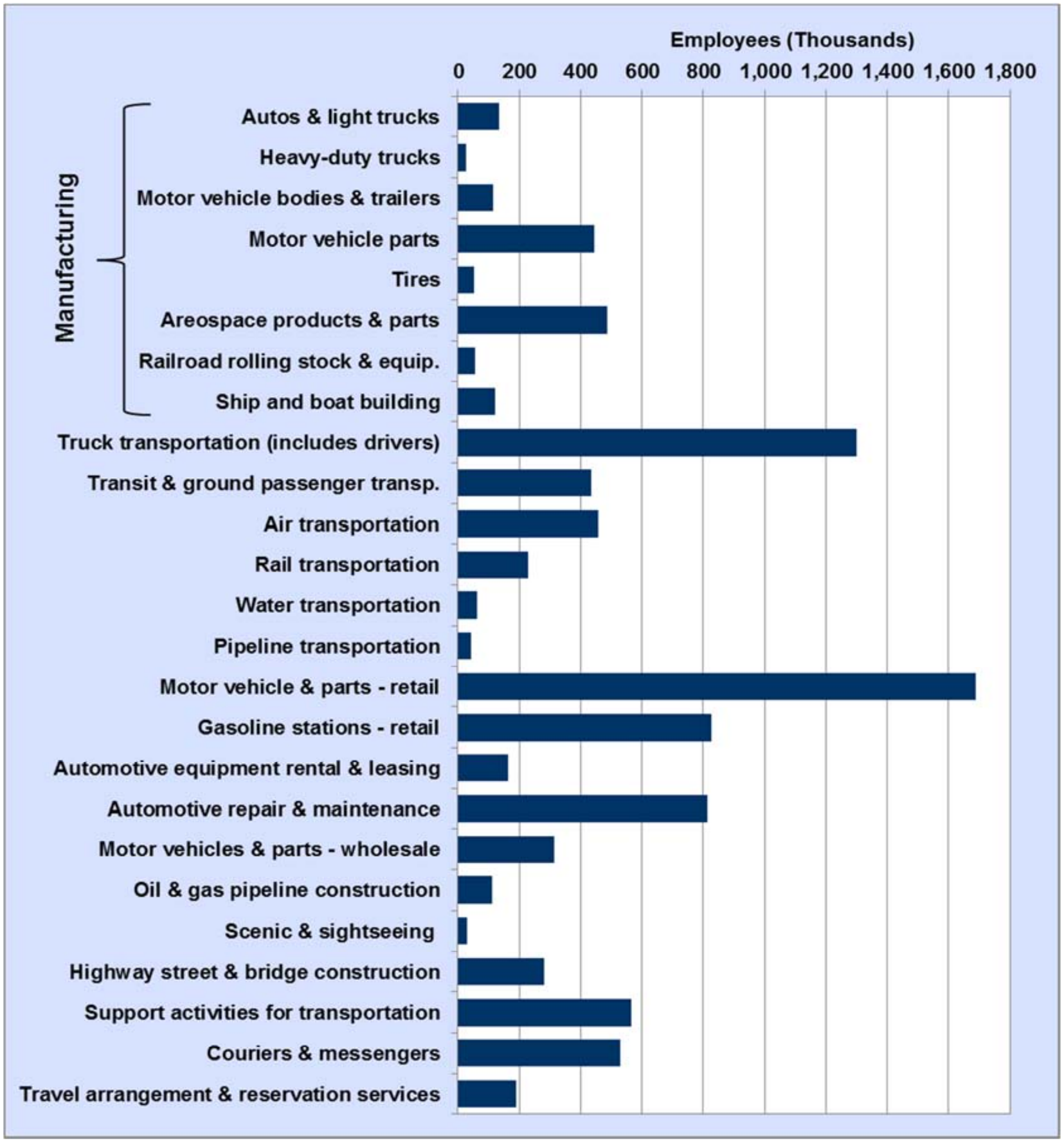
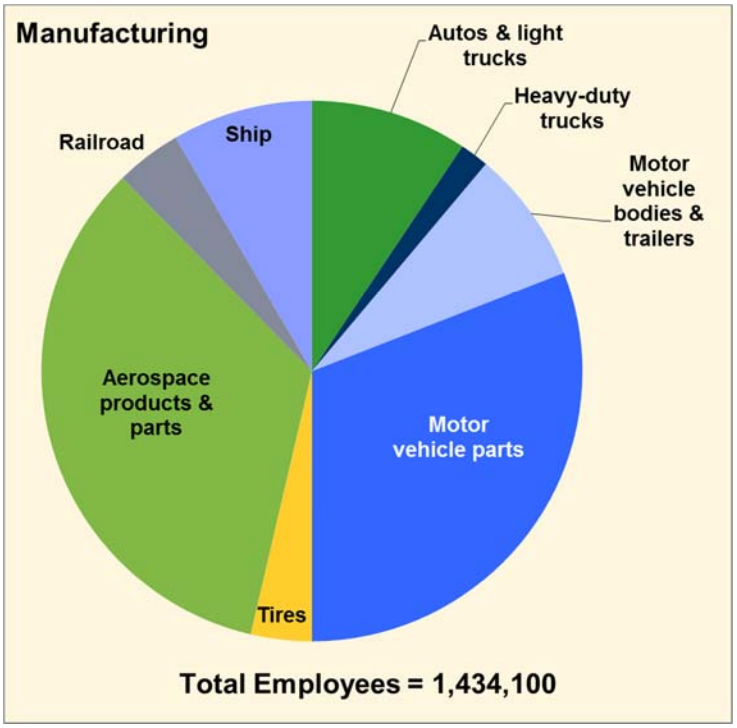


FIGURE 21. Transportation-Related Employment, 2011

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

Vehicle Manufacturing, Parts Manufacturing, and Truck Transportation Employ Many People



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 2.5 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.

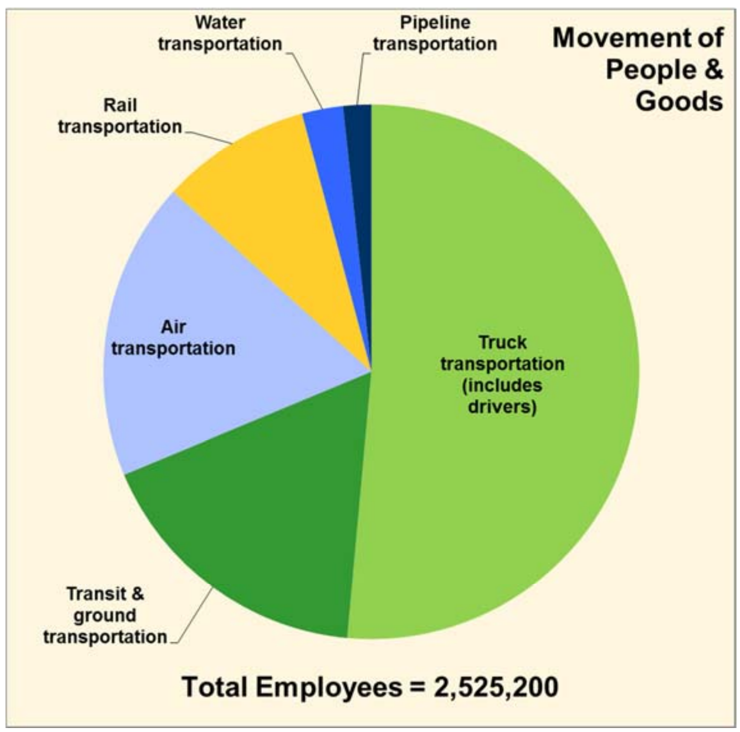


FIGURE 22. Transportation Manufacturing-Related and Mode-Related Employment, 2011

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. While many manufacturers have recovered to near 2006-prices, stock prices for Toyota in 2012 are 28% lower than their 2006 level. Volkswagen (VW) stock experienced a "wild ride" of ups and downs in late October 2008 due to Porsche's increased holdings in VW. 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).

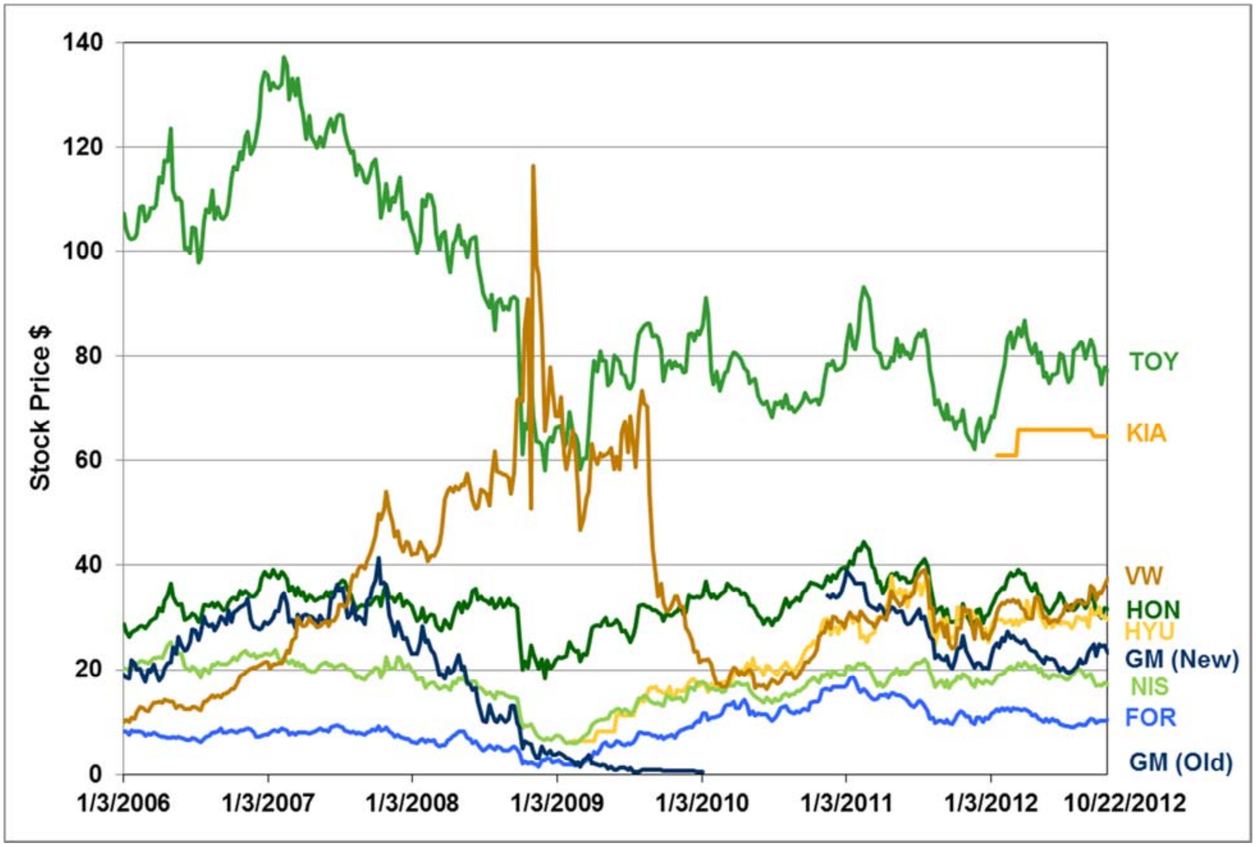


FIGURE 23. Stock Price by Manufacturer, 2006-2012

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 2012 and 2013 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
2013	Buick LaCrosse eAssist[1]	29	$0	$835	0
	Buick LaCrosse	21			
2013	Buick Regal eAssist[1]	29	$0	$493	0
	Buick Regal	23			
2013	Lincoln MKZ Hybrid[1]	45	$0	$959	0
	Lincoln MKZ	26			
2013	Cadillac Escalade Hybrid 4WD	21	$2,175	$1,265	1.7
	Cadillac Escalade AWD	15			
2013	Lexus ES 300h	40	$2,750	$949	2.9
	Lexus ES 350	24			
2013	Toyota Highlander Hybrid 4WD	28	$3,095	$1,013	3.1
	Toyota Highlander SE 4WD	19			
2013	Ford Fusion Hybrid SE	47	$3,500	$1,007	3.5
	Ford Fusion SE	26			
2012	Toyota Prius c One[2]	50	$2,521	$666	3.8
	Toyota Yaris 5-Door LE	32			
2012	Honda Civic Hybrid	44	$2,095	$515	4.1
	Honda Civic EX-L	32			
2012	Toyota Prius Trim 2[2]	50	$4,016	$970	4.1
	Toyota Matrix	28			
2013	GMC Yukon Denali Hybrid 4WD	21	$5,125	$1,265	4.1
	GMC Yukon Denali AWD	15			
2013	Honda Insight[2]	42	$2,375	$529	4.5
	Honda Fit	31			
2012	Toyota Camry Hybrid XLE	40	$2,725	$594	4.6
	Toyota Camry XLE	28			
2012	Kia Optima Hybrid	36	$2,500	$505	5
	Kia Optima EX	28			
2013	Acura ILX Hybrid[3]	38	$3,000	$598	5
	Acura ILX Auto[3]	28			

Note: The hybrid models shown have a payback period of about 5 years or less based on the assumptions shown at the top of the table. Hybrid models with longer payback periods or those where no conventional counterpart could be identified for comparison, are not included. 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 for themselves how similar the vehicles are.

[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]For unique hybrids with no conventional counterpart, a different model was chosen from the same manufacture if it appeared to be reasonably similar.

[3]Uses premium gasoline

Source:
www.fueleconomy.gov - Data accessed November 16, 2012.

Chapter 2.

LIGHT VEHICLES

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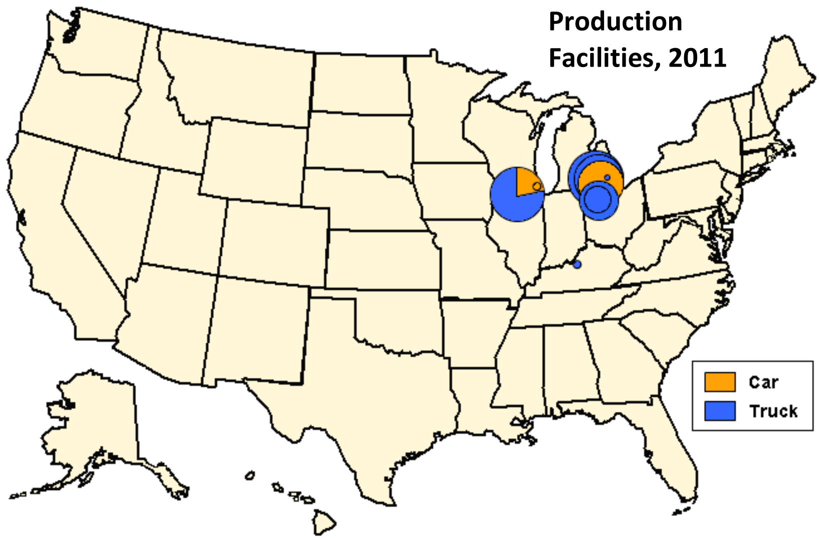
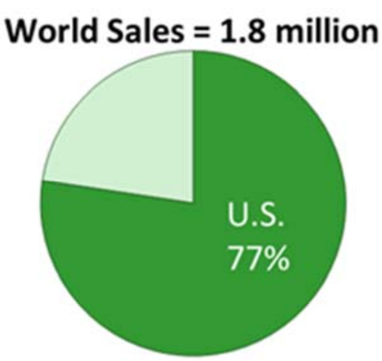
Chrysler Company Profile

Number of U.S. Employees	
18,300	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	30.6 mpg
Import Cars	None
Light Trucks	24.3 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	7
Natural Gas	0
Propane	0
Hybrid Electric	0
Plug-In Hybrid Electric	0
Electric	0





Chrysler Plants	Type	2011 Production
Toledo, OH - North & South	Truck	269,131
Detroit, MI - Jefferson North	Truck	246,460
Warren, MI	Truck	211,142
Sterling Heights, MI	Car	198,576
Belvidere, IL	Truck	185,403
Belvidere, IL	Car	51,841
Chicago, IL	Car	12,636
Louisville, KY	Truck	9,785
Dearborn, MI	Truck	408

FIGURE 24. Chrysler Company Profile

Fuel Saving Technologies

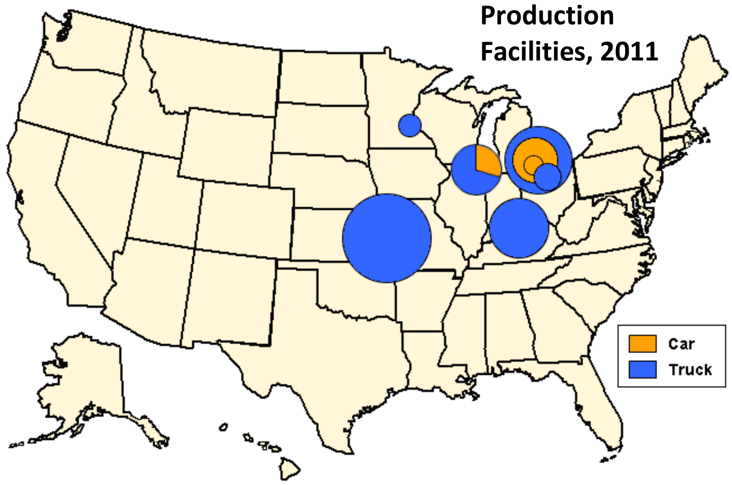
Chrysler has developed an 8-speed transmission for 2012 and is also working on a 9-speed transmission that is scheduled for 2013. Additionally, a 6-speed automatic double-clutch transmission became available to consumers in 2012 with the introduction of the all-new 2013 Dodge Dart. This transmission is mechanically similar to a manual transmission but allows for automated shifting and eliminates the break in power between gear shifts which improves efficiency and performance.

In addition to engine and transmission technologies, Chrysler is planning to bring stop-start technologies and active grill shutters to improve aerodynamics at highway speeds. Chrysler is also planning to bring an all-electric version of the Fiat 500 to market in 2013 called the 500e.

Chrysler is looking toward diesel to increase vehicle efficiency particularly with their SUVs and trucks where diesel offers the benefit of low-end torque, greater towing and greater fuel economy compared to gasoline engines. Currently about 9% of Chrysler trucks produced are diesel. A diesel option will be offered on the 2014 Jeep Grand Cherokee and other models will follow. Like other manufactures, Chrysler is also increasing fuel economy throughout their line-up by downsizing engines and shifting away from 6-cylinder engines in favor of more efficient high output 4-cylinder engines. For trucks that require the larger V8 engines, Chrysler is employing cylinder deactivation to provide 4-cylinder efficiency during low load operation and regular V8 power when needed.

Ford Company Profile

Number of U.S. Employees	
39,122	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	34.9 mpg
Import Cars	31.0 mpg
Light Trucks	24.4 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	12
Natural Gas	1
Propane	0
Hybrid Electric	3
Plug-In Hybrid Electric	0
Electric	2



Ford Plants	Type	2011 Production
Kansas City, MO	Truck	456,129
Dearborn, MI	Truck	344,038
Louisville, KY	Truck	301,212
Wayne, MI	Car	221,514
Chicago, IL	Truck	170,676
Avon Lake, OH	Truck	133,850
St. Paul, MN	Truck	97,222
Flat Rock MI	Car	78,286
Chicago, IL	Car	77,664

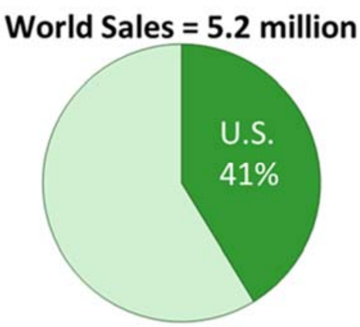


FIGURE 25. Ford Company Profile

Fuel Saving Technologies

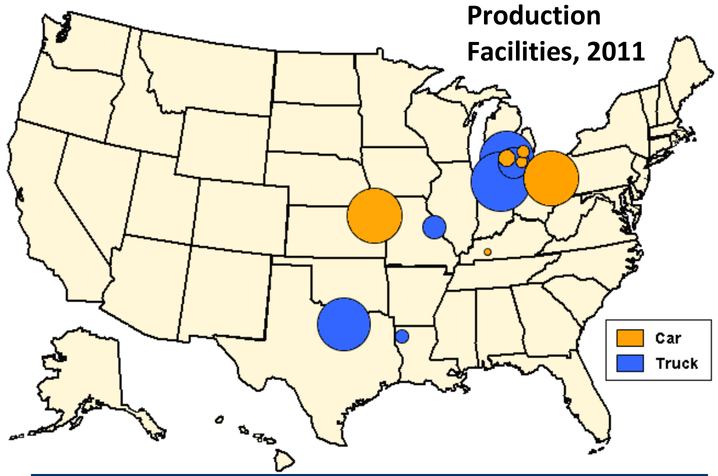
Ford has been very successful in developing and marketing their EcoBoost technology that uses gasoline direct injection combined with turbocharging to increase engine output while also increasing efficiency. This has allowed Ford to downsize their engine offerings while providing comparable performance. The EcoBoost technology is being deployed throughout Ford's line-up of vehicles from work trucks down to the 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 that limit airflow to the engine compartment to improve aerodynamics at high speed.

Ford has also developed transmission technology like the automatic 6-speed PowerShift transmission which shifts automatically but uses a dry double clutch similar to a manual transmission but without the loss of power between shifts which improves efficiency by up to 10% and improves performance as well. PowerShift transmissions are available on the 2012 and 2013 Focus and Fiesta and helped them achieve a highway rating of 40 mpg. Also announced in 2012, Ford will begin working with General Motors in the development of 9-speed automatic transmissions for passenger cars and 10 speed transmissions for larger vehicles like full-size trucks and SUVs.

Ford has implemented full hybrid systems like those used in the Fusion hybrid and C-Max hybrid and has launched their first plug-in hybrid, the 2013 C-Max Energi. Although the Ford Transit Connect EV, which was produced by Azure Dynamics, was discontinued, Ford remains committed to full electric vehicles and has launched the 2012 Focus EV.

General Motors Company Profile

Number of U.S. Employees	
77,000	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	32.9 mpg
Import Cars	None
Light Trucks	23.5 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	28
Natural Gas	2
Propane	0
Hybrid Electric	7
Plug-In Hybrid Electric	1
Electric	0



GM Plants	Type	2011 Production
Fort Wayne, IN	Truck	307,360
Lansing, MI - Delta	Truck	281,837
Lordstown, OH	Car	281,810
Kansas City, KS	Car	279,117
Arlington, TX	Truck	268,229
Flint, MI	Truck	144,331
Wentzville, MO	Truck	105,376
Lansing, MI - Grand River	Car	66,842
Shreveport, LA	Truck	54,220
Orion, MI	Car	40,998
Hamtramck, MI	Car	36,907
Bowling Green, KY	Car	13,222

FIGURE 26. General Motors Company Profile

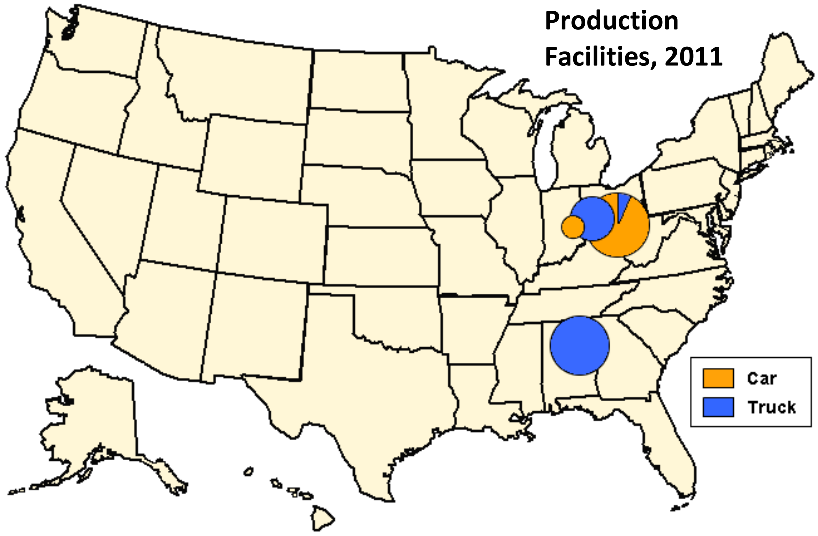
Fuel Saving Technologies

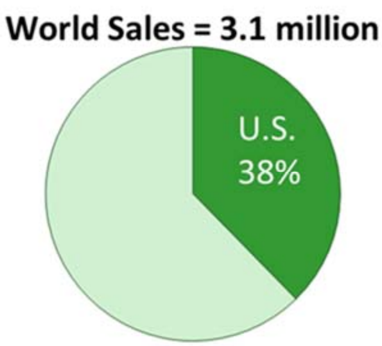
General Motors (GM) has implemented a wide range of technologies to achieve greater fuel efficiency. On full-sized trucks and SUVs where towing is important, GM is using cylinder deactivation to increase fuel economy while retaining V8 power when needed. GM also offers a Two-Mode hybrid system for large trucks and SUVs that provide the fuel economy benefits of hybrid technology while still providing towing capability. In addition to this robust and costly hybrid drivetrain technology, GM is also implementing lower cost "mild hybrid" technology that it has termed eAssist. The eAssist technology is currently offered on the Buick LaCrosse and 2013 Chevrolet Malibu Eco and is now standard on the 2013 Buick Regal.

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. GM will be expanding the use of the Voltec plug-in hybrid technology when they launch the 2014 Cadillac ELR. In 2013 the all-electric Chevrolet Spark EV and a diesel version of the Chevrolet Cruze will be available as 2014 models. GM is also planning to have a fuel cell vehicle ready for the commercial market by about 2015. However, the introduction of a fuel cell vehicle will depend on the refueling infrastructure in place in California where fuel cell vehicles will be launched initially.

Honda Company Profile

Number of U.S. Employees	
26,000	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	37.6 mpg
Import Cars	40.6 mpg
Light Trucks	27.9 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	0
Natural Gas	1
Propane	0
Hybrid Electric	3
Plug-In Hybrid Electric	0
Electric	1





Honda Plants	Type	2011 Production
Marysville, OH	Car	265,202
Lincoln, AL	Truck	262,125
East Liberty, OH	Truck	192,179
Greensburg, IN	Car	84,767
Marysville, OH	Truck	19,377

FIGURE 27. Honda Company Profile

Fuel Saving Technologies

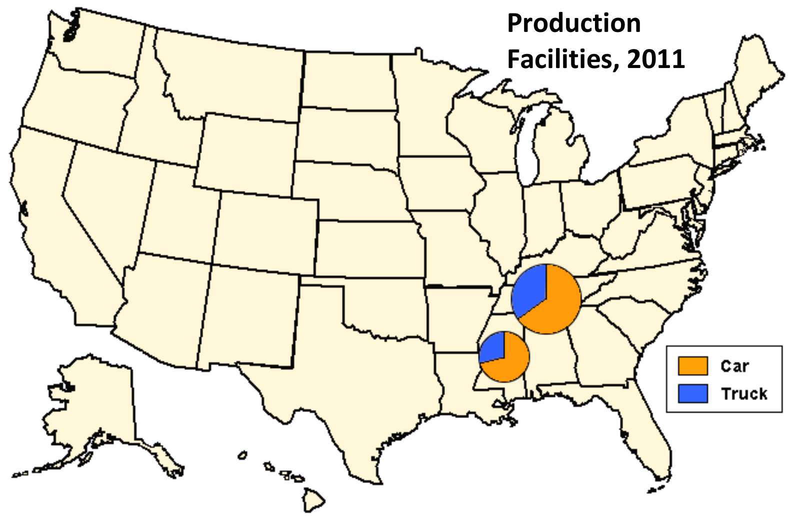
Beginning with the 2012 model year Honda introduced new fuel efficient technologies to its lineup under the marketing name “Earth Dreams” which is an umbrella term for their new fuel efficient technologies. These technologies will include a new generation of direct injection engines, turbocharging, and greater use of continuously variable transmissions (CVTs). Improvements to previously used technologies like cylinder deactivation are also expected. 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.

Honda is moving beyond their Integrated Motor Assist (IMA) hybrid technology that they have relied on in the past in favor of a more diversified hybrid strategy. For small hybrids, Honda will be using a one-motor hybrid system paired with a dual clutch for responsive performance. Larger vehicles like the Accord will get the two-motor hybrid system while sport models offering greater handling and all-wheel-drive will be fitted with a three-motor hybrid system. In addition, a plug-in hybrid electric Accord is expected to go on sale in early 2013.

The 2013 Honda Fit EV was launched 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 vehicle 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 was the first commercial fuel cell vehicle and has been available to consumers as a lease vehicle since 2008 for those living in Southern California.

Nissan Company Profile

Number of U.S. Employees	
11,200	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	35.1 mpg
Import Cars	35.2 mpg
Light Trucks	24.7 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	2
Natural Gas	0
Propane	0
Hybrid Electric	2
Plug-In Hybrid Electric	0
Electric	1



World Sales = 3.9 million

Nissan Plants	Type	2011 Production
Smyrna, TN	Car	216,656
Canton, MS	Car	168,453
Smyrna, TN	Truck	115,038
Canton, MS	Truck	60,878

FIGURE 28. Nissan Company Profile

Fuel Saving Technologies

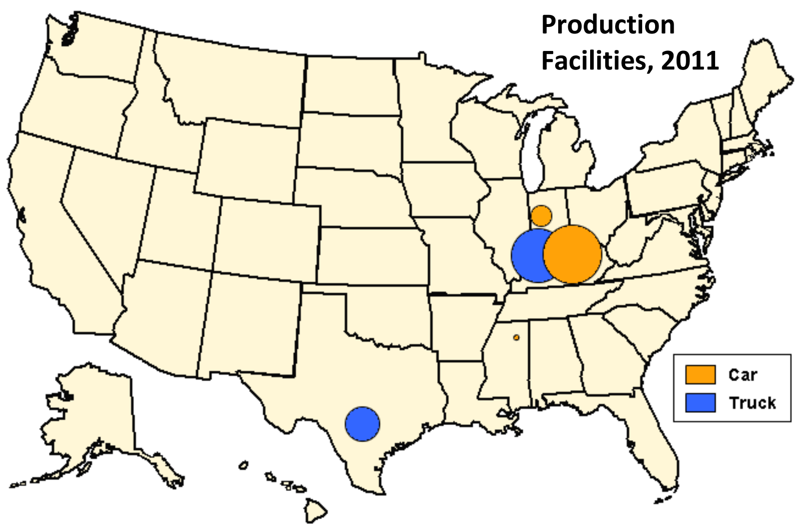
Of the major manufacturers, Nissan has been the most aggressive in promoting electric vehicles (EVs) not only in the U.S. but also around the world. Though sales of the all-electric Leaf have been fairly slow in the United States following its launch two years ago, Nissan expects sales to increase as it brings down costs and improves on the technology. By the end of 2012, Nissan will begin producing the Nissan Leaf and its battery pack in Tennessee which is expected to lower production costs. Nissan will also bring a luxury EV to the U.S. market in 2014 when it introduces the Infiniti LE which will use wireless charging. Although Nissan's emphasis has been on pure EVs, a new hybrid system is being developed that may be introduced with an Infiniti model.

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.

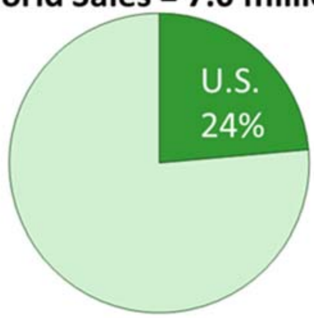
Nissan has also been a leader in the development and implementation of Continuously Variable Transmissions or CVTs. Nissan's CVT allows engines to operate at an optimum speed throughout the entire range of gear ratios which helps to improve efficiency. Without fixed gear ratios, the CVT provides smooth "stepless" acceleration and Nissan's XTRONIC CVT offers one of the widest gear ratio ranges in the industry.

Toyota Company Profile

Number of U.S. Employees	
30,160	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	36.4 mpg
Import Cars	46.9 mpg
Light Trucks	25.6 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	2
Natural Gas	0
Propane	0
Hybrid Electric	9
Plug-In Hybrid Electric	1
Electric	1



World Sales = 7.0 million



Toyota Plants	Type	2011 Production
Georgetown, KY	Car	266,347
Princeton, IN	Truck	247,818
San Antonio, TX	Truck	149,017
Lafayette, IN	Car	79,170
Blue Springs, MS	Truck	1,967

FIGURE 29. Toyota Company Profile

Fuel Saving Technologies

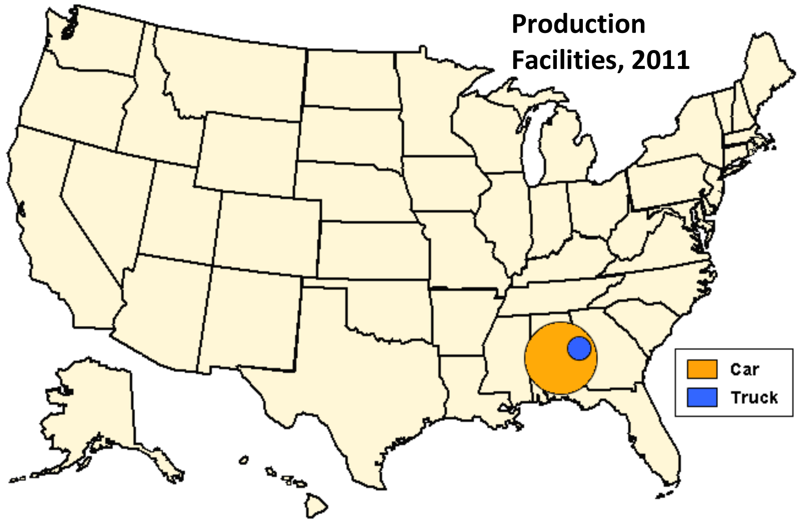
For the 2012 model year, Toyota expanded the Prius into a family of dedicated hybrid models. The new Prius models introduced in 2012 include a larger Prius that offers more cargo space called the Prius V as well as the smaller Prius c that achieves similar fuel economy to the standard Prius but at a base price of less than $20,000. A plug-in version of the standard Prius also arrived in 2012 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.

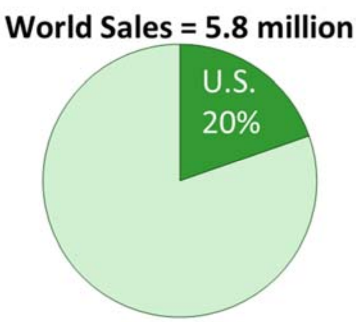
Beyond the dedicated Prius hybrid family, Toyota has expanded their hybrid Synergy Drive throughout their lineup in models like the Camry, Highlander, and various Lexus models. In late 2012, Toyota introduced the redesigned 2013 Avalon which will be available as a hybrid. For full electric vehicles (EVs), Toyota has been working with Tesla to develop a new version of the RAV4 EV and they have also produced the Scion iQ EV, both of which will have limited availability beginning with California in late 2012 as 2013 models.

For conventional gasoline engine powered passenger vehicles, Toyota is employing direct injection and turbo-charging on some models to increase engine output and efficiency. Toyota is also increasing their use of 6- and 8-speed automatic transmissions and CVT transmissions in the small and midsize cars.

Hyundai Company Profile

Number of U.S. Employees	
5,000	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	None
Import Cars	38.7 mpg
Light Trucks	29.0 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	0
Natural Gas	0
Propane	0
Hybrid Electric	1
Plug-In Hybrid Electric	0
Electric	0





Hyundai Plants	Type	2011 Production
Montgomery, AL	Car	338,127
West Point, GA	Truck	91,155

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.

FIGURE 30. Hyundai Company Profile

Fuel Saving Technologies

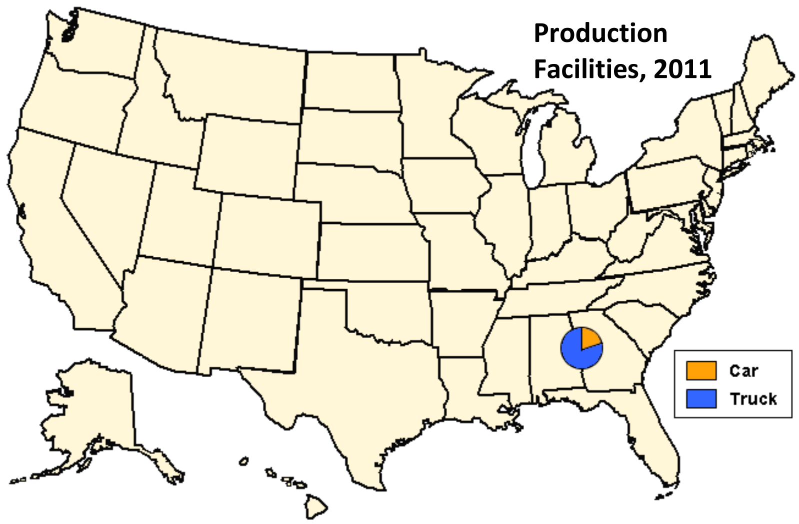
In 2012, it was announced by the Environmental Protection Agency that procedural errors were made by Hyundai that overstated the official fuel economy in a number of vehicles spanning the 2011-2013 model years. As a result, the official fuel economy numbers were lowered by one to two miles per gallon on most of the affected vehicles.

Despite this announcement, Hyundai has been very aggressive in their pursuit of fleet-wide improvement of fuel economy. Hyundai is employing a wide array of technologies to achieve their goals for higher fuel economy. A key component for achieving greater fuel economy is downsizing the 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.

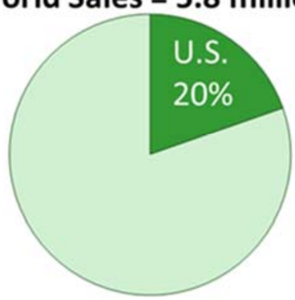
Additionally, Hyundai is deploying full hybrid drive trains like that found on the Sonata hybrid as well as continual improvements to aerodynamics. Other technologies that Hyundai is developing include diesel and fuel cells. However, one technology that Hyundai is not embracing is continuously variable transmission (CVT). Though dual clutch transmissions do not offer the same smooth transition as a CVT, the distinct shift points offered by a dual clutch transmission may be well suited to performance-oriented vehicles. The dual clutch automatic transmission will be offered as an option on the 2013 Veloster.

Kia Company Profile

Number of U.S. Employees	
3,450	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	None
Import Cars	36.2 mpg
Light Trucks	28.0 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	0
Natural Gas	0
Propane	0
Hybrid Electric	1
Plug-In Hybrid Electric	0
Electric	0



World Sales = 5.8 million



Kia Plants	Type	2011 Production
West Point, GA	Truck	146,017
West Point, GA	Car	35,132

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.

FIGURE 31. Kia Company Profile

Fuel Saving Technologies

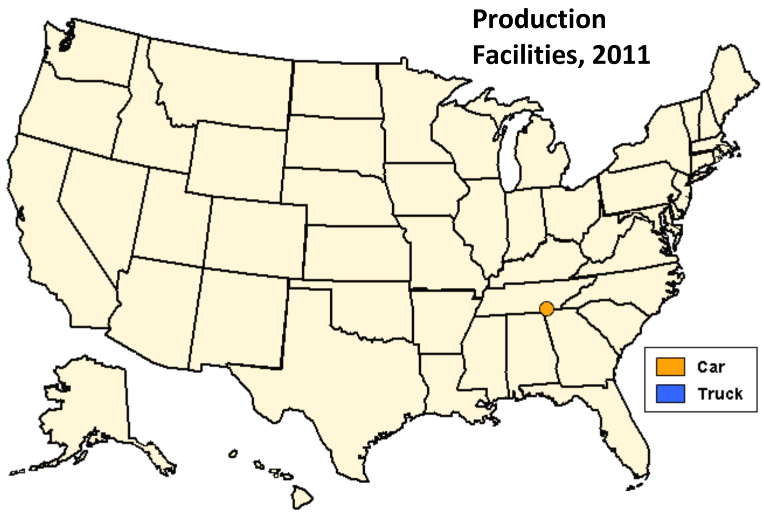
In 2012 it was announced by the Environmental Protection Agency that procedural errors were made by Kia that overstated the official fuel economy in a number of vehicles spanning the 2011-2013 model years. As a result, the official fuel economy numbers were lowered on the affected vehicles from one mile per gallon on some models to six miles per gallon on the highway rating for the 2.0L Kia Soul.

