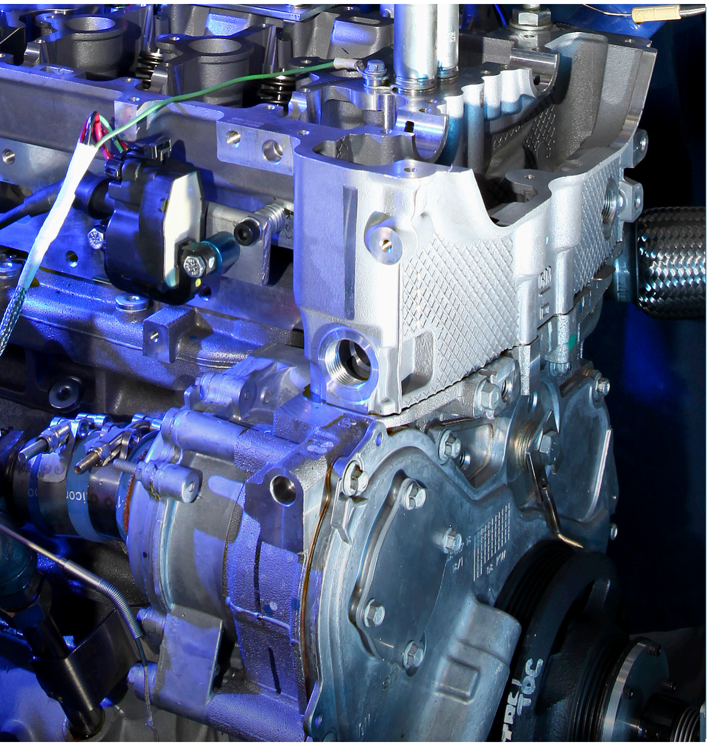
2011 Vehicle Technologies Market Report



February 2012

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

OAK RIDGE NATIONAL LABORATORY
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Quick Facts

Energy and Economics

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

Light Vehicles

- The top eight U.S. manufacturers produce only half of world's vehicles
- U.S. sales volumes rose in 2010, reversing downward trend
- Sales-weighted data on new light vehicles sold show a 110% increase in horsepower and 34% decrease in 0-60 time from 1980 to 2010, with the fuel economy of vehicles improving 17.2%
- Nearly 14% of cars sold in 2010 have continuously variable transmissions
- Two-thirds of new light vehicles sold in 2010 have transmissions with more than 5 speeds

Heavy Trucks

- Class 3 truck sales have recovered to pre-recession levels in 2010
- Sales of class 4-7 trucks were up slightly in 2010, but were 60% below the 2006 level
- Class 8 truck sales since 2008 have been less than half of what they were in 2006
- Diesel comprised 73% of the class 3-8 trucks sold in 2010, down from 84% in 2006
- Class 8 combination trucks consume an average of 6.5 gallons per thousand ton-miles
- Combination trucks average over 60,000 miles per year
- Idling a truck-tractor's engine can use a gallon of fuel per hour

Technologies

- About 275,000 hybrid vehicles were sold in 2010
- At least 27 different models of plug-in vehicles are available or coming soon to the market
- Nearly 70 flex-fuel vehicle models will be offered in model year 2011
- There are more than 4,400 electric vehicle charging stations throughout the nation
- Single wide tires on a Class 8 truck improve fuel economy by 7% on flat terrain
- There are 58 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
- Vehicles purchased in the 2009 Cash for Clunkers Program are, on average, 19% above the average fuel economy of all new vehicles at that time, and 59% above the average fuel economy of vehicles that were traded in.
- Proposed Corporate Average Fuel Economy Standards for cars is 56 miles per gallon (mpg)
- Proposed Corporate Average Fuel Economy Standards for light trucks is 40.3 mpg
- Diesel engine emission standards in 2010 are more strict – 0.2 grams per horsepower-hour (g/HP-hr) for nitrogen oxides and 0.01 g/HP-hr for particulate matter

ORNL/TM-2012/016

2011 VEHICLE TECHNOLOGIES MARKET REPORT

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Cover Photos: Aerodynamics testing on tractor trailer from Lawrence Livermore National Laboratory. Engine and electric vehicles from Oak Ridge National Laboratory.

Contents

Page

Page

List of Figures

Figure **Page**

Figure		Page

Figure **Page**

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List of Tables

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Introduction

Welcome to the 2011 Vehicle Technologies Market Report. This report 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 Program (VTP), and, in accord with its mission, pays special attention to the progress of high-efficiency and alternative-fuel technologies.

This third edition since this report was started in 2008 offers several marked improvements relative to its predecessors. Most significantly, where earlier editions of this report focused on supplying information through an examination of market drivers, new vehicle trends, and supplier data, this edition uses a different structure. 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. In addition to making this sectional re-alignment, this year's edition of the report also takes a different approach to communicating information. While previous editions relied heavily on text accompanied by auxiliary figures, this third edition relies primarily on charts and graphs to communicate trends. Any accompanying text serves to introduce the trends communication by the graphic and highlight any particularly salient observations.

The opening section on Energy and Economics discusses the role of transportation energy and vehicle markets on a national (and even international) scale. For example, Figures 11 through 13 discuss the connections between global oil prices and U.S. GDP, and Figures 20 and 21 show U.S. employment in the automotive sector. The following section examines Light-Duty Vehicle use, markets, manufacture, and supply chains. Figures 26 through 33 offer snapshots of major light-duty vehicle brands in the U.S. and Figures 38 through 43 examine the performance and efficiency characteristics of vehicles sold. The discussion of Medium and Heavy Trucks offers information on truck sales (Figures 58 through 61) and fuel use (Figures 64 through 66). The Technology section offers information on alternative fuel vehicles and infrastructure (Figures 68 through 77), and the Policy section concludes with information on recent, current, and near-future Federal policies like the Cash for Clunkers program (Figures 87 and 88) and the Corporate Automotive Fuel Economy standard (Figures 90 through 99) and.

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 VTP, 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
Lead Analyst
Vehicle Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

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Chapter 1.

ENERGY AND ECONOMICS

Page

Contents

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

In 2010, the transportation sector used 27.4 quadrillion Btu of energy, which was 28% of total U.S. energy use. Nearly all of the energy consumed in this sector is petroleum (94%), 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.

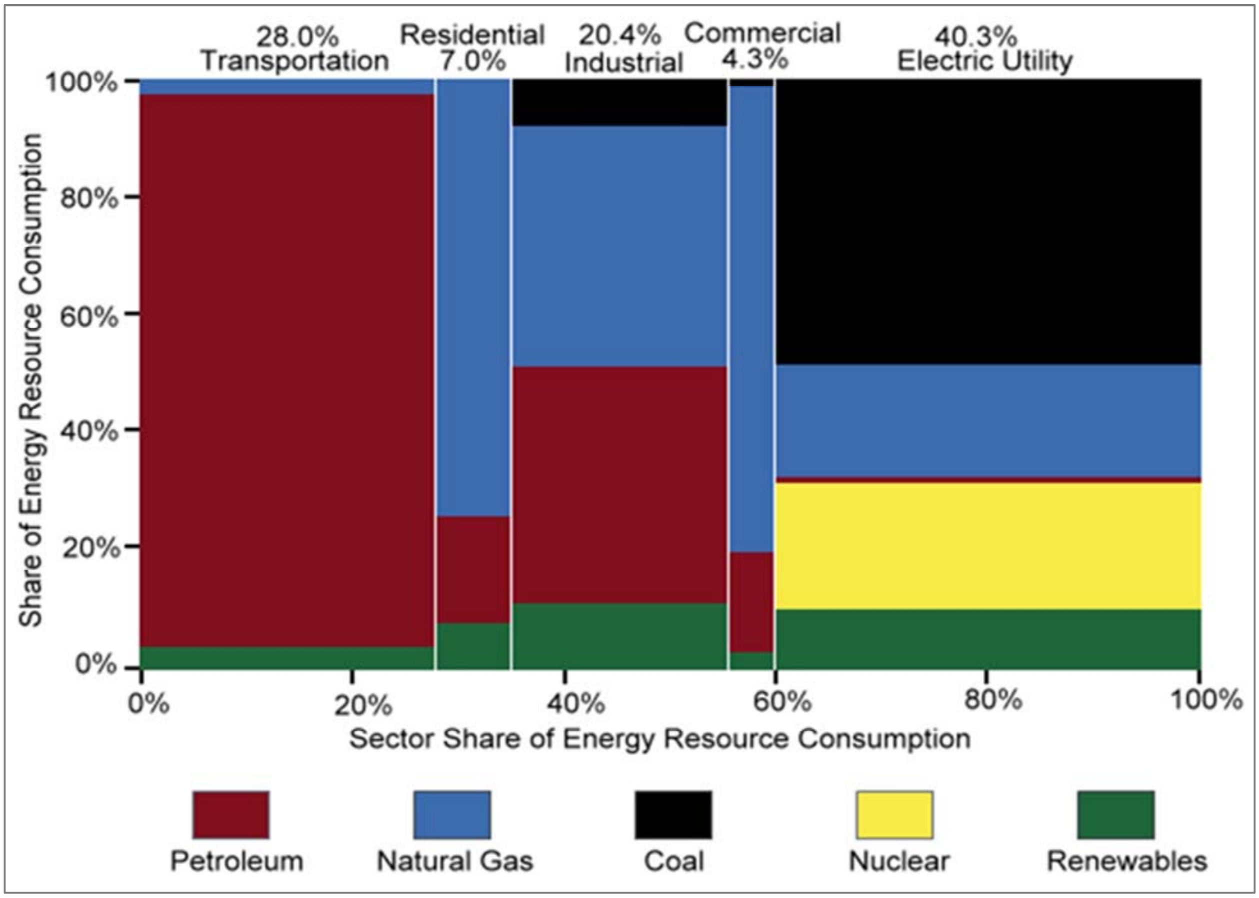


FIGURE 1. U.S. Energy Consumption by Sector and Energy Source, 2010

Sources:

Energy Information Administration, *Monthly Energy Review, July 2011*, 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 almost 17 million barrels per day; at that time, the gap between U.S. production and transportation consumption will be almost 4 million barrels per day when including the non-petroleum sources and 7 million barrels per day if using only conventional sources of petroleum fuel.

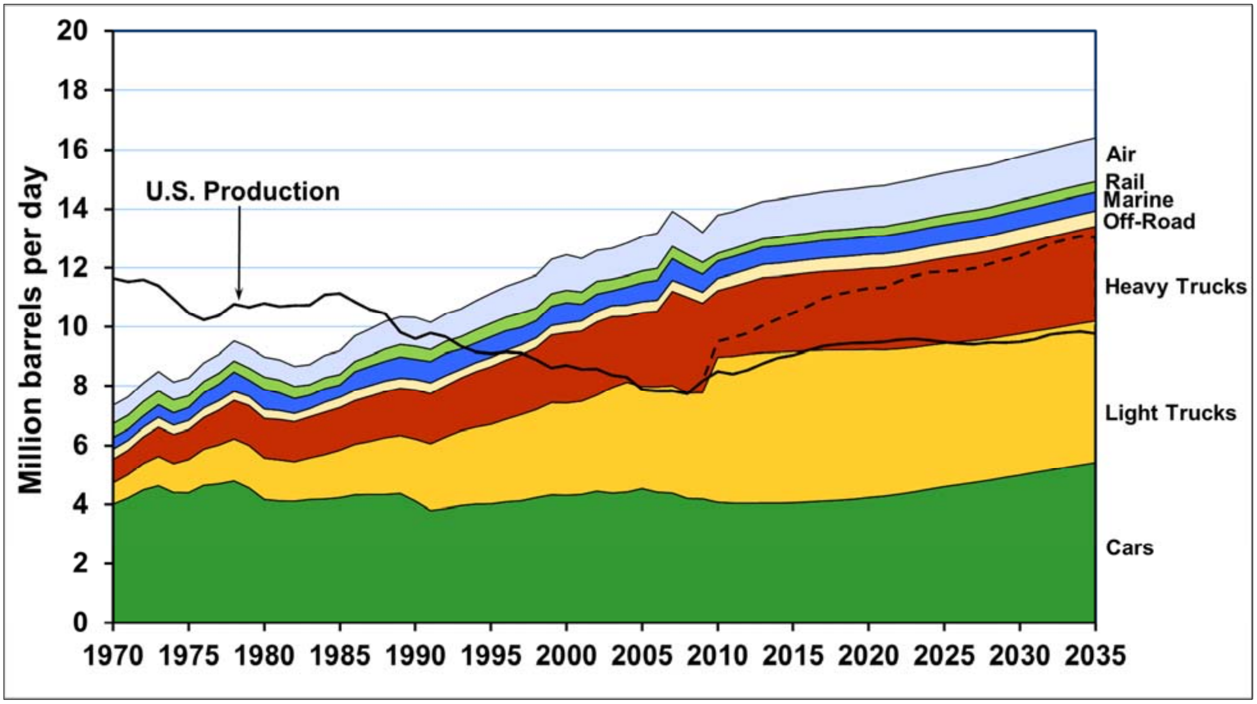


FIGURE 2. Transportation Petroleum Use by Mode and the U.S. Production of Petroleum, 1970-2035