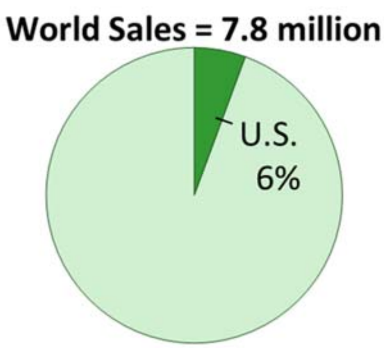
As for the technologies that Kia is using to boost fuel economy, there are a number of different approaches that Kia is taking including weight reduction and “Idle Stop & Go” or ISG. This is a simple system that reduces unnecessary idle time by shutting down the engine when a vehicle comes to a stop and then automatically restarting it which Kia estimates reduces consumption by 10% to 15% in city driving. Kia is offering ISG on several models including the 2012 Rio 5 and Soul.

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.

Volkswagen Company Profile

Number of U.S. Employees	
5,900	
Corporate Average Fuel Economy, MY 2012	
Domestic Cars	33.6 mpg
Import Cars	32.9 mpg
Light Trucks	27.4 mpg
Number of Alternative Fuel Models, MY 2012	
Flex Fuel	1
Natural Gas	0
Propane	0
Hybrid Electric	1
Plug-In Hybrid Electric	0
Electric	0





Volkswagen Plants	Type	2011 Production
Chattanooga, TN	Car	45,857

FIGURE 32. Volkswagen Company Profile

Fuel Saving Technologies

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

The TSI (turbo stratified injection) 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 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 the wheels.

Volkswagen has 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. Although there are no definitive plans for the U.S. market, Volkswagen is developing diesel hybrid vehicles to combine the benefits of both diesel and hybrid technologies. Also under development are pure electric models like the Volkswagen E-Up! and the Audi e-Tron.

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

The companies that made 91% of all vehicles produced in the United States in 2011 are together responsible for only about half of the vehicles produced worldwide. Volkswagen, which did not produce vehicles in the United States until 2011, held 8% of World production in 2011. Hyundai produced 7% of the World's vehicles and only 5% of U.S. vehicles. Toyota had produced 9% in the World but only 8% in the United States. Many companies, like recent upstarts in China and India, comprise the other 51% of world production. The U.S. produces about 11% of the world's vehicles.

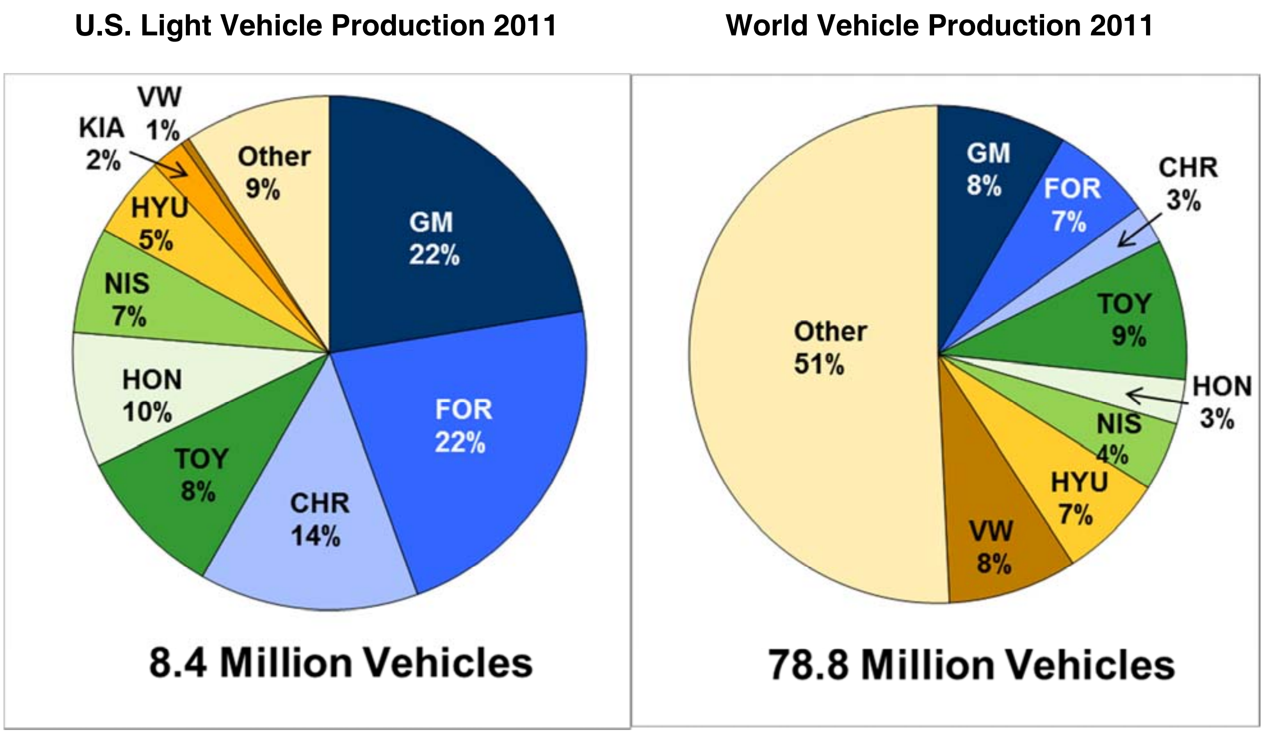


FIGURE 33. Production of U.S. and World Vehicles in 2011 by Manufacturer

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 5.3% share in 2011.

Source:
Wards AutoInfoBank.

U.S. Sales Volumes Continued to Rise in 2011, Reversing Downward Trend

From 2007 to 2009, car and light truck sales declined each year. The trend reversed in 2010 and 2011. Even with the increase, about 20% fewer cars and light trucks were sold in 2011 than in 2007. Most of the major manufacturers experienced sales declines over this period. The exceptions are Hyundai and Kia. Hyundai sold 70% more cars in 2011 than in 2007. Kia sold 85% more cars and 33% more light trucks.

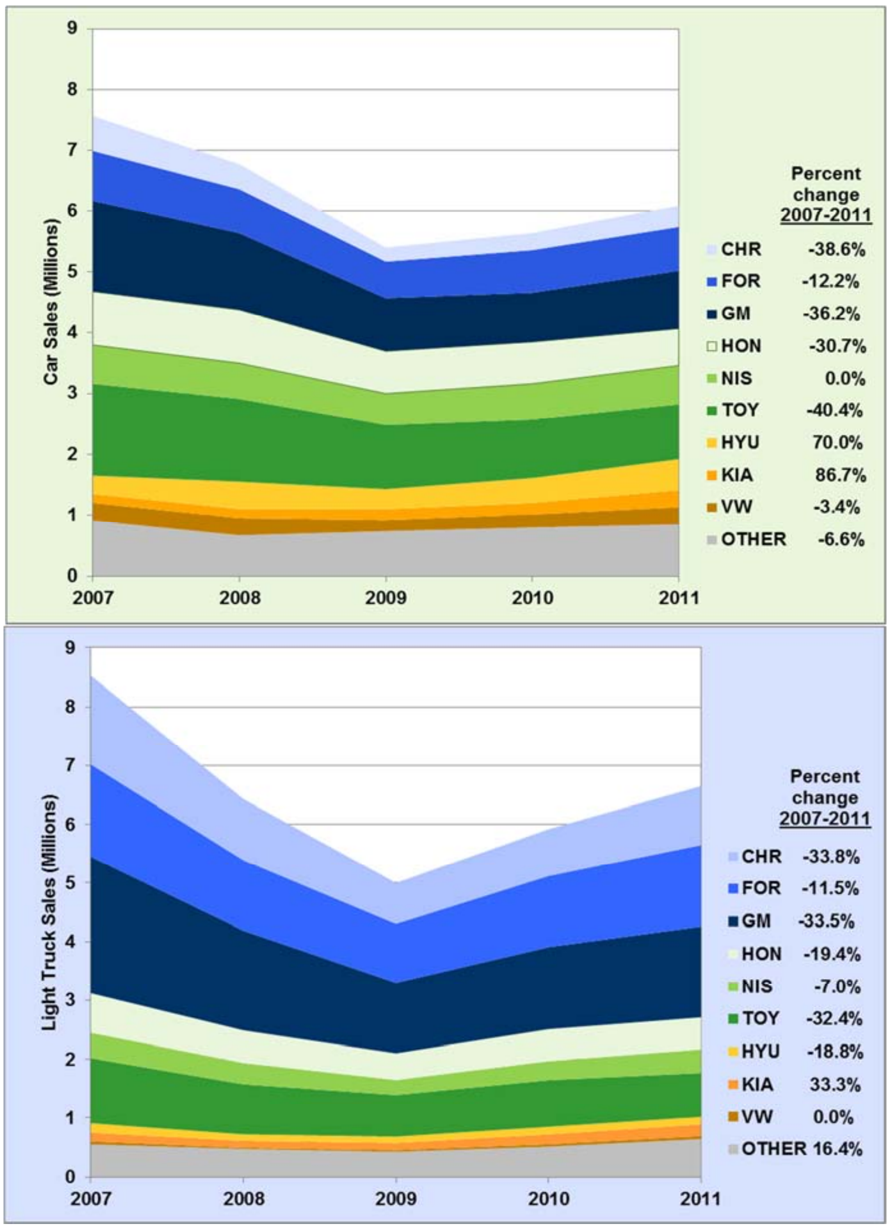


FIGURE 34. New Light Vehicle Sales by Manufacturer, 2007-2011

Source:
Wards AutoInfoBank.

Market Share Shifted Among Manufacturers

Smaller manufacturers are gaining market share. In the car market, General Motors, Chrysler, Honda and Toyota all lost market share from 2007 to 2011, while Ford, Hyundai, Nissan, Volkswagen and Kia gained. The three domestic manufacturers accounted for over 63% of the light truck market share in 2007, but declined to 59% in 2011.

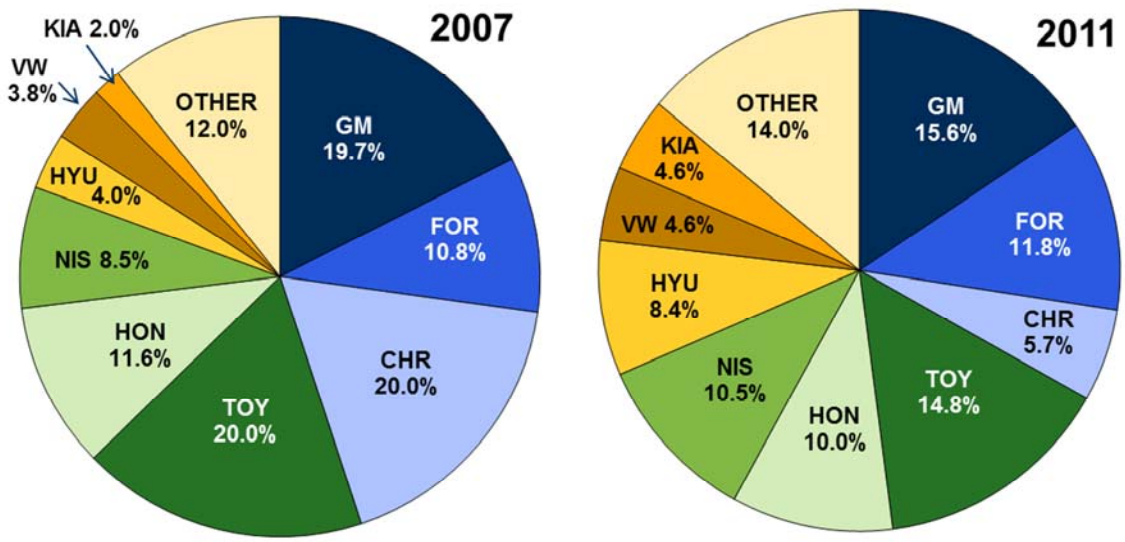


FIGURE 35. New Car Market Share by Manufacturer, 2007 and 2011

Source:
Ward's AutoInfoBank

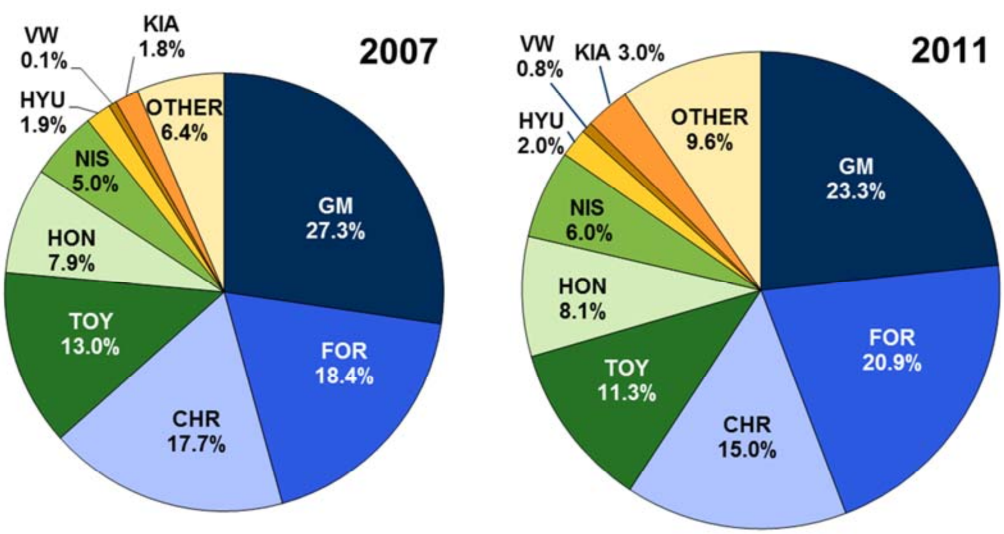


FIGURE 36. New Light Truck Market Share by Manufacturer, 2007 and 2011

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. Volkswagen's dramatic decrease in truck engine size is a reflection of their limited truck offerings in 2008 followed by the introduction of the small 2.0 liter, 4-cylinder Tiguan in the 2009 model year.

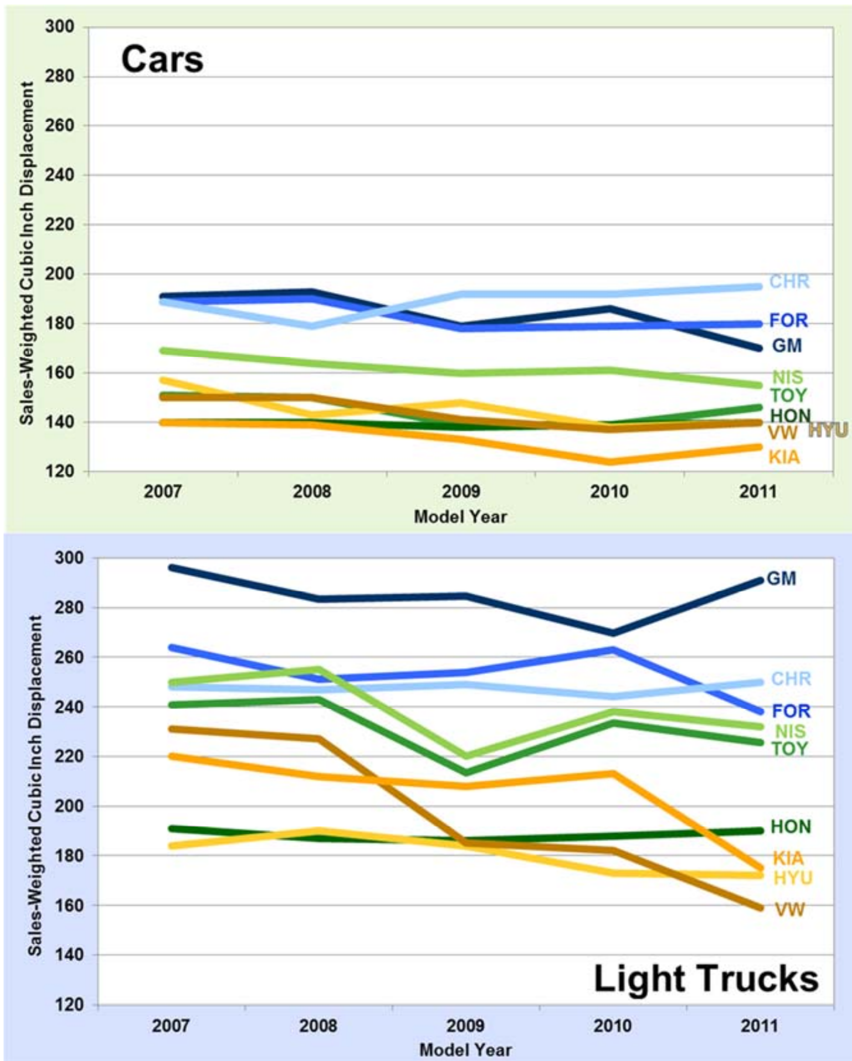


FIGURE 37. Car and Light Truck Engine Size by Manufacturer, 2007-2011

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Light Truck Horsepower Is Up in 2011

Engine displacement and horsepower are often closely related. However, 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 2011 model year light trucks. Nissan and Volkswagen had a large decline in light truck horsepower between 2008 and 2009. Average horsepower for cars has not significantly changed over the five-year time period.

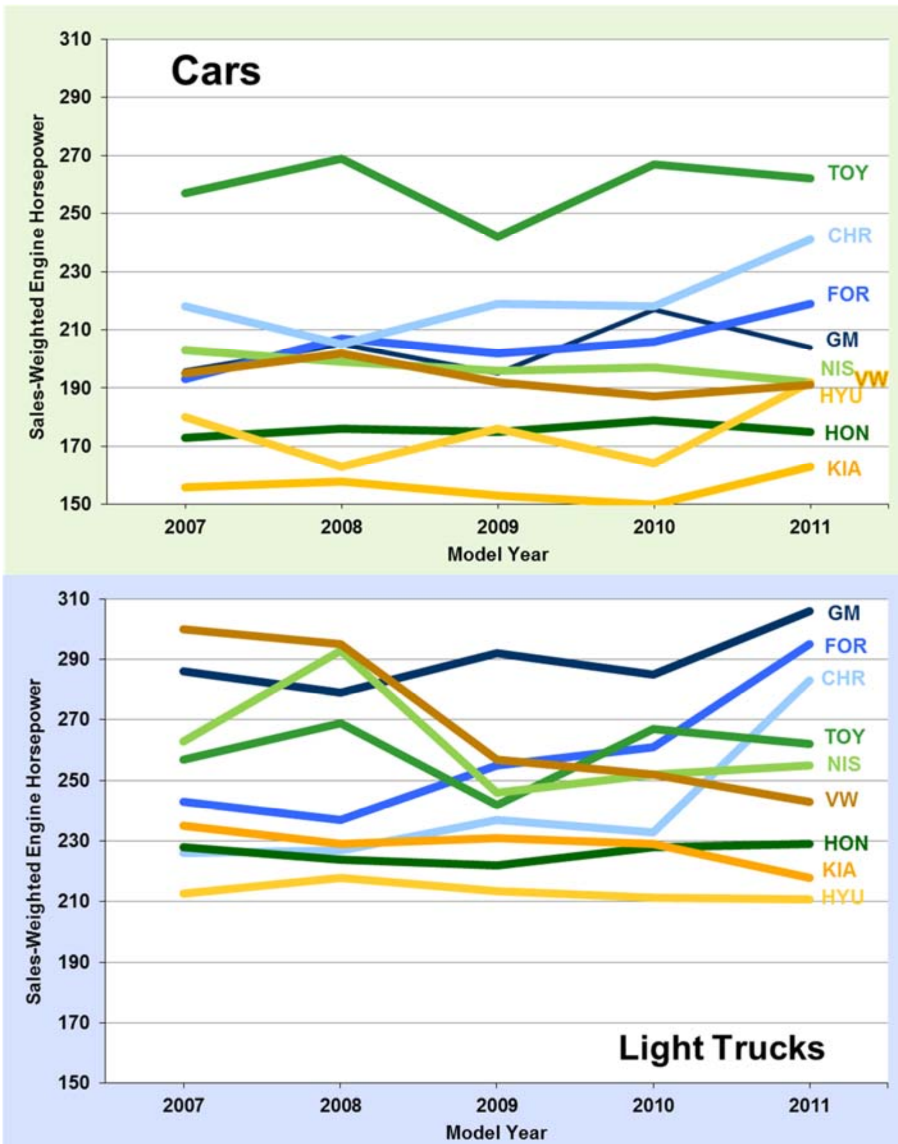


FIGURE 38. Car and Light Truck Horsepower by Manufacturer, 2007-2011

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Technology Has Improved Performance More Than Fuel Economy

Despite a 119% increase in horsepower and 35% decrease in 0-60 time from 1980 to 2011, the fuel economy of vehicles improved almost 19%. All of these data series are sales-weighted averages. The weight of the vehicle appears to have an inverse relationship with fuel economy.

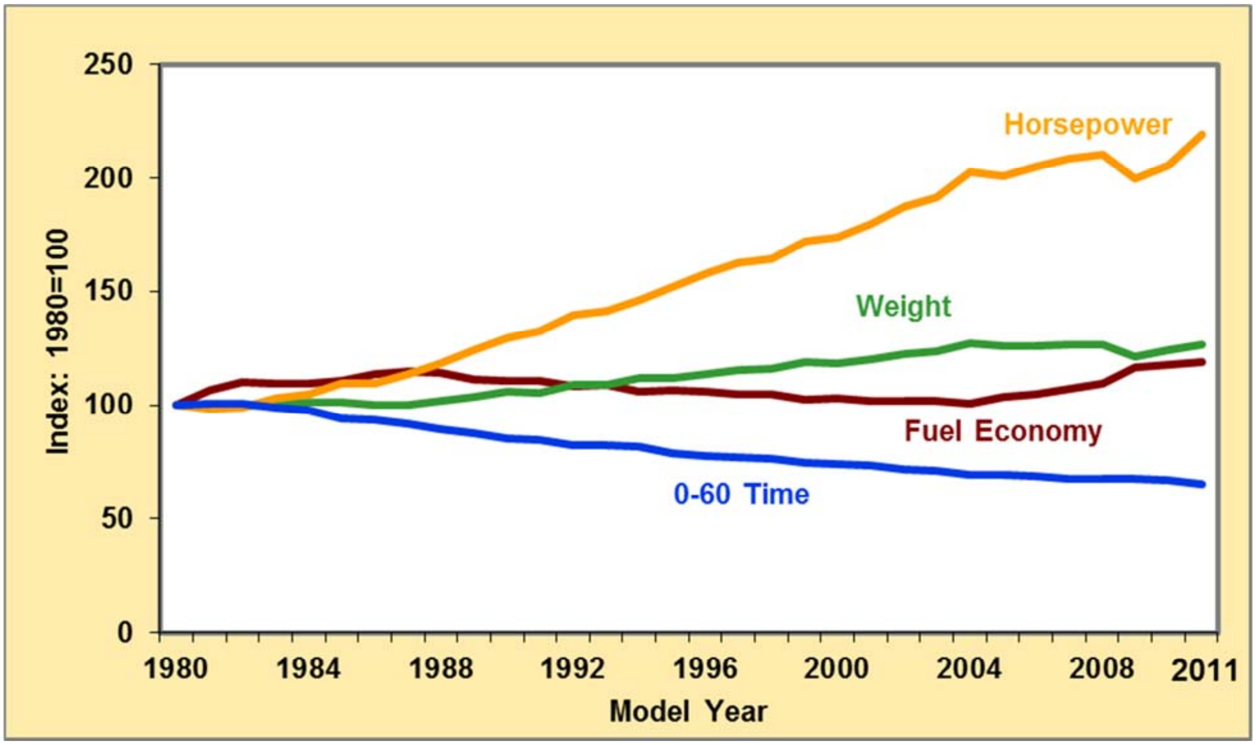


FIGURE 39. Characteristics of Light Vehicles Sold, 1980-2011

Note: Data are sales-weighted.

Source:
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

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

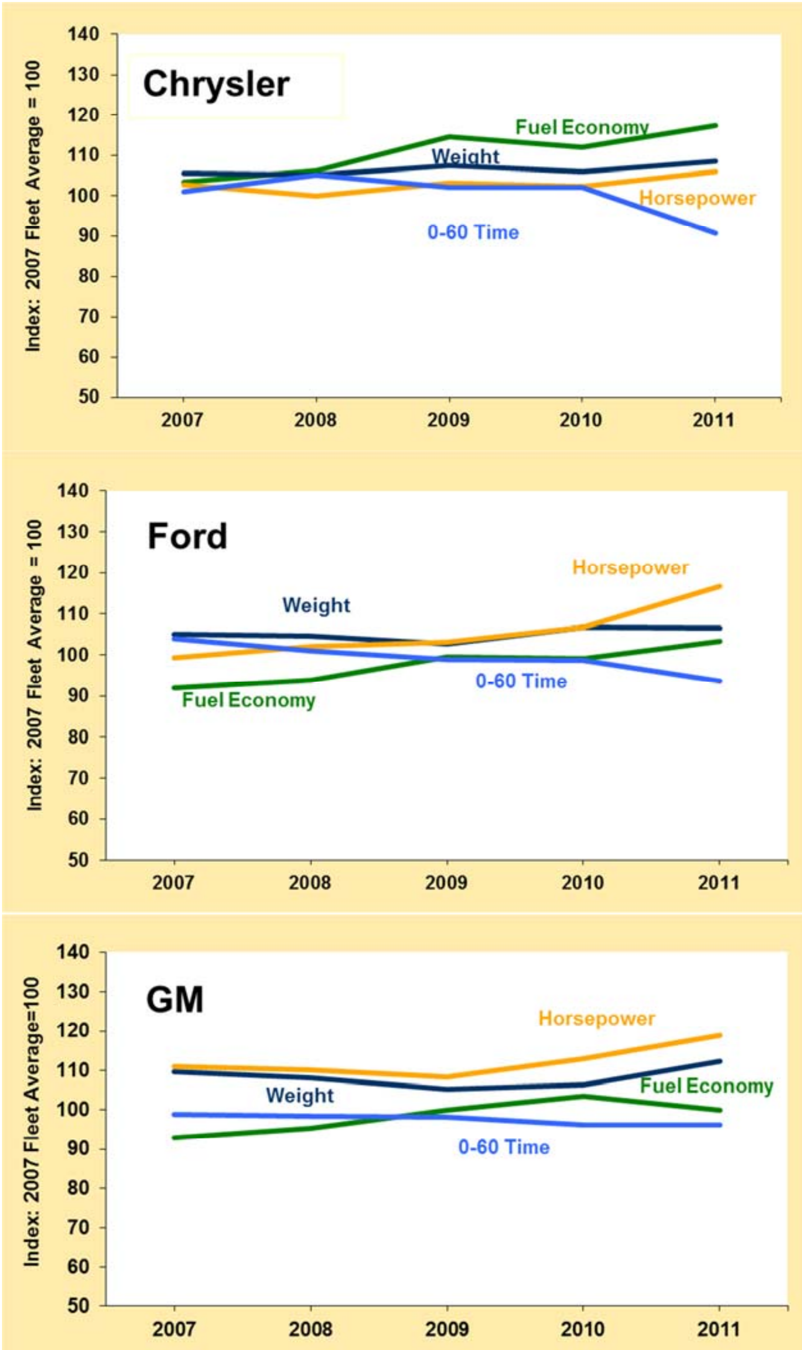


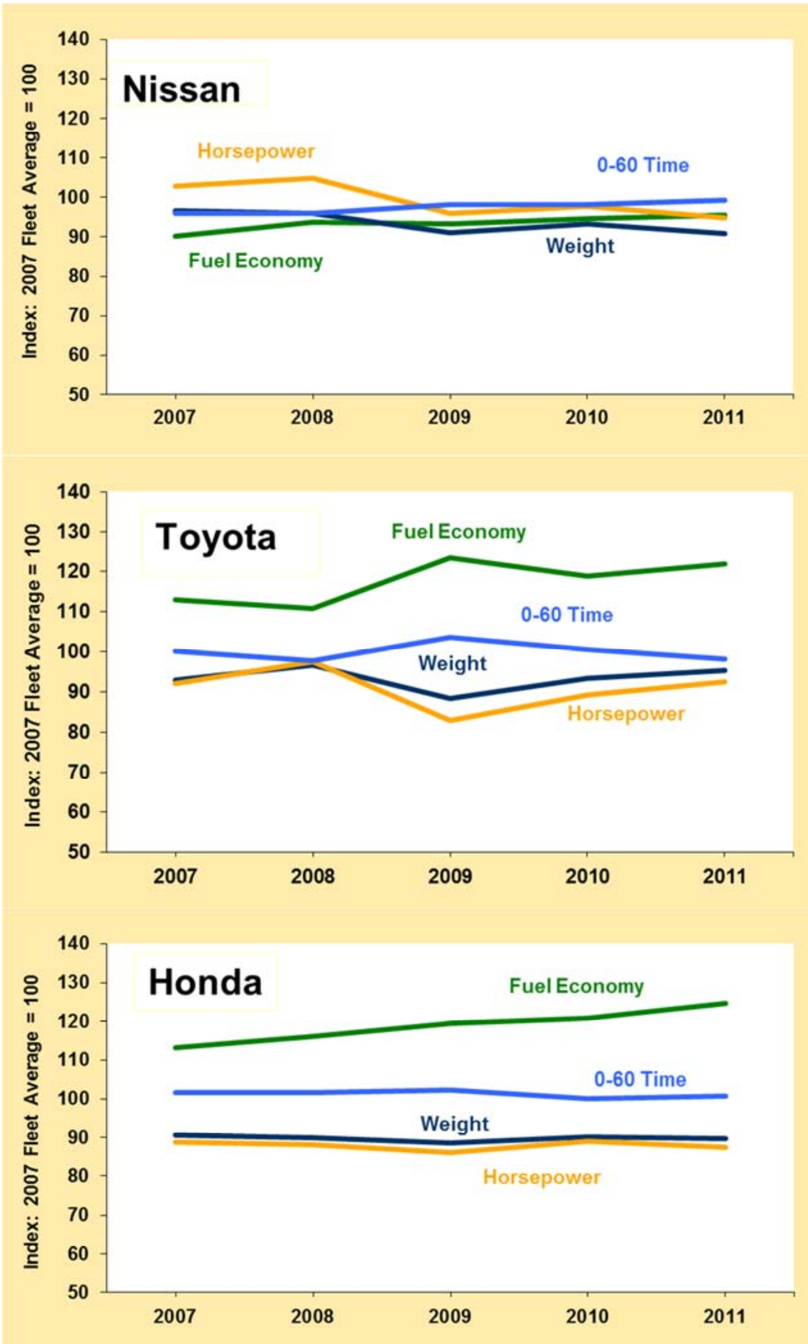
FIGURE 40. Characteristics of Detroit 3 Light Vehicles Sold, 2007-2011

These sales-weighted averages show that all of the Detroit 3 manufacturers are increasing the horsepower and decreasing 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 14% improvement from 2007 to 2011. In the same time frame, Ford had a 12% and General Motors (GM) an 8% improvement. Fuel economy in 2007 was below the fleet average (below 100 on the graph) for both Ford and GM manufacturers.

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Fuel Economy Above Fleet Average and Weight Below Fleet Average for Toyota and Honda



These sales-weighted averages show that the fuel economy of Toyota and Honda has been at or above the fleet average (above 100 on the graph) over the last five years. Honda had the greatest fuel economy improvement of any manufacturer – 10% over the five year period. Unlike the Detroit 3, these Japanese manufacturers have not increased horsepower in the last five years. In fact, horsepower is lower for Nissan and Honda, and stayed the same for Toyota. Weight for all three manufacturers was below fleet average.

FIGURE 41. Characteristics of Japanese Light Vehicles Sold, 2007-2011

Source:
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Fuel Economy Above Fleet Average and Horsepower Below Fleet Average for Other Large Manufacturers

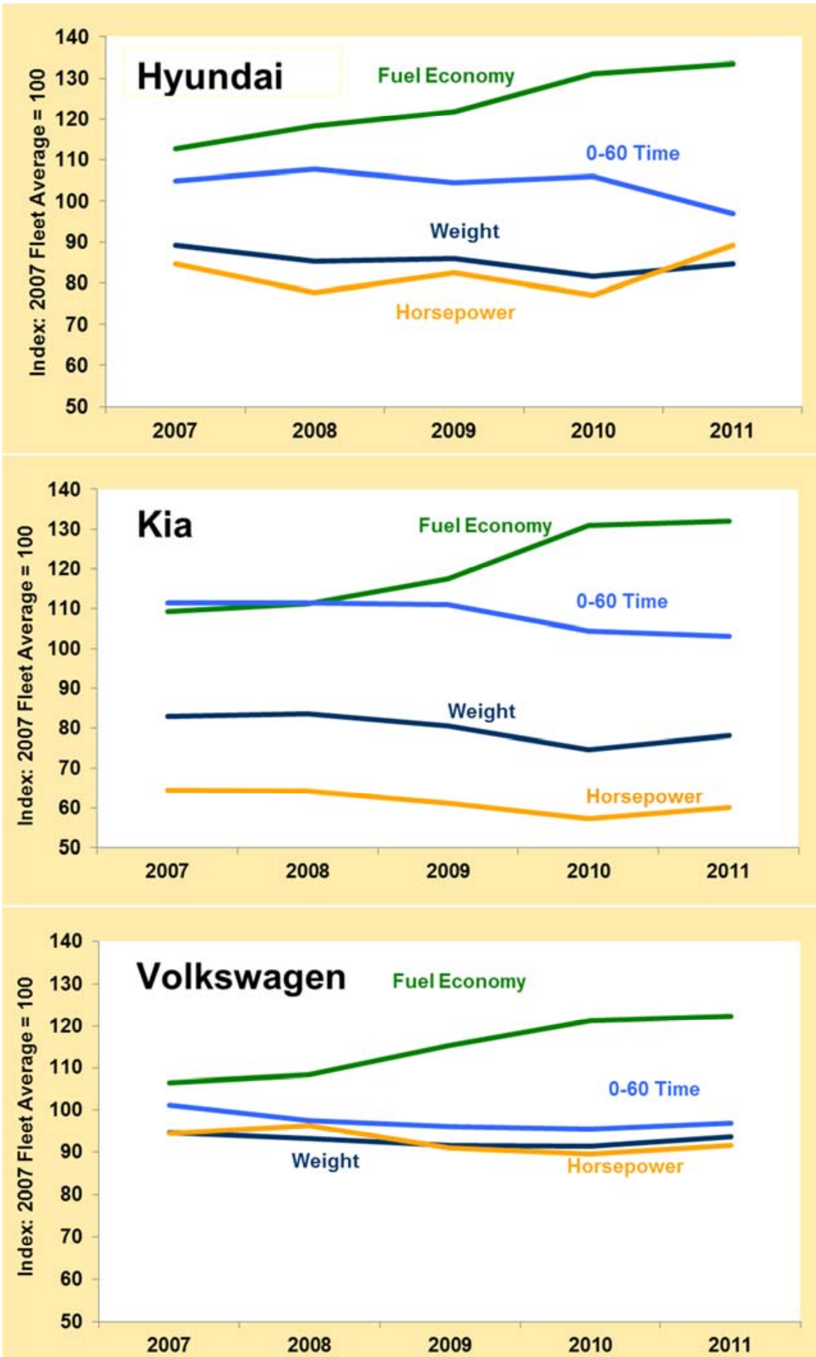


FIGURE 42. Characteristics of Light Vehicles Sold by Other Large Manufacturers, 2007-2011

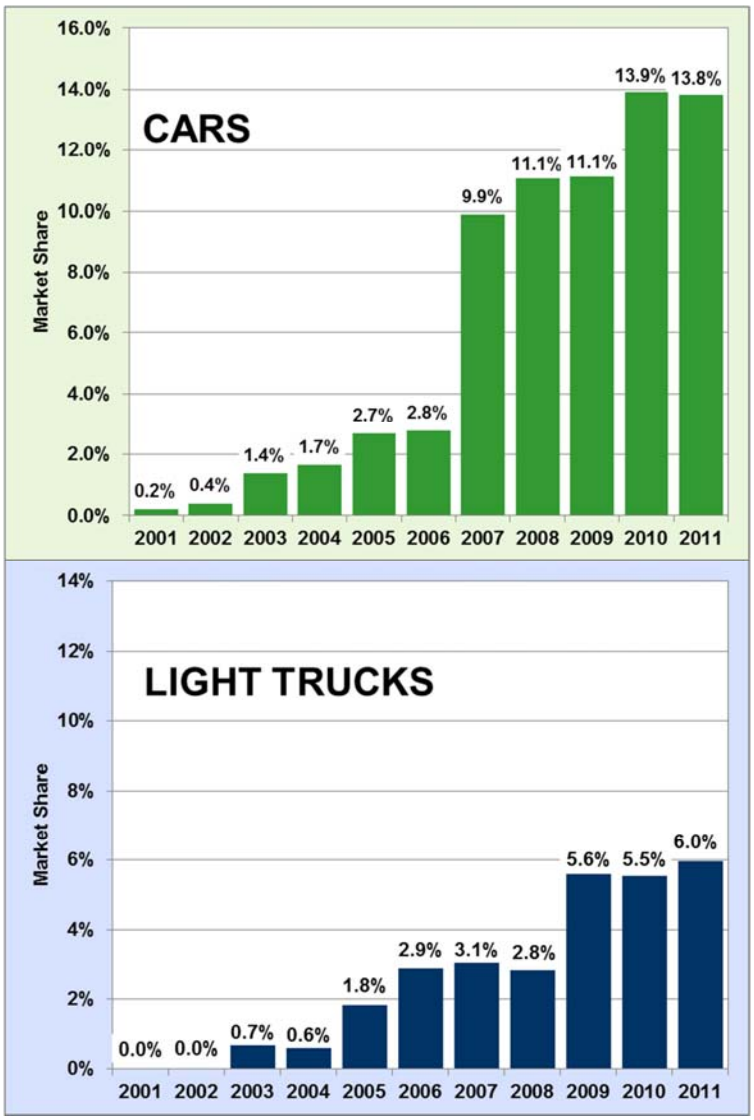
These sales-weighted averages show that Hyundai, Kia and Volkswagen have greatly improved fuel economy since 2007. The fuel economy for all three companies' light vehicles in 2007 was higher than the fleet average (higher than 100 on the graph). Hyundai decreased 0-60 time by 5% from 2007 to 2011, while horsepower increased by 5%. Kia and Volkswagen decreased 0-60 time over the period while also decreasing horsepower. Horsepower and weight were below the fleet averages for all three manufacturers.

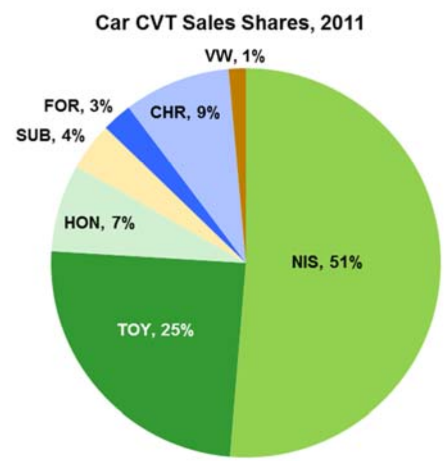
Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Nearly 14% 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 13.8% of car and 6.0% of light truck market share. With CVT making up a relatively small percentage of all transmissions, changes to model offerings with CVTs can have a pronounced effect on the year to year percentages shown in the graphs below. Nissan sold more than half of the cars and the light trucks in 2011 that were equipped with CVT.





Note: SUB = Subaru

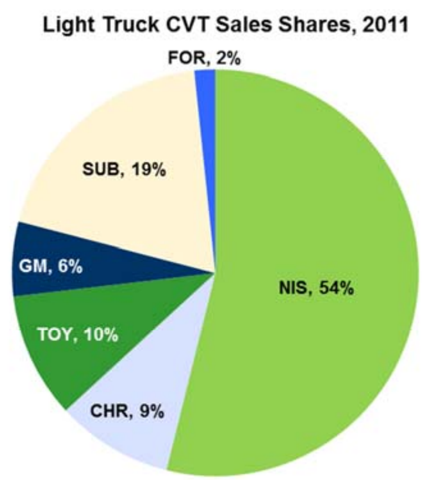


FIGURE 43. CVT Market Share, 2001-2011 and CVT Manufacturer's Share, 2011

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. 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 2011. Continuously variable transmissions (CVT) are also making their way into the market.

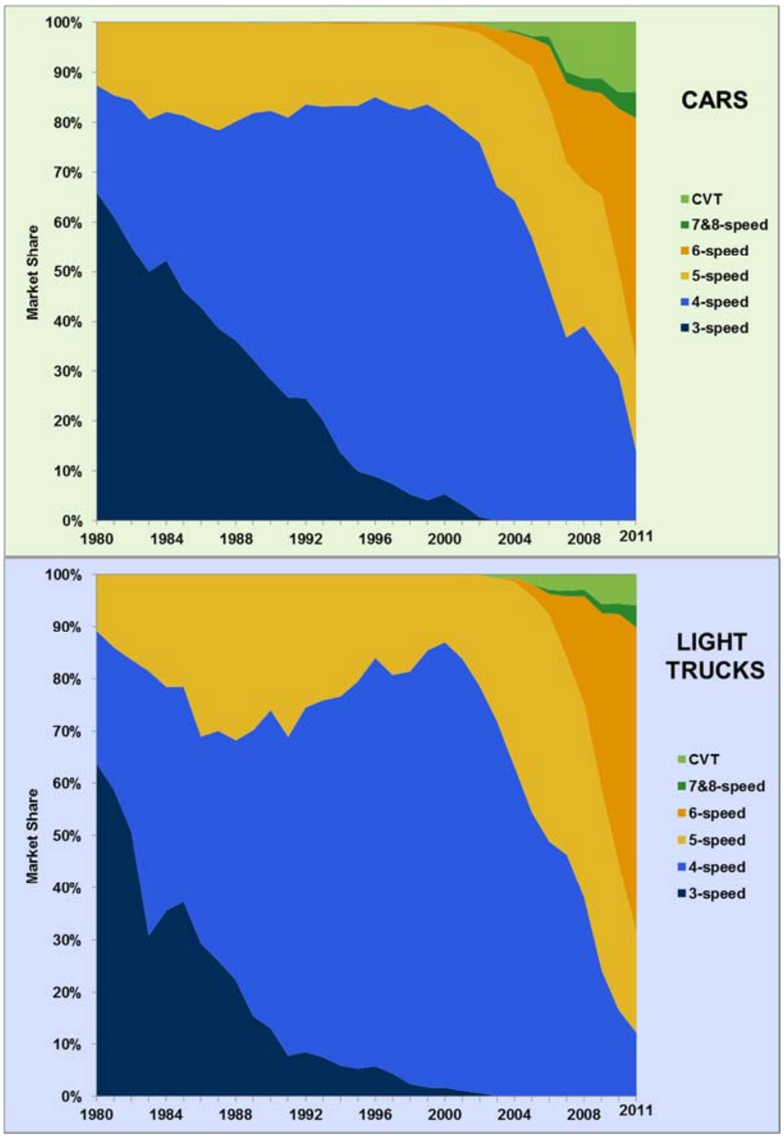


FIGURE 44. Market Share of Transmission Speeds, 1980-2011

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

More Than 13% of Light Vehicles Sold Have Gasoline Direct Injection

Gasoline direct injection (GDI) was first used in cars in 2007 and in light trucks in 2008. By 2011, the market share for GDI is over 13% for cars and light trucks. General Motors has GDI in both cars and light trucks, while Ford uses GDI mainly in light trucks.

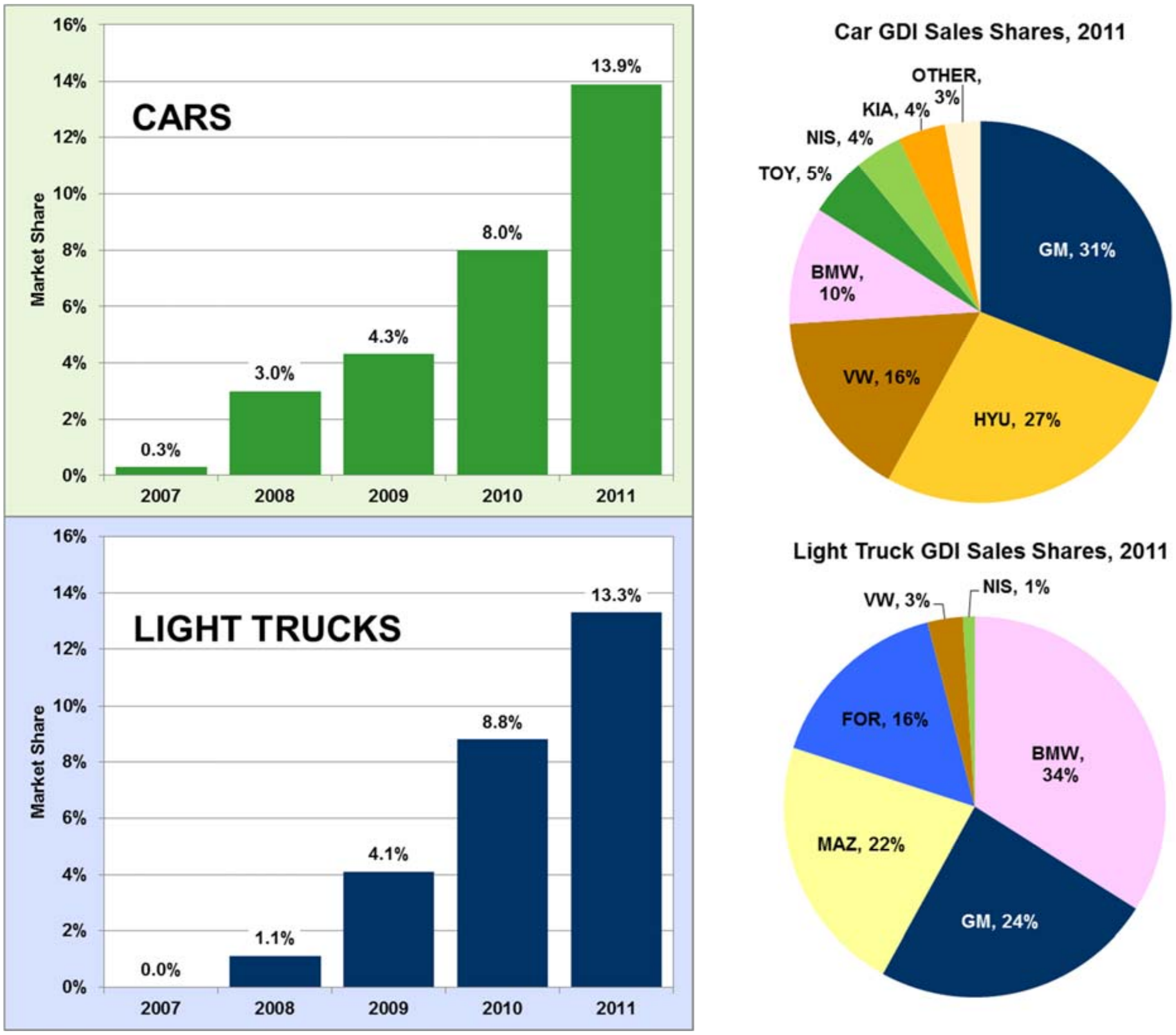


FIGURE 45. GDI Market Share, 2007-2011 and GDI Manufacturer's Share, 2011

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

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Number of Light Vehicle Diesel Models Have 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 2012, four different manufacturers have 12 light vehicle models for sale with clean diesel engines that meet current emission standards.

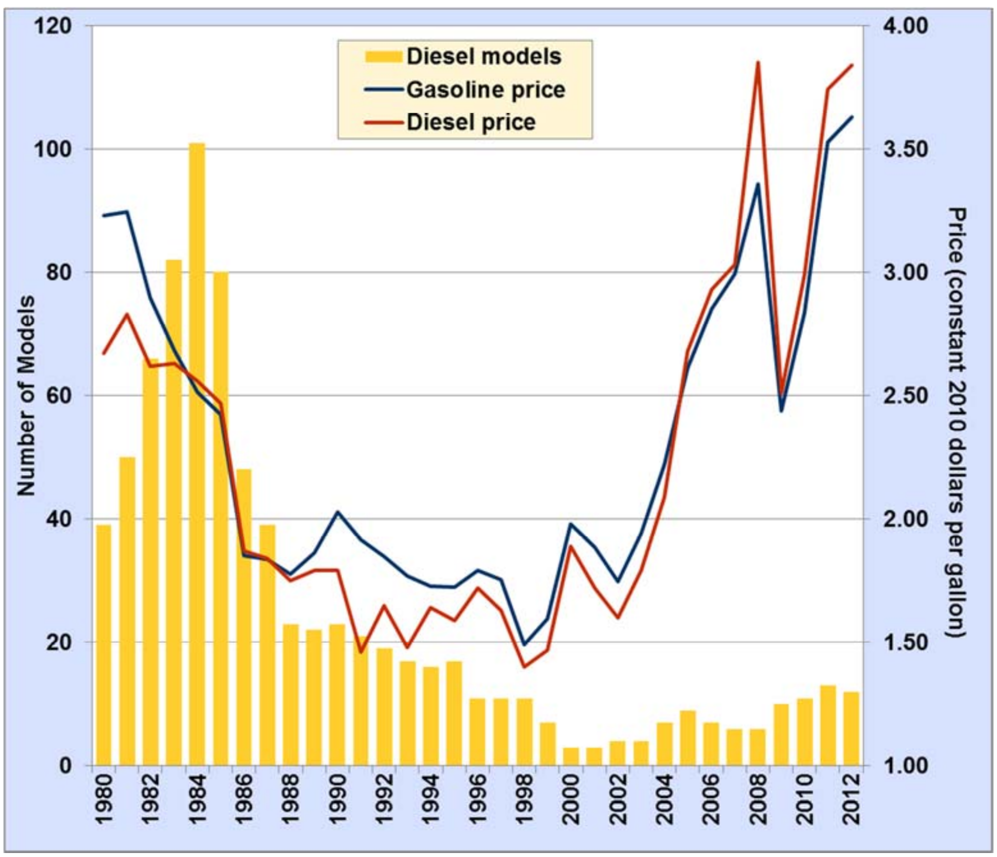


FIGURE 46. Number of Diesel Models and the Price of a Gallon of Gasoline and Diesel, 1980-2012

Sources:

U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy Guide website, November 2012. http://www.fueleconomy.gov

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

General Motors, Ford, and Chrysler Sell a Mix of Small, Medium, and Large Cars

The Detroit 3 have always sold a mix of small, medium, and large cars. In 2011, all three manufacturers expanded sales of mid-size cars.

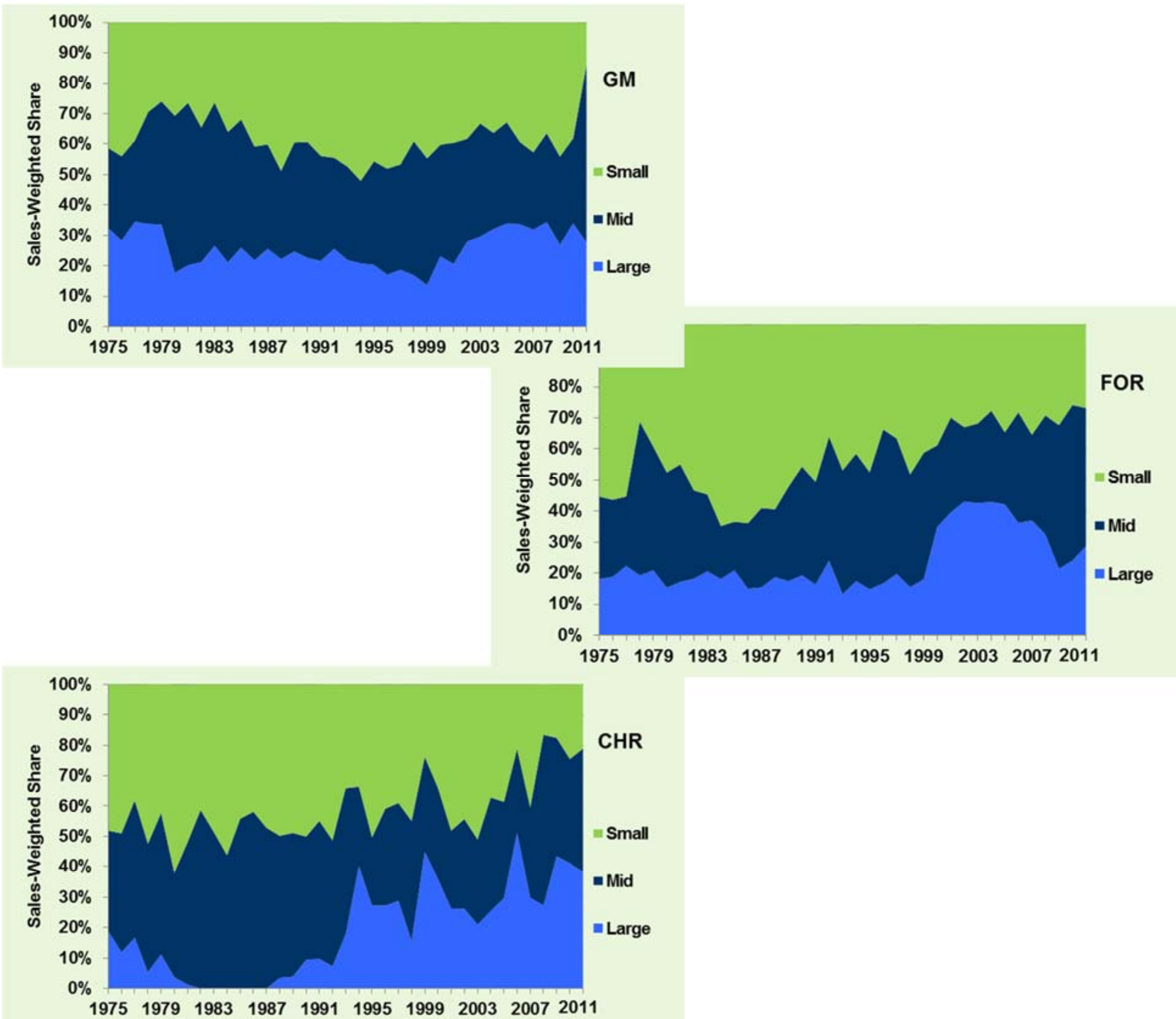


FIGURE 47. Car Market Share for Selected Manufacturers by Size, 1975-2011 (1)

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Toyota, Nissan, Volkswagen, and Kia Sell Mainly Small and Mid-Size Cars

These manufacturers started out selling small cars exclusively. In 2011 Toyota, Nissan, and Kia sell a larger share of mid-size cars than small cars. In model year (MY) 2011 Volkswagen's small cars made up more than 92% of their market.

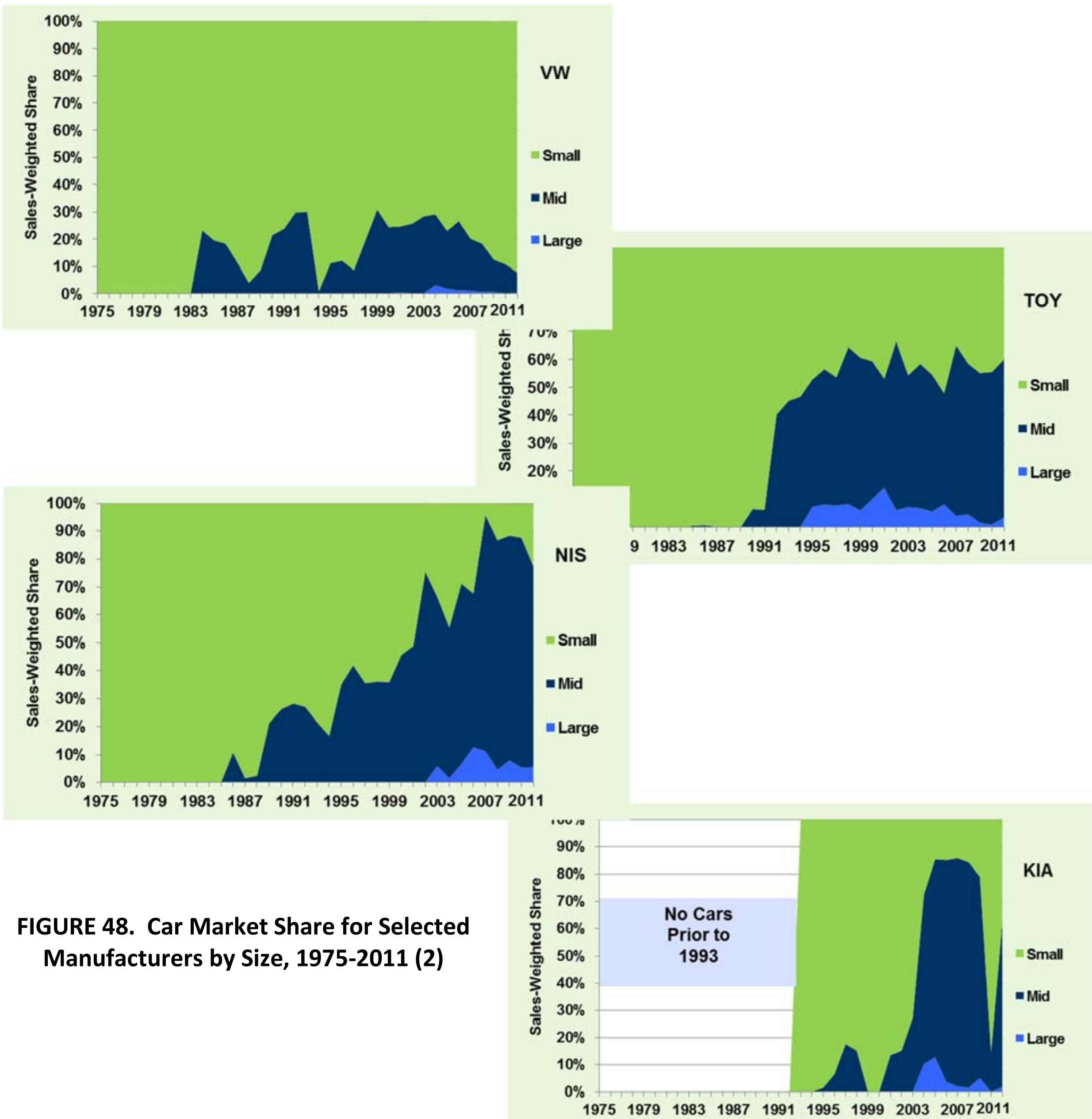


FIGURE 48. Car Market Share for Selected Manufacturers by Size, 1975-2011 (2)

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Honda and Hyundai Have Diversified Their Offerings

Though both manufacturers started out selling small cars exclusively, in 2011 Honda and Hyundai had more than 40% of sales in large cars. Hyundai had nearly 40% in mid-size cars as well.

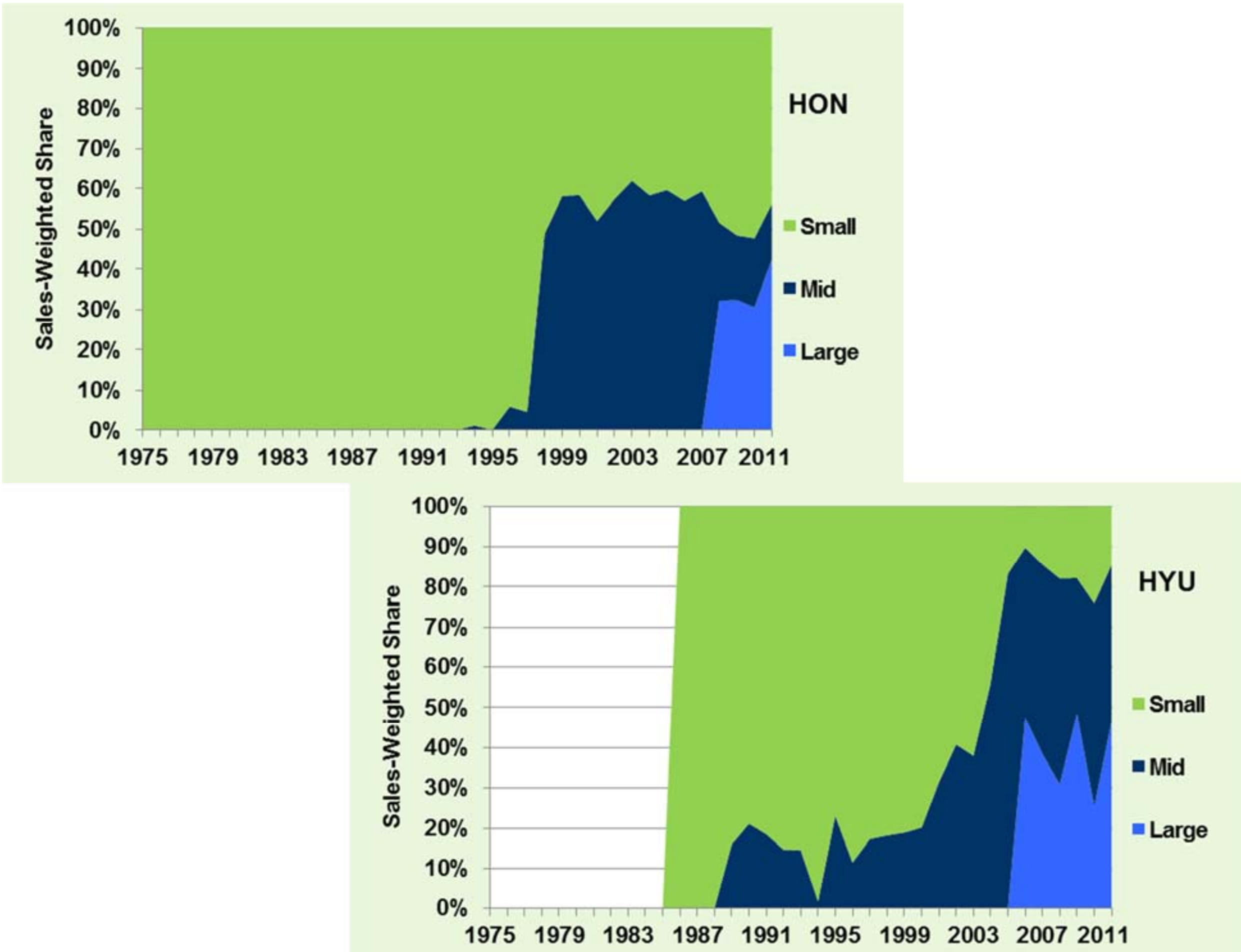


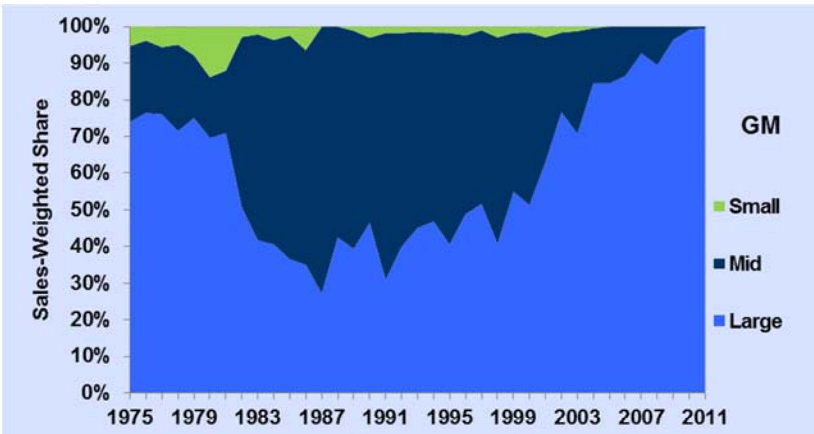
Figure 49. Car Market Share for Selected Manufacturers by Size, 1975-2011 (3)

Source:

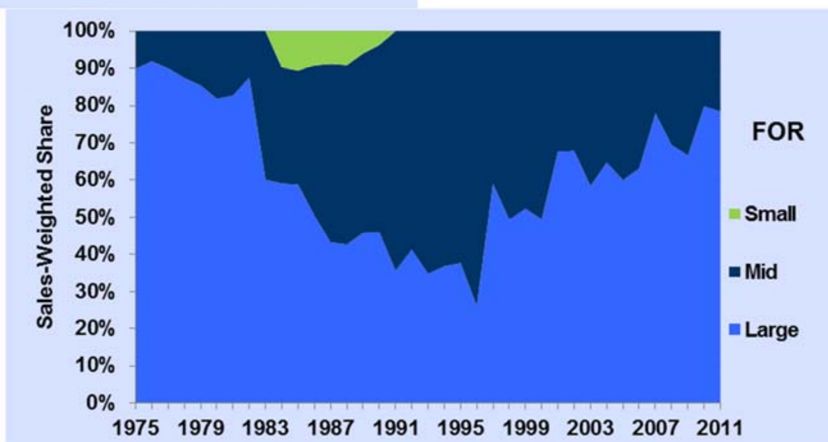
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

General Motors and Ford Have High Market Share for Large Light Trucks

Large trucks were 99% of General Motors' light truck market in model year 2011 and 78% of Ford's market. Chrysler is the only Detroit 3 company still making small trucks.



Note: Light trucks include pickups, sport-utility vehicles, and vans.



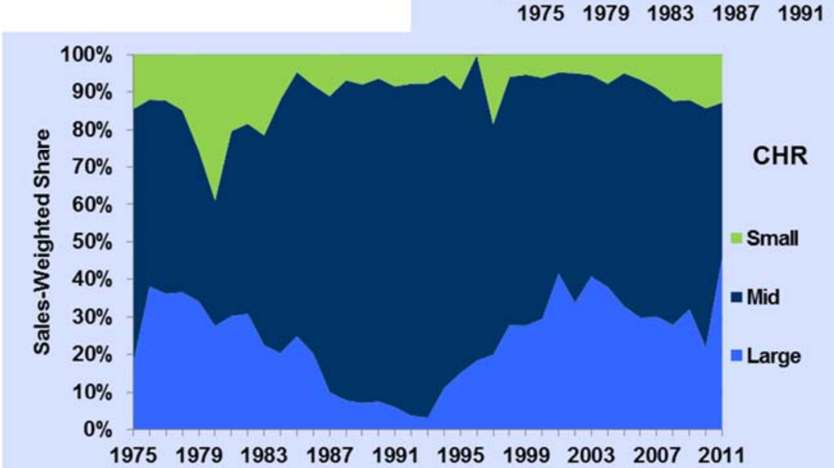


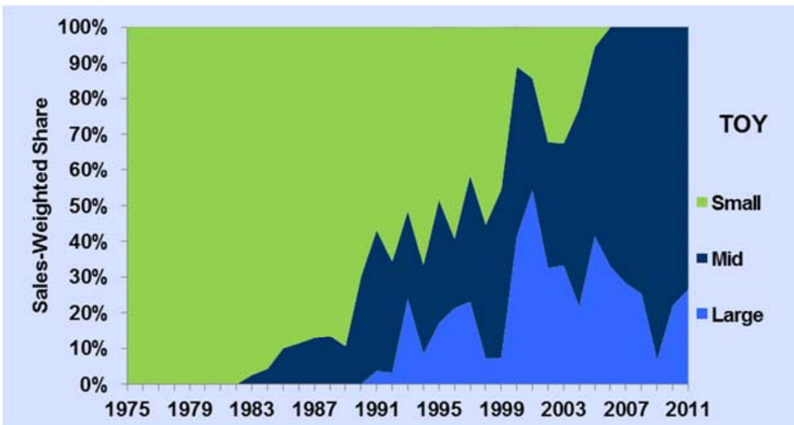
FIGURE 50. Light Truck Market Share for Selected Manufacturers by Size, 1975-2011 (1)

Source:

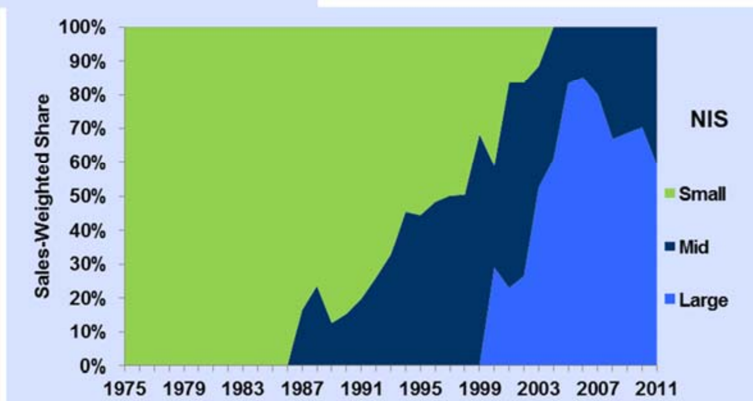
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Toyota, Nissan and Volkswagen Moved to Larger Light Trucks

Toyota, Nissan and Volkswagen predominantly sold small light trucks until the 1990's. Toyota now sells mostly mid-size pickups. More than half of Nissan and Volkswagen light truck sales in model year 2011 are large, with the others being mid-size trucks. Hyundai, Kia, and Honda (not pictured) sold mostly mid-size trucks over the last ten years, with less than 10% large trucks for each.



Note: Light trucks include pickups, sport-utility vehicles, and vans.



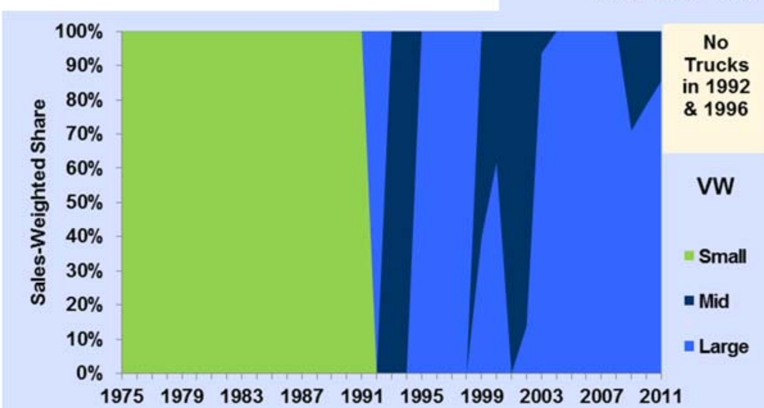
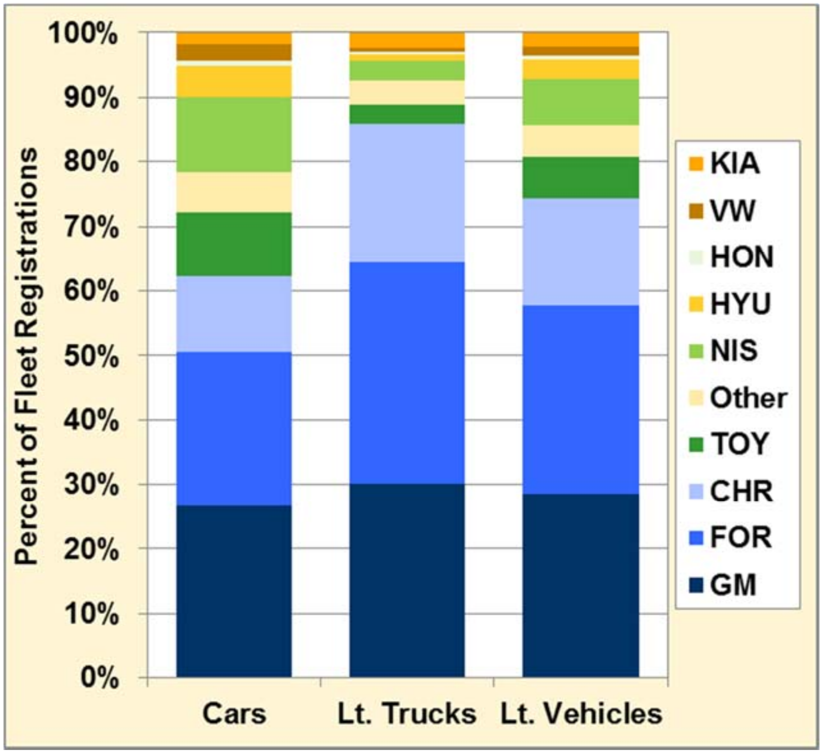


FIGURE 51. Light Truck Market Share for Selected Manufacturers by Size, 1975-2011 (2)

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

Detroit 3 Dominate New Fleet Registrations in 2011



Ford, General Motors, and Chrysler together accounted for 62% of new fleet car registrations and 86% of the new fleet light truck registrations in 2011. New registrations are often used as a proxy for sales. Of the top eight 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 2011 than Chrysler, Chrysler had the largest proportion of fleet vehicles vs. total – total being the sum of fleet vehicles and retail vehicles. Over 39% of the new Chrysler cars registered in 2011 were registered to fleets. Honda had only 11.1% of total new vehicles registered to fleets.

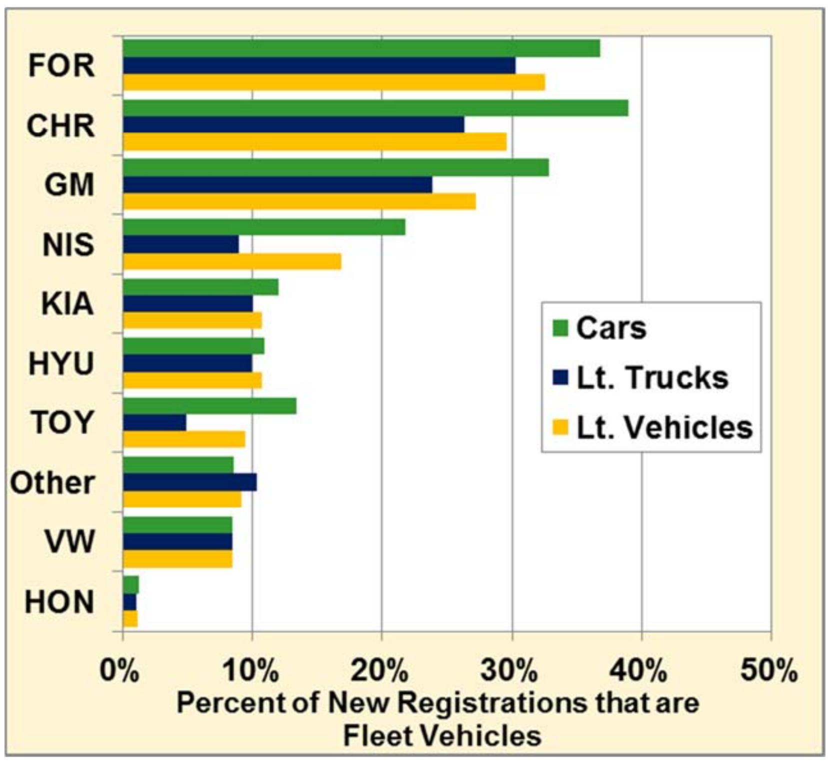


FIGURE 52. New Fleet Registration Data by Manufacturer, 2011

Source:
Bobit Publishing Company, *Automotive Fleet Factbook 2011*. http://www.automotive-fleet.com/statistics

Chevrolet Impala Was the Top New Fleet Car in 2011

The Chevrolet Impala topped the list of new cars which were registered to fleets in 2011. New registrations are often used as a proxy for sales. Over 72% of the new Impalas registered in 2011 were fleet vehicles, most of them in rental fleets. The Ford Crown Victoria 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 3. Top 25 New Registrations of Cars in Fleets in 2011

Make	Model	Commercial	Government	Rental	Total Fleet	Total Retail	Total	% Fleet vs Total
Chevrolet	Impala	16,370	9,064	104,508	129,942	48,643	178,585	72.8%
Ford	Fusion	29,088	5,185	49,507	83,780	157,199	240,979	34.8%
Chevrolet	Malibu	13,172	5,841	62,709	81,722	125,895	207,617	39.4%
Ford	Crown Victoria	27,363	26,696	15,363	69,422	3,940	73,362	94.6%
Nissan	Altima	5,435	240	62,755	68,430	190,592	259,022	26.4%
Ford	Focus	11,455	8,069	37,954	57,478	124,473	181,951	31.6%
Toyota	Corolla	3,230	125	42,501	45,856	190,764	236,620	19.4%
Chevrolet	Cruze	1,776	348	42,007	44,131	184,288	228,419	19.3%
Toyota	Camry	3,450	173	39,855	43,478	251,096	294,574	14.8%
Dodge	Avenger	1,510	1,266	40,007	42,783	21,861	64,644	66.2%
Dodge	Charger	6,671	6,038	26,961	39,670	33,302	72,972	54.4%
Chrysler	200	1,615	53	29,872	31,540	51,417	82,957	38.0%
Ford	Taurus	11,196	1,471	18,254	30,921	33,587	64,508	47.9%
Nissan	Versa	1,836	158	25,913	27,907	70,864	98,771	28.3%
Hyundai	Sonata	901	47	25,333	26,281	189,264	215,545	12.2%
Nissan	Sentra	1,688	40	24,496	26,224	88,545	114,769	22.8%
Volkswagen	Jetta	1,291	24	17,325	18,640	157,297	175,937	10.6%
Hyundai	Elantra Sedan	510	32	17,411	17,953	155,875	173,828	10.3%
Toyota	Yaris	374	10	16,864	17,248	15,811	33,059	52.2%
Mazda	6	584	21	15,480	16,085	20,538	36,623	43.9%
Chevrolet	Aveo	501	8	15,186	15,695	13,208	28,903	54.3%
Ford	Mustang	462	48	14,192	14,702	54,119	68,821	21.4%
Mazda	3	292	25	11,682	11,999	90,338	102,337	11.7%
Mitsubishi	Galant	43	2	9,995	10,040	5,542	15,582	64.4%
KIA	Optima	189	7	8,887	9,083	69,840	78,923	11.5%

Source:
Bobit Publishing Company, *Automotive Fleet Factbook 2011*. http://www.automotive-fleet.com/statistics

Ford F-Series Was the Top New Fleet Truck in 2011

The Ford F-series topped the list of new light trucks which were registered to fleets in 2011. New registrations are often used as a proxy for sales. About 26% percent of the new F-Series trucks registered in 2011 were fleet vehicles, the majority of them in commercial fleets. The F-Series was also the top model for government fleets. The Dodge Caravan and the Ford Escape were the models with the most new registrations in rental fleets.

TABLE 4. Top 25 New Registrations of Trucks in Fleets in 2011

Make	Model	Commercial	Government	Rental	Total Fleet	Total Retail	Total	% Fleet vs Total
Ford	F-Series	84,175	24,044	38,645	146,864	416,784	563,648	26.1%
Chevrolet	Silverado	49,585	9,960	22,696	82,241	335,802	418,043	19.7%
Dodge	Caravan	16,988	7,175	55,808	79,971	40,212	120,183	66.5%
Ford	Econoline	31,381	8,087	39,041	78,509	25,140	103,649	75.7%
Ford	Escape	20,707	3,371	46,882	70,960	175,061	246,021	28.8%
Chevrolet	Express	31,239	8,378	17,153	56,770	21,735	78,505	72.3%
Dodge	Ram	15,593	3,519	24,007	43,119	193,811	236,930	18.2%
Chevrolet	Tahoe	9,091	7,415	17,018	33,524	52,348	85,872	39.0%
Chevrolet	Traverse	2,808	211	30,336	33,355	72,937	106,292	31.4%
Ford	Explorer	10,429	3,757	17,444	31,630	102,749	134,379	23.5%
Chrysler	Town & Country	680	64	28,499	29,243	64,662	93,905	31.1%
Chevrolet	HHR	2,264	356	24,434	27,054	10,921	37,975	71.2%
Ford	Edge	3,884	229	18,605	22,718	98,167	120,885	18.8%
Jeep	Liberty	1,494	611	19,743	21,848	44,890	66,738	32.7%
Chevrolet	Equinox	8,851	786	12,210	21,847	171,348	193,195	11.3%
Ford	Ranger	13,090	2,526	5,426	21,042	51,271	72,313	29.1%
Chevrolet	Suburban	2,736	1,529	15,550	19,815	29,817	49,632	39.9%
Dodge	Journey	2,562	182	15,021	17,765	36,897	54,662	32.5%
Ford	Expedition	4,795	3,209	8,708	16,712	26,337	43,049	38.8%
Ford	Transit Connect	10,393	924	4,449	15,766	16,230	31,996	49.3%
Toyota	Sienna	4,666	337	10,663	15,666	91,400	107,066	14.6%
Jeep	Patriot	2,256	81	13,246	15,583	38,453	54,036	28.8%
Dodge	Durango	742	182	14,518	15,442	33,619	49,061	31.5%
Jeep	Grand Cherokee	2,902	547	10,411	13,860	111,652	125,512	11.0%
GM	Sierra	10,076	1,536	1,377	12,989	135,708	148,697	8.7%

Source:
Bobit Publishing Company, *Automotive Fleet Factbook 2011*. http://www.automotive-fleet.com/statistics

Fleet Management Companies Remarket Vehicles On-Line

The top ten fleet management companies owned or managed over 3.5 million vehicles in 2011. They remarketed 11% 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-seven percent of the vehicles remarketed in 2011 by the top ten fleet management companies were remarketed on-line. Donlan and Emkay remarketed over 60% of their vehicles on-line.