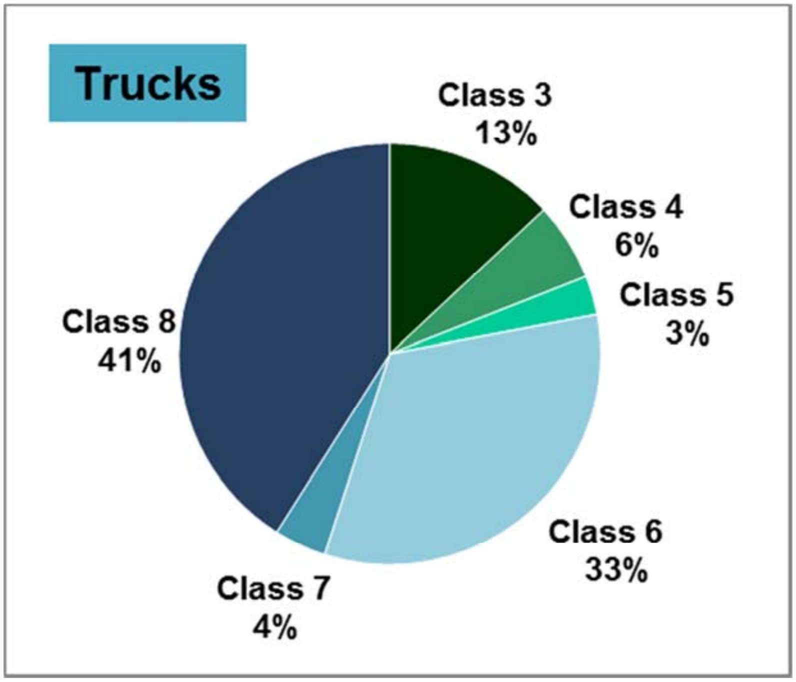
Note: The U.S. production has two lines after 2005. The solid line is conventional sources of petroleum, including crude oil, natural gas plant liquids, and refinery gains. The dashed line adds in other non-petroleum sources, including ethanol, biomass, liquids from coal, other blending components, other hydrocarbons, and ethers. The sharp increase in values between 2009 and 2010 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 30*, Oak Ridge, TN, 2011. http://cta.ornl.gov/data

2010-2035: Energy Information Administration, *Annual Energy Outlook 2011*, DOE/EIA-0383(2011), Washington, DC, 2011. http://www.eia.gov/oiaf/archive/aeo10/index.html

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 69 for truck class definitions.

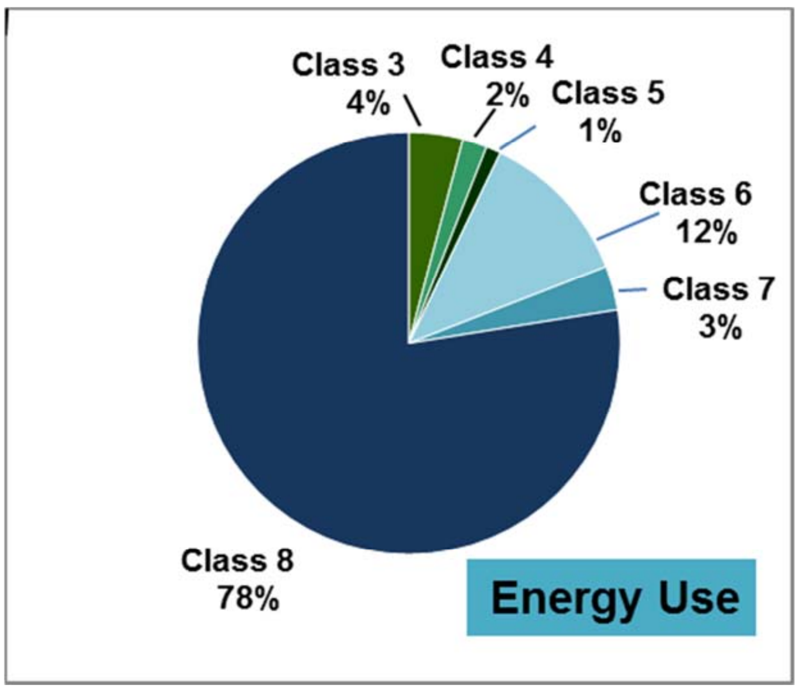


FIGURE 3. Medium and Heavy Truck Fleet Composition and Energy Usage, 2002

Source:
Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 30*, Oak Ridge, TN, 2011. http://cta.ornl.gov/data

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

An increase in fuel economy by 5 miles per gallon (mpg) does not translate to a constant fuel savings amount. Thus, 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 15 mpg for a new one that gets 20 mpg will save 16.7 gallons of fuel for every 1,000 miles driven. In contrast, trading a 35 mpg car for a new car that gets 40 mpg will save 3.6 gallons of fuel for every 1,000 miles driven. These fuel savings are additive; that is, going from 15 mpg to 25 mpg saves 26.7 gallons per thousand miles driven — 16.7 gallons (15-20 mpg difference) plus 10.0 gallons (20-25 mpg difference).

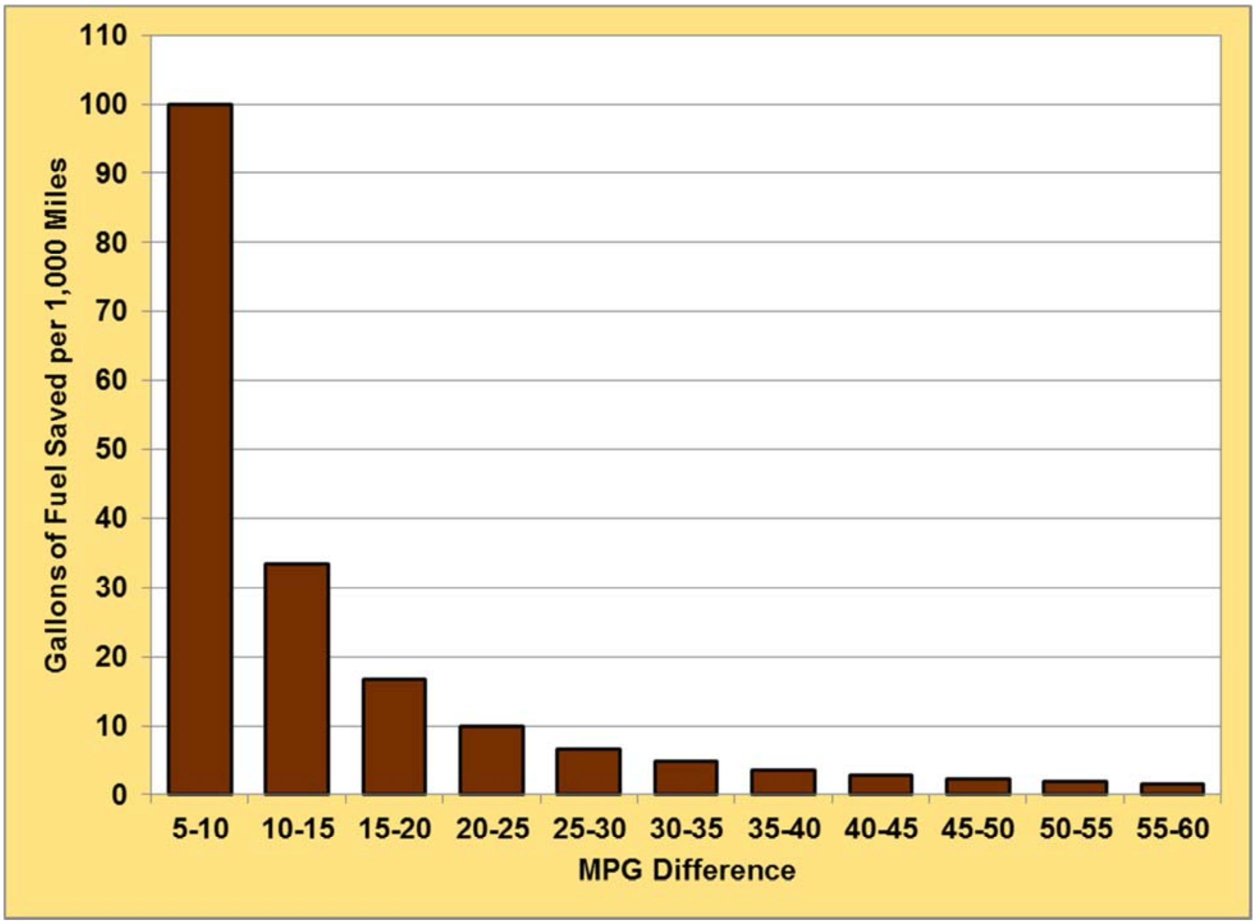


FIGURE 4. Fuel Savings per Thousand Miles

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 Grow

Carbon dioxide (CO_2) emissions grew by 16% — from 1,489 million metric tons in 1990 to 1,724 in 2009. Increases in the amount of CO_2 emissions from highway vehicles, both light and heavy, can be attributed to greater miles traveled. The increased use of ethanol in gasoline nationwide, however, means that CO_2 emissions have not grown at the same rate as fuel use.

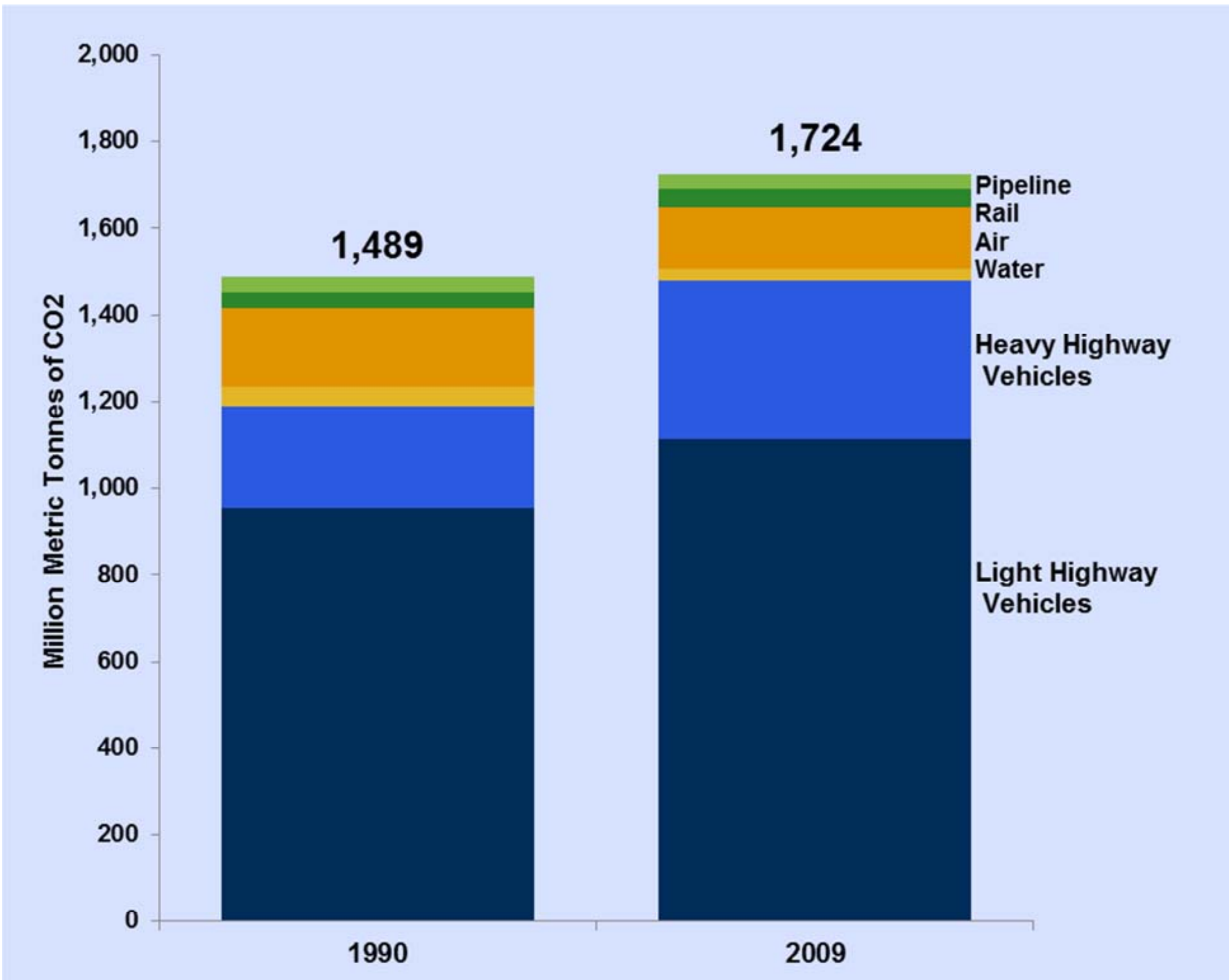


FIGURE 5. Transportation Carbon Dioxide Emissions, 1990 and 2009

Source:

U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009, Table 3-12, April 2011. http://epa.gov/climatechange/emissions/usinventoryreport.html

Many Cars Pollute Less Despite Increases in Engine Size and Interior Volume

As new vehicles become more efficient, the amount of carbon dioxide (CO_2) they produce decreases. The Ford Taurus is an example of a car that has increased in both engine size and interior volume over the years, but the amount of CO_2 coming from the tailpipe has decreased. In 1986, the 3.0 liter (L) Taurus with an interior volume of 117 cubic feet emitted 444 grams of CO_2 per mile. Improvements to the vehicle and engine design by 2010 resulted in less CO_2 emissions, despite the larger 3.5L engine and larger interior volume. Moving from a 4-speed transmission to a 6-speed transmission is one of the improvements that made a difference, along with lighter materials, improved aerodynamics, and other factors.

TABLE 1. Carbon Dioxide Emissions from a Ford Taurus

Model Year	Tailpipe CO2 Emissions (Grams per Mile)	Engine Description	Interior Volume (Cubic Feet)	Photo
1986	444	Automatic, 4-spd, 6 cyl, 3.0L	117	
1996	423	Automatic, 4-spd, 6 cyl, 3.0L	118	
2006	444	Automatic, 4-spd, 6 cyl, 3.0L	122	
2010	404	Automatic, 6-spd, 6 cyl, 3.5L	129	

Source:

U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy Guide website, June 2011. 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) 2010 the sales-weighted average of CO_2 emitted by cars was 7.2 tons annually per car. For light trucks, the average was 9.8 tons annually per truck.

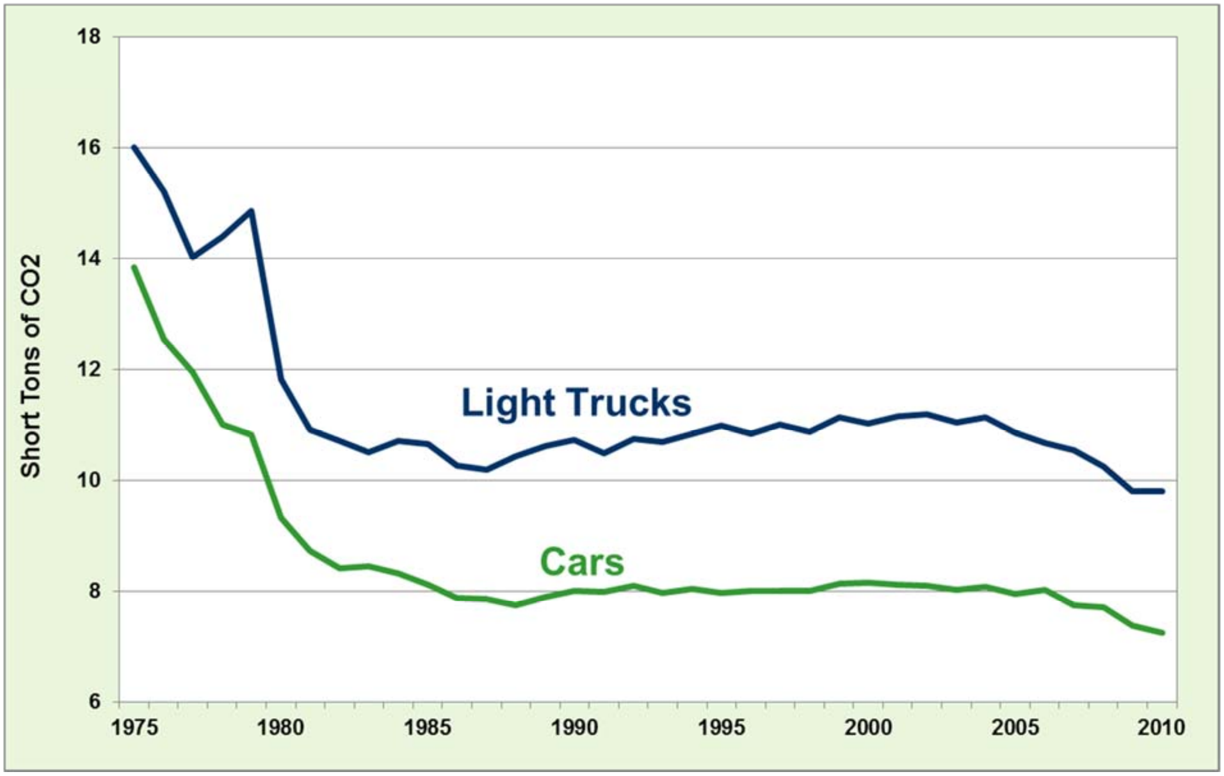


FIGURE 6. Average Carbon Footprint for Cars and Light Trucks Sold, 1980-2010

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

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

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 2010*, EPA420-R-10-023, November 2010. 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 2011, carbon monoxide (CO) emissions declined by 71%; volatile organic compound (VOC) emissions declined by 70%; particulate matter emissions less than 10 microns (PM-10) declined 68%; and nitrogen oxide (NOx) emissions declined by 54%.

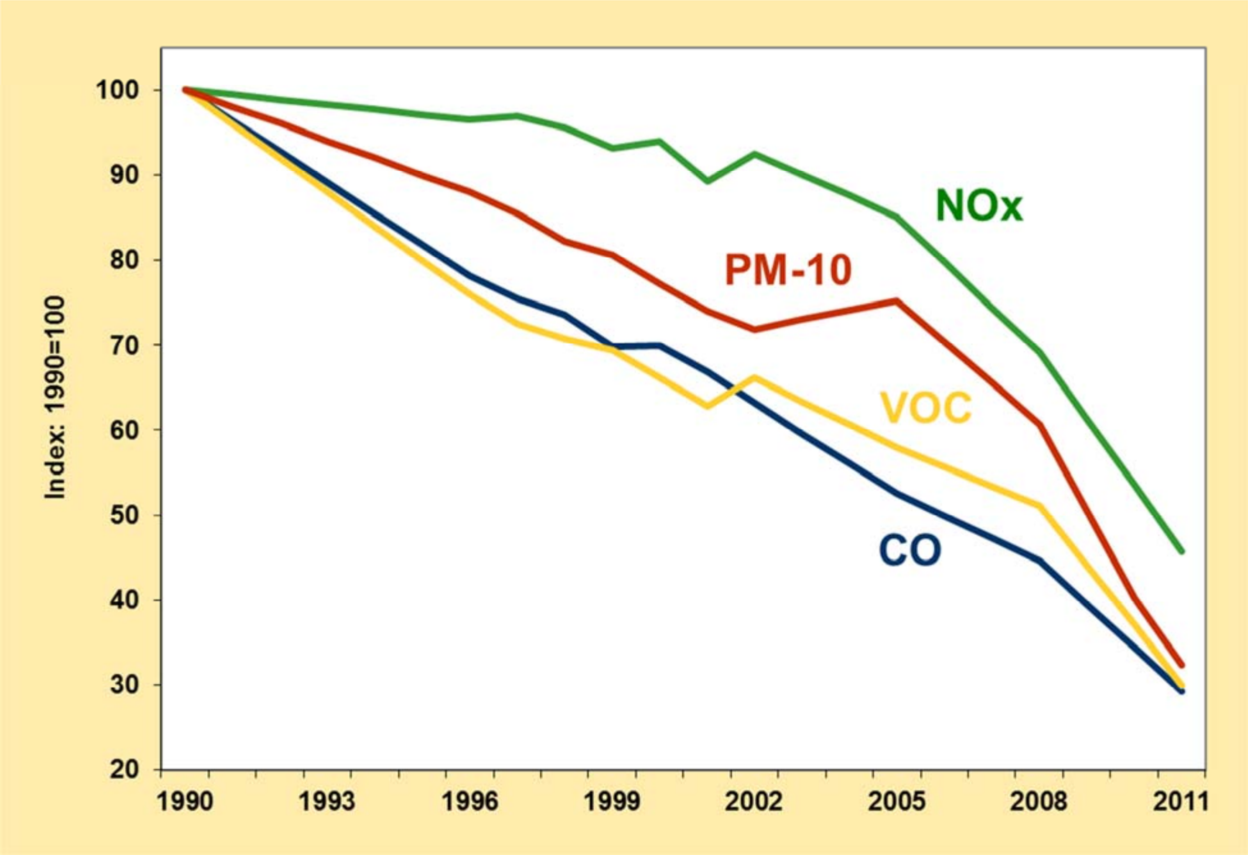


FIGURE 7. Total Transportation Pollutant Emissions, 1990-2011

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

Source:

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

Highway Vehicles Responsible for Declining Share of Pollutants

Over 70% of carbon monoxide (CO) emissions from the transportation sector in 1990 were from highway vehicles; by 2011 that fell to 53%. The share of transportation's nitrogen oxide (NOx) emissions from highway vehicles experienced a gradual decline from 38% in 1990 to 31% in 2011. The highway share of volatile organic compound (VOC) emissions declined by 15% during this same period. Nonhighway vehicles, such as planes, ships and locomotives, are responsible for the majority of the particulate matter emissions.