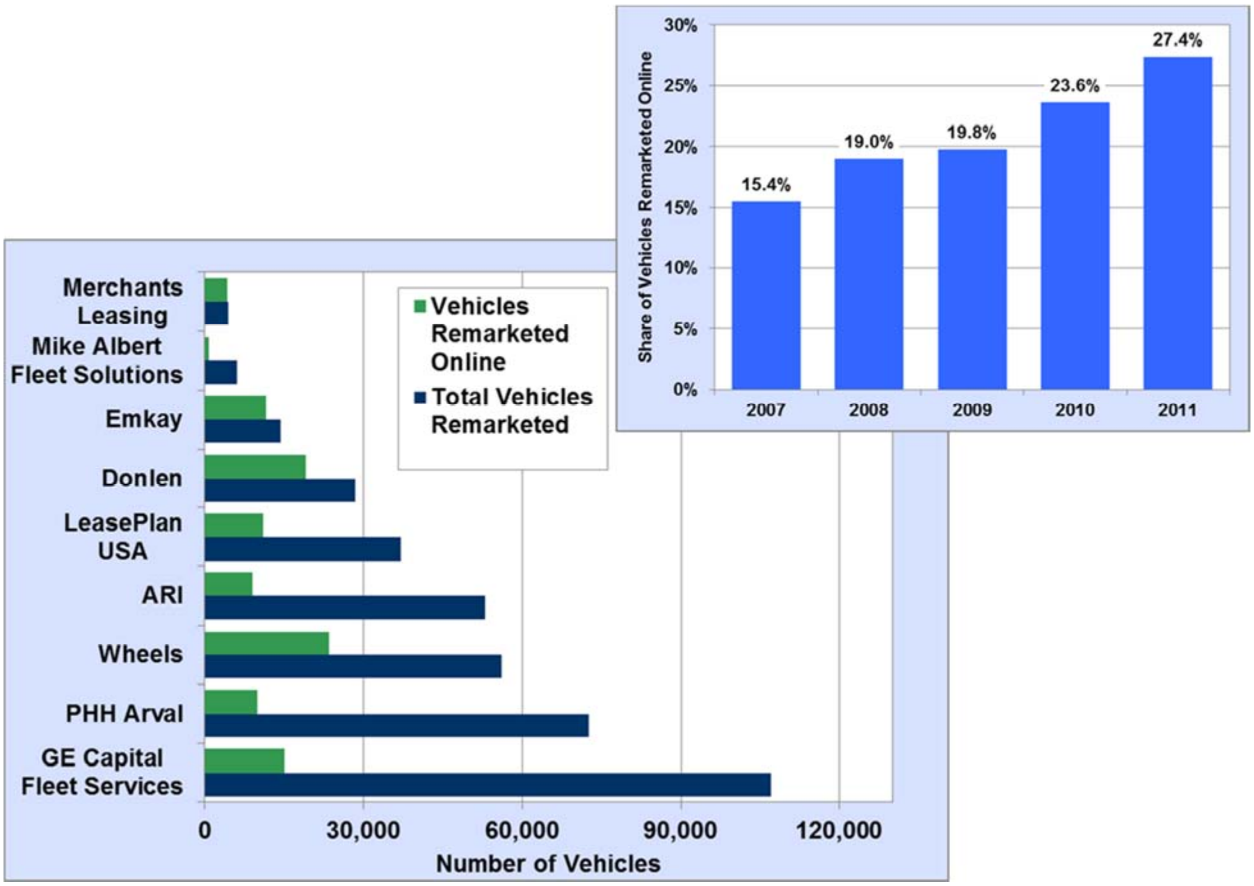
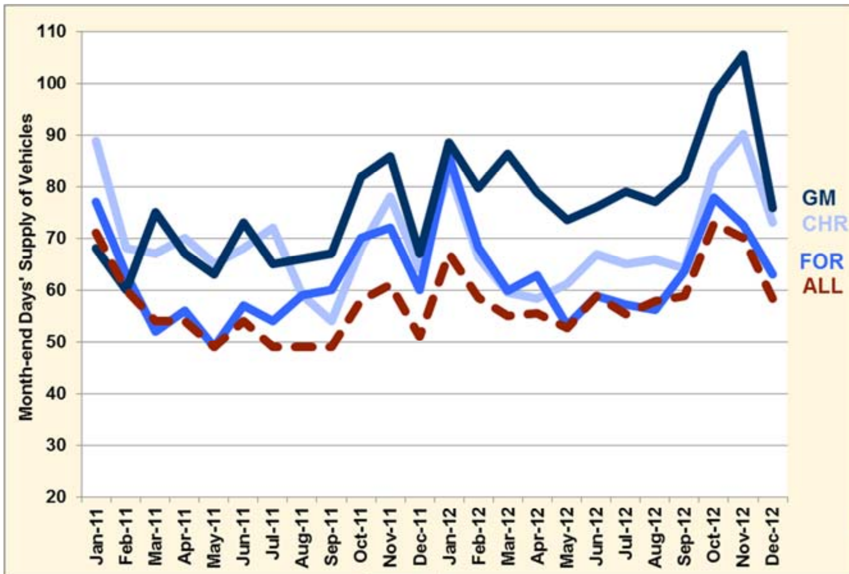


FIGURE 53. Vehicles Remarketed by the Top Ten Fleet Management Companies, 2011, and Share of Vehicles Remarketed On-Line, 2007-2011

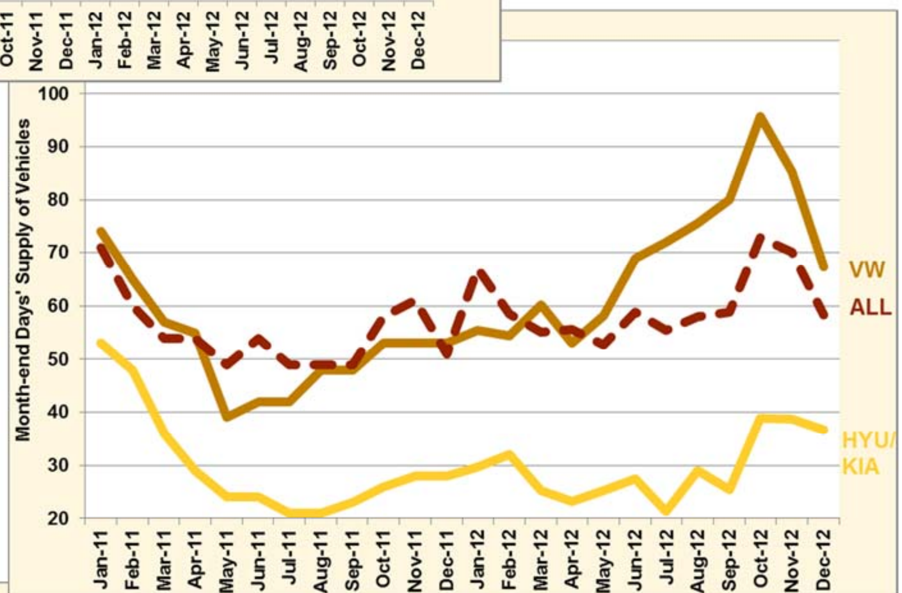
Source:
Bobit Publishing Company, *Automotive Fleet Factbook 2012*. http://www.automotive-fleet.com/statistics

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.

Honda, Toyota, and Nissan had supply disruptions due to Japan's March 2011 earthquake/tsunami and the October 2011 flood in Thailand. Hyundai/Kia sales are up and the supply has decreased significantly.



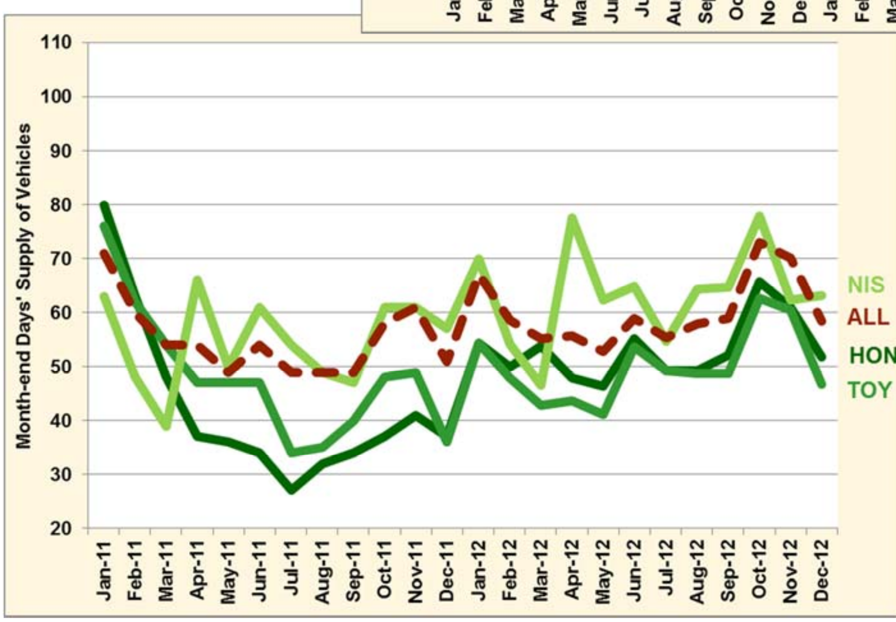


FIGURE 54. Monthly Inventory Supplies by Manufacturer, 2011-2012

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 2012, large cars, trucks, and sport utility vehicles (SUVs) stayed on the lot more than 80 days, on average, while the compact and subcompact cars stayed about 50 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.

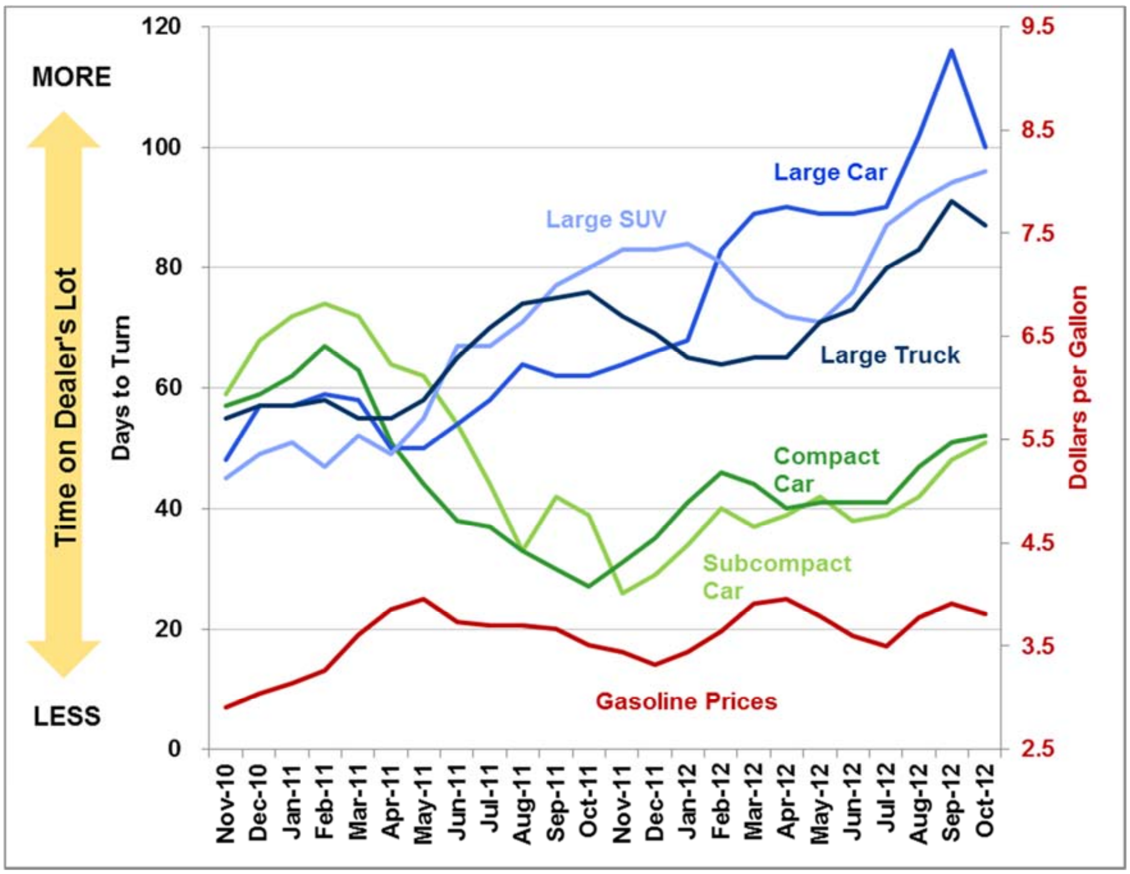


FIGURE 55. Days to Turn Trend by Vehicle Class, 2010-2012

Source:
Edmunds website data, www.Edmunds.com; U.S. Department of Energy, Energy Information Administration, International Statistics website, November 2012.

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 nearly $40 billion in parts sales to OEMs in 2011. Within the top ten suppliers, only one – Magna International, Inc. – has the majority (52%) 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 5. List of Top Ten Tier 1 Global Suppliers, 2011

Rank	Company	Company Headquarters	Market Share: North America	Europe	Asia	Rest of World	Total
1	Robert Bosch GMbH	Germany	14%	54%	26%	6%	100%
2	Denso Corp.	Japan	16%	12%	70%	2%	100%
3	Continental AG	Germany	19%	52%	25%	4%	100%
4	Magna International, Inc.	Canada	52%	43%	0%	5%	100%
5	Aisin Seiki Co., Ltd.	Japan	12%	10%	77%	1%	100%
6	Faurecia	France	21%	62%	11%	6%	100%
7	Johnson Controls, Inc.	United States	37%	51%	12%	0%	100%
8	Hyundai Motors	Korea	20%	11%	69%	0%	100%
9	ZF Friedrichshafen AG	Germany	15%	61%	17%	7%	100%
10	Delphi Automotive PLC	United States	32%	45%	16%	7%	100%

Note: Rank based on total global OEM automotive parts sales in 2011.

Source:
Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2012. http://www.autonews.com/

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

There are 12 U.S.-based companies in the top 50 automotive global suppliers. Of these companies, none has more than half of its parts sales in North America.

TABLE 6. U.S.-Based Tier 1 Suppliers in the Top 50, 2011

Rank	Company	Percent North America Sales	Products
7	Johnson Controls, Inc.	37%	Seating, overhead systems, door & instrument panels, center & overhead consoles, interior electronics, lead-acid & hybrid vehicle batteries
10	Delphi Automotive PLC	32%	Mobile electronics; powertrain, safety, thermal, controls & security systems; electrical/electronic architecture; in-car entertainment technologies
12	TRW Automotive Holdings Corp.	32%	Steering, suspension, braking & engine components; fasteners, occupant-restraint systems, electronic safety & security systems
13	Lear Corp.	35%	Seating & electrical power management systems
19	Cummins, Inc.	44%	Diesel & natural gas engines
22	Visteon Corp.	16%	Climate-control systems, electronics, interiors
24	Dana Holding Corp.	45%	Axles, driveshafts, sealing & thermal management products, tire management products
27	BorgWarner, Inc.	26%	Turbochargers, engine valve-timing systems, ignition systems, emissions systems, thermal systems, transmission-clutch systems, transmission-control systems & AWD systems
31	DuPont	30%	Paint & coatings, high-performance polymers, elastomers, renewable sourced polymers, fibers & fluoropolymers; battery separator & electronic material technologies, fabricated products, advanced composite materials, specialty chemicals, lubricants, refrigerants, films, bio-based fuels
34	Tenneco, Inc.	46%	Emission control systems, manifolds, catalytic converters, diesel aftertreatment systems, catalytic reduction mufflers, shock absorbers, struts, electronic suspension products & systems
46	Federal-Mogul Corp.	28%	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
48	Goodyear Tire & Rubber Co.	40%	Tires

Note: Rank based on total global OEM automotive parts sales in 2011.

Source:
Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2012.
http://www.autonews.com/

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

There are ten U.S. automotive parts suppliers that sold more than $5 billion in parts to original equipment manufacturers in 2011. 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 decreased their share of sales to the United States from 2007 to 2011. Likely, China and India are the growing Asian markets.

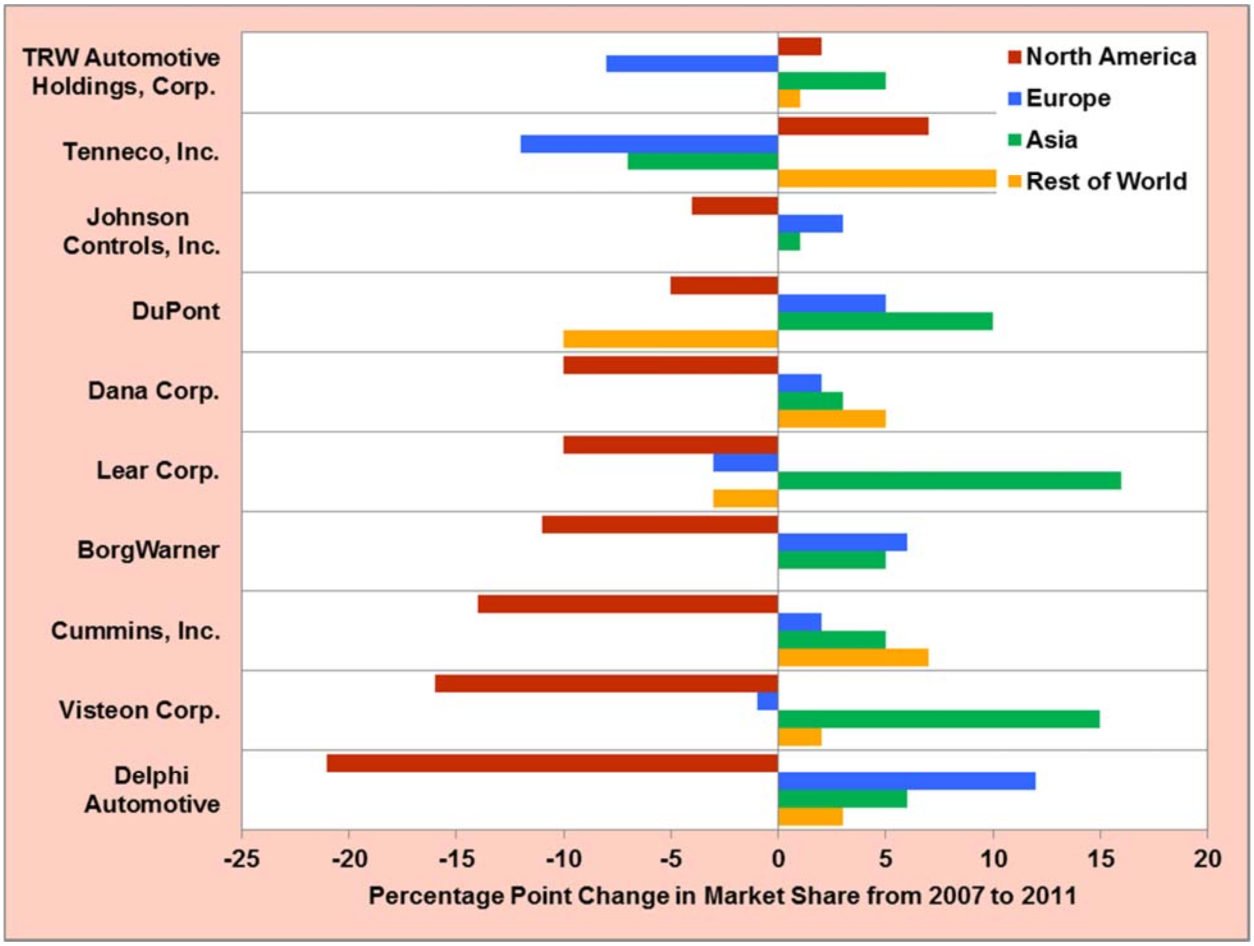


FIGURE 56. Change in Market Share of Top U.S.-Based Tier 1 Suppliers, 2007-2011

Source:
Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2012 and June 2008. 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.

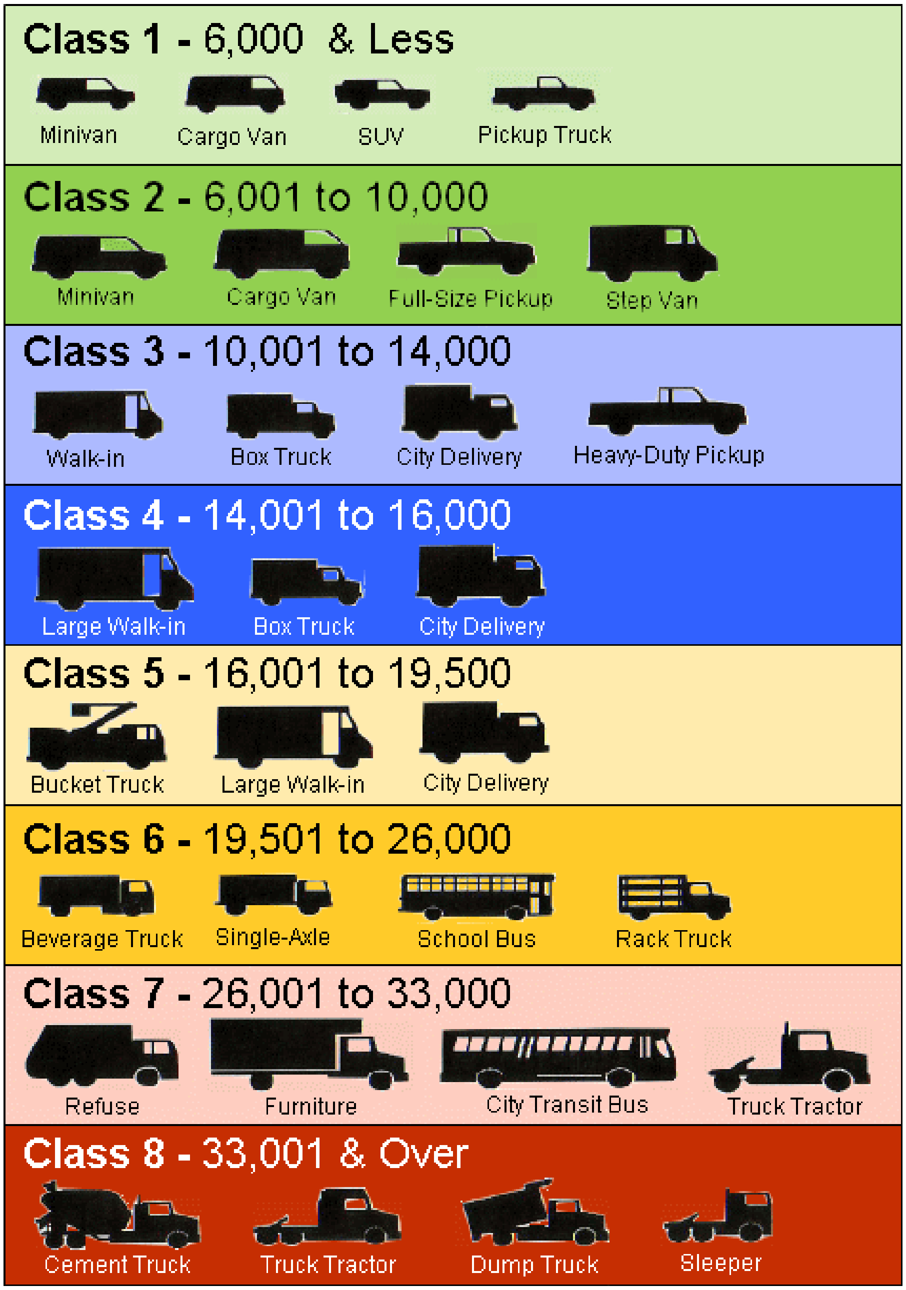

FIGURE 57. Examples of Trucks in Each Truck Class

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 7. 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 Pick-Ups	4,000 - 6,000	3,200 - 4,500	250 - 1,500	20-25	58.8
2a	Large SUVs, Standard Pick-Ups	6,001 - 8,500	4,500 - 6,000	250 - 2,500	20-21	38.5
2b	Large Pick-Ups, 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).

TABLE 8. Production of Medium and Heavy Trucks by Manufacturer, 2011

Freightliner & Western Star	Hino	International	Kenworth	Mack	Peterbilt	Volvo
45.5	4.8	43.0	30.6	20.3	28.1	25.2

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

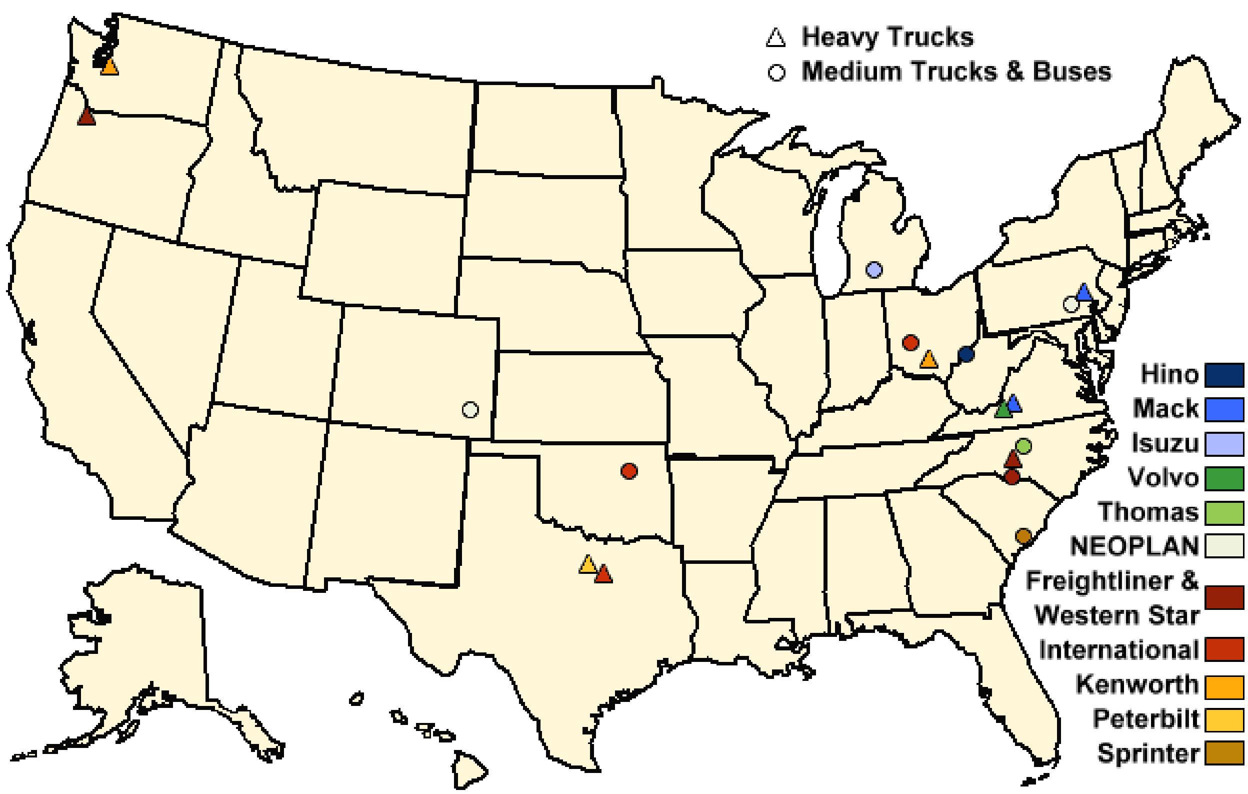

FIGURE 58. Heavy Truck Manufacturing Plants by Location, 2012

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

Class 3 Truck Sales Are Up in 2011

Class 3 truck sales fell with the economy in 2008 and 2009, but recovered in 2010 and 2011. In fact, 2011 sales were 18% above 2007 sales. Chrysler, Ford, and General Motors continue to dominate the class 3 market.

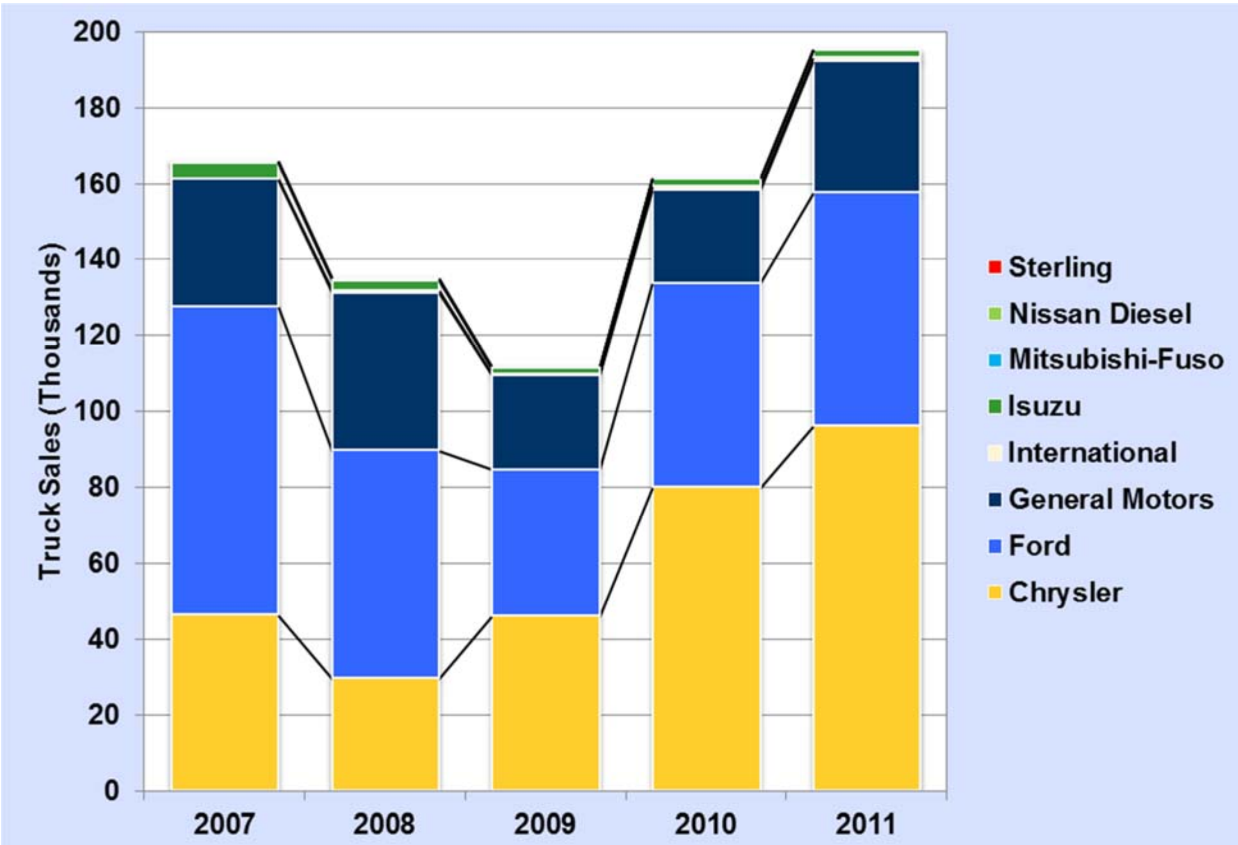

FIGURE 59. Class 3 Truck Sales by Manufacturer, 2007-2011

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2012*, Southfield, MI, 2012.
http://wardsauto.com

Class 4-7 Truck Sales Continue to Be Low

Though the sales of class 4-7 trucks were up slightly in 2011, they were 39% below the 2007 level. However, most companies kept their market share of the significantly lower market, with General Motors (GM) being the notable exception. In 2007 GM sold over 34,000 class 4-7 trucks, while in 2011 they sold almost none. Freightliner, Hino, Isuzu, Mack, and Kenworth all gained one or two percent of the market share after GM's decline. International gained nine percent from 2007 to 2011.

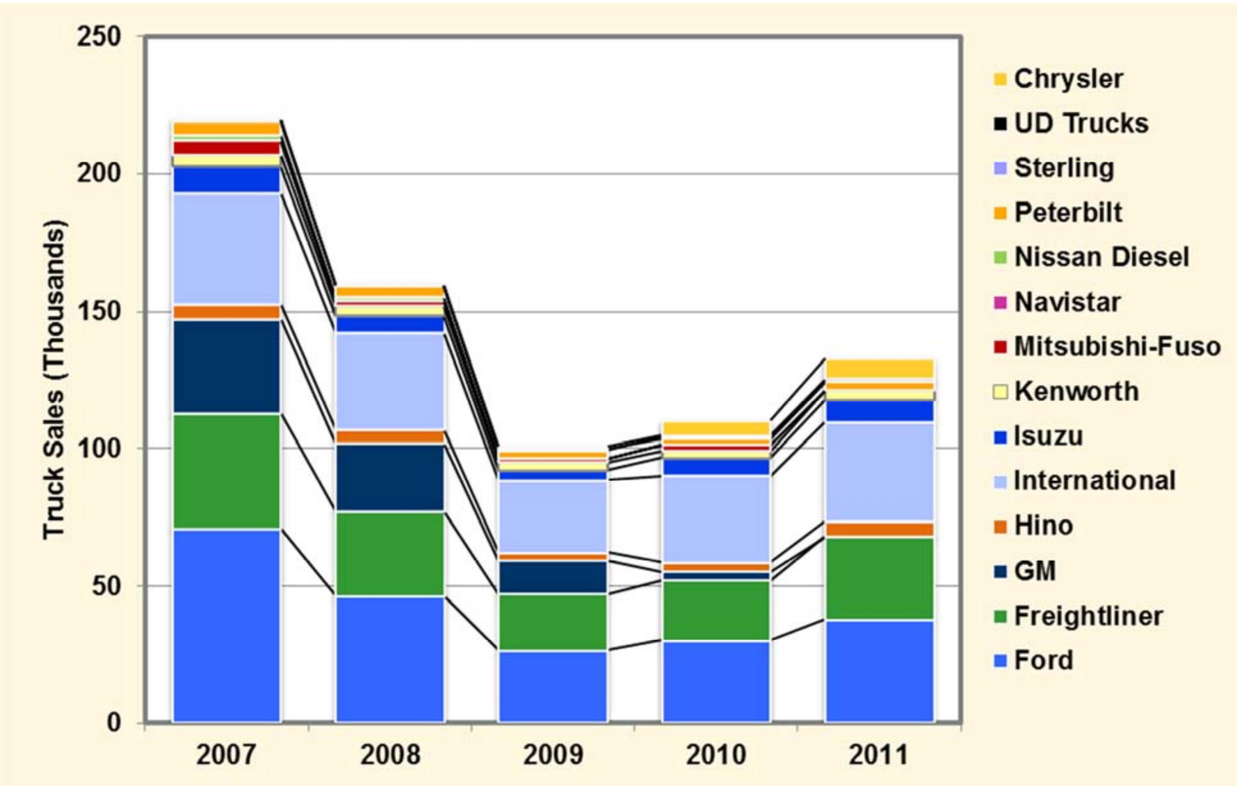

FIGURE 60. Class 4-7 Truck Sales by Manufacturer, 2007-2011

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

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2012*, Southfield, MI, 2012. http://wardsauto.com

Class 8 Truck Sales Are Up in 2011

Mainly due to the economic recession, class 8 truck sales in 2008 and 2009 declined, but grew in 2010 and 2011. There was not a large shift in market share among the manufacturers over the last five years. Freightliner had 32% of the market in 2011 and International had 21%. All other companies listed have less than a 15% share of the market.

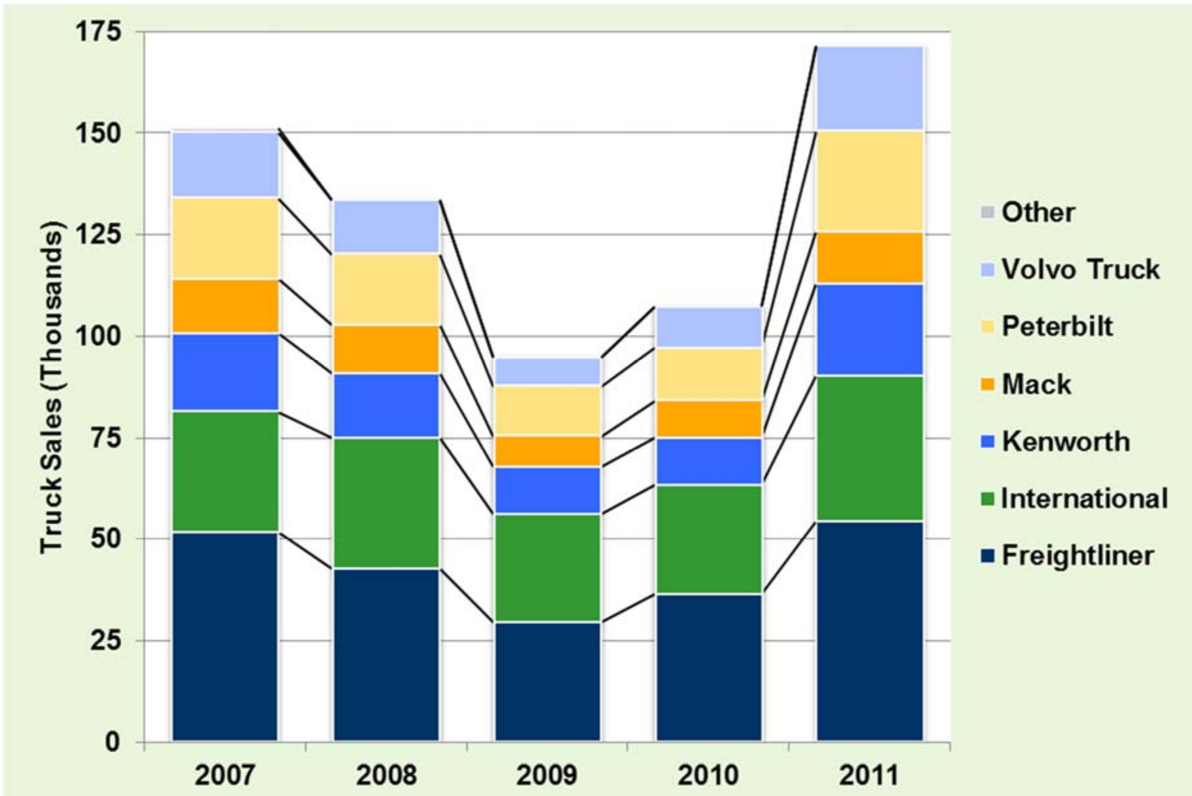

FIGURE 61. Class 8 Truck Sales by Manufacturer, 2007-2011

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2012*, Southfield, MI, 2012.
http://wardsauto.com

Diesel Engine Use Increases for Medium Trucks

In 2007, about half of class 6 trucks sold were diesel; in 2011, nearly all of class 6 trucks sold were diesel. Class 8 trucks have always been near 100% diesel and that has not changed. Overall, diesel comprised 75% of the class 3-8 trucks sold in 2011, up from 68% in 2007.

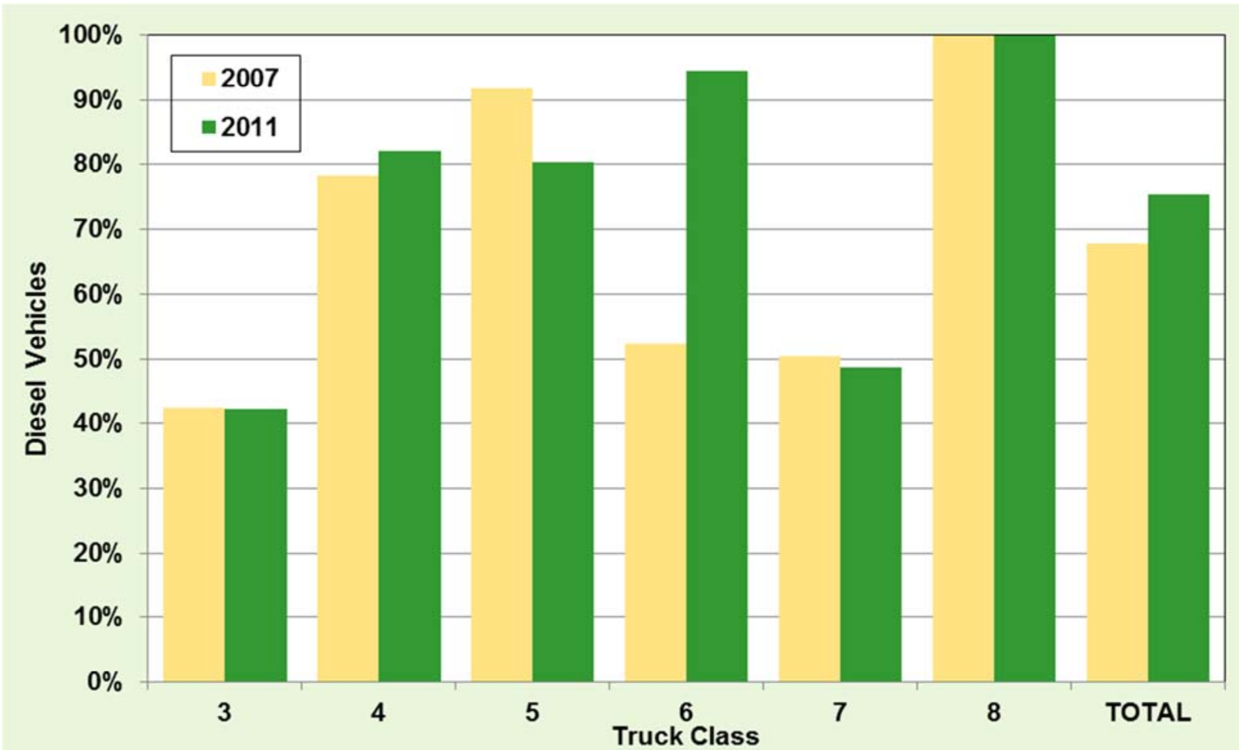

FIGURE 62. Share of Diesel Truck Sales by Class, 2007 and 2011

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

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2012*, Southfield, MI, 2012.
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 9. Diesel Engine Suppliers by Manufacturer, 2011

Make	Engine Manufacturer	Share
Freightliner	Cummins	59.1%
	Detroit Diesel	40.2%
	Mercedes Benz	0.7%
	Total	**100.0%**
Hino	Hino	100%
International	Caterpillar	0.1%
	Cummins	2.4%
	International	97.5%
	Total	**100.0%**
Kenworth	Caterpillar	0.2%
	Cummins	75.5%
	PACCAR	24.3%
	Total	**100.0%**
Mack	Mack	100%
Peterbilt	Cummins	76.2%
	PACCAR	23.8%
	Total	**100.0%**
Volvo	Cummins	23.2%
	Volvo	76.8%
	Total	**100.0%**
Western Star	Caterpillar	0.6%
	Cummins	17.6%
	Detroit Diesel	81.8%
	Total	**100.0%**
Other	Cummins	100.0%

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

Cummins Leads Heavy Truck Diesel Engine Market

In 2007, International (also known as Navistar) held a 67% share of the heavy truck diesel engine market. By 2011, International's share had declined to 20% and Cummins held the largest share of the market (42%).

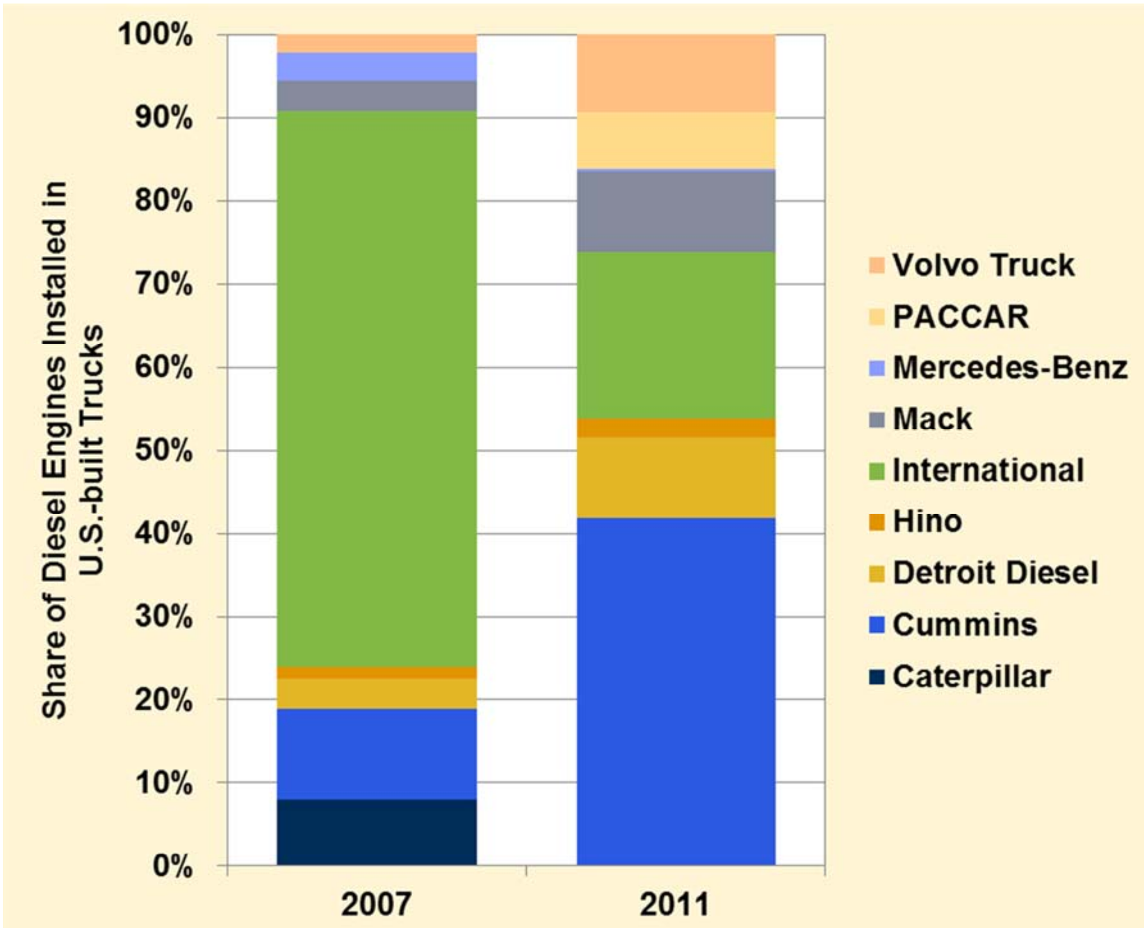

FIGURE 63. Diesel Engine Manufacturers Market Share, 2007 and 2011

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

Combination Trucks Average Over 68,000 Miles per Year

According to the latest Federal Highway Administration estimates, the average miles traveled per truck was over 68,000 miles for a combination truck in 2010, down from over 70,000 miles in 2008. 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 2010 while the combination truck fuel economy was 5.9 mpg. The combination trucks typically have larger engines to carry heavier loads than the single-unit trucks.

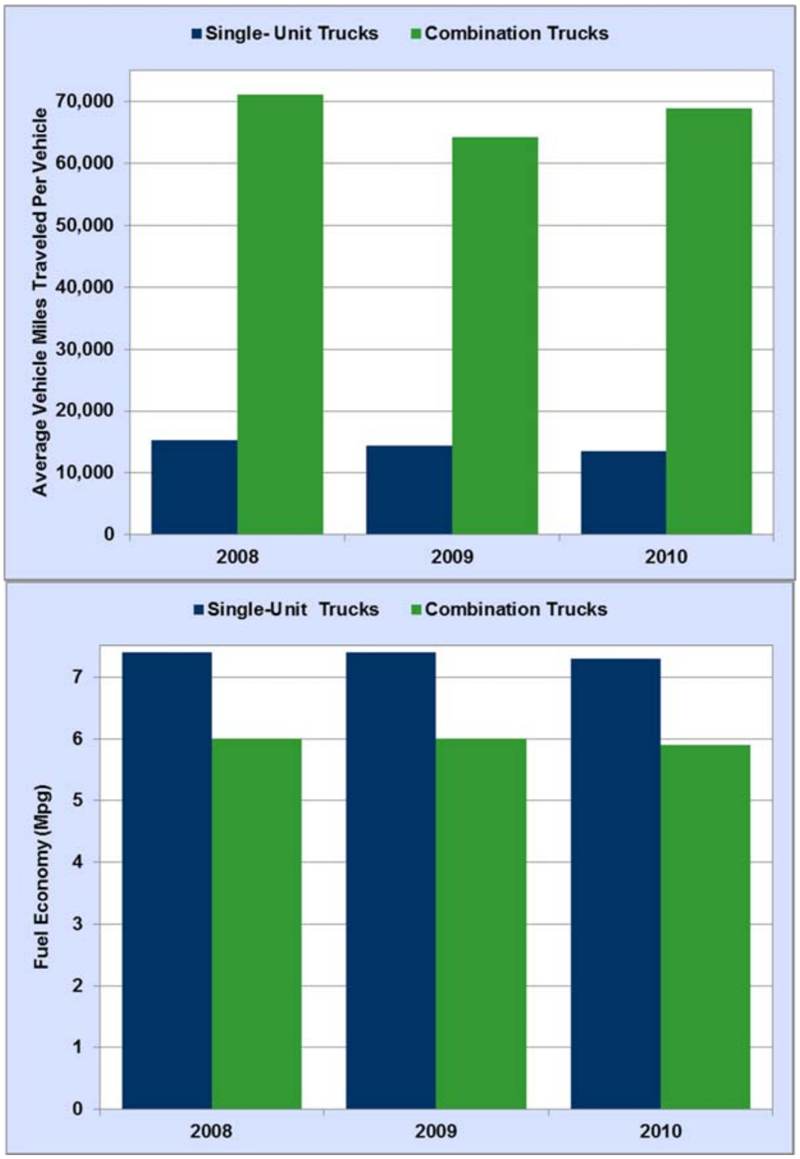

FIGURE 64. Vehicle-Miles of Travel and Fuel Economy for Heavy Trucks, 2008-2010

Source:

U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2010*, Table VM-1, April 2011. http://www.fhwa.dot.gov/policyinformation/statistics/2010/vm1.cfm

Real-World Class 8 Fuel Economy Ranges from 7.9 to 9.5 mpg

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 10. 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.

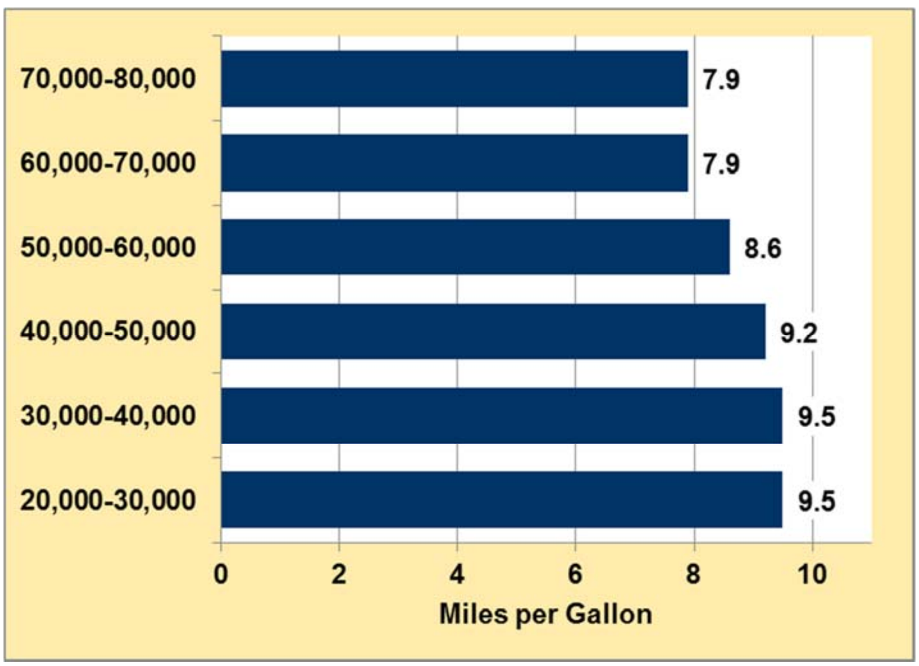

FIGURE 65. Fuel Efficiency of Class 8 Trucks by Vehicle Weight Range on Flat Terrain

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 Effects 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.

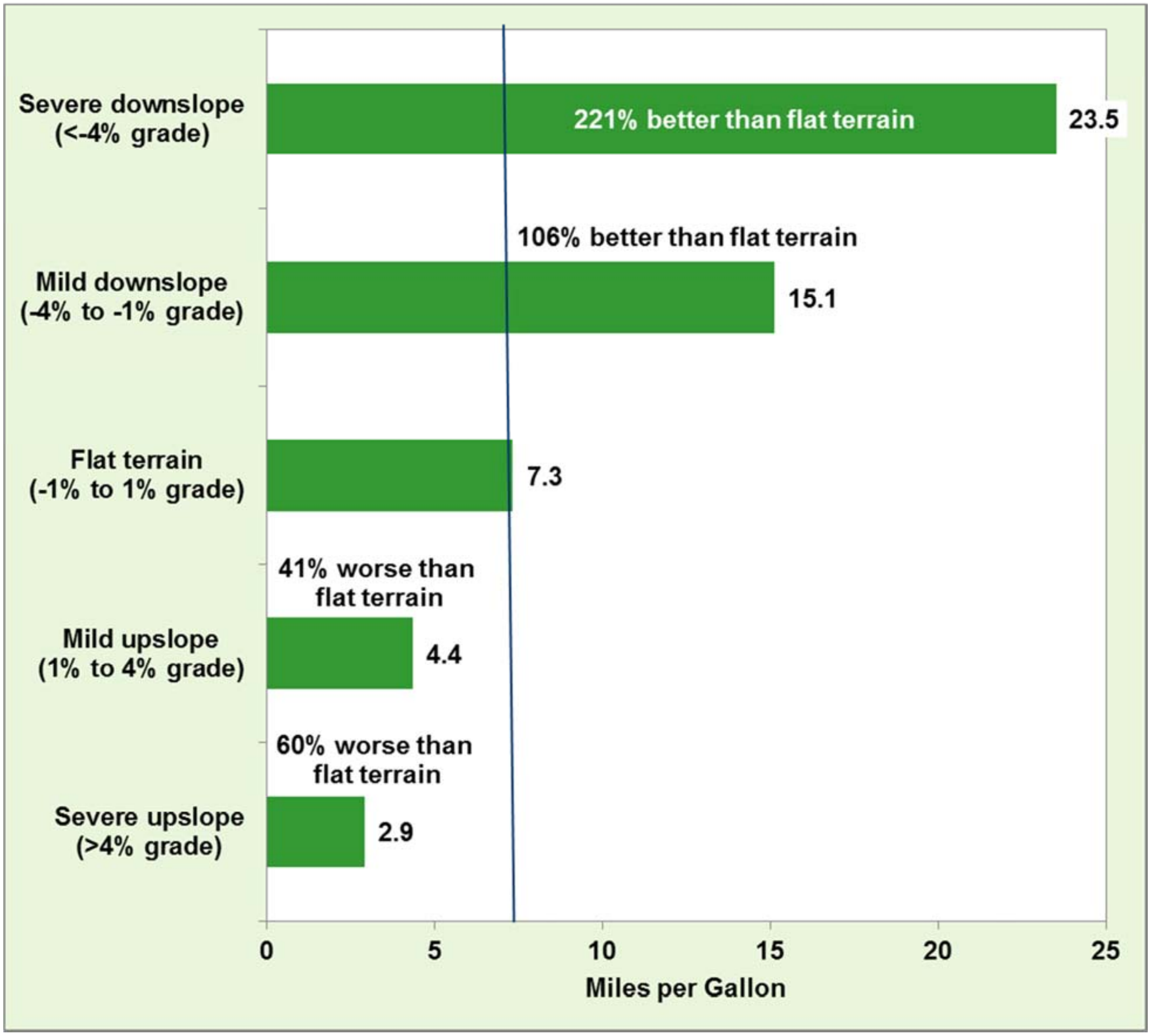

FIGURE 66. Fuel Efficiency of Class 8 Trucks by Roadway Grade

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.

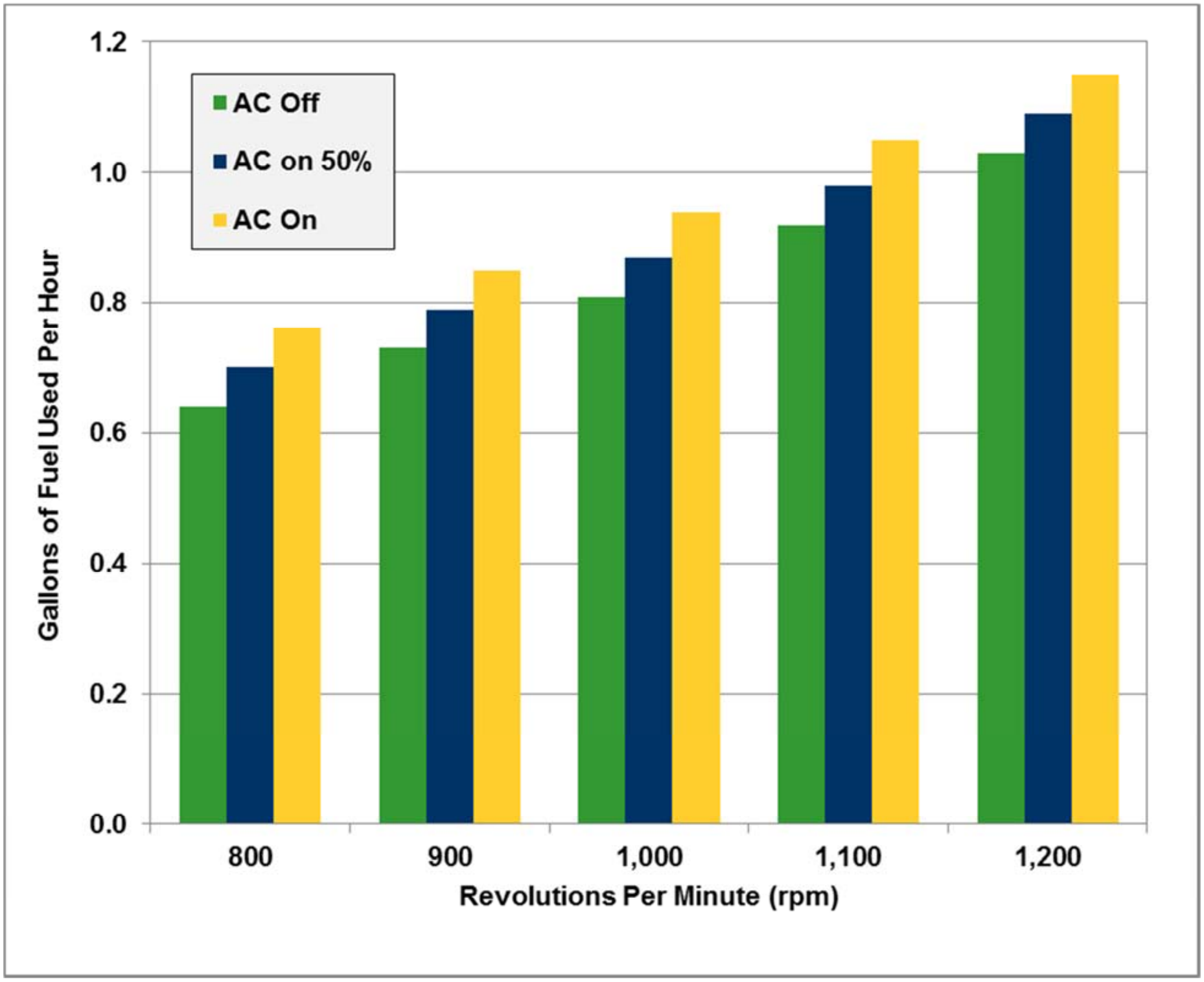

FIGURE 67. Average Amount of Fuel Used for Idling a Truck-Tractor

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

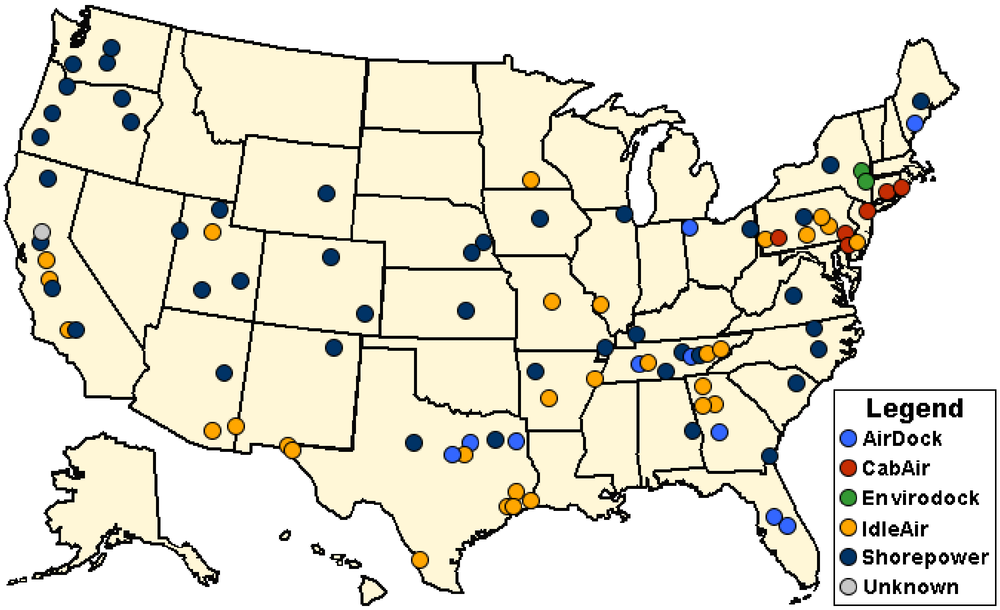

FIGURE 68. Map of Truck Stop Electrification Sites, 2012

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 93 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.

TABLE 11. Number of Truck Stop Electrification Sites by State, 2012

State	Number of Sites	State	Number of Sites
Alabama	1	Nebraska	2
Arizona	3	New Jersey	2
Arkansas	3	New Mexico	1
California	8	New York	3
Colorado	2	North Carolina	2
Connecticut	2	Ohio	2
Delaware	2	Oregon	5
Florida	2	Pennsylvania	6
Georgia	5	South Carolina	1
Illinois	2	Tennessee	8
Iowa	1	Texas	13
Kentucky	1	Utah	5
Kansas	1	Virginia	1
Maine	2	Washington	3
Minnesota	1	Wyoming	1
Missouri	2		
Total	**93**		

Source:

Alternative Fuels and Advanced Vehicles Data Center. Accessed January 8, 2013.
http://www.afdc.energy.gov/afdc/locator/tse/state

Chapter 4.

TECHNOLOGIES

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Many Hybrid Nameplates Have Entered the U.S. Market

In 1999, the Honda Insight debuted as the first hybrid-electric vehicle (HEV) on the market, followed closely by the Toyota Prius in 2000. While the Prius continues to be the best selling HEV, many other manufacturers have entered the market. As of 2011 there were 38 different HEVs sold. Likely due to the economic recession and relatively low gasoline prices, the total sales of HEVs were highest in 2007 at just over 350 thousand vehicles.

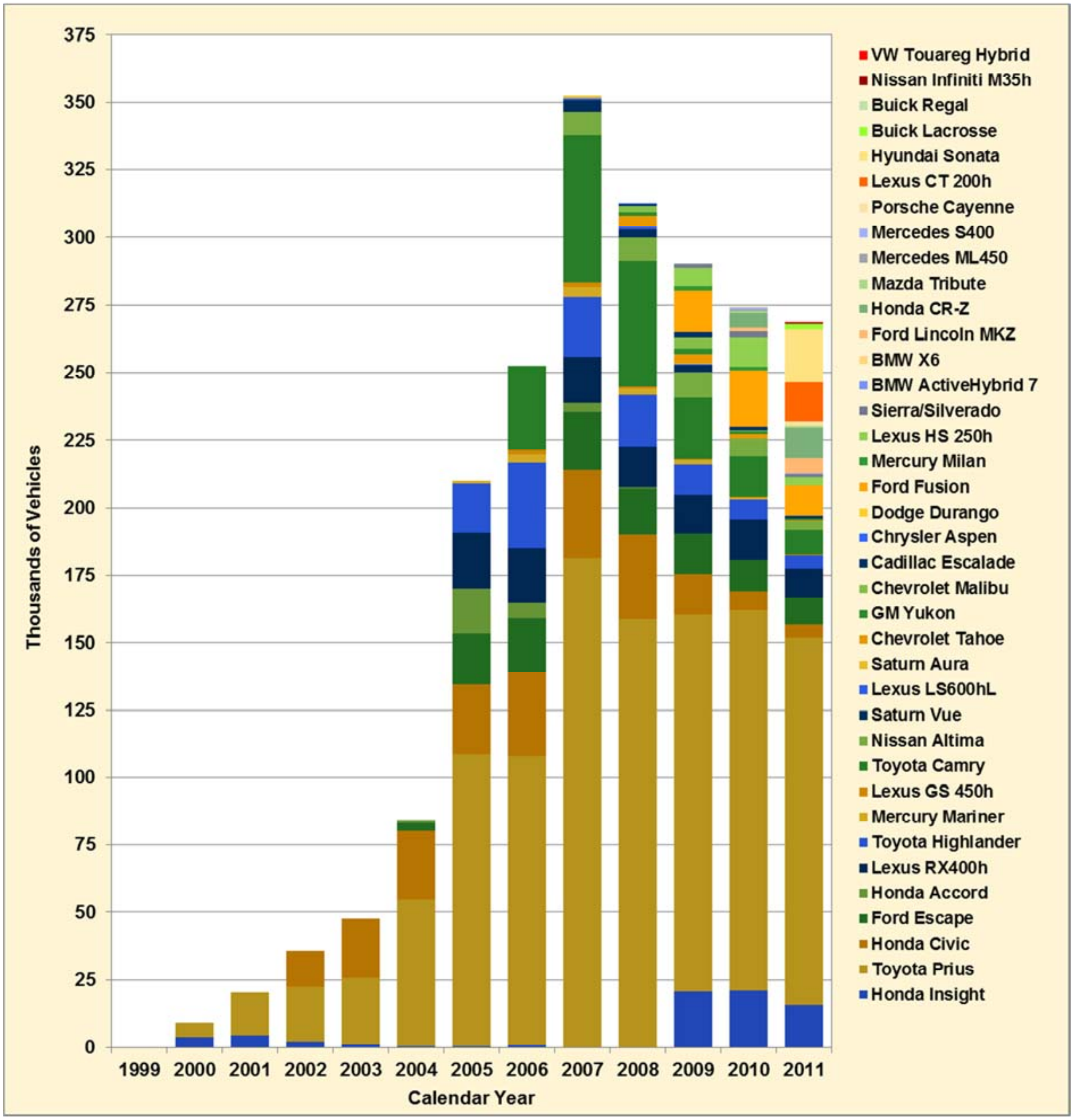


FIGURE 69. Hybrid-Electric Vehicle Sales, 1999-2011

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

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.

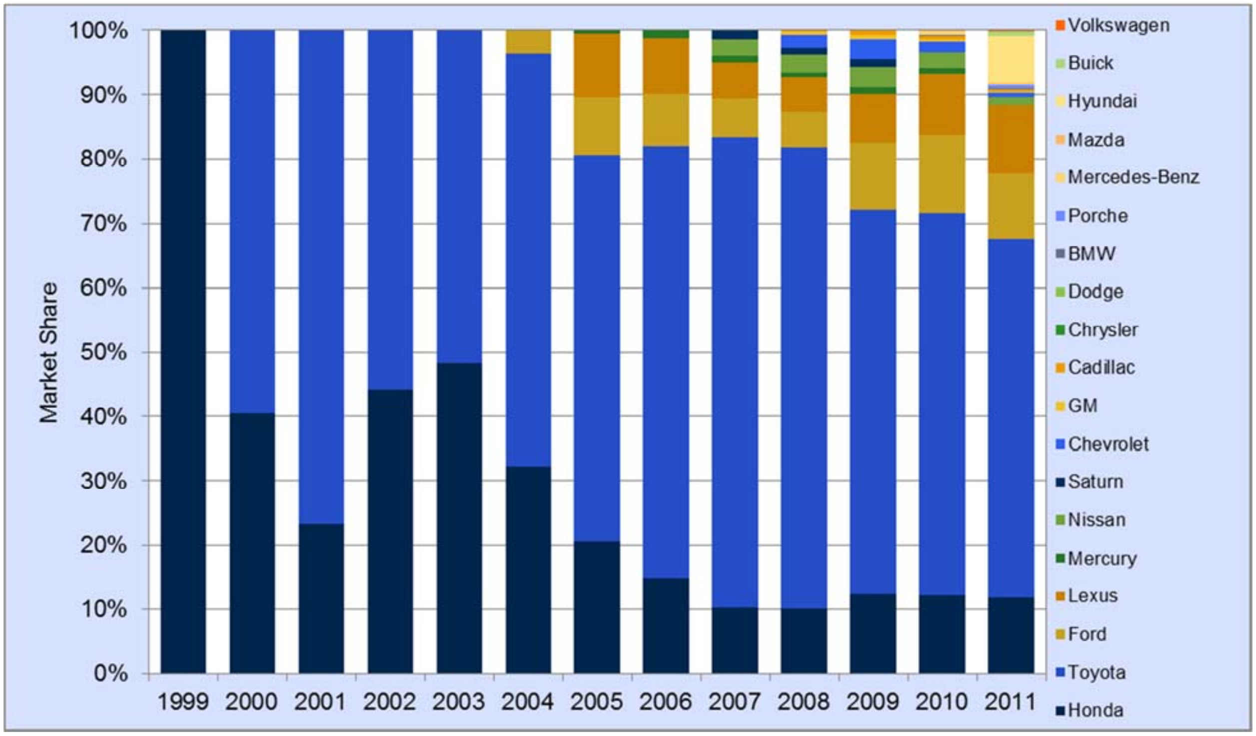


FIGURE 70. Hybrid-Electric Vehicle Market Share, 1999-2011

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, and the Prius PHEV when they were first introduced.

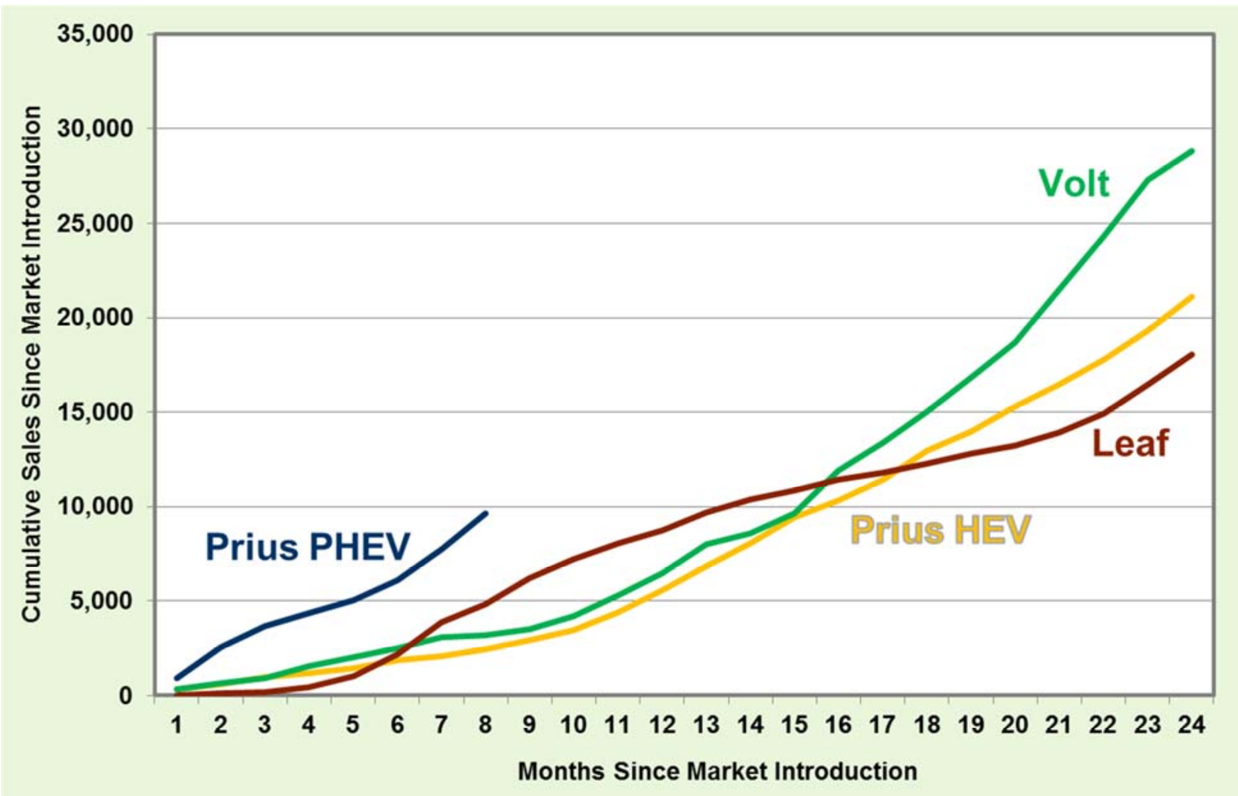


FIGURE 71. Monthly Sales since Market Introduction for Hybrid Vehicles and Plug-In Vehicles

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.

Source:
Data compiled by Argonne National Laboratory, Argonne, Illinois, December 2012.

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 17 models from eight manufacturers 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 12. Hybrid and Electric Cargo Trucks on the Market

Make	Model	Body Type/Application	GVW Class
Gasoline Hybrid			
Bright Automotive	IDEA	Cargo Van	1
Ford	E450	Step Van, Shuttle Bus	3
GM	TC5500	Utility	5
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-

New Plug-In Vehicles Are on the Horizon

There are already 13 cars that plug into electrical outlets to get all or part of their fuel. More models are planned by various manufacturers for 2013-2014. The concept vehicles listed are not all-inclusive, as many different manufacturers have concepts for future plug-in vehicles.

TABLE 13. Plug-In Vehicles Available or Coming Soon

Manufacturer	Specific Product	Availability	All-Electric Range	Specifications
BMW	ActiveE	Available	94 Miles	32 kWh lithium-ion battery
Chevrolet	Volt	Available	35 miles	1.4-liter engine, 16 kWh lithium-ion battery, 150-hp electric motor
Coda	Electric Sedan	Available	88 miles	34 kWh lithium-ion battery
Fisker	Karma	Available	32 miles	2.0-liter engine, 22 kWh lithium-ion battery, 400-hp electric motors (2)
Ford	Focus Electric	Available	76 miles	23 kWh lithium-ion battery
Ford	C-Max Energi	Available	21 miles	7.6 kWh lithium-ion battery
Honda	Fit EV	Available	82 miles	20 kWh battery, 120 kW electric motor
Mitsubishi	i-MiEV	Available	62 miles	16 kWh lithium-ion battery, 47 kW motor
Nissan	Leaf	Available	73 miles	24 kWh lithium-ion battery, 80 kW electric motor
Tesla	Roadster	Available	245 miles	53 kWh battery, 185 kWh, 248 hp electric motor
Tesla	Model S	Available	300 miles	85 kWh lithium-ion battery,
Toyota	Prius Plug-In Hybrid	Available	11 miles	lithium-ion battery, 1.8-liter aluminum 4-cyl engine
Toyota	Rav4 EV	Available	100 miles	42 kWh battery
BMW	i3	2013	100 miles	22 kWh lithium-ion battery, 170 hp electric motor
BYD	e6 Wagon	2013	250 miles	1.0-liter engine, iron-phosphate Fe battery, 75kW motor
BYD	F3DM	2013	60 miles	1.0-liter engine, 16 kWh lithium-ion battery, 50kW traction motor
Chevrolet	Spark EV	2013	N/A	20 kWh lithium-ion battery pack, 110 kW electric motor
Fiat	500e	2013	80 miles	24 kWh lithium-ion battery, 83 kW electric motor
Honda	Accord PHEV	2013	10-15 miles	6.7 kWh lithium-ion battery, 124 kWh electric motor, 2.0 L, 4cyl gasoline engine
Smart	ED	2013	70 miles	16 kWh lithium-ion battery, 55 kW electric motor
Volkswagen	E-Up!	2013	80 miles	18 kWh battery, 80 hp electric motor
Volvo	V70 Plug-In Hybrid	2013	30 miles	11.3 kWh battery
Audi	A3 eTron	2014	N/A	N/A
BMW	i8	2014	30 miles	356 hp, 10.8 kWh lithium-ion battery
Cadillac	ELR	2014	N/A	N/A
Mercedes-Benz	B-Class EV	2014	125 miles	100 kW electric motor
Scion	iQ EV	2014	50 miles	12 kWh lithium-ion battery, 47 kW electric motor

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

Primearth EV Energy Was the Largest Hybrid-Electric Battery Supplier in 2010 and 2011

Primearth EV Energy, a joint venture of Panasonic and Toyota, is the supplier for Toyota and GM hybrid trucks. Most of the hybrid vehicles sold in calendar year 2010 and 2011 run on Primearth batteries. Sanyo, Panasonic and LG Chem also supplied a large number of batteries for the hybrid-electric (HEV) and plug-in hybrid electric (PHEV) market. Automotive Energy Supply Corporation supplied nearly all of the batteries for electric vehicles (EV) sold in 2011.