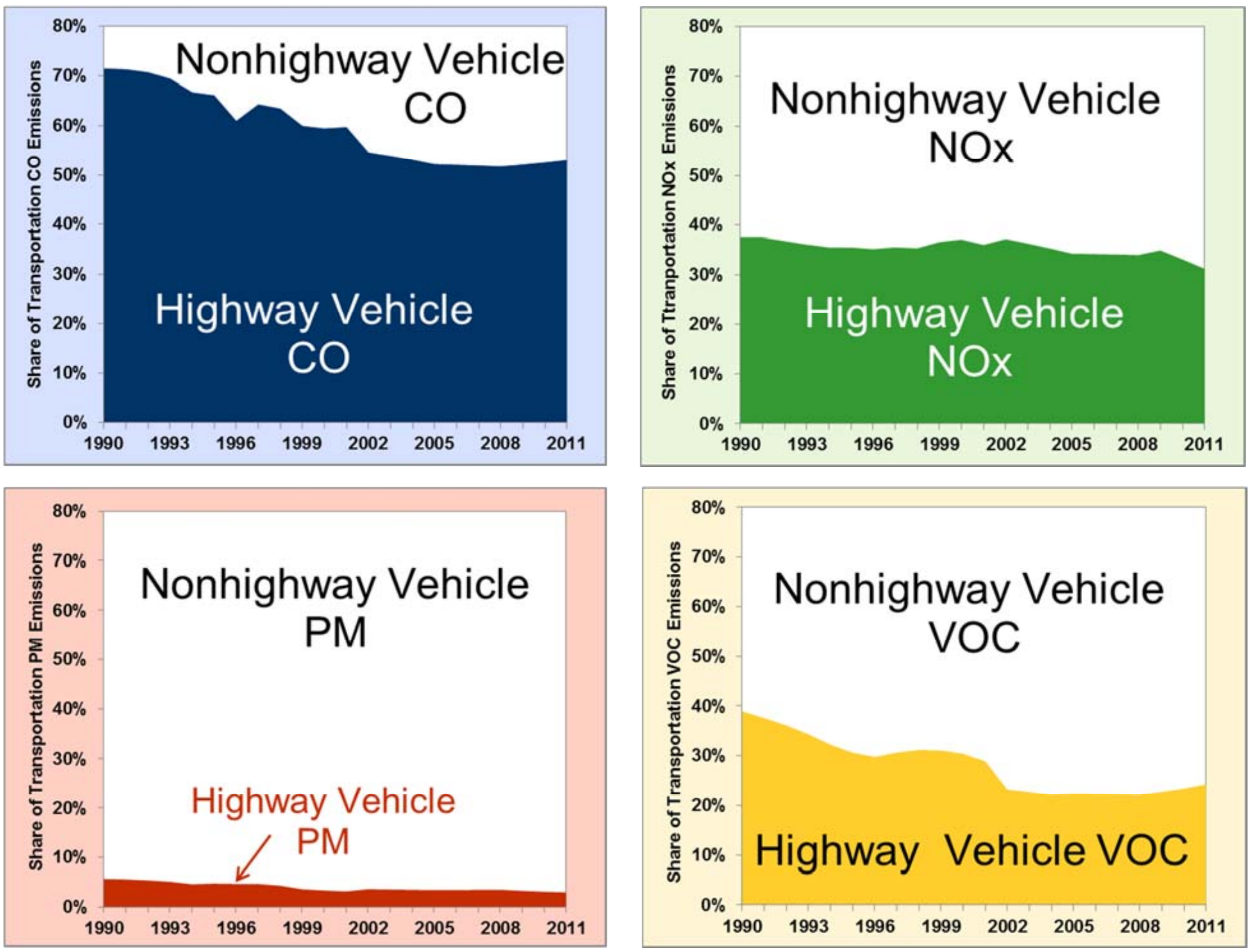


FIGURE 8. Highway and Nonhighway Share of Transportation Pollutant Emissions, 1990-2011

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 held steady from the early 1990's to 2008, showing that the fuel economy for new vehicles was fairly stagnant during that period. Data for the year 2009 shows a decline in fuel use per mile indicating that the vehicle population is improving in efficiency.

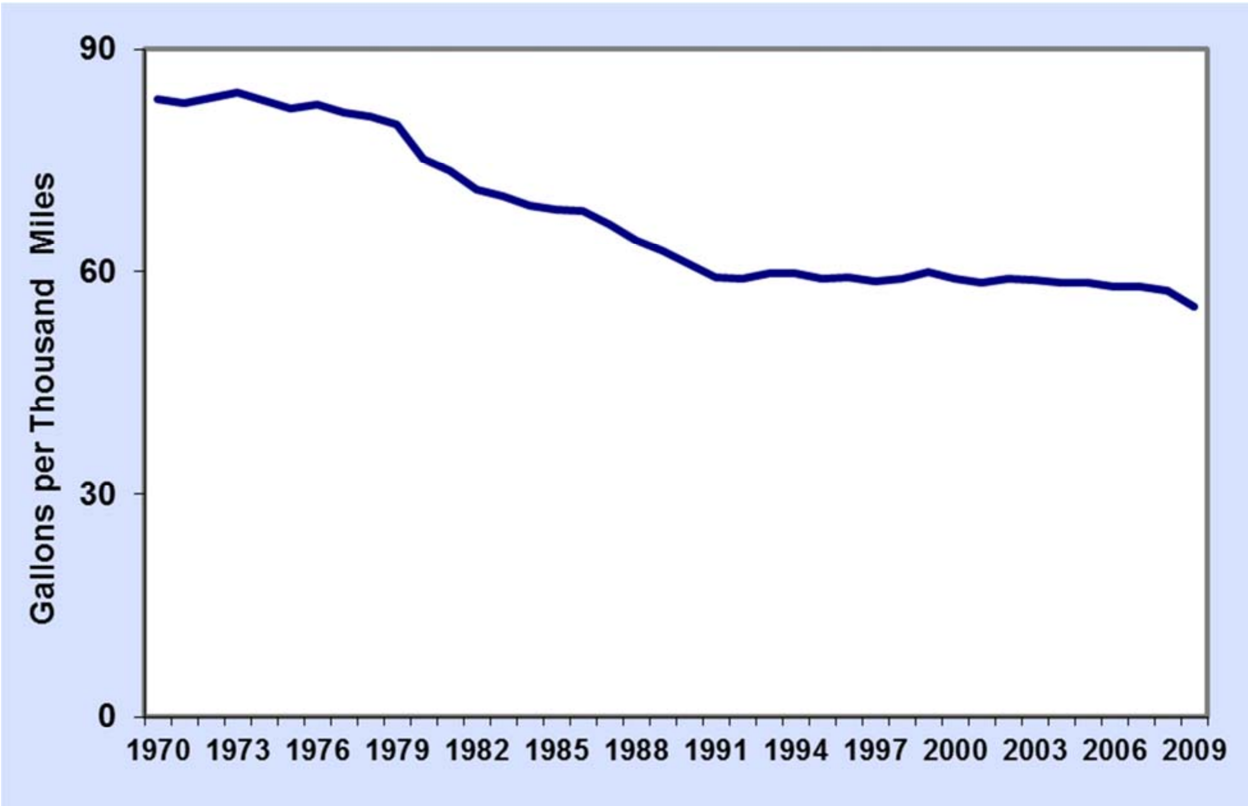


FIGURE 9. Fuel Use per Thousand Miles on the Highways, 1970-2009

Sources:

Federal Highway Administration, *Highway Statistics 2009*, Table VM-1 and previous annual editions. http://www.fhwa.dot.gov/policyinformation/statistics/2009

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. 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.

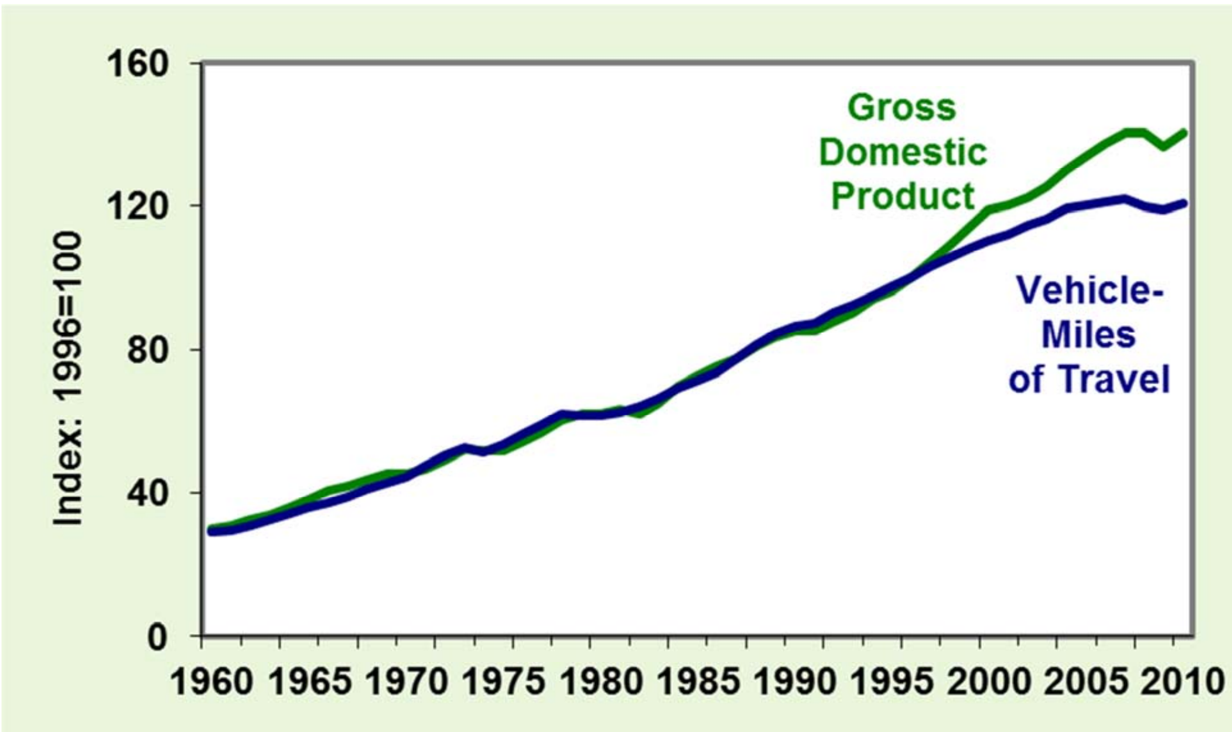


FIGURE 10. Relationship of VMT and GDP

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 2009*, Table VM-1 and previous annual editions.
http://www.fhwa.dot.gov/policyinformation/statistics/2009

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.

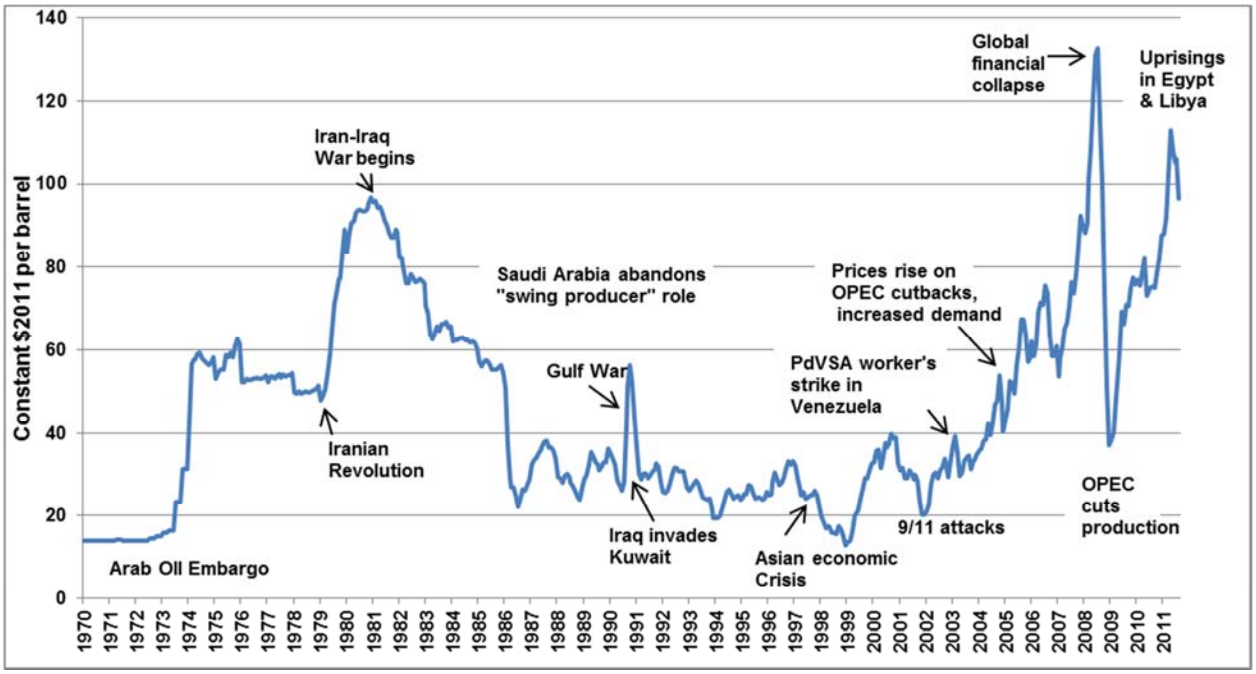


FIGURE 11. World Crude Oil Price and Associated Events, 1970-2011

Note: Refiner acquisition cost of imported crude oil.

Sources:

Energy Information Administration, "What Drives Crude Oil Prices?" September 2011. 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, 2008). Most of the oil price shocks were followed by an economic recession in the United States.

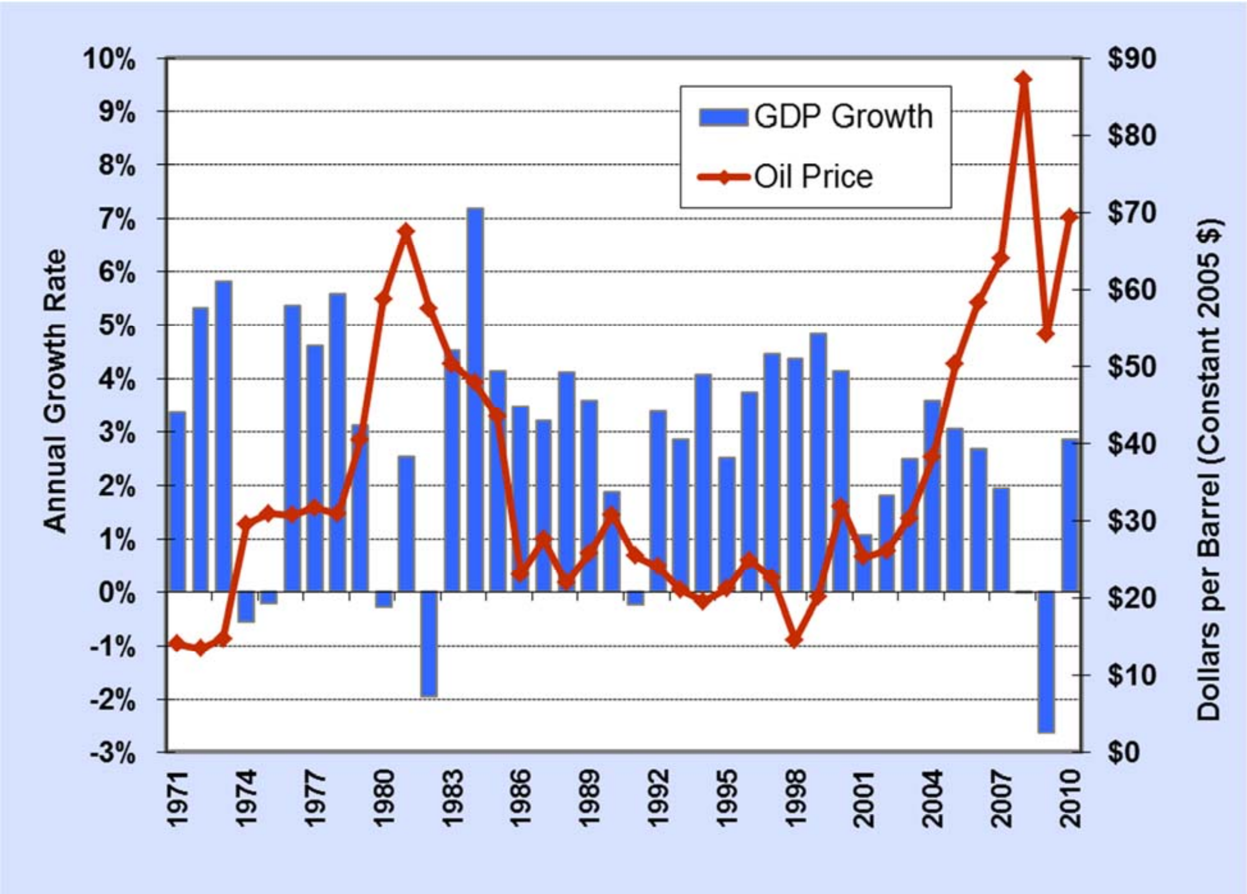


FIGURE 12. The Price of Crude Oil and Economic Growth

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, 2011. 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 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 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.

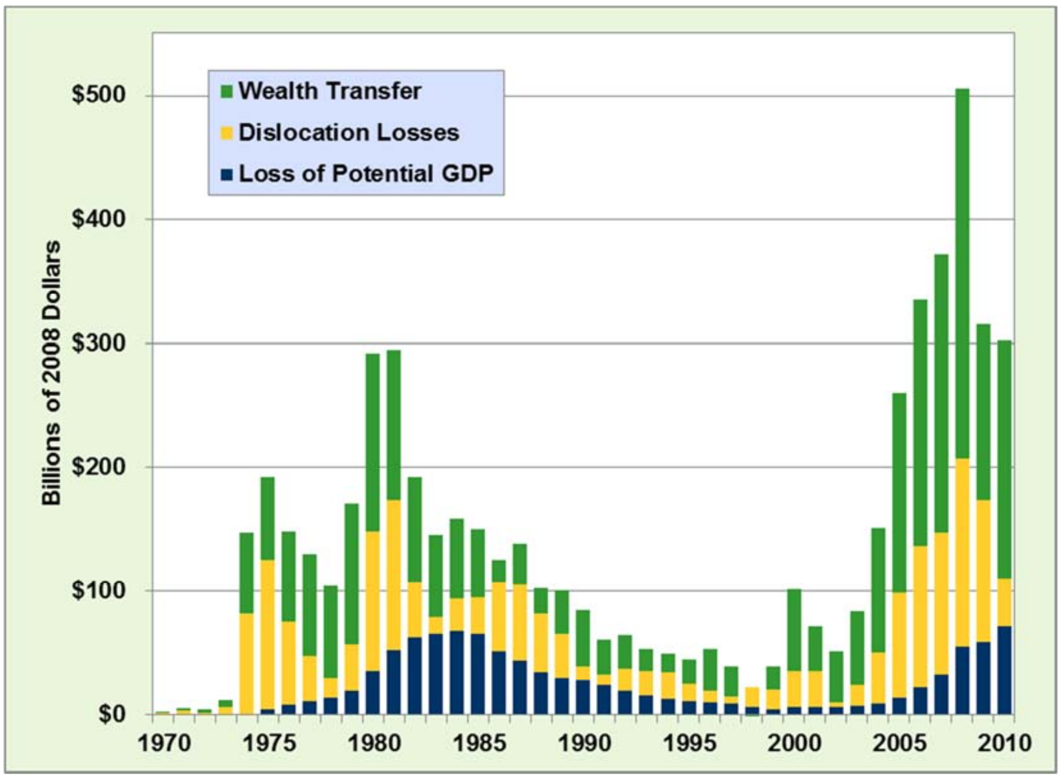


FIGURE 13. Costs of Oil Dependence to the U.S. Economy

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 Gross Domestic Product (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.

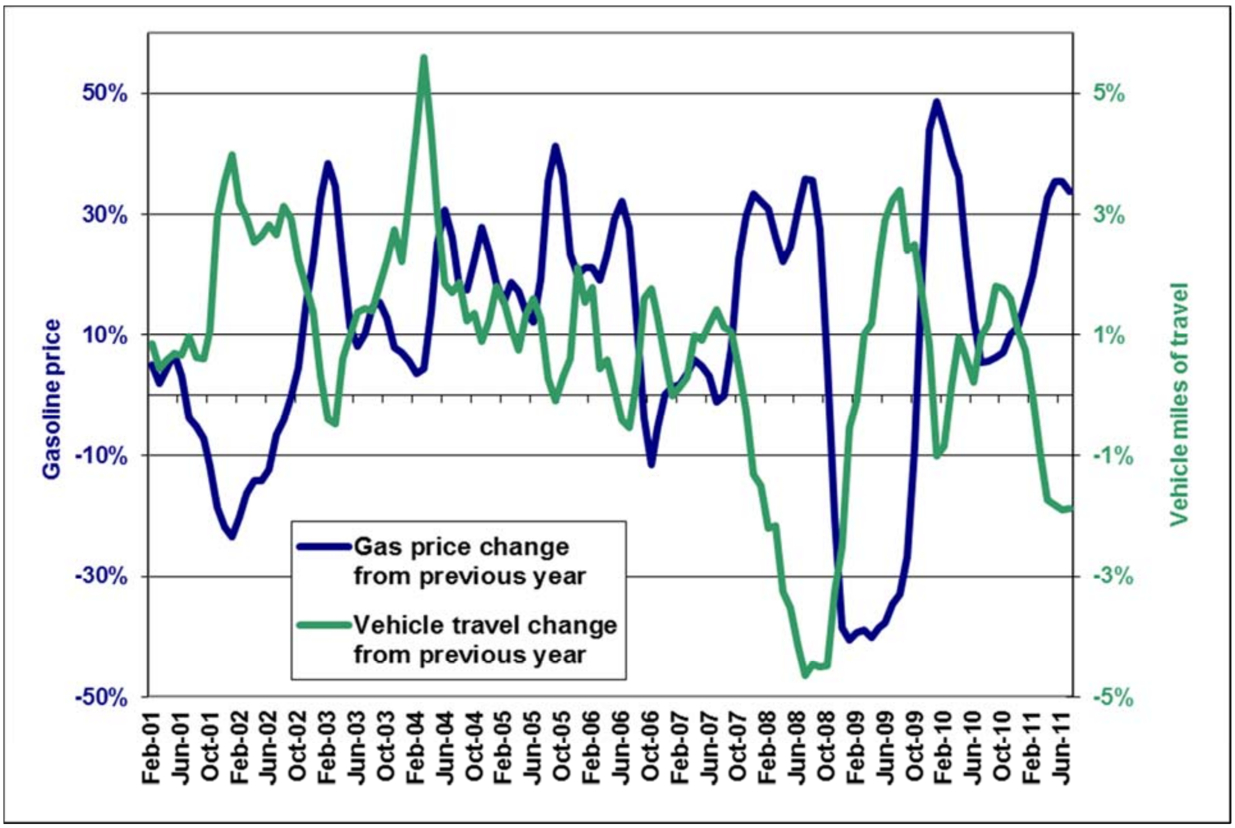


FIGURE 14. Relationship of Vehicle Miles of Travel and the Price of Gasoline

Sources:

Federal Highway Administration, *August 2011 Traffic Volume Trends,* and previous monthly editions.
http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Energy Information Administration, *Monthly Energy Review, October 2011*, Table 9.4.
http://www.eia.gov/totalenergy/data/monthly

The Average Price of a New Car is just under $25,000

The average price of a car in 2010 was $24,296, up slightly from the averages for 2008 and 2009 (constant 2010 dollars). That price is down, however, from a high of $27, 242 in 1998, mainly driven by the high price of import cars. The price of imports peaked in 1998 at $39,049. Until 1982, domestic cars were more expensive than imports.

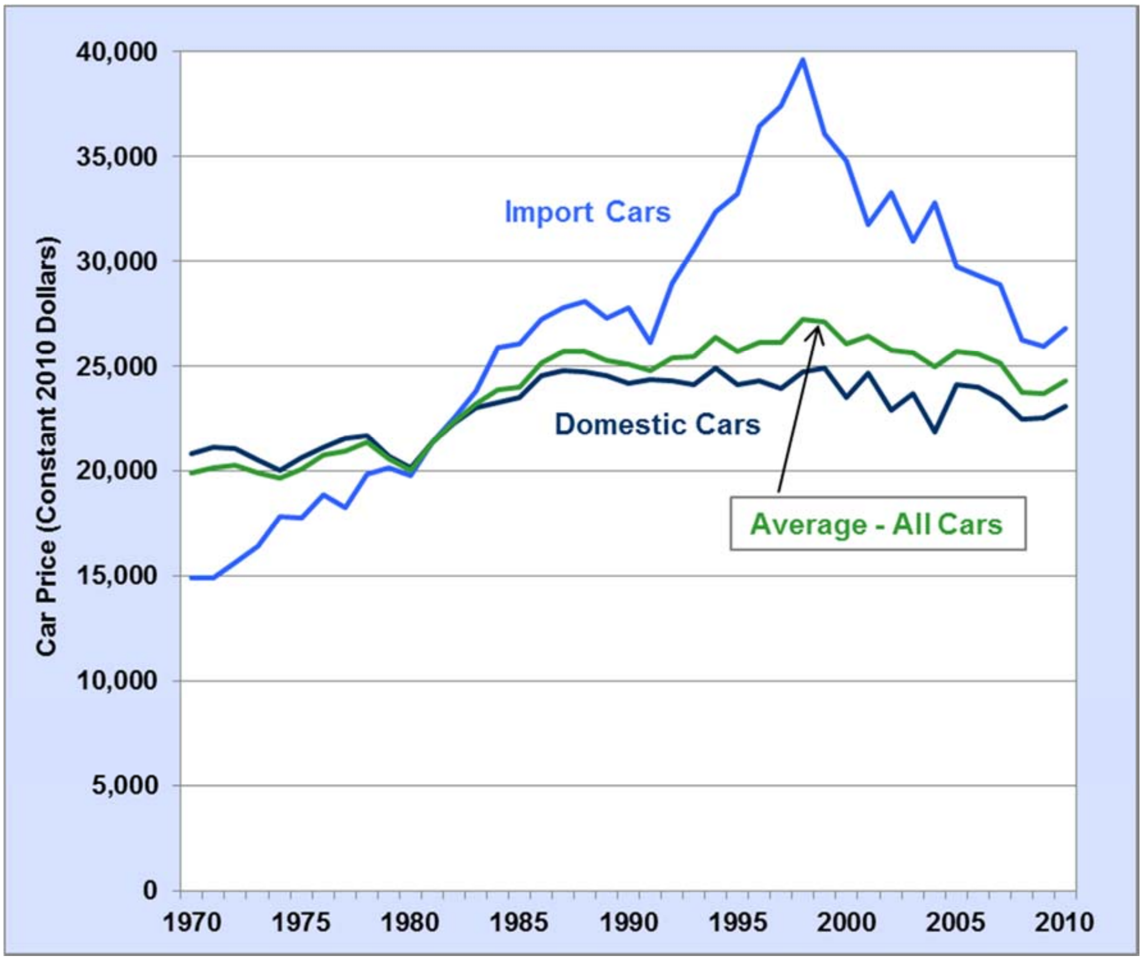


FIGURE 15. Average Price of a New Car, 1970-2009

Sources:

U.S. Department of Commerce, Bureau of Economic Analysis, *National Income and Product Accounts*, underlying detail estimates for Motor Vehicle Output, Washington, DC 2011.

Thirty Percent of Survey Respondents Consider Fuel Economy Most Important When Purchasing a Vehicle

A 2011 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. Thirty percent of the survey respondents indicated that fuel economy would be the most important vehicle attribute, while only 22% of respondents chose dependability.

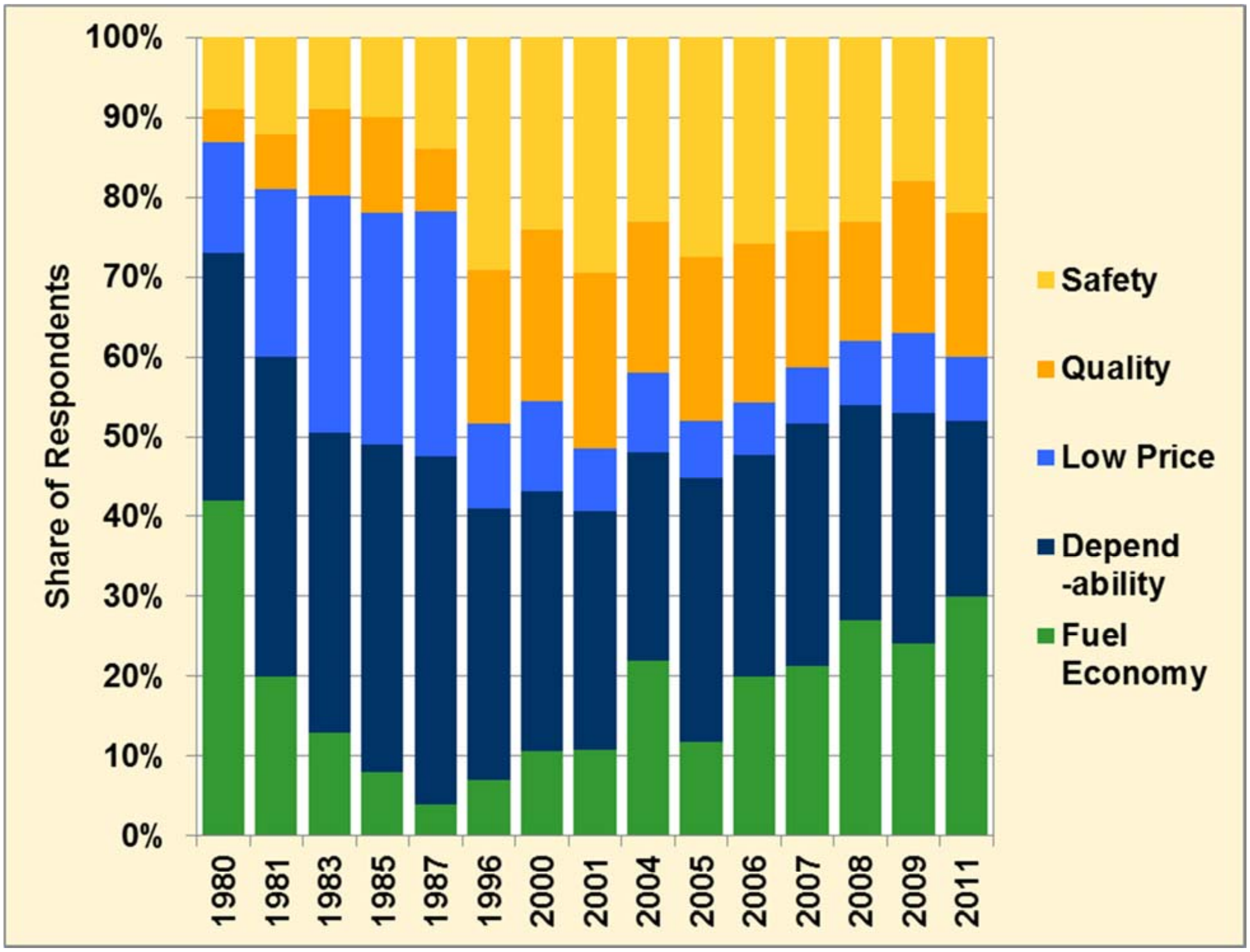


FIGURE 16. Most Important Vehicle Attribute

Sources:
1980-87: J. D. Power (based on new car buyers). 1998-2011: 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.

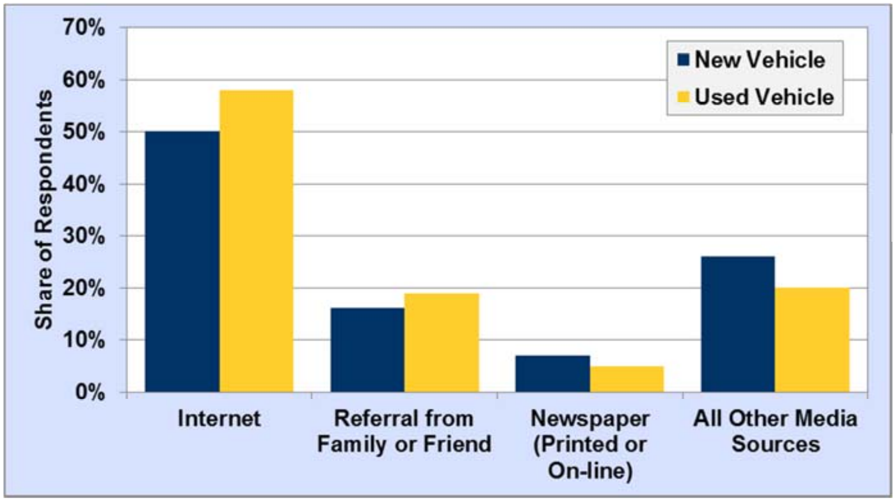


FIGURE 17. Media Which Led a Consumer to the Vehicle Dealer

FIGURE 18. Reasons for Using the Internet While Shopping for a Vehicle

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

Sixteen Percent of Household Expenditures are for Transportation

Except for housing, transportation was the largest single expenditure for the average American household in 2010. Of the transportation expenditures, vehicle purchases and gas & 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%.

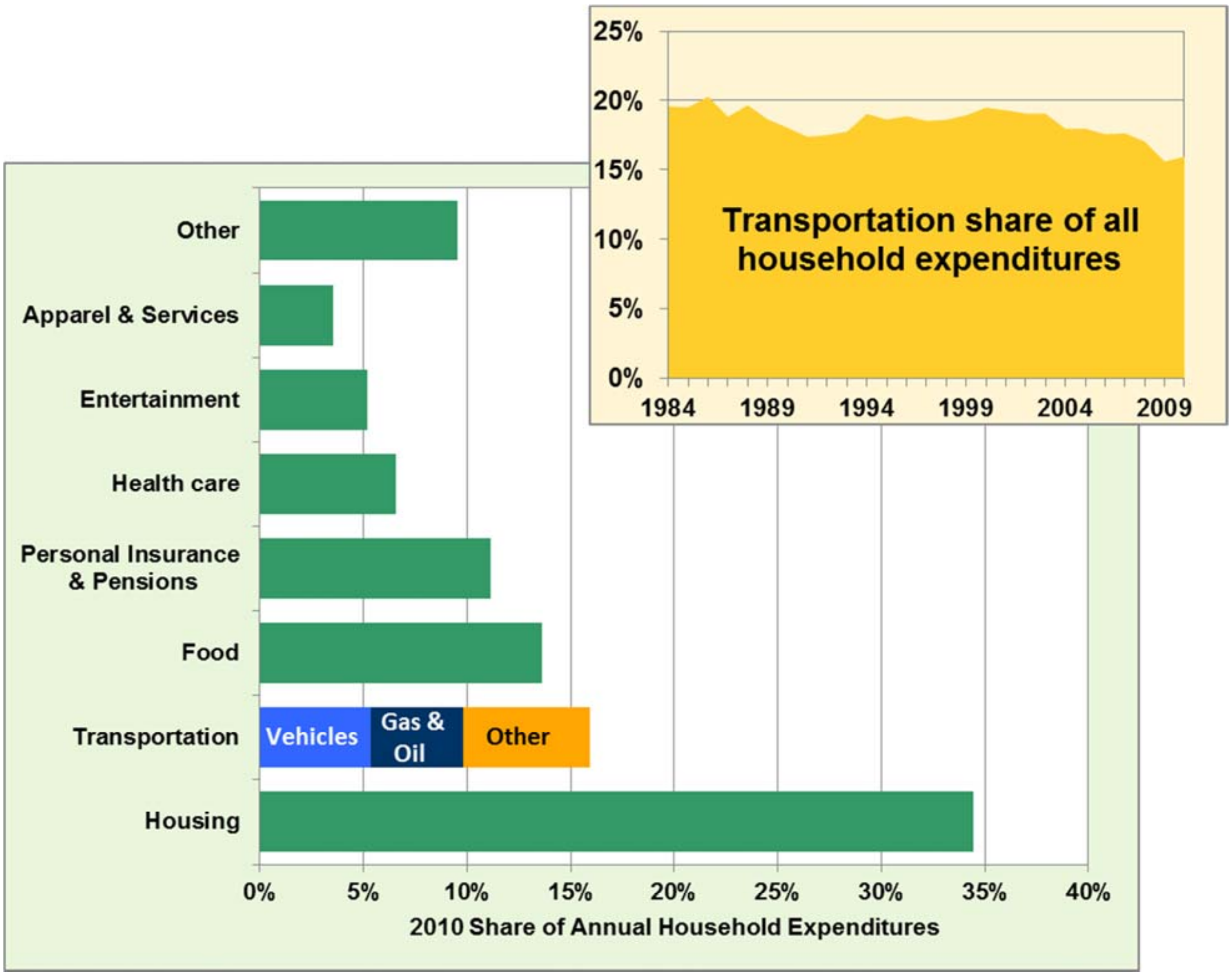


FIGURE 19. Share of Household Expenditures by Category, 2010, and Transportation Share of Household Expenditures, 1984-2010

Sources:

U.S. Department of Labor, *Consumer Expenditure Survey 2010*, Table 2, Washington, DC, 2011, 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, 9.2 million people are employed in transportation-related jobs. These transportation-related jobs account for 7.1% 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.

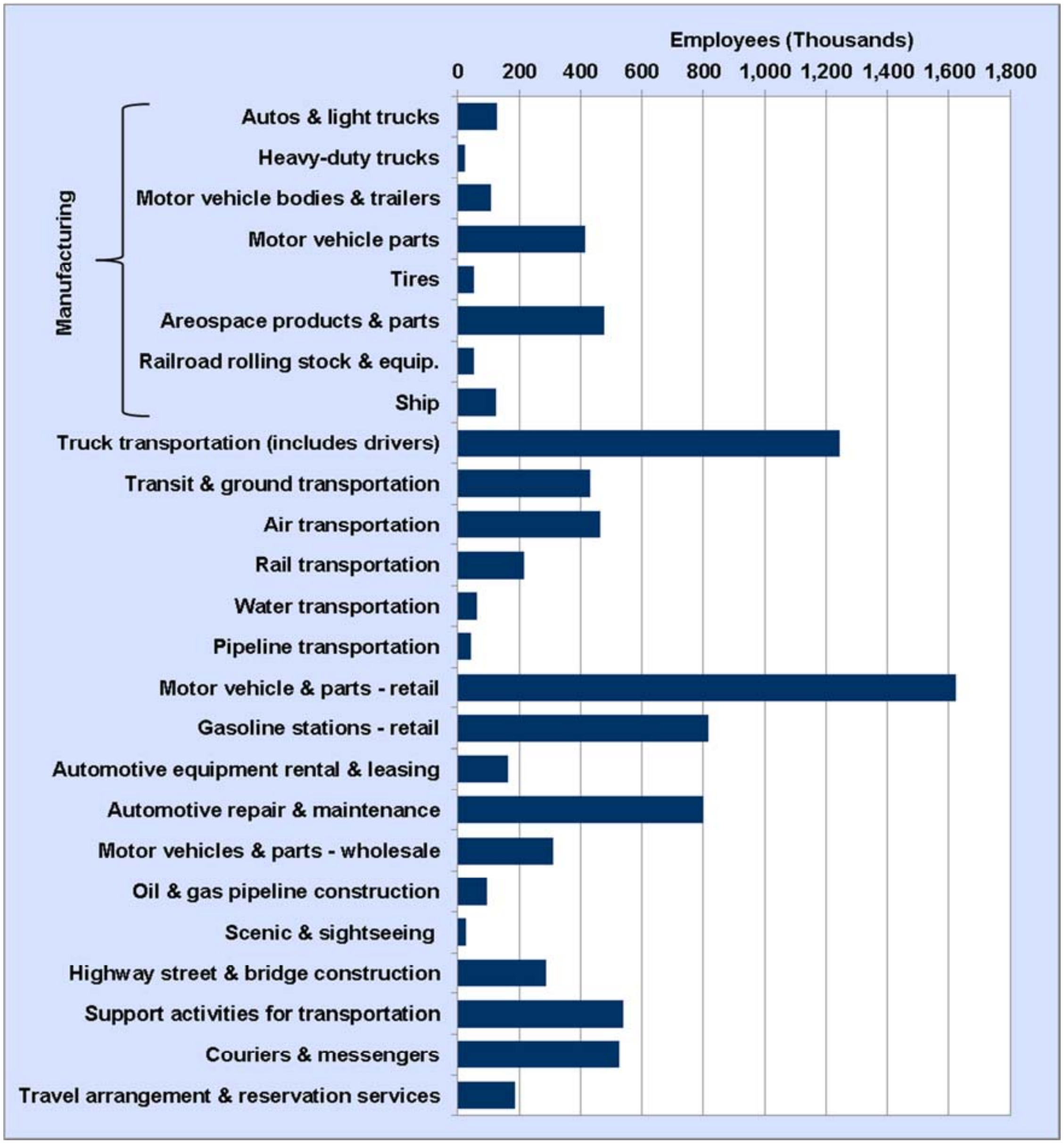
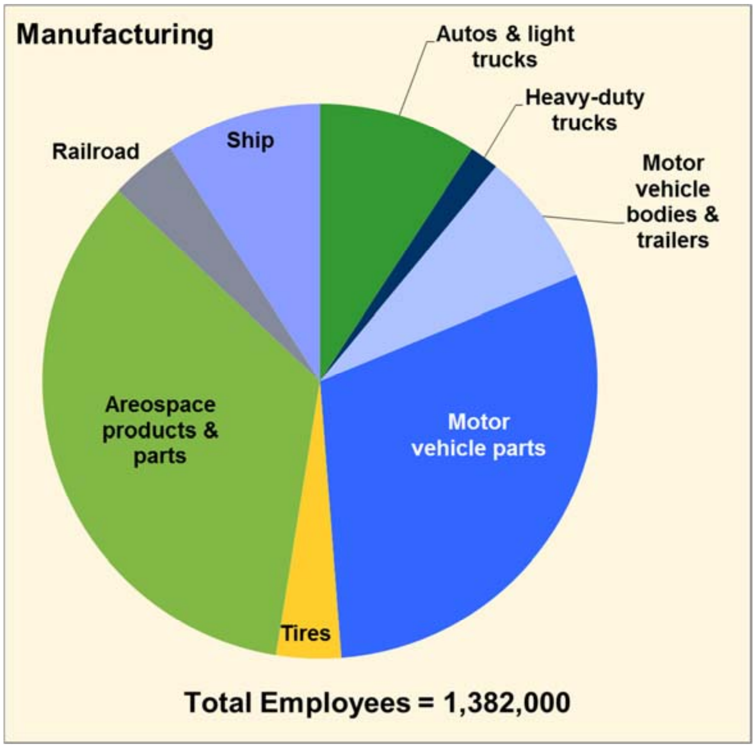


FIGURE 20. Transportation-related Employment, 2010

Source:

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

Vehicle Manufacturing, Parts Manufacturing, and Truck Transportation Employs 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 about half of the 2.4 million employees. Transit and ground transportation, which includes bus drivers and other transit and ground transportation employees, makes up 19% of the total. Air transportation, which includes everything from pilots to airport workers, makes up 18% of the total.

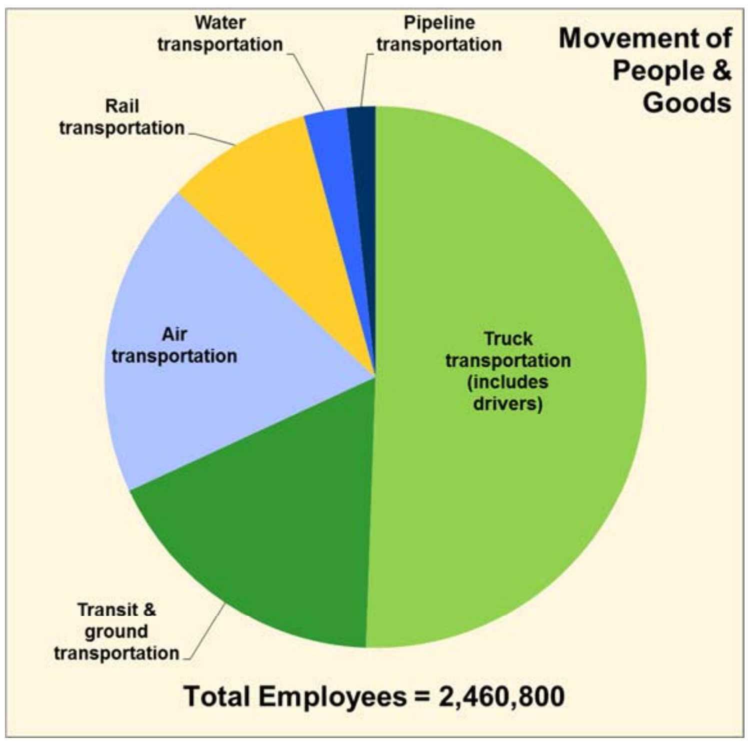


FIGURE 21. Transportation Manufacturing-related and Mode-related Employment, 2010

Source:
Bureau of Labor Statistics, Web Site 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 2011 are 40% lower than their 2006 level. Volkswagen 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 is shown twice – once before bankruptcy (GM-Old) and after the initial public stock offering in late 2010 (GM-New).

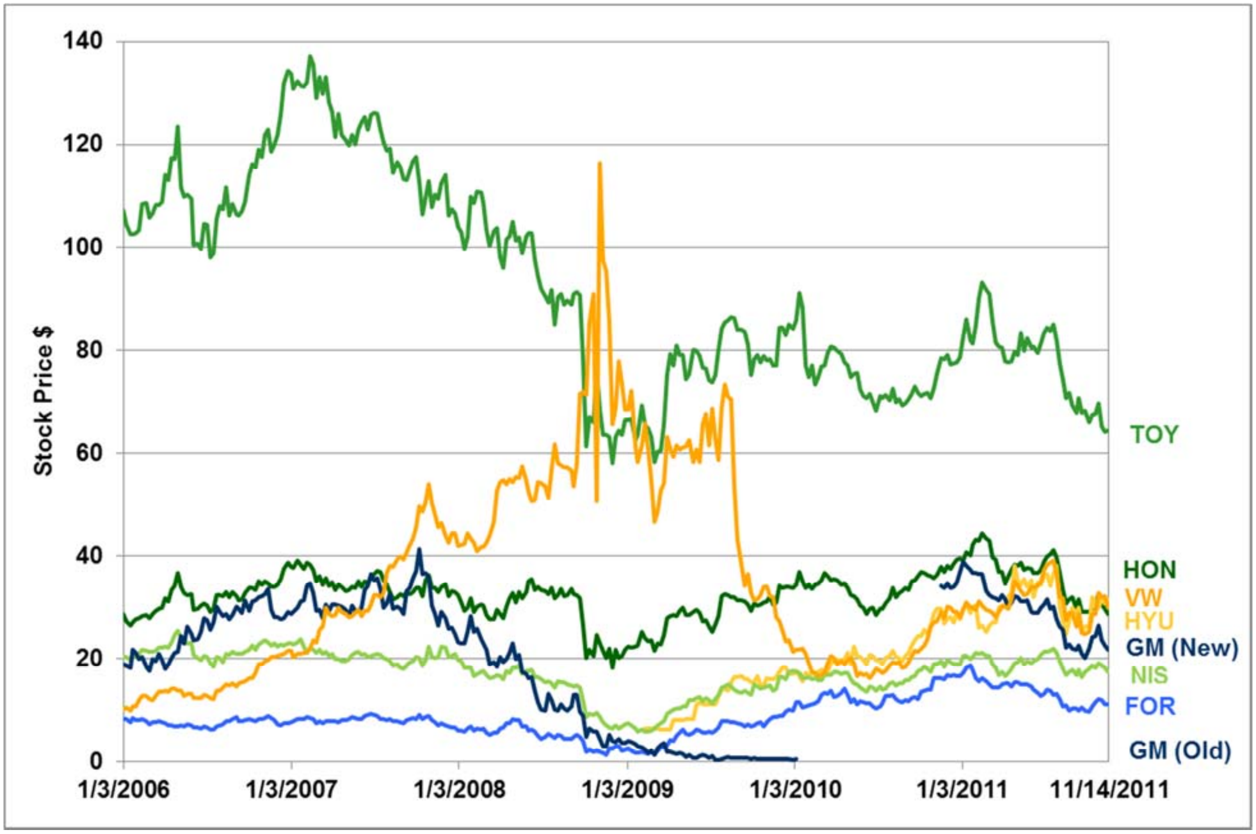


FIGURE 22. Stock Price by Manufacturer

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 2. 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

Hybrid vehicles are typically very well equipped with standard amenities comparable to those found on the upper trim levels of their non-hybrid counterparts. Many consumers do not settle for the base model but rather opt for the higher trim levels offering features and amenities that come standard on the hybrid model. For these consumers, a hybrid vehicle can offer savings over time. The table below shows a selection of hybrid vehicles available for the 2011 model year paired with a comparably equipped non-hybrid vehicle from the same manufacturer. Of the selected vehicles below, the cost premiums for the hybrid models fall within a range of about $2,000 to $6,000. Accounting for the cost premium and fuel savings, the Cadillac Escalade hybrid and Toyota Prius have the shortest payback periods and offer the greatest savings over 10 years compared with their non-hybrid counterparts.

TABLE 3. Selected 2011 Model Year Hybrid Vehicles Paired with a Comparably Equipped Non-Hybrid Vehicle

Manufacturer	Model	Price Difference Comparably Equipped	Combined MPG	Years to Pay Back at $3.50/gal	Years to Pay Back at $4.00/gal	Years to Pay Back at $5.00/gal	10 Years of Fuel Savings at $4.00/gal minus Price Difference
Toyota	Prius hybrid	$2,180	50	2.2	2.0	1.6	$8,897
Toyota	Camry Automatic		26				
Toyota	Camry Hybrid	$2,360	33	5.5	4.8	3.9	$2,535
Toyota	Camry SE Automatic		26				
Honda	Insight hybrid	$2,300	41	5.6	4.9	3.9	$2,421
Honda	Fit Automatic		31				
Honda	Civic Hybrid	$1,995	41	3.8	3.3	2.6	$4,061
Honda	Civic EX-L Automatic		29				
Ford	Fusion Hybrid	$2,105	39	2.8	2.4	2.0	$6,510
Ford	Fusion SEL 4cyl		25				
Ford	Escape Hybrid	$5,710	32	8.9	7.8	6.2	$1,627
Ford	Escape XLT Fwd		23				
Hyundai	Sonata Hybrid	$3,000	37	5.0	4.4	3.5	$3,861
Hyundai	Sonata SE Automatic		26				
Toyota	Highlander Hybrid 4wd	$2,740	28	3.1	2.7	2.2	$7,410
Toyota	Highlander 4wd SE		19				
Lexus	RX 450h 2wd hybrid	$5,560	30	7.4	6.5	5.2	$3,011
Lexus	RX 350 2wd		21				
Lexus	RX 450h 4wd hybrid	$5,750	29	7.1	6.2	4.9	$3,560
Lexus	RX 350 4wd		20				
Porsche	Cayenne S Hybrid	$3,300	21	7.9	6.9	5.5	$1,462
Porsche	Cayenne S		18				
GMC	Yukon Denali Hybrid 4wd	$5,125	21	5.1	4.5	3.6	$6,304
GMC	Yukon Denali Awd		15				
GMC	Sierra 1500 Hybrid 4wd Crew Cab	$4,693	21	8.0	7.0	5.6	$2,030
GMC	Sierra 1500 4wd Crew Cab SLE		17				
Cadillac	Escalade Hybrid 4wd	$2,175	21	2.2	1.9	1.5	$9,254
Cadillac	Escalade Premium Awd		15				
Chevrolet	Silverado 1500 Hybrid 4wd Crew Cab	$4,973	21	8.5	7.4	5.9	$1,750
Chevrolet	Silverado 1500 4wd Crew Cab		17				
Chevrolet	Tahoe Hybrid 4wd	$5,495	21	9.3	8.2	6.5	$1,228
Chevrolet	Tahoe LT with Luxury Package 4wd		17				
Mercedes	ML 450 Hybrid 4matic	$5,920	22	8.4	7.4	5.9	$2,101
Mercedes	ML 350 4matic		17				

Note: Fuel saving and years to pay back are based on an assumption of 15,000 annual miles. Hybrid vehicles were matched to their most comparable non-hybrid counterpart in terms of vehicle content and performance within the same manufacturer. The Toyota Prius and Honda Insight are unique hybrid models without a direct non-hybrid counterpart for comparison. They were matched to the model that was deemed closest to offering the same utility and amenities.

Source:

Compiled from manufacturer websites and the *Fuel Economy Guide* by Robert Boundy, Roltek, Inc., Clinton, TN. Data accessed May 5, 2011.

Japan Earthquake and Tsunami Effects: North American Production Fell Drastically in April 2011

The earthquake and tsunami that hit Northern Japan on March 11, 2011 had a dramatic effect on the production of motor vehicles for Japanese manufacturers, even here in the United States, due to the lack of key parts that were sourced from Japan. Honda and Toyota, which had plants in the northern part of Japan, were the hardest hit by parts shortages. Honda vehicle production from April to July stayed near 40-45,000 vehicles – about half of what production was in March. Toyota's production fell to 20,000 vehicles in May, but rose to above 50,000 in June. Nissan's worst month was April, right after the event. The dotted red line on the graph shows the average monthly production of these three companies in 2010 when there was no weather-related crisis.

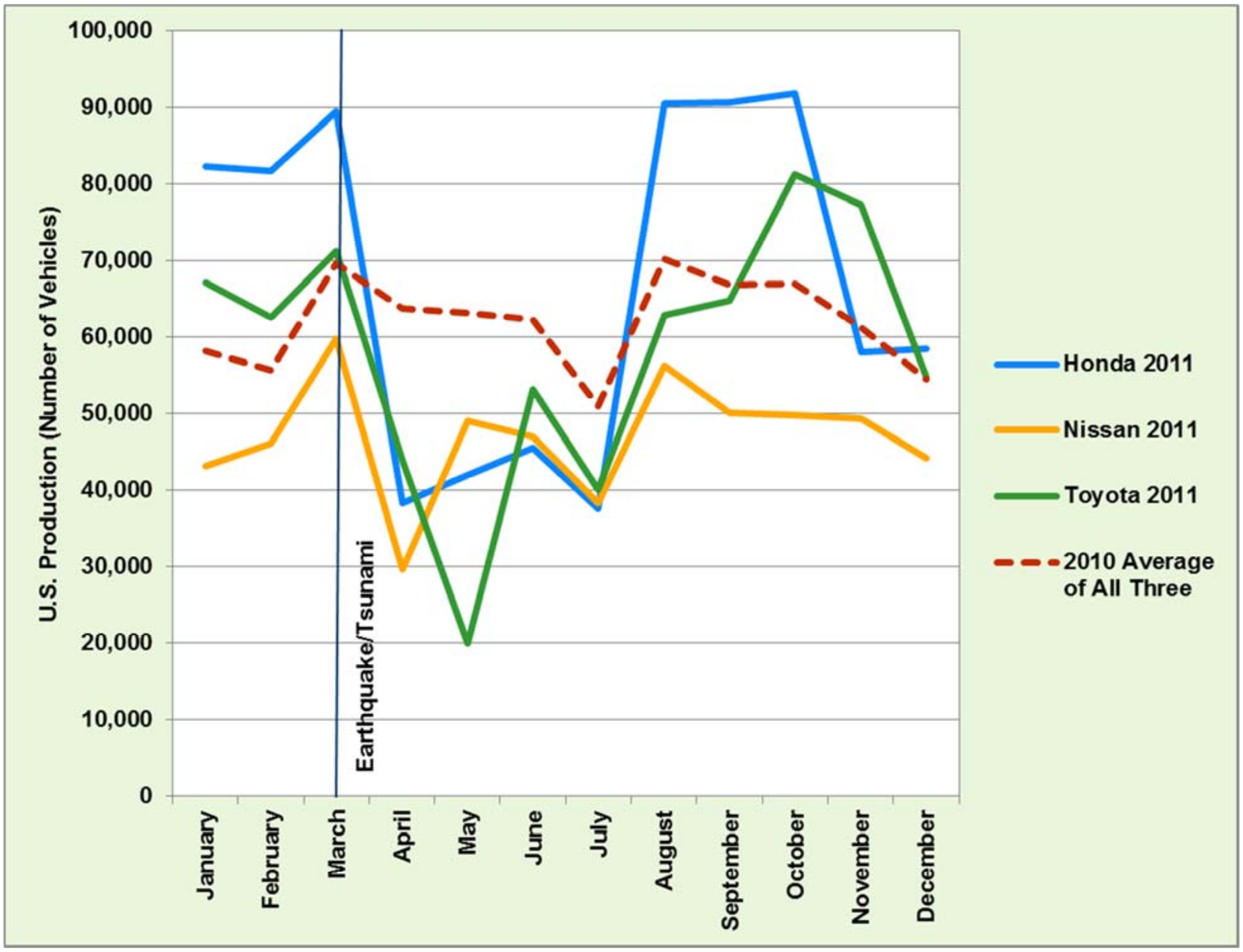


FIGURE 23. U.S. Production of Light Vehicles for Japanese Manufacturers by Month, 2011

Source:

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

Japan Earthquake and Tsunami Effects: Days' Supply of Vehicles for Honda and Toyota Hit Low Point in July 2011

The earthquake and tsunami that hit Northern Japan on March 11, 2011 had a great effect on the supply of motor vehicles for Japanese manufacturers. Nissan's supply of vehicles in the United States was the lowest in the month of March, while Honda and Toyota's supplies continued to decline to a low at the end of July 2011. The dotted red line on the graph shows the average monthly vehicle supply of these three companies in 2010 when there was no weather-related crisis.

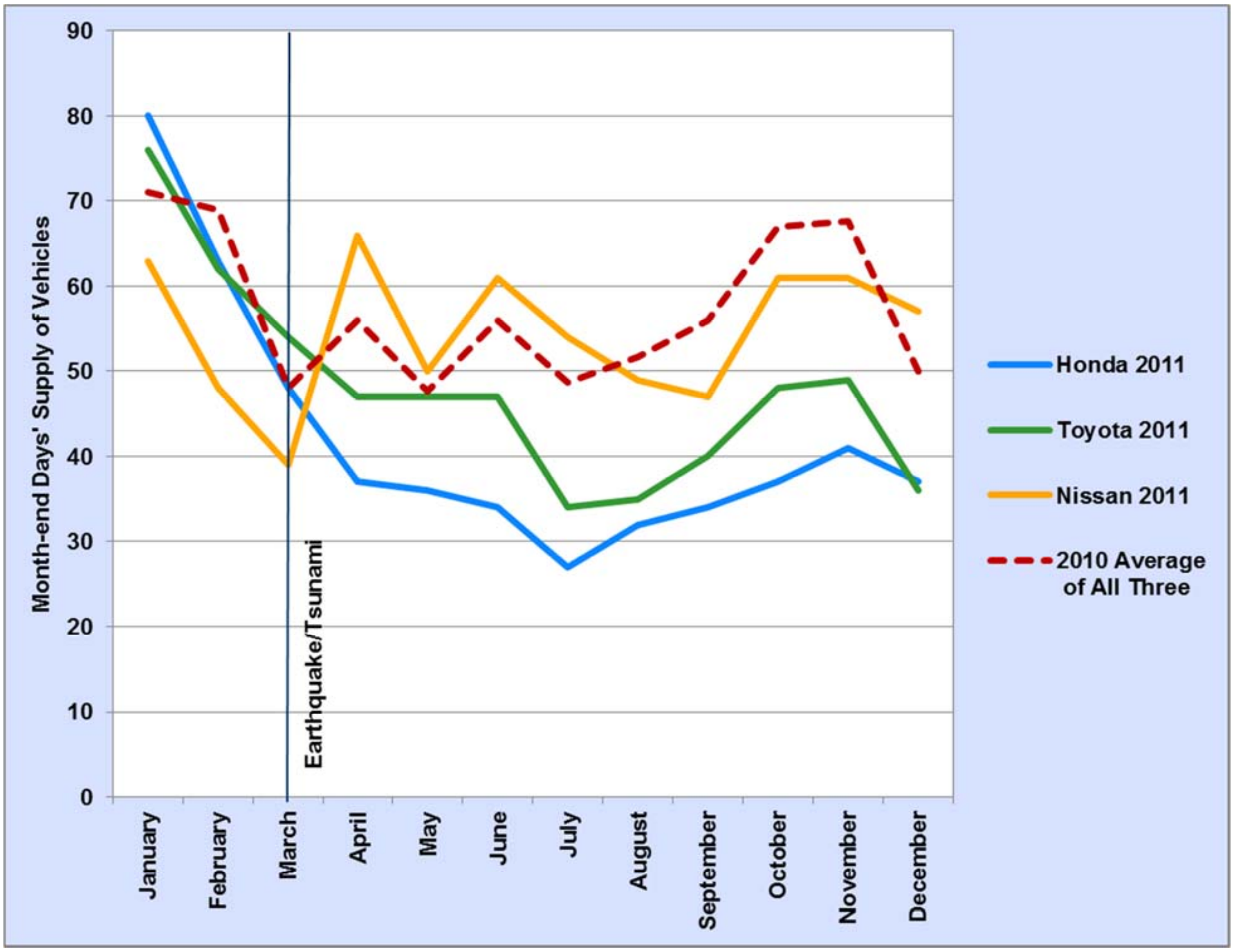


FIGURE 24. Light Vehicle Inventory Supply for Japanese Manufacturers by Month, 2011

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

Japan Earthquake and Tsunami Effects: Dramatic U.S. Sales Decline in April and May 2011

Sales of motor vehicles from Japanese manufacturers were down in 2011 due to the earthquake and tsunami that hit Northern Japan on March 11, 2011. Due to good supplies, and vehicles and parts already on their way to the United States, the