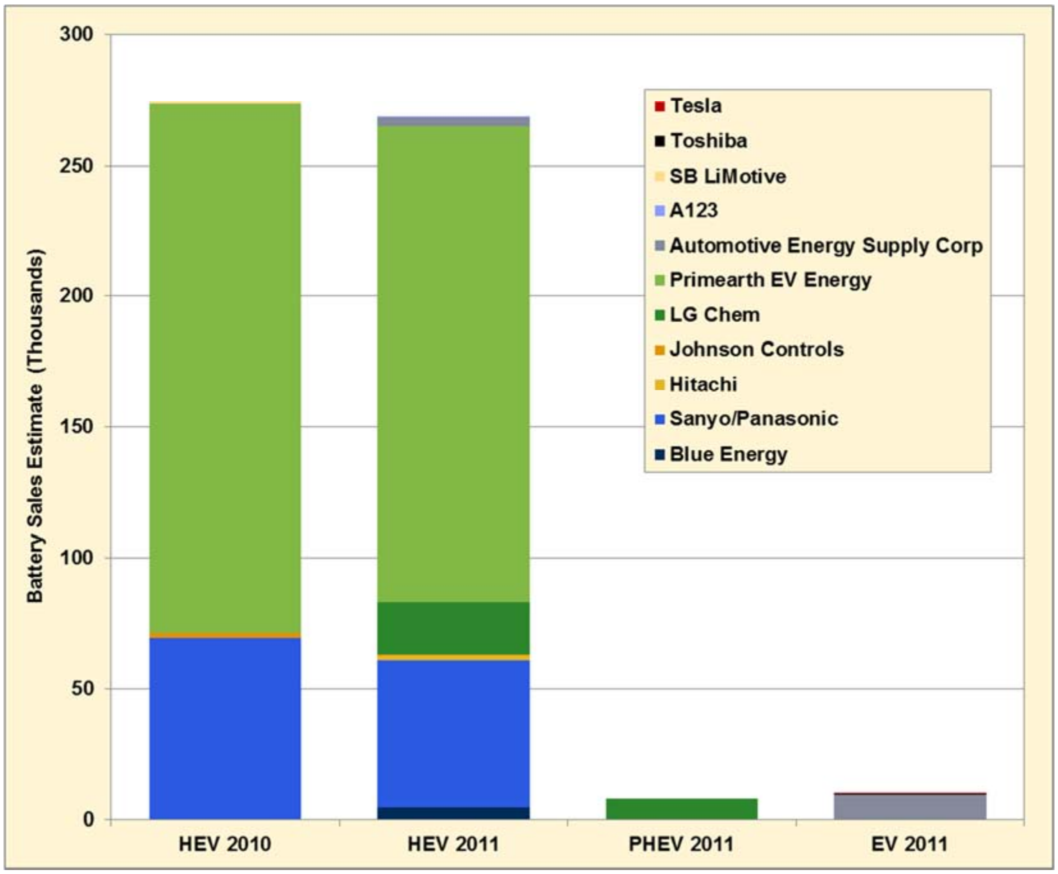


FIGURE 72. Battery Sales Estimates, 2010 and 2011

Note: Primearth EV Energy was formerly known as Panasonic EV Energy.

Sources:
Estimated using hybrid vehicle sales and battery suppliers for hybrid vehicles.
Hybrid vehicle sales – U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/data/#tab/vehicles/data_set/10304

Battery supplier for each vehicle – compiled from various public sources, Oak Ridge National Laboratory.

Batteries for Upcoming Plug-In Vehicles

The upcoming plug-in hybrid electric (PHEV) and electric vehicles (EV) are using lithium-ion (Li-ion) batteries from a variety of suppliers. Many of the suppliers are joint ventures between automotive companies and electronics companies (see notes below).

TABLE 14. Batteries for Selected Upcoming Plug-In Vehicles

Vehicle	Model Year	Vehicle type	Battery type	Supplier
Think City	2011	*EV*	Li-ion	EnerDel
Coda Automotive Coda	2012	EV	Li-ion	LIO Energy Systems
Fisker Karma	2012	PHEV	Li-ion	A123
Mitsubishi i-MiEV	2012	EV	Li-ion	Lithium Energy Japan
Mitsubishi i-MiEV	2012	EV	Li-ion	Toshiba
Nissan Leaf	2012	EV	Li-ion	AESC
Tesla Model S	2012	EV	Li-ion	Pansonic
Toyota Prius	2012	PHEV	Li-ion	Primearth
Toyota RAV4 EV	2012	EV	Li-ion	Tesla
BMW ActiveE	2013	EV	Li-ion	SB LiMotive
Chevrolet Volt	2013	PHEV	Li-ion	LG Chem
Ford C-MAX Energi	2013	PHEV	Li-ion	Panasonic
Ford Focus Electric	2013	EV	Li-ion	LG Chem
Ford Fusion Energi	2013	PHEV	Li-ion	Panasonic
Honda Accord PHEV	2013	PHEV	Li-ion	Blue Energy
Honda Fit EV	2013	EV	Li-ion	Toshiba
BMW i3	2014	EV	Li-ion	SB LiMotive
Chevrolet Spark EV	2014	EV	Li-ion	A123
Fiat 500e	2014	EV	Li-ion	SB LiMotive
Mitsubishi Outlander Plug-in Hybrid	2014	PHEV	Li-ion	Lithium Energy Japan

Notes: SB Limotive was a joint venture between Samsung and Bosch; it was dissolved in September 2012, but existing supply contracts will be honored.

LIO energy systems is a joint venture between Coda Automotive and Tianjin Lishen Battery.

Primearth EV Energy, formerly Panasonic EV Energy, is a joint venture between Panasonic and Toyota; Toyota currently owns a controlling stake (80%) in the company.

Blue Energy is a joint venture between GS Yuasa and Honda.

Lithium Energy Japan is a joint venture between GS Yuasa and Mitsubishi.

Automotive Energy Supply Corporation is a joint venture between NEC and Nissan.

It is unclear how the bankruptcy and sale of A123 Systems may impact future production contracts.

Source:

Compiled from public sources by Josh Pihl, Oak Ridge National Laboratory, December 2012.

Batteries for Upcoming Hybrid-Electric Vehicles

There are many new models of hybrid-electric vehicles (HEV) coming into the market. The first HEVs used nickel-metal hydride (NiMH) batteries, but many of the new HEVs use lithium-ion (Li-ion) or lithium-polymer batteries.

TABLE 15. Batteries for Selected Upcoming Hybrid-Electric Vehicles

Vehicle	Model Year	Vehicle Type	Battery Type	Supplier
BMW ActiveHybrid 3	2013	HEV	Li-ion	A123
BMW ActiveHybrid 5	2013	HEV	Li-ion	A123
BMW ActiveHybrid 7	2013	HEV	Li-ion	A123
Mercedes-Benz E400 Hybrid	2013	HEV	Li-ion	Johnson Controls
Mercedes-Benz S400 Hybrid	2013	HEV	Li-ion	Johnson Controls
Ford C-MAX Hybrid	2013	HEV	Li-ion	Panasonic
Ford Fusion Hybrid	2013	HEV	Li-ion	Panasonic
Lincoln MKZ Hybrid	2013	HEV	Li-ion	Panasonic
Buick Regal eAssist	2013	HEV	Li-ion	Hitachi
Cadillac Escalade Hybrid	2013	HEV	NiMH	Primearth
Chevrolet Malibu eco	2013	HEV	Li-ion	Hitachi
Chevrolet Silverado Hybrid	2013	HEV	NiMH	Primearth
Chevrolet Tahoe Hybrid	2013	HEV	NiMH	Primearth
GM Sierra Hybrid	2013	HEV	NiMH	Primearth
GM Yukon Hybrid	2013	HEV	NiMH	Primearth
Acura ILX Hybrid	2013	HEV	Li-ion	Blue Energy
Honda Civic Hybrid	2012	HEV	Li ion	Blue Energy
Honda CR-Z Hybrid	2013	HEV	Li-ion	Blue Energy
Honda Insight	2013	HEV	NiMH	Sanyo
Hyundai Sonata Hybrid	2012	HEV	Li- polymer	LG Chem
Kia Optima Hybrid	2012	HEV	Li-polymer	LG Chem
Infiniti M Hybrid	2013	HEV	Li-ion	AESC
Lexus CT 200h	2013	HEV	NiMH	Primearth
Lexus ES 300h	2013	HEV	NiMH	Primearth
Lexus GS 450h	2013	HEV	NiMH	Primearth
Lexus LS 600h	2013	HEV	NiMH	Primearth
Lexus RX 450h	2013	HEV	NiMH	Primearth
Toyota Avalon Hybrid	2013	HEV	NiMH	Primearth
Toyota Highlander Hybrid	2013	HEV	NiMH	Primearth
Toyota Camry Hybrid	2012	HEV	NiMH	Primearth
Toyota Prius	2013	HEV	NiMH	Primearth
Toyota Prius C	2012	HEV	NiMH	Primearth
Toyota Prius V	2013	HEV	NiMH	Primearth
Audi Q5 Hybrid	2013	HEV	Li-ion	Sanyo
Porsche Cayenne S Hybrid	2012	HEV	NiMH	Sanyo
Porsche Panamera S Hybrid	2012	HEV	NiMH	Sanyo
Volkswagen Jetta Hybrid	2013	HEV	Li-ion	Sanyo
Volkswagen Touareg Hybrid	2013	HEV	NiMH	Sanyo

Notes: Primearth EV Energy, formerly Panasonic EV Energy, is a joint venture between Panasonic and Toyota; Toyota currently owns a controlling stake (80%) in the company.
Blue Energy is a joint venture between GS Yuasa and Honda.
Sanyo is a wholly-owned subsidiary of Panasonic.
It is unclear how the bankruptcy and sale of A123 Systems may impact future production contracts.

Source:
Compiled from public sources by Josh Pihl, Oak Ridge National Laboratory, December 2012.

Flex-Fuel Vehicle Offerings Declined Slightly for Model Year 2012

In the last five years, General Motors and Chrysler have been the front-runners in the number of flex-fuel models offered to the public (includes cars and light trucks). Ford and Nissan have offered flex-fuel models each of the last five years, too. Toyota's first flex-fuel vehicle was offered in 2009. Other manufacturers, like Mercedes-Benz, Mazda, and Saab expanded their flex-fuel offerings in 2011, and in 2012 there were 62 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.

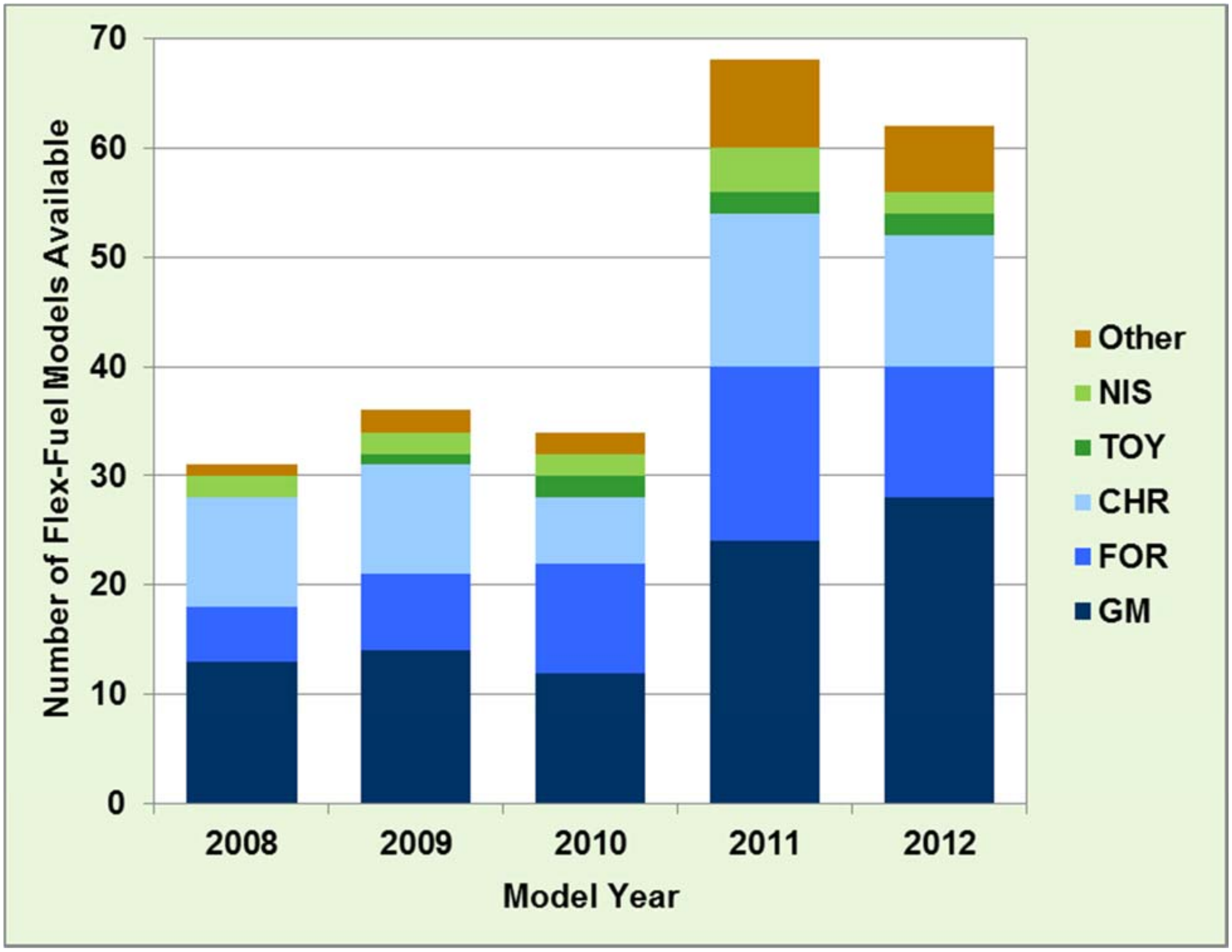
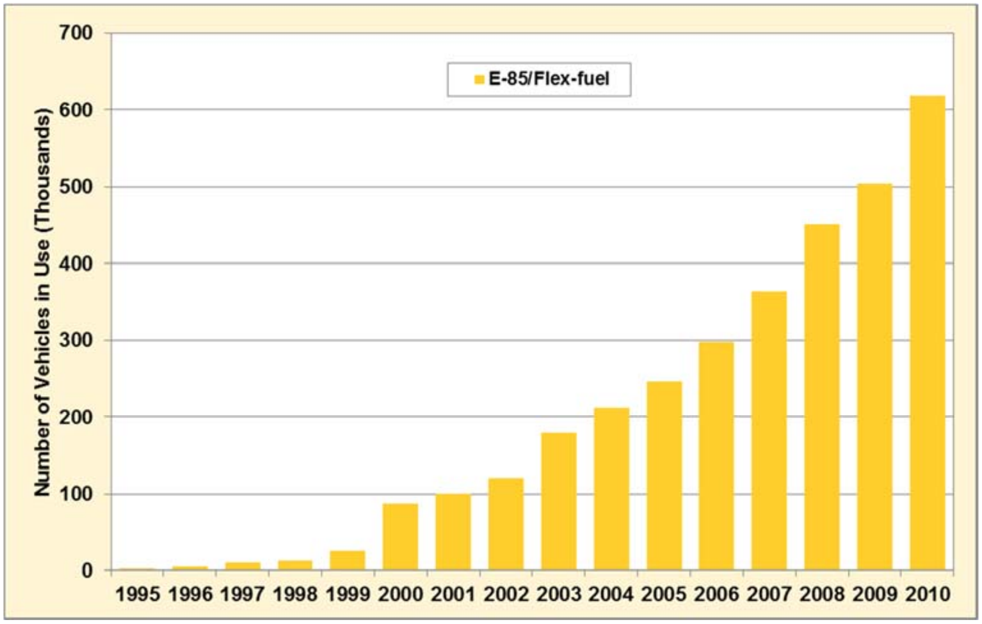


FIGURE 73. Number of Flex-Fuel Models Available, 2008-2012

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 600 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 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.

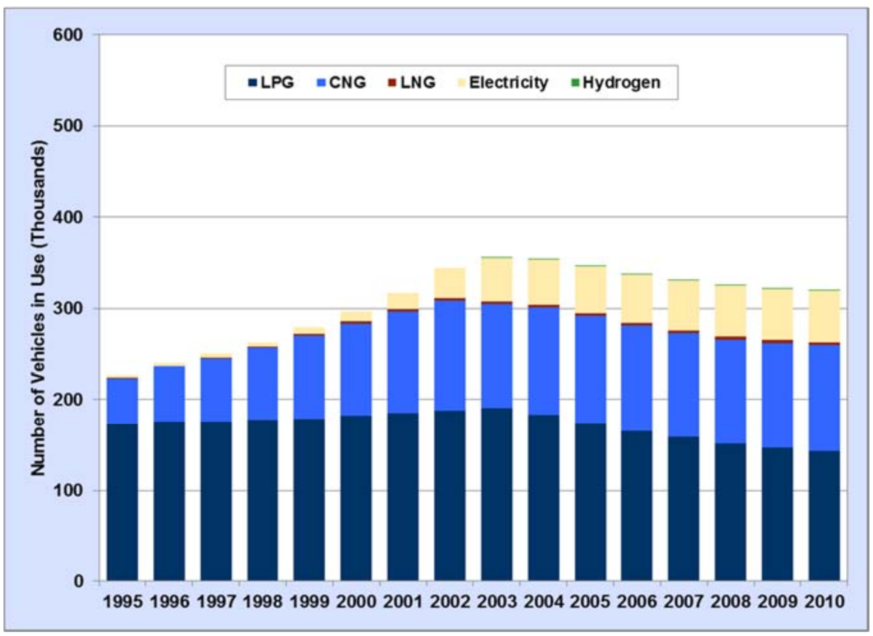


FIGURE 74. Number of Alternative Fuel Vehicles in Use, 1995-2010

Source:
U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/data/#tab/vehicles/data_set/10300

Biofuel Stations Spread Beyond the Midwest

E-85, which is nominally 85% ethanol and 15% gasoline, is sold at 2,535 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 685 stations across the country, with the predominance of stations in the Southeast. Data are as of December 6, 2012.

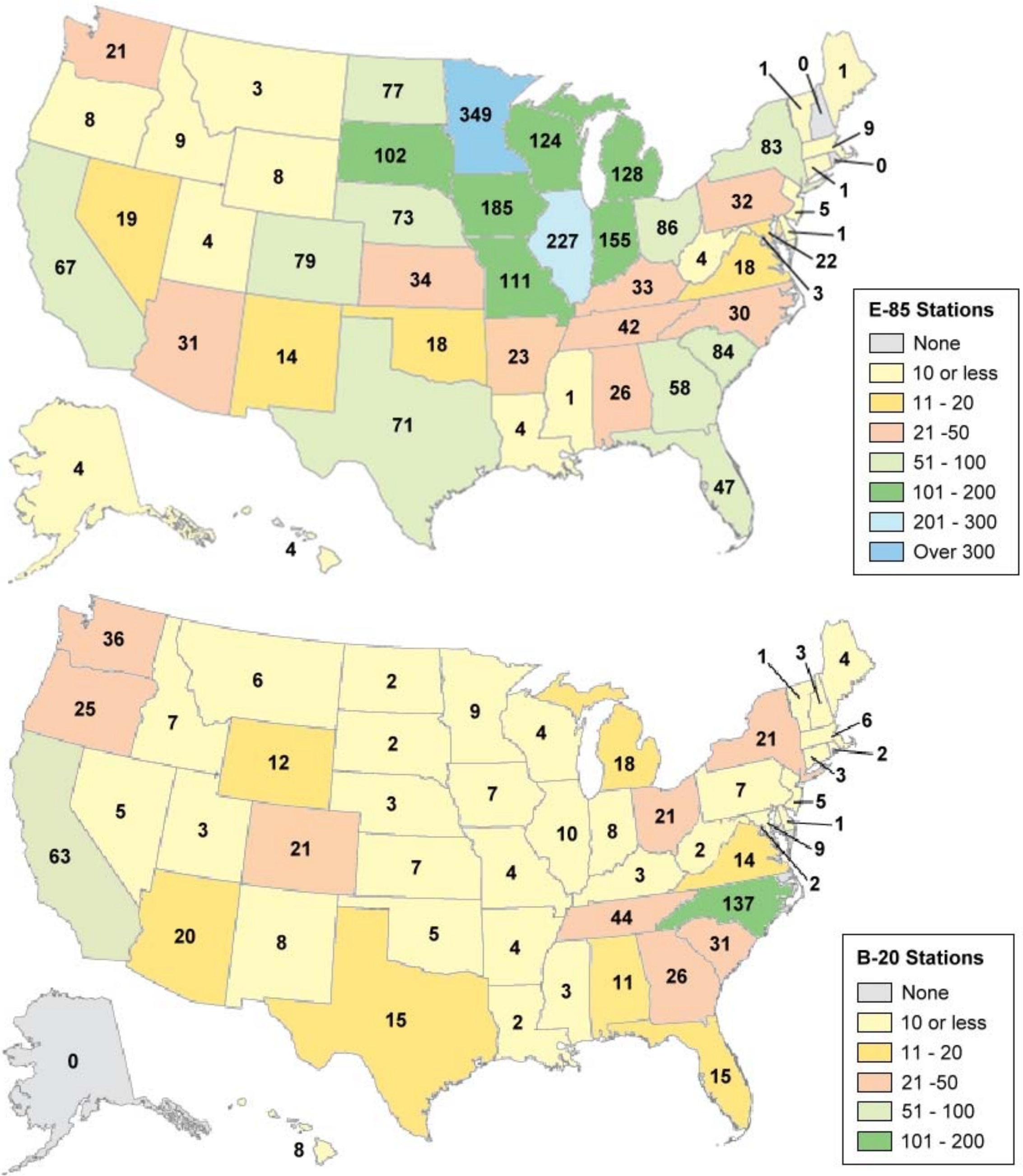


FIGURE 75. Number of E-85 (top) and B-20 Stations by State, 2012

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 2,649 propane stations across the county. Texas and California together comprise 26% of the propane stations. Natural gas, compressed or liquefied, is not as widely available as many other alternative fuels. There are 1,194 stations nationwide. New York and California have the most natural gas stations. Data are as of December 6, 2012.

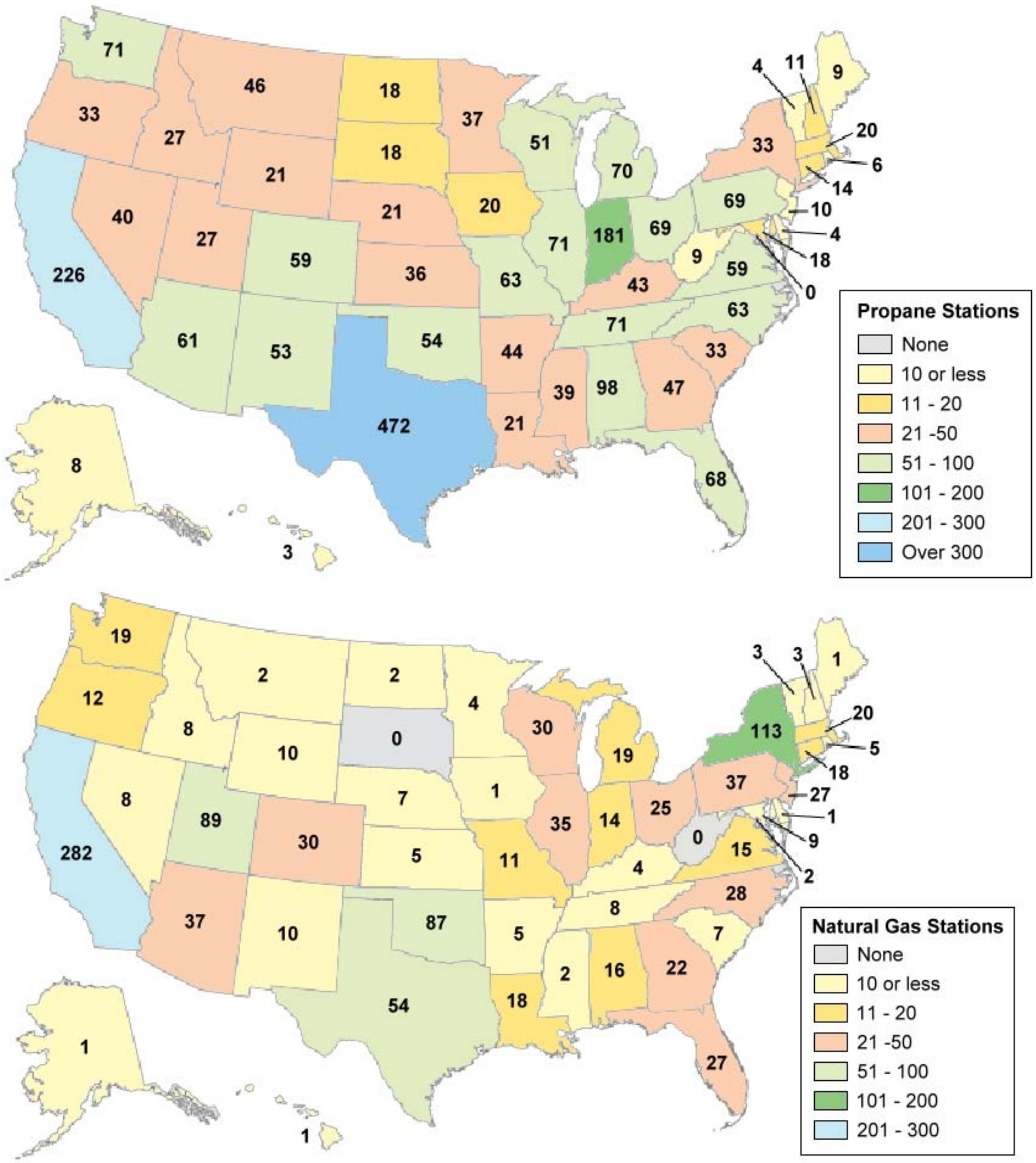


FIGURE 76. Number of Propane (top) and Natural Gas Stations by State, 2012

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 Growing

The number of electric vehicle charging stations has grown due to the debut of highway vehicles that use electricity. At this time, there are more electric stations than any other alternative fuel (14,594 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 December 6, 2012.

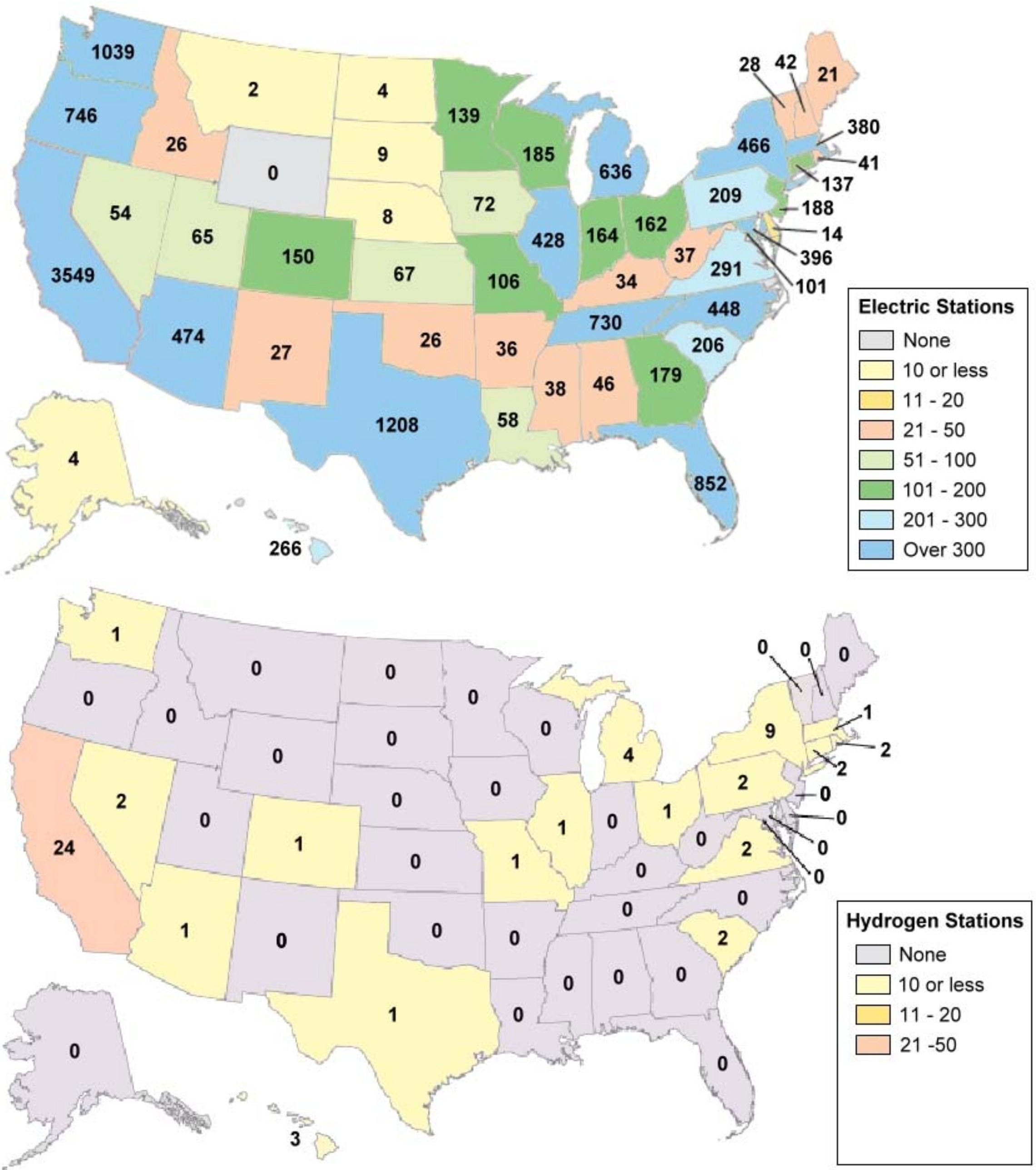


FIGURE 77. Number of Electric (top) and Hydrogen Stations by State, 2012

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 16 million gasoline-equivalent gallons (GGEs) of biofuels (E-85 and biodiesel) were used in 2011. Federal use of other alternative fuels has been less than one million GGEs combined in 2009-2011. Note the large difference in the scales of the two graphs.

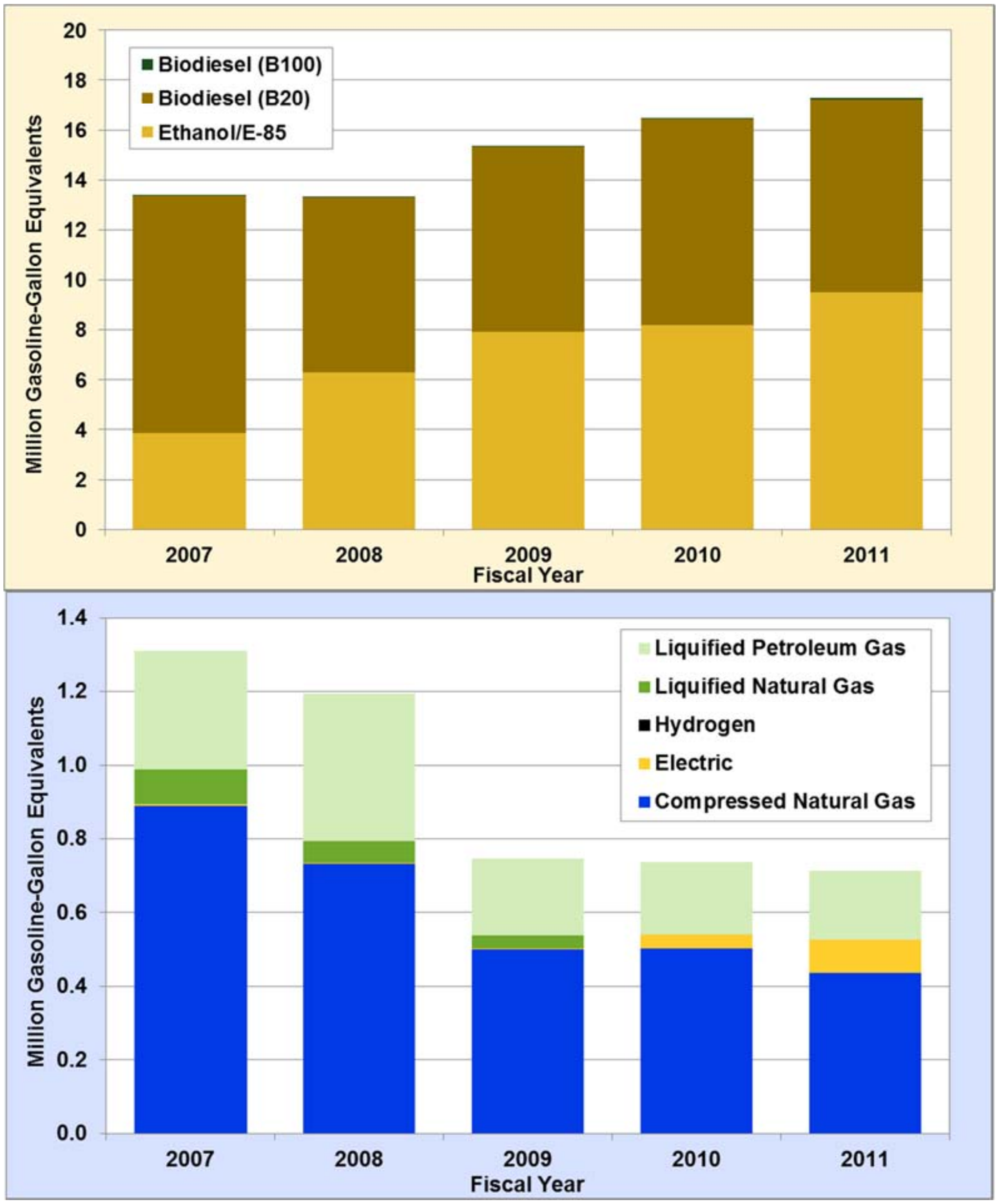


FIGURE 78. Alternative Fuel Use by the Federal Government, 2007-2011

Source:

U.S. General Services Administration, *FY 2011 Federal Fleet Report*, Washington, DC, 2012. 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 2009 and 2011.

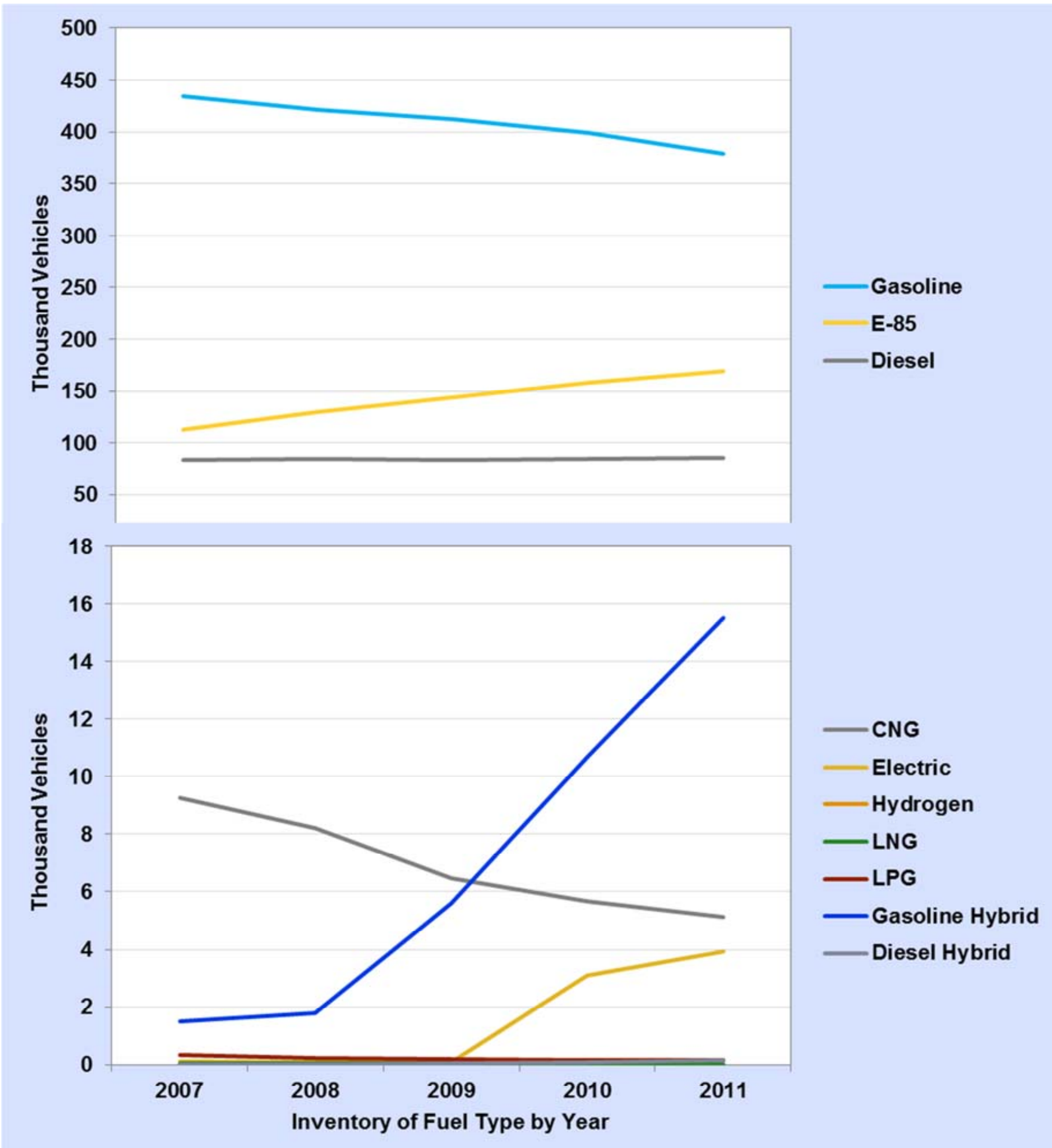


FIGURE 79. Federal Government Vehicles by Fuel Type, 2007-2011

Source:
U.S. General Services Administration, FY 2011 Federal Fleet Report, Washington, DC, 2012. 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 Comcast Corp. uses more than 6,000 alternative fuel vehicles, most of them flex-fuel. Eighty-four percent of Schwan's Home Service vehicles run on propane.

TABLE 16. Top 25 Commercial Fleets Using Alternative Fuel and Advanced Technology Vehicles, 2010

	Company	Total Alt Fuel	CNG*	Propane*	Flex-Fuel	Biodiesel	Hybrid/ Electric*	Total Vehicles	Percent Alt Fuel	Percent Hybrid/Electric
1	Comcast Corp.	6,555	0	0	6,300	0	255	38,240	17%	1%
2	GE Healthcare	6,045	0	0	6,005	0	40	6,045	100%	1%
3	State Farm Mutual Auto Insurance Co.	5,692	0	0	4,857	1	834	12,208	47%	7%
4	Waste Management	5,568	1,144	20	2,100	2,300	4	5,568	100%	0%
5	AT&T	5,196	3,466	0	85	0	1,645	66,977	8%	2%
6	Merck & Co., Inc.	5,190	0	0	5,000	0	190	8,710	60%	2%
7	Schwan's Home Service, Inc.	4,800	0	4,800	0	0	0	5,700	84%	0%
8	Cox Enterprises	4,591	2	0	4,328	0	261	12,098	38%	2%
9	DirecTV Home Services	3,240	0	40	3,200	0	0	6,375	51%	0%
10	Pacific Gas & Electric	3,138	918	0	0	1,547	673	11,768	27%	6%
11	Liberty Mutual Insurance	2,647	0	0	2,647	0	0	2,755	96%	0%
12	Honeywell International, Inc.	2,460	0	0	2,460	0	0	4,003	61%	0%
13	Public Service Enterprise Group (PSE&G)	2,331	60	0	0	1,741	530	4,060	57%	13%
14	VPSI, Inc.	2,296	0	0	2,296	0	0	6,430	36%	0%
15	Johnson & Johnson Services, Inc.	2,269	0	0	0	0	2,269	8,330	27%	27%
16	Xerox Corp.	2,030	0	0	2,000	0	30	5,499	37%	1%
17	Monsanto Co.	2,021	0	0	2,017	0	4	3,409	59%	0%
18	Kellogg Company	2,002	0	0	2,000	0	2	3,900	51%	0%
19	Consolidated Edison Company of New York	1,962	149	149	0	1,450	214	4,561	43%	5%
20	Xcel Energy	1,939	59	0	1,500	368	12	2,925	66%	0%
21	Bristol-Myers Squibb Co.	1,925	0	0	1,875	0	50	2,735	70%	2%
22	PepsiCo, Inc.	1,893	18	85	49	0	1,741	23,722	8%	7%
23	Novartis Pharmaceuticals	1,889	0	0	915	278	696	6,643	28%	10%
24	Florida Power & Light	1,623	0	0	10	1,251	362	1,773	92%	20%
25	Ecolab, Inc.	1,606	0	0	1,538	0	68	7,787	21%	1%

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

Source:
Bobit Publishing, *Automotive Fleet 500*, "Top 50 Green Fleets," 2010.
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 an average of almost 90 pounds per vehicle from 1995 to 2010 while the use of high and medium strength steels has increased by 235 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 58% 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.

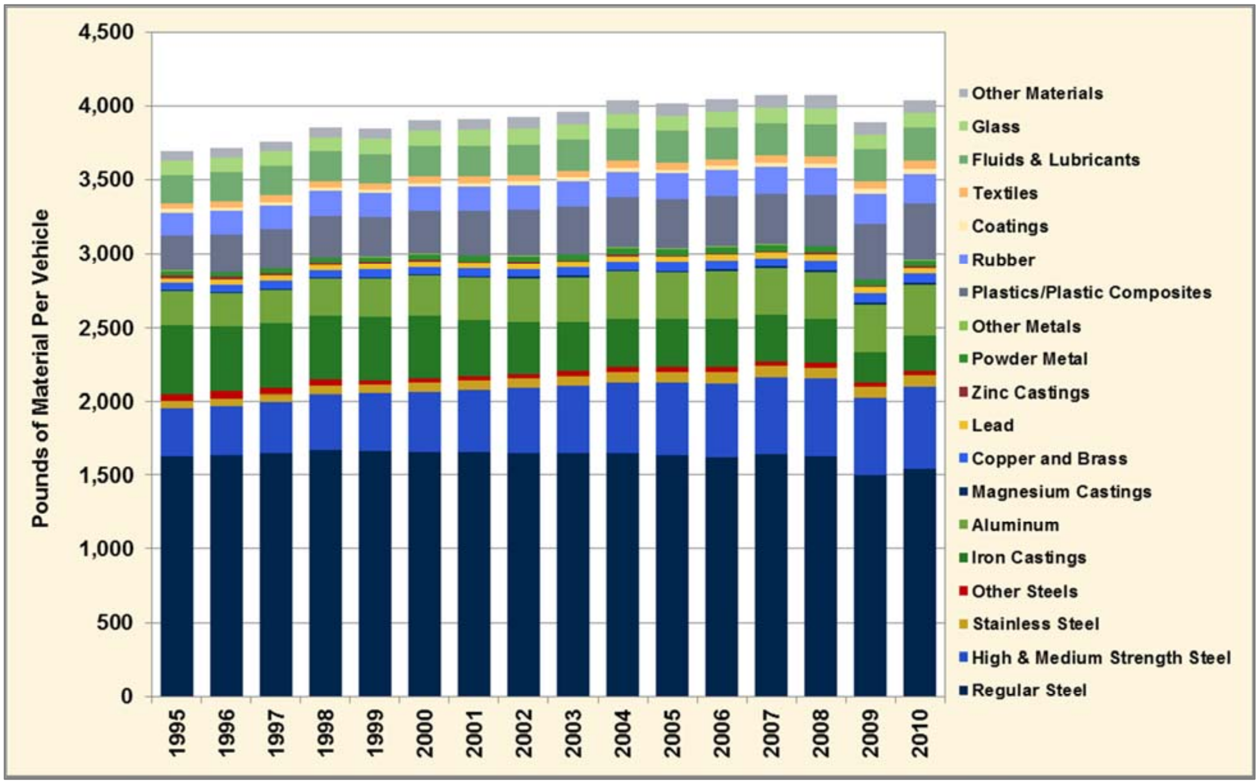


FIGURE 80. Average Materials Content of Light Vehicles, 1995-2010

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.

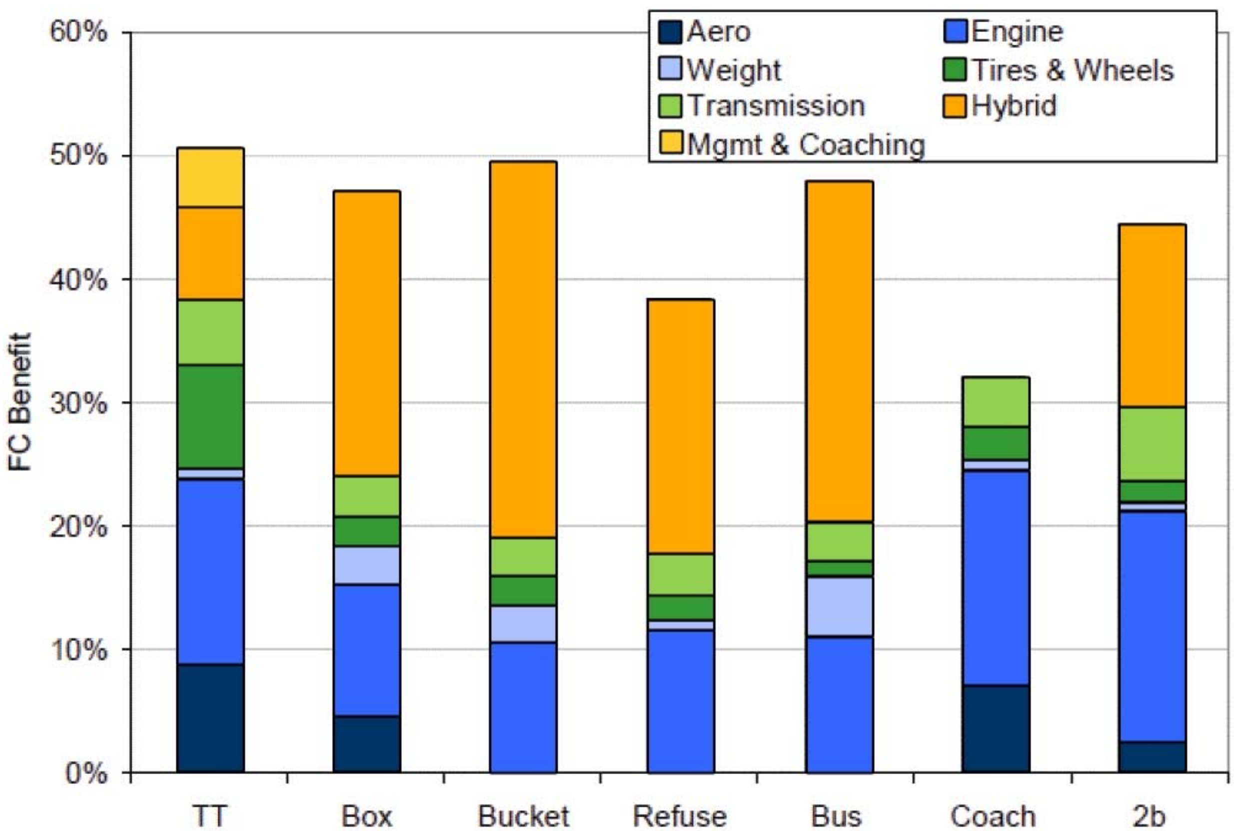


FIGURE 81. Comparison of 2015-2020 New Vehicle Potential Fuel Saving Technologies

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

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, they are given a SmartWay designation.

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.

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 17. SmartWay Certified Manufacturers

Tractors	Trailers	Low Rolling Resistance Tires	
Daimler	Great Dane Trailers	Advance	Hercules
Kenworth	Hyundai Translead	Aeolus	Kumho
Mack	Manac, Inc.	Arisun	Leao
Navistar	Stoughton Trailers, LLC	Atlas	Linglong
Peterbilt	Strick Trailers, LLC	BF Goodrich	Michelin
Volvo	Utility Trailer Manufacturing Company	Bridgestone	Roadmaster (Cooper)
	Vanguard National Trailer Corporation	Continental	Roadone
	Wabash National Corporation	Double Coin	Roadpro
	Wilson Trailer Co.	Dunlop Tire	Sailun
		Falken	Samson
		Firestone	Sumitomo
		General	Toyo Tires
		Geostar	Triangle
		Goodride	Westlake
		Goodyear	Yokohama
		GT Radial	Wanli
		Hankook	

Source:
U.S. Environmental Protection Agency, SmartWay Technology Program.

http://www.epa.gov/smartway /index.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 18. 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 18. 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.

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 19. Drivetrain Technologies

Hybrid Technologies	
Integrated Starter/Generator	Often referred to as "Start-Stop" or "Mild Hybridization", this system shuts off the engine during deceleration and when stopped but instantly restarts the engine when the accelerator is depressed. This type of system can be integrated with regenerative breaking. General Motors first introduced this technology in 2008 with the Malibu Hybrid and is implementing an advanced form of this technology which they have termed eAssist beginning with 2011 Buick modes.
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 well suited to hybrid vehicles because they allow 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 8 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 82. 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 83. Hybrid Bus

FIGURE 84. 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: (Pictures from the National Renewable Energy Laboratory.)

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

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.

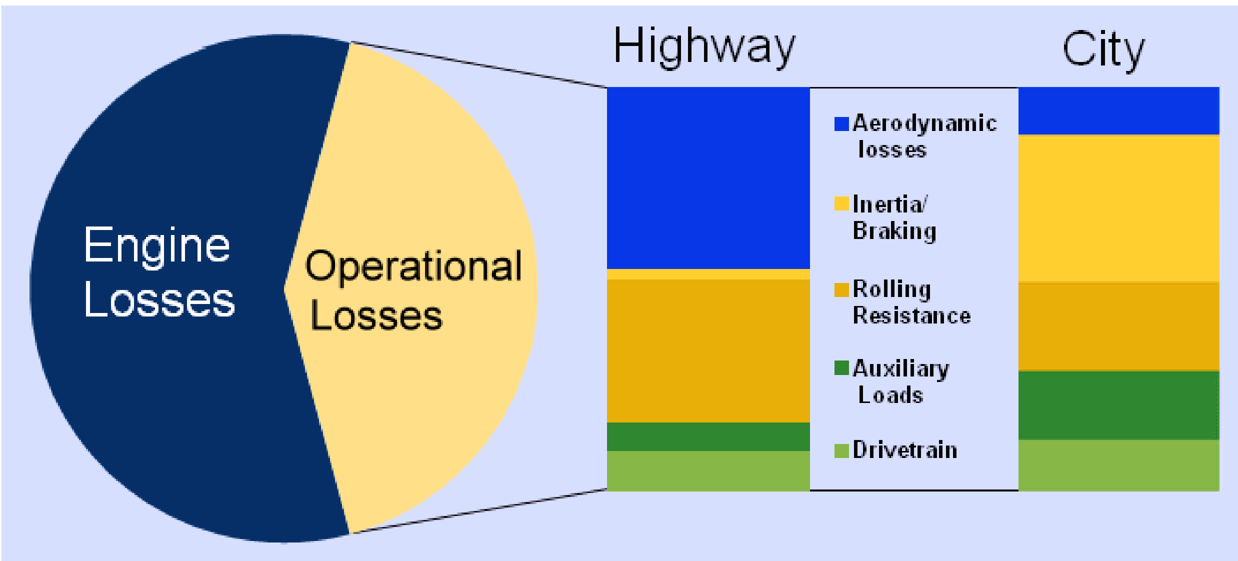


FIGURE 85. Class 8 Truck-Tractor Energy Losses

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

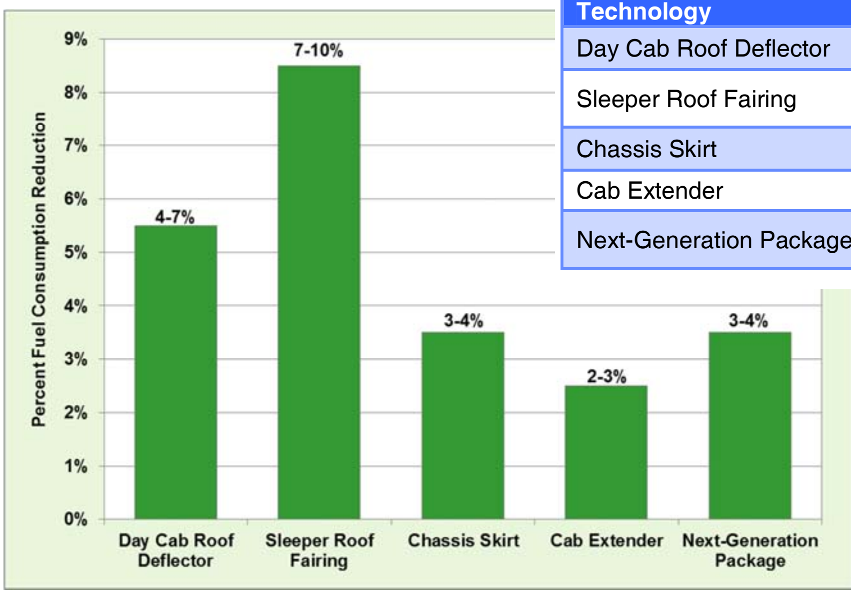


FIGURE 86. Fuel Consumption Reduction Rate, Approximate Cost, and Industry Adoption Rate for Aerodynamic Technologies

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.

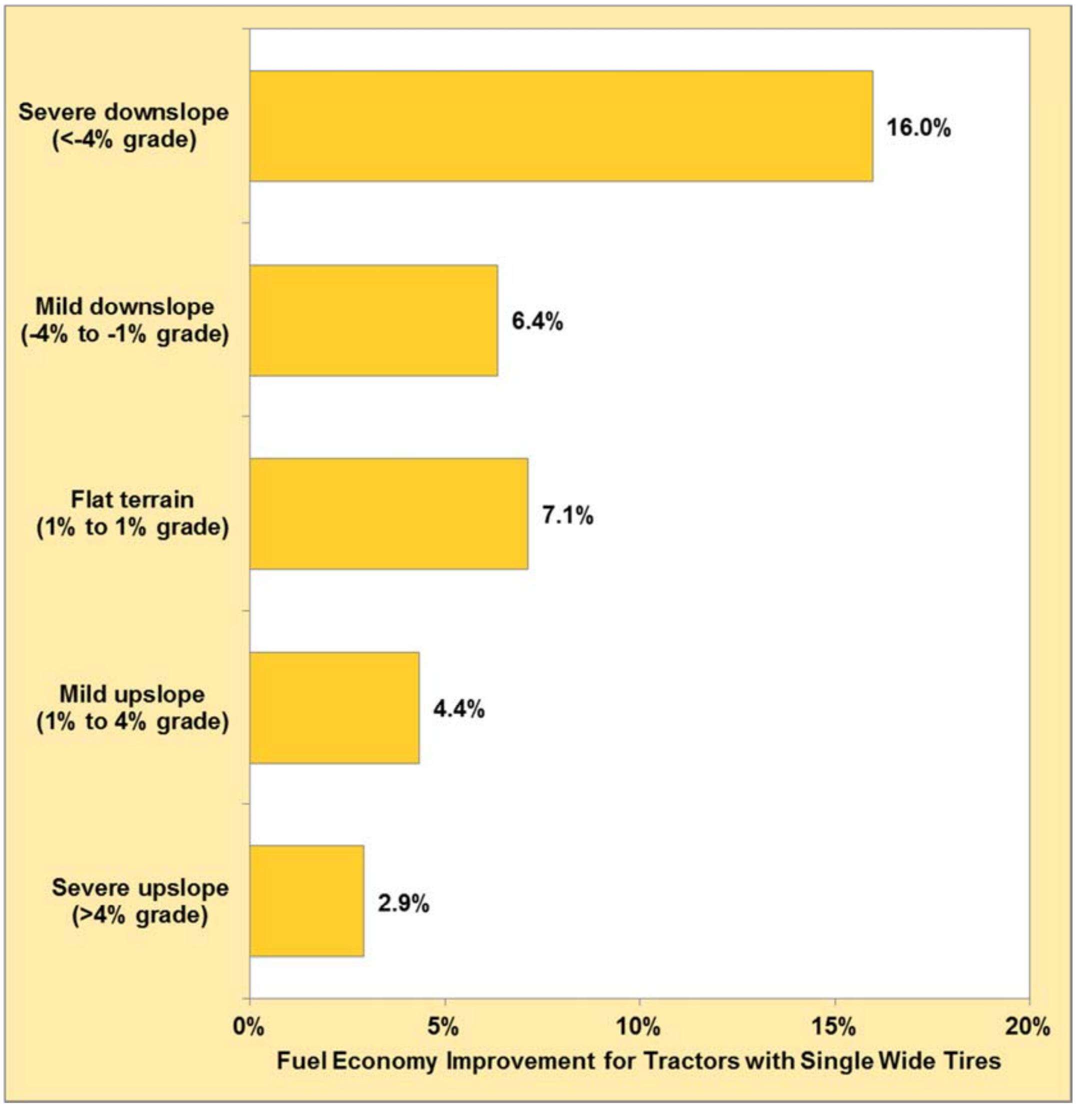


FIGURE 87. Fuel Economy Improvement for Class 8 Tractors with Single Wide Tires

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 four plug-in hybrid-electric vehicle models that currently qualify for a credit, and 16 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 Ford C-MAX Engeri have lower maximums than the other vehicles.

TABLE 20. Federal Government Tax Incentives for Advanced Technology Vehicles

Vehicle Type	Calendar Year in which the Vehicle was Purchased	Maximum Credit Amount	Vehicles Currently Eligible for a Tax Credit
Plug-in Hybrid-Electric Vehicles	2010-on	$7,500	2011-2013 Chevrolet Volt 2012 Fisker Karma Sedan
		$2,500	2012 Toyota Prius Plug-in Hybrid
		$3,751	2013 Ford C-MAX Energi
Electric Vehicles	2010 - on	$7,500	2012 AMP GCE Electric Vehicle 2012 AMP MLE 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 2012-2013 Ford Focus EV 2011-12 Ford Transit Connect EV 2012 Mitsubishi i-MiEV 2011-12 Nissan Leaf 2011 Smart ForTwo EV 2012 Tesla Model S 2008-2011 Tesla Roadster 2011 Think City EV 2012 Toyota RAV4 EV 2011 Wheego LiFe

Source:
U.S. Department of Energy and U.S. Environmental Protection Agency, www.fueleconomy.gov website, November 2012. http://www.fueleconomy.gov/feg/taxcenter.shtml

EPA and NHTSA Redesigned Window Stickers for 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); however, some automakers voluntarily began using the new labels for the 2012 MY.

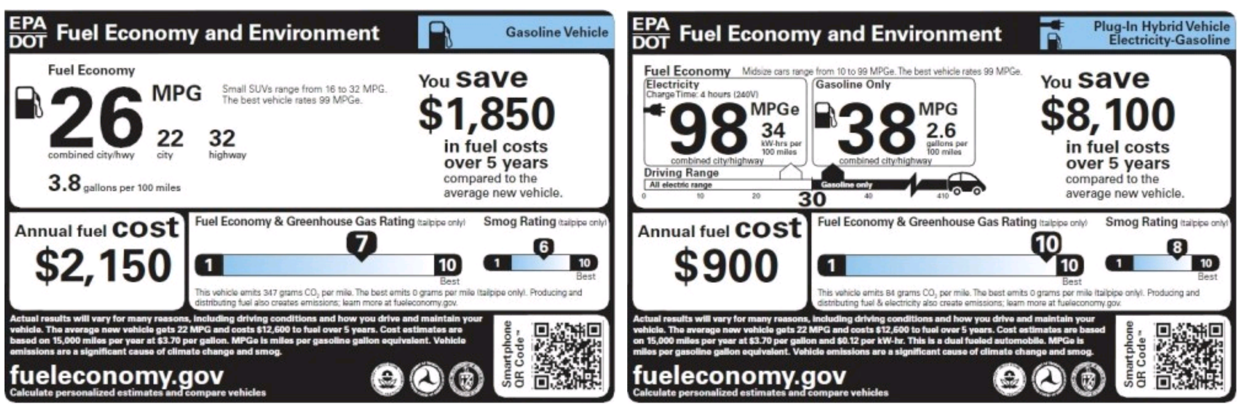


FIGURE 88. Window Stickers for MY 2013 Cars and Light Trucks

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/

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.

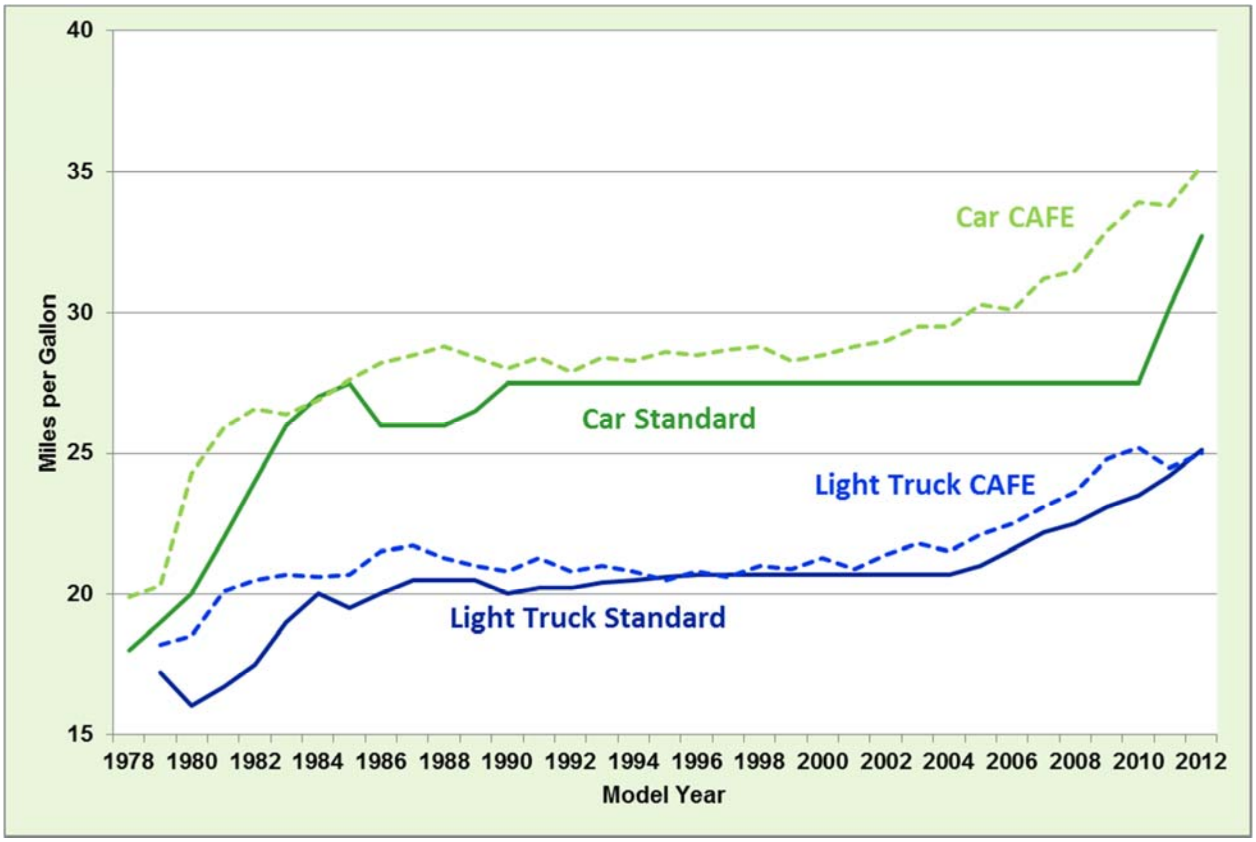


FIGURE 89. CAFE for Cars and Light Trucks, 1978-2012

Note: Light truck standards for MY 2008-2010 are based on "unreformed" standards. MY 2011 and 2012 data are estimates based on product plans.

Source:
National Highway Traffic Safety Administration, "Summary of Fuel Economy Performance," October 2012.
http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/Oct2012_Performance_Summary_Report.pdf

Corporate Average Fuel Economy: Manufacturers' Ups and Downs

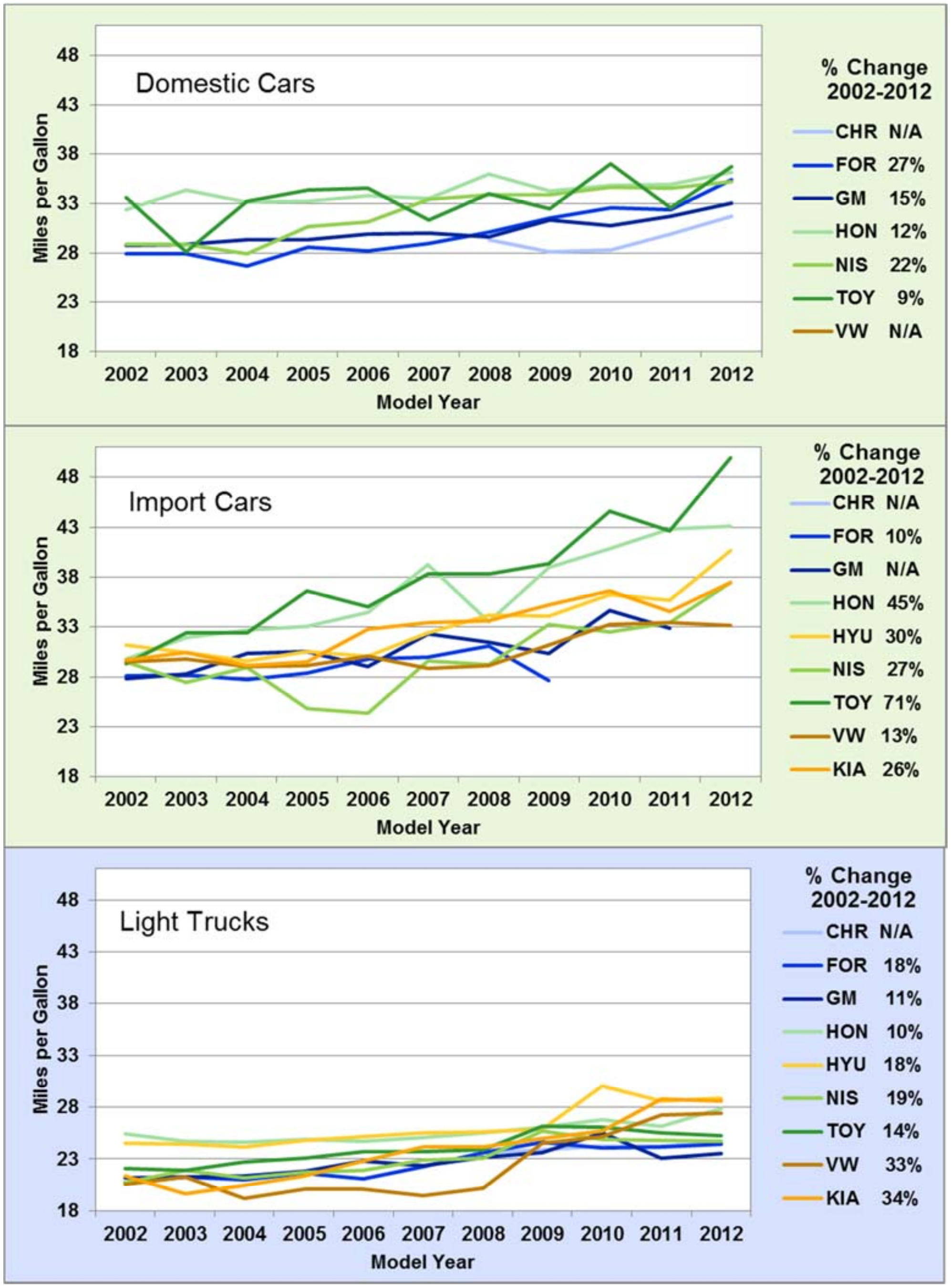


FIGURE 90. CAFE for Domestic and Import Cars and Light Trucks by Manufacturer, 2002-2012

Note: Data for Chrysler begin in 2008 after the merger with Daimler ended. Ford has no import cars past 2009. General Motors has no import cars in 2012. Volkswagen domestic cars begin in 2012.

Source:
National Highway Traffic Safety Administration, "Summary of Fuel Economy Performance," October 2012. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/Oct2012_Performance_Summary_Report.pdf

Corporate Average Fuel Economy: Flex-Fuel Vehicle Credits

The Alternative Motor Fuels Act (AMFA) of 1988 enabled manufacturers to increase their calculated Corporate Average Fuel Economy (CAFE) by producing flex-fuel vehicles. The act encourages the production of motor vehicles capable of operating on alternative fuels. It gives a manufacturer a credit of up to 1.2 miles per gallon (mpg) toward the manufacturer's CAFE. GM and Ford have taken full advantage of the credit in both cars and light trucks for the last five years. Chrysler received the maximum credit for light trucks beginning in model year (MY) 2008, but did not receive the maximum credit for cars until MY 2011. Nissan is the only other manufacturer to receive AMFA credits. In MY 2008 Nissan received the maximum credit for light trucks, but has not produced enough flex-fuel trucks since then to receive the 1.2 mpg maximum.

TABLE 21. Flex-Fuel Vehicle CAFE Credits by Manufacturer, 2008-2012
(miles per gallon credit)

Cars				
Model Year	Chrysler	Ford	GM	
2008	0.9	1.2	1.2	
2009	0.3	1.2	1.2	
2010	0.3	1.2	1.2	
2011	1.2	1.2	1.2	
2012	1.2	1.2	1.2	
Light Trucks				
Model Year	Chrysler	Ford	GM	Nissan
2008	1.2	1.2	1.2	1.2
2009	1.2	1.2	1.2	0.7
2010	1.2	1.2	1.2	1.1
2011	1.2	1.2	1.2	1.0
2012	1.2	1.2	1.2	1.1

Note: The maximum credit available is 1.2 miles per gallon.

Source:
National Highway Traffic Safety Administration, "Fuel Economy Performance With and Without AMFA," March 2012.
http://www.nhtsa.gov/staticfiles/rulemaking/pdf/CAFE_AMFA_2003-2012_PMY_3-1-2012.pdf

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 augural 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.

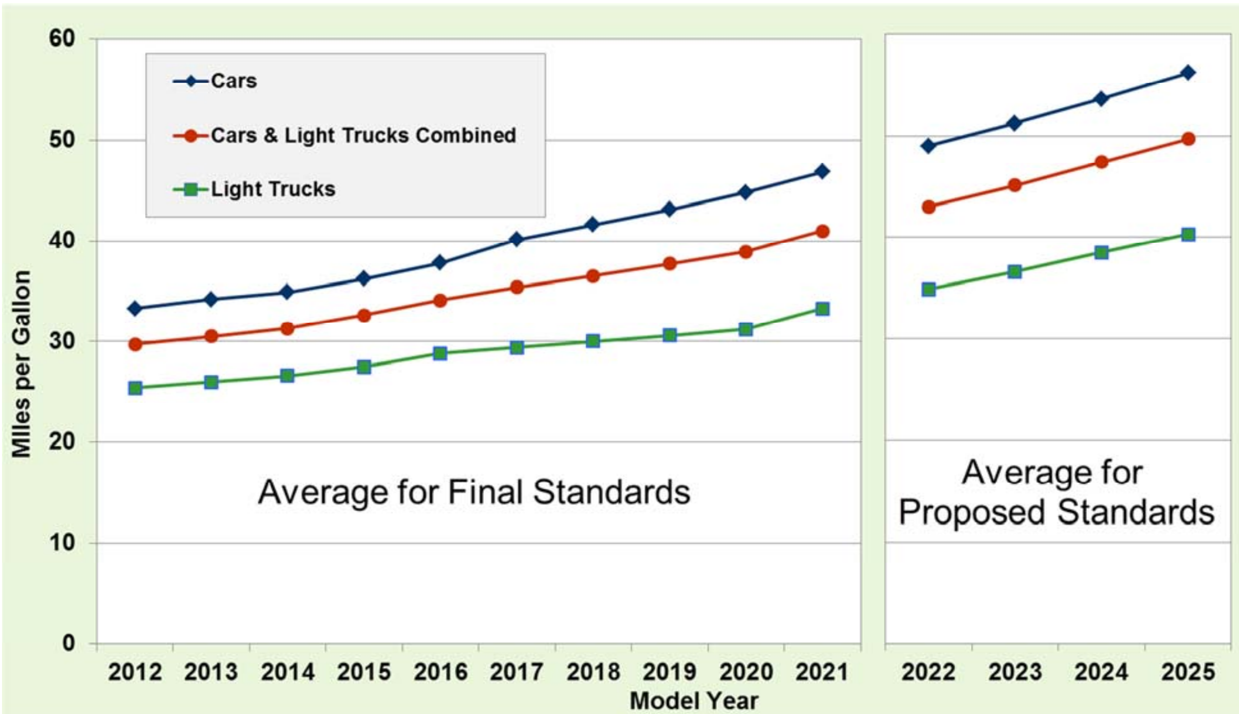


FIGURE 91. Average CAFE Standards for MY 2012-2025

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.

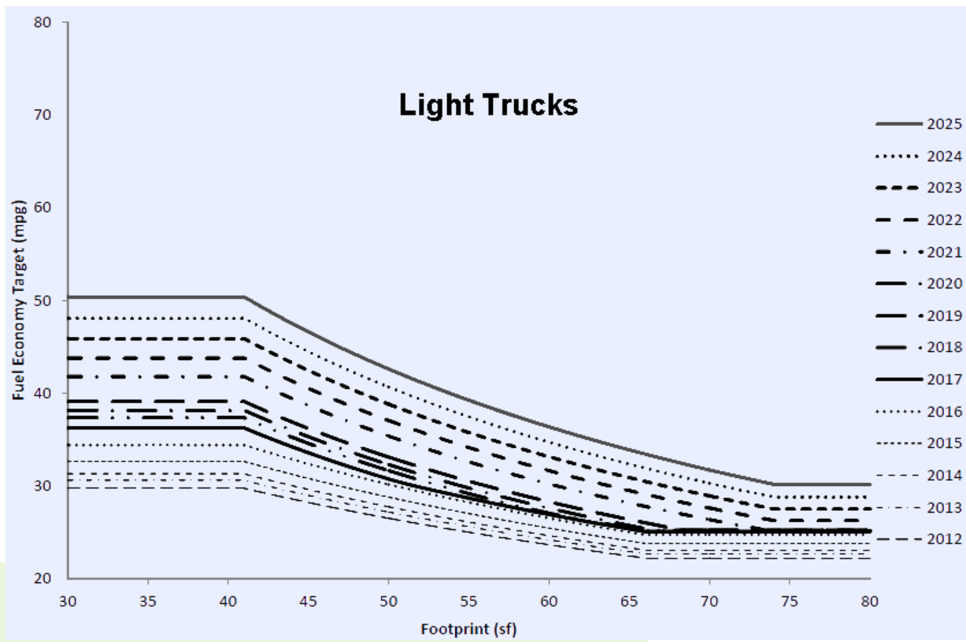
Sources:

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.



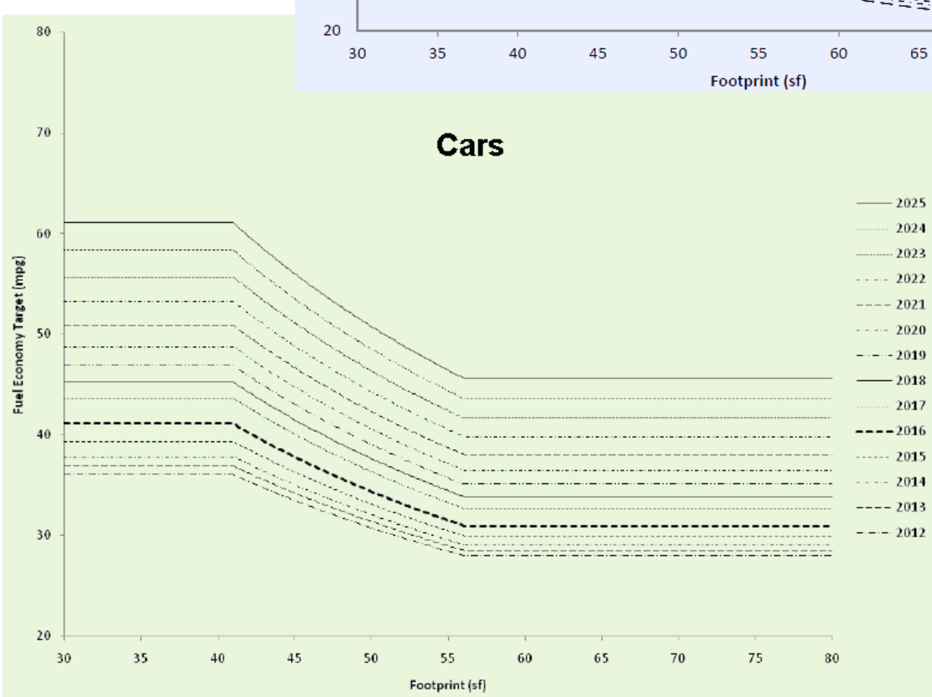


FIGURE 92. CAFE Standards for Cars and Light Trucks, MY 2012-2025

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) 2011 was 45.8 square feet (sq. ft.), up just 0.2 sq. ft. from MY 2008. The average footprint for light trucks was higher – 55.9 in 2011. The table shows selected vehicles and their MY 2012 footprint.

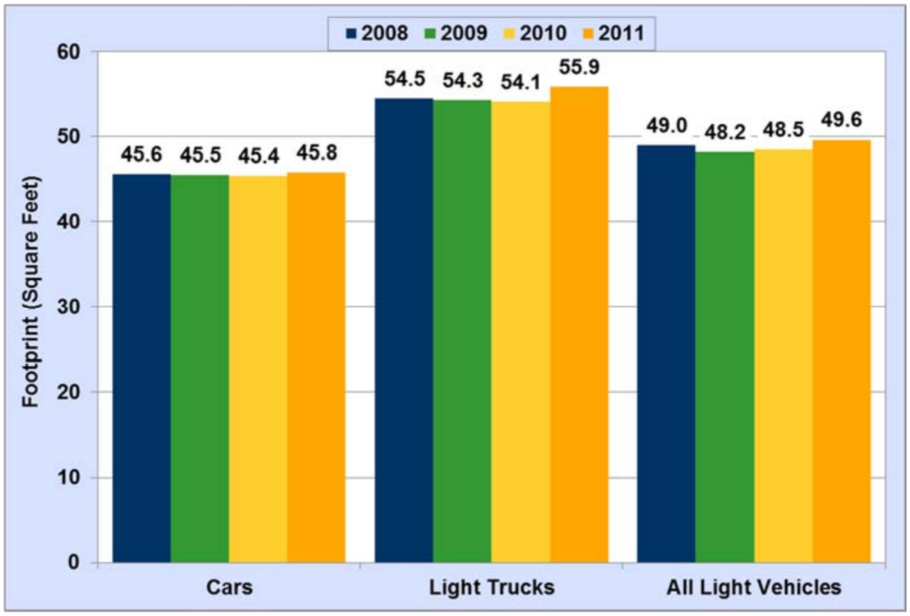


FIGURE 93. Average Vehicle Footprint, MY 2008-2011

TABLE 22. 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 2011*, EPA420-S-12-001a, March 2012. 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 2011, 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.

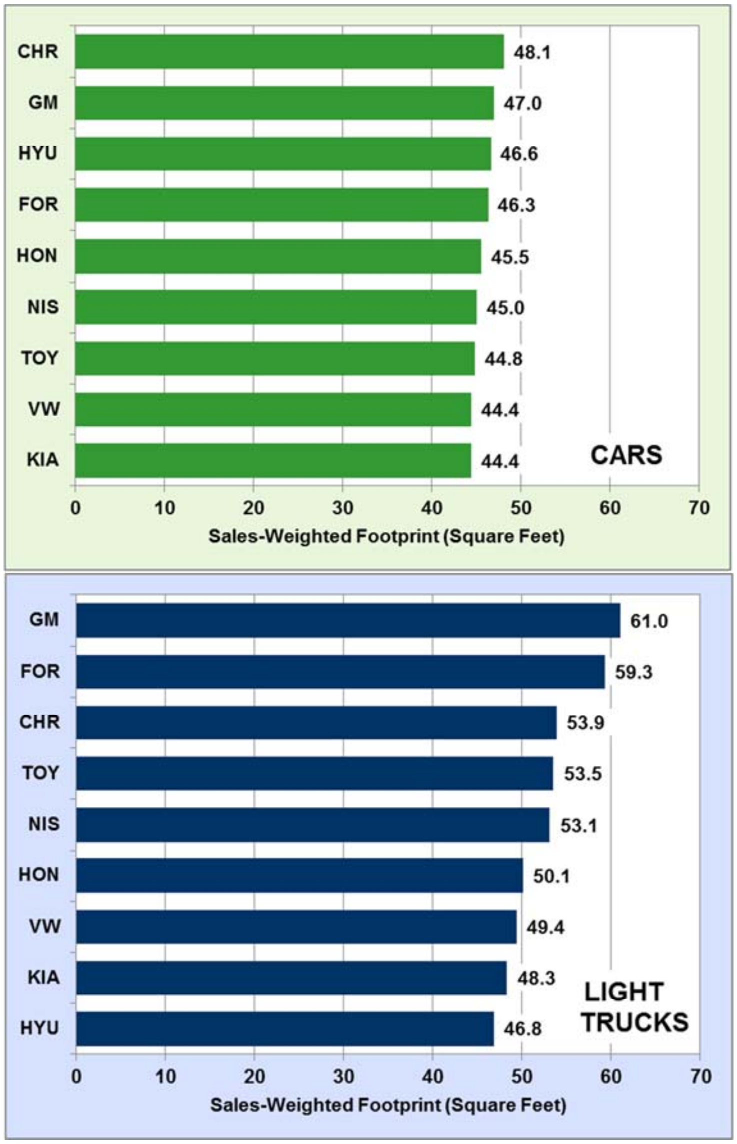


FIGURE 94. Car and Light Truck Footprint by Manufacturer, 2011

Sources:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

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

For All Light Vehicles, General Motors Has the Highest Footprint Due to a Large Share of Light Trucks

General Motors (GM) has a sales-weighted average footprint of 54.5 square feet in model year (MY) 2011, which is the largest average of all the manufacturers listed. The share of light trucks sold by GM in MY 2011 was 53.4%, which was second only to Chrysler. Manufacturers with higher footprints would have the least stringent standards when the new Corporate Average Fuel Economy standards begin in MY 2012.

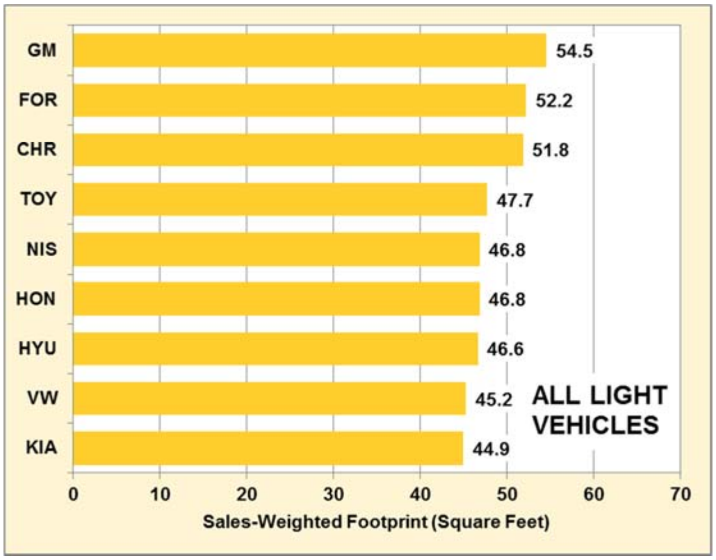


FIGURE 95. Light Vehicle Footprint by Manufacturer, MY 2011

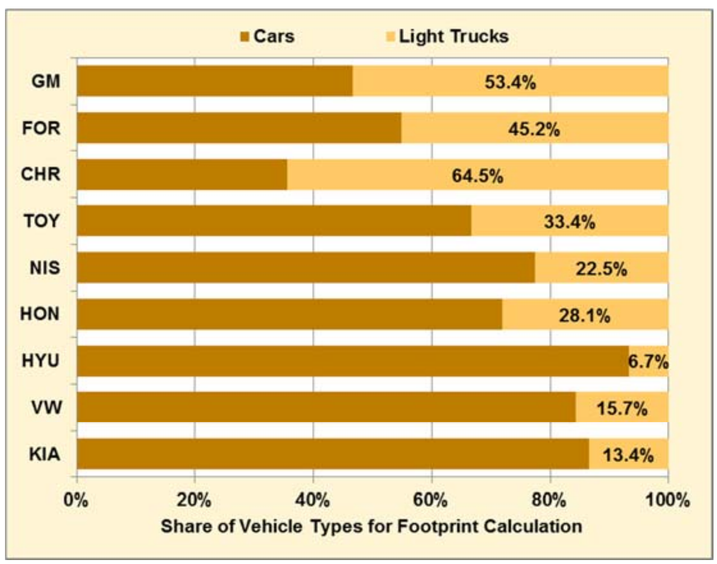


FIGURE 96. Vehicle Type Shares for Footprint Calculation, MY 2011

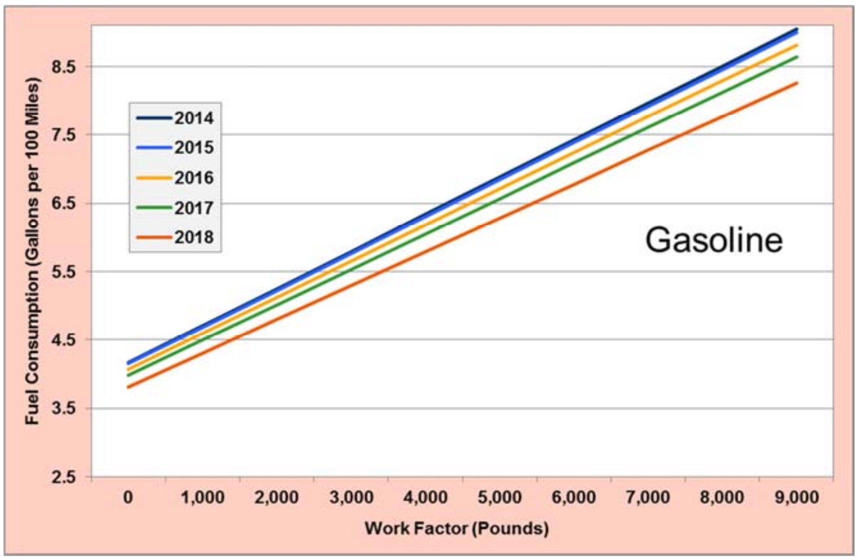
Sources:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2011*, EPA420-S-12-001a, March 2012. http://www.epa.gov/otaq/fetrends.htm

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

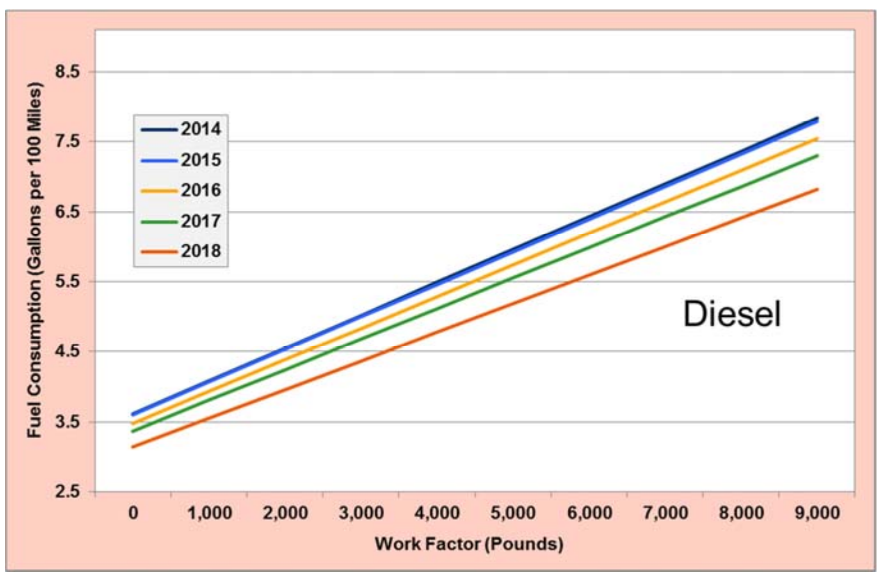
Fuel Consumption Standards Set for Heavy Pickups and Vans

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 97. 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. 25324 - 25728.

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).

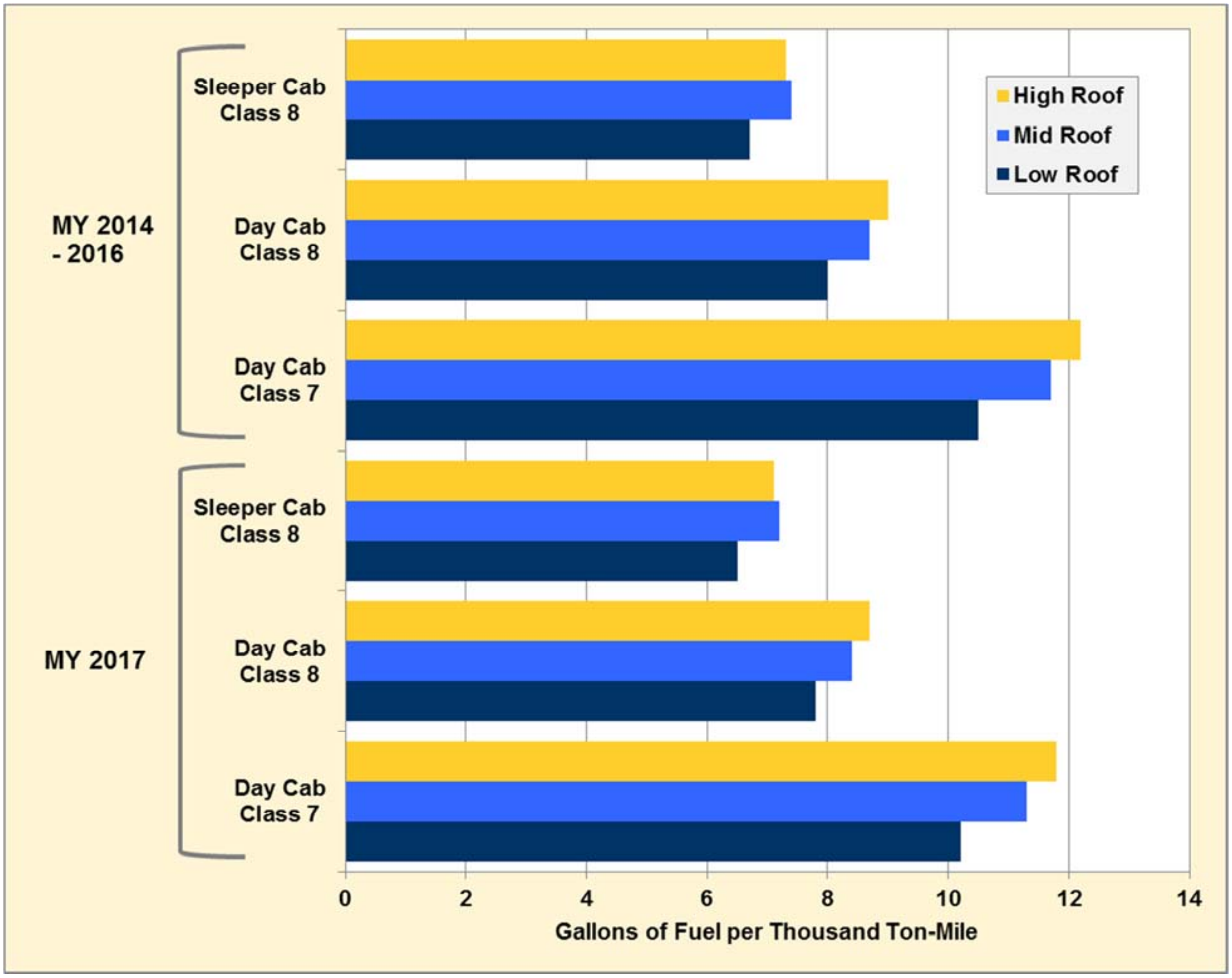


FIGURE 98. Fuel Consumption Standards for Combination Tractors, MY 2014-2017

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. 25324 - 25728.

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).

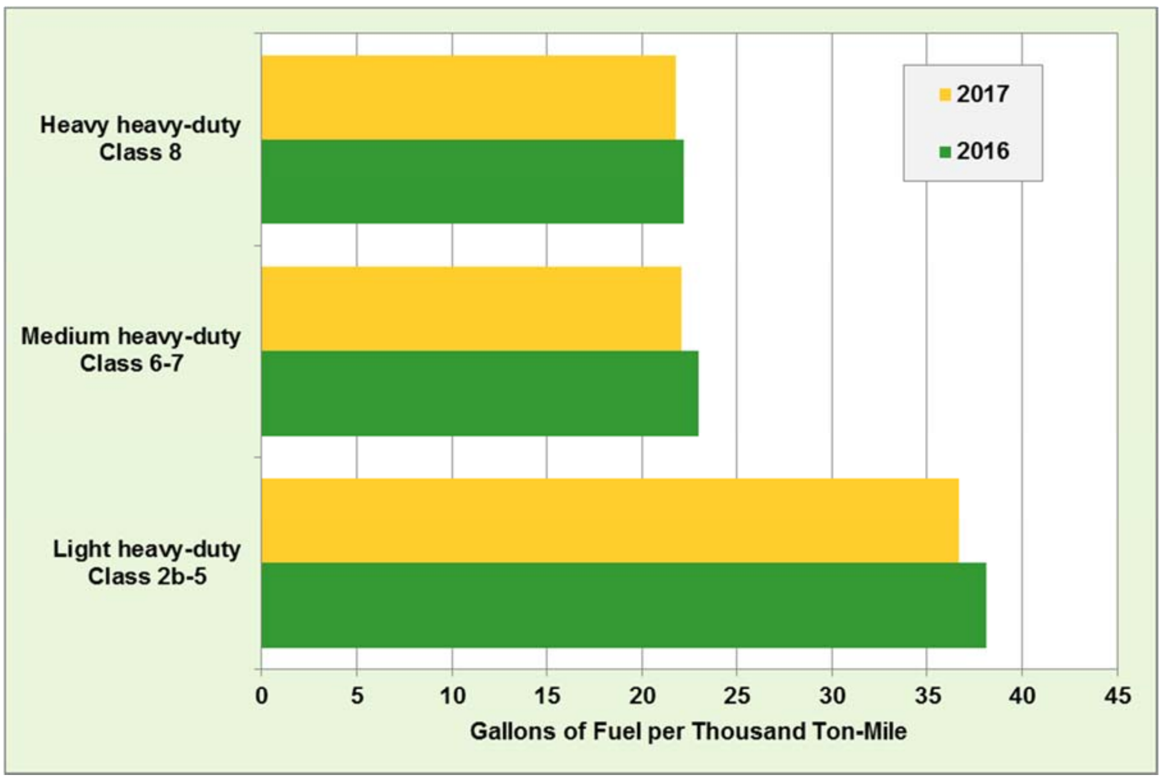


FIGURE 99. Vocational Vehicle Fuel Consumption Standards, MY 2016 and 2017

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. 25324 - 25728.

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.

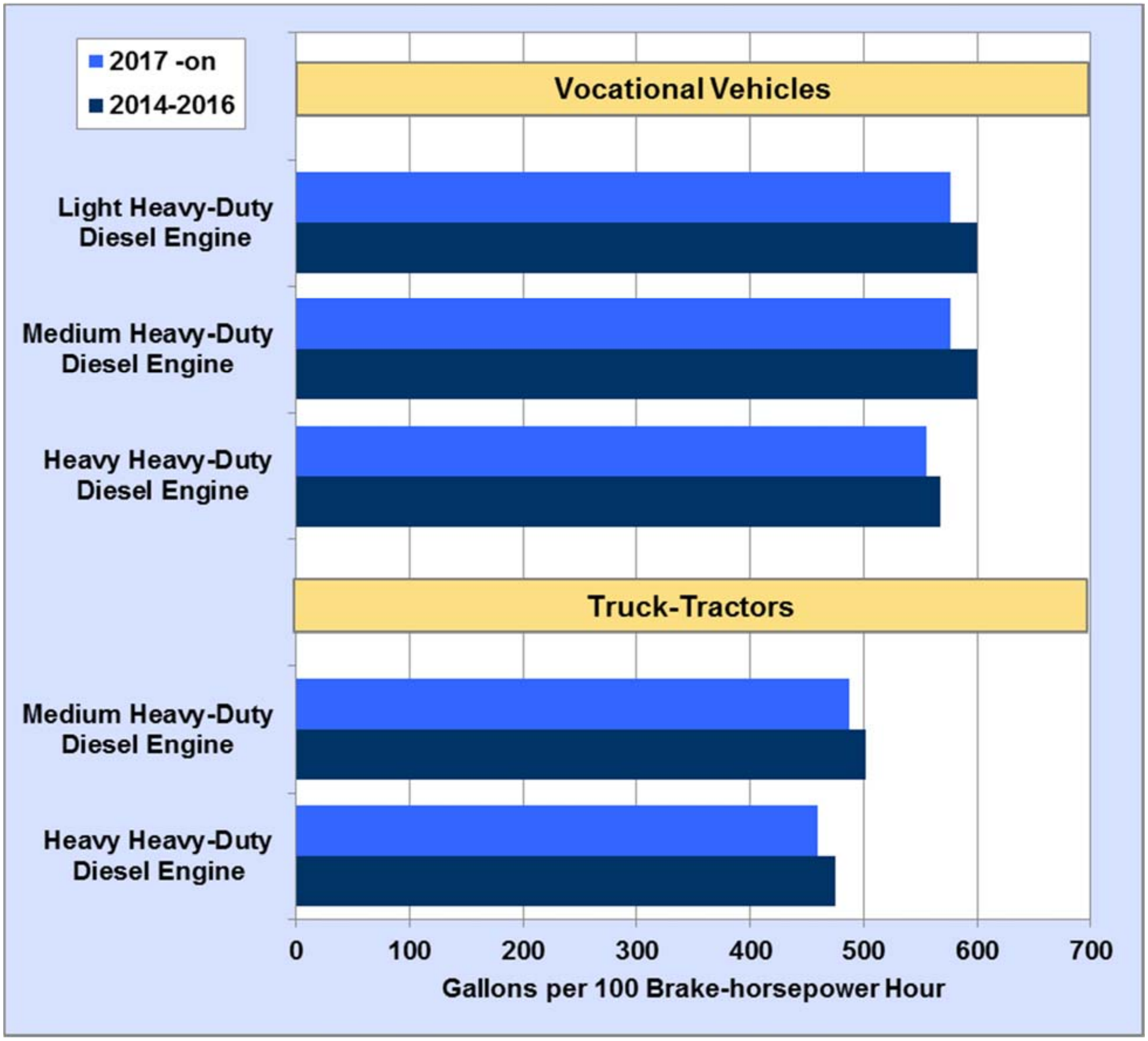


FIGURE 100. Fuel Standards for New Diesel Engines, MY 2014-On

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. 25324 - 25728.

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 400-pound 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 400 lbs. (dark green). Other States have a 400-lb. weight allowance which is granted by enforcement personnel (light green). Massachusetts has legislation pending at this time while another six states plus the District of Columbia have not adopted the weight exemption (gold).

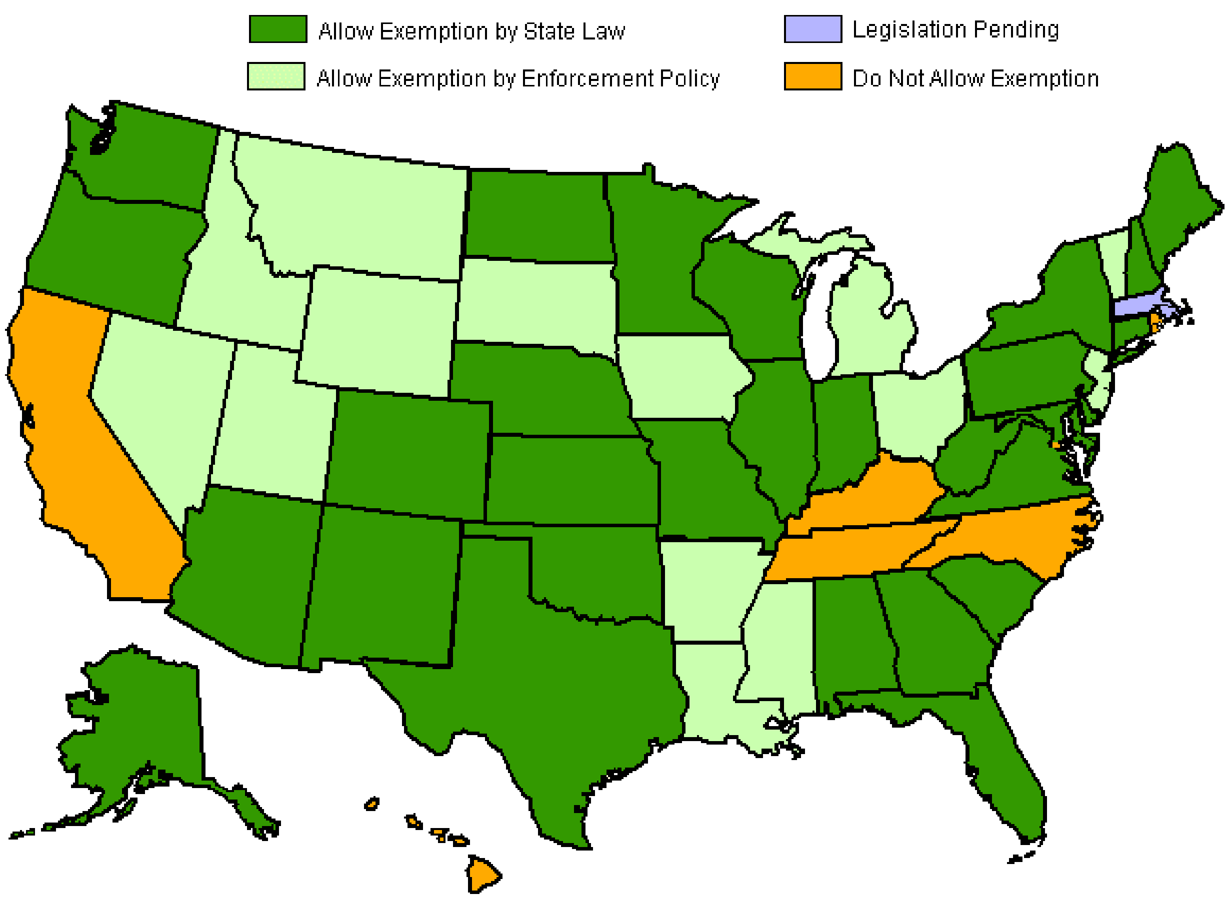


FIGURE 101. States Adopting 400-Pound Weight Exemption for Idling Reduction Devices, 2012

Source:

U.S. Department of Energy, Energy Efficiency & Renewable Energy, *National Idling Reduction News*, August 2012. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/idling_news/aug12_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
- 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
- DC Power Solutions APU
- Diamond Power Systems
- Dometic Corporation
- Driver Comfort System
- EnergyXtreme
- Freightliner
- Glacier Bay
- 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

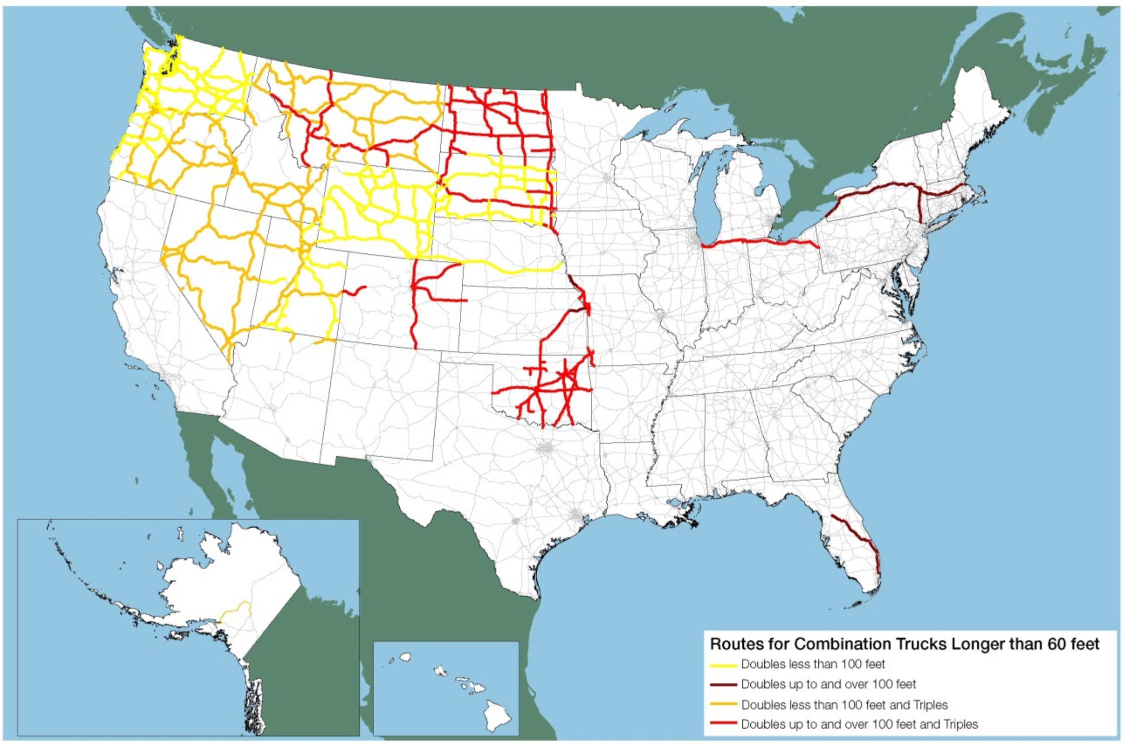
Figure 102. Idle Reduction Technologies Which Are Granted Exemption from Federal Excise Taxes

Source:
U.S. Environmental Protection Agency, SmartWay Technology Program. October 2012. http://www.epa.gov/smartway/technology/excise-tax.htm#exempt

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.

Permitted Longer Combination Vehicles on the National Highway System: 2010



Note: Empty Triples are allowed on I-80 in Nebraska.

Source: U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, special compilation by the Freight Operations and Technology Team, 2010.

FIGURE 103. Routes where Longer Combination Vehicles Are Permitted, 2010

Source:

U.S. Department of Transportation, Federal Highway Administration, *Freight Facts and Figures 2011,* FHWA-HOP-12-002, November 2011. 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.

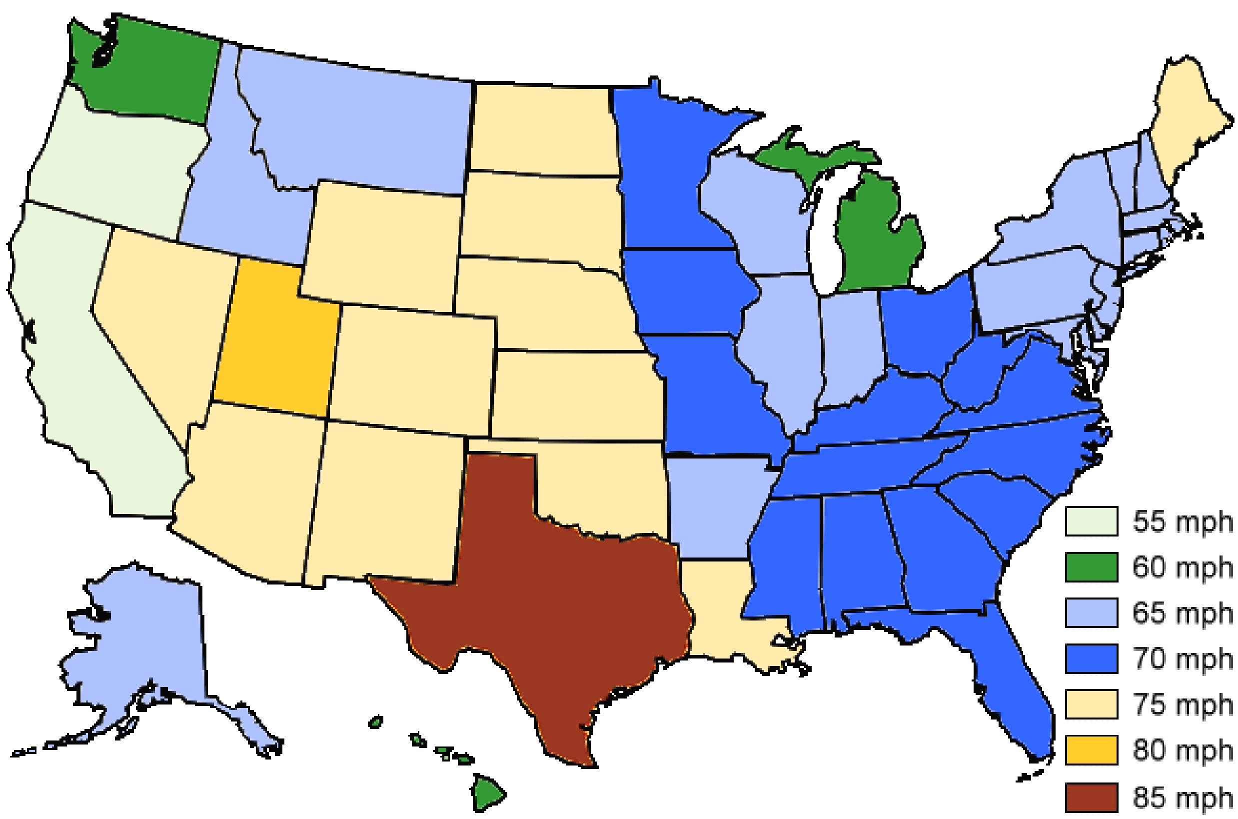


FIGURE 104. Maximum Daytime Truck Speed Limits by State, 2012

Source:
Insurance Institute for Highway Safety, Highway Loss Data Institute, October 2012.
http://www.iihs.org/laws/speedlimits.aspx

Fuel Sulfur Standards Provide Cleaner Gasoline and Diesel

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., and in the case of diesel fuel, highway and non-highway fuel was held to separate standards. 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 (15 ppm) and by 2010, all diesel fuel must be ultra-low sulfur. The standards for large refineries are shown here; see the Environmental Protection Agency website for additional details on sulfur standards.

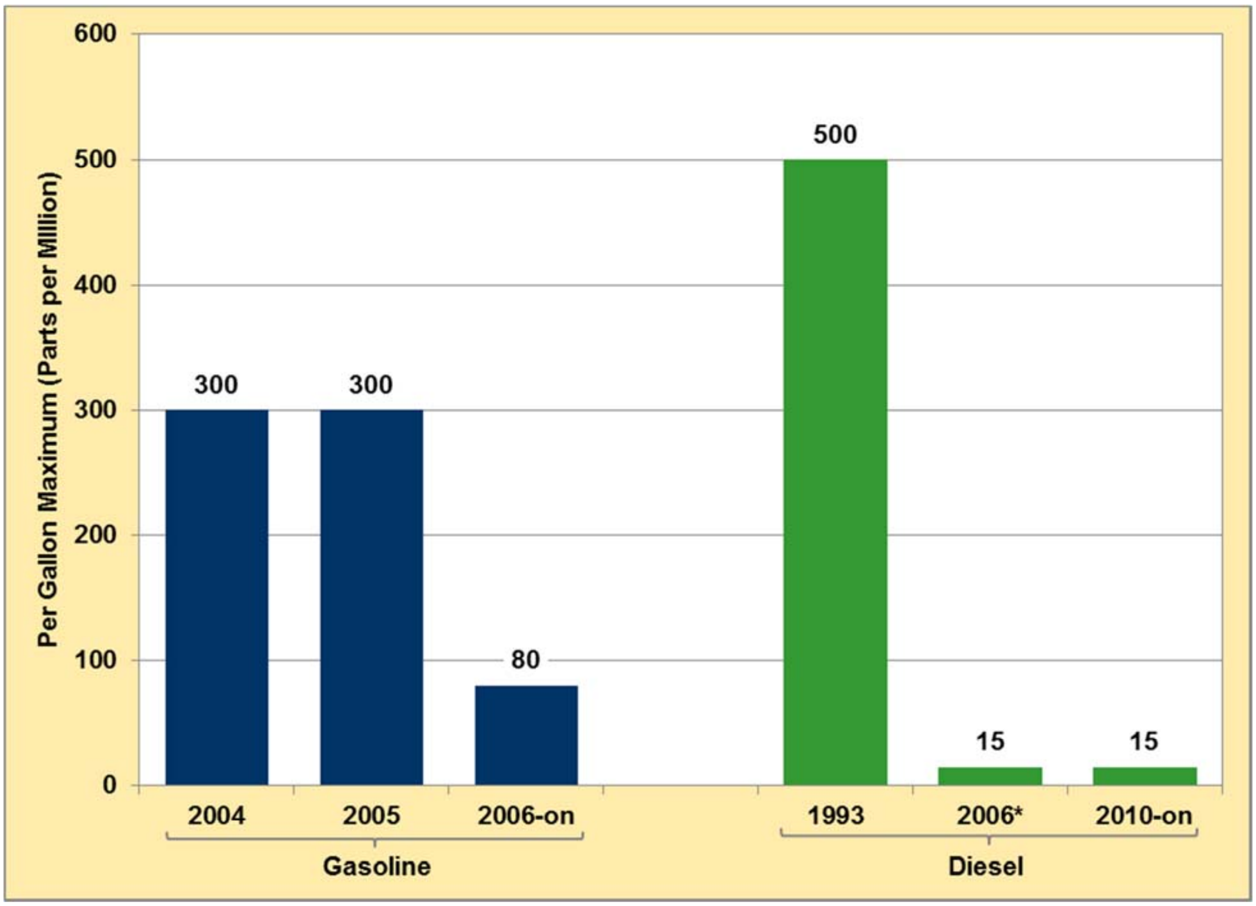


FIGURE 105. Gasoline and Diesel Sulfur Standards, 1993-On

* By October 2006 80% of the diesel fuel produced must be 15 ppm. In 2010, 100% produced must be 15 ppm.

Source:
U.S. Environmental Protection Agency, http://www.epa.gov/otaq/fuels/gasolinefuels/tier2/index.htm and http://www.epa.gov/otaq/highway-diesel/regs/2007-heavy-duty-highway.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.

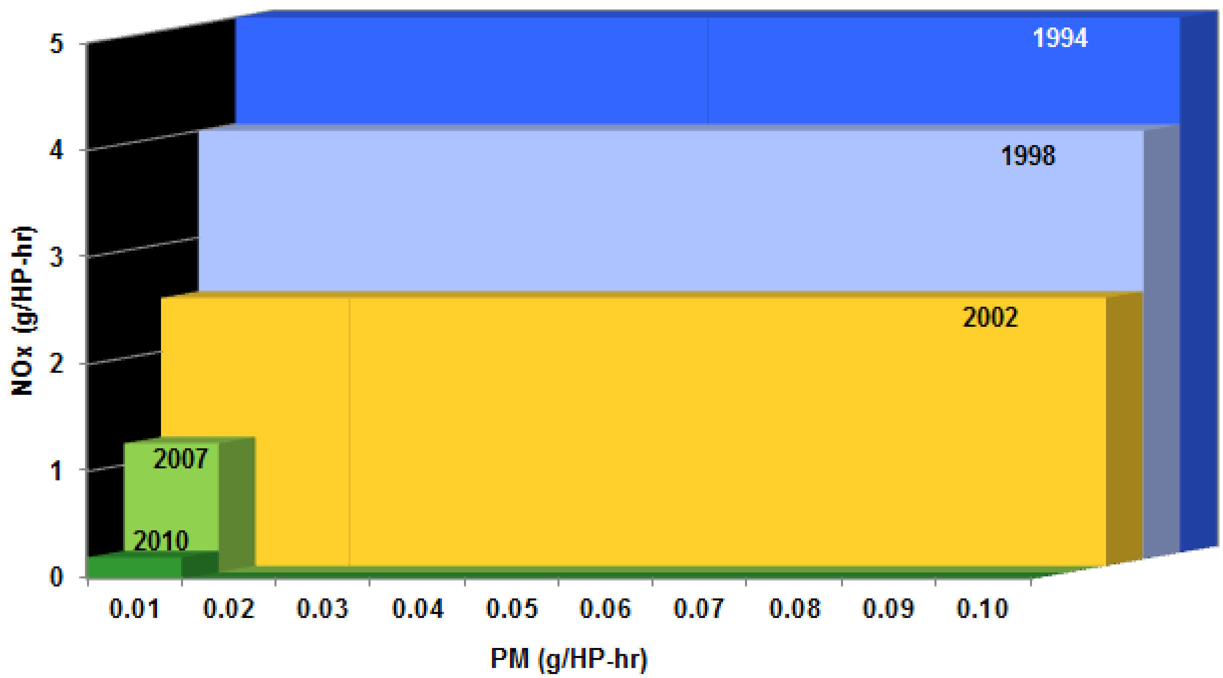


FIGURE 106. Diesel Emission Standards, 1994-2010

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.

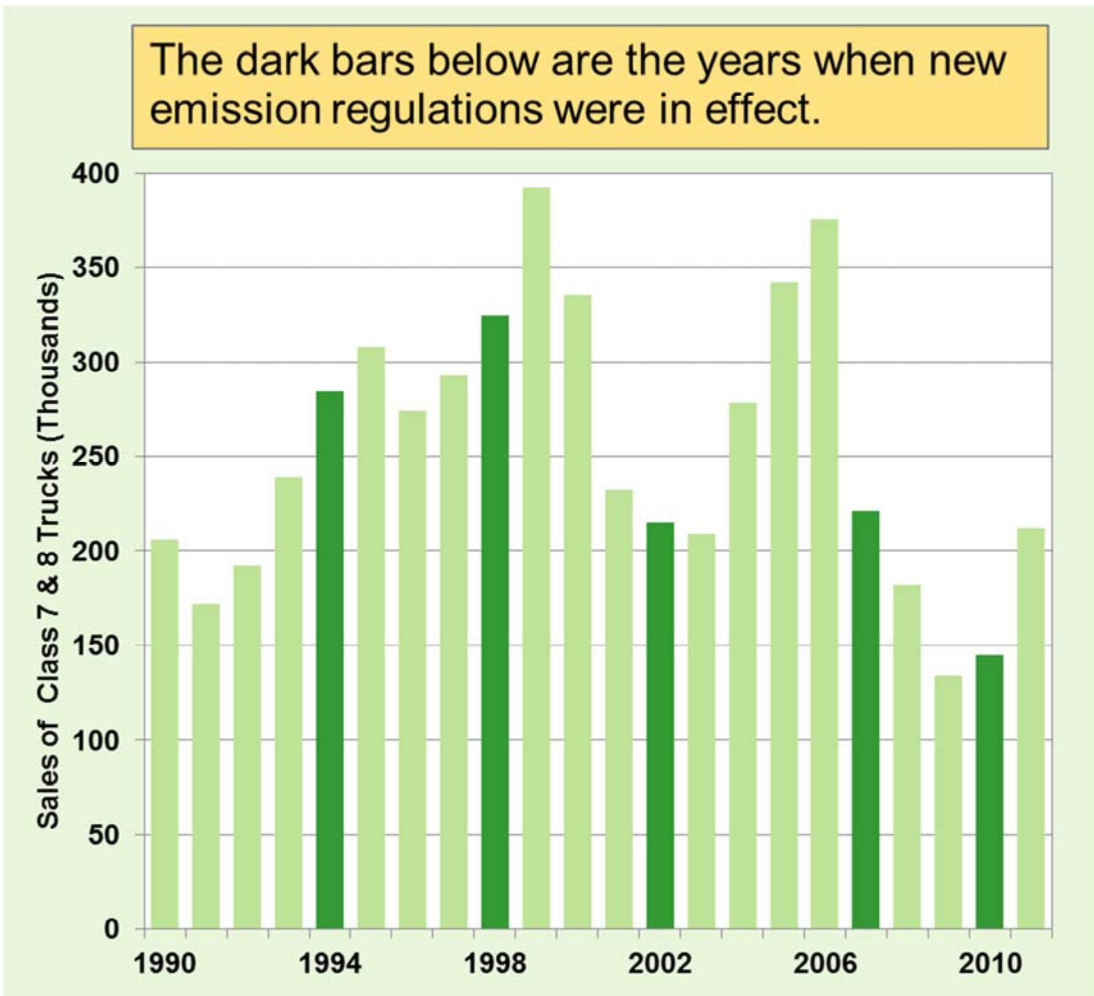


FIGURE 107. Class 7 and 8 Truck Sales, 1990-2011

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2012*, Southfield, MI, 2012.
http://wardsauto.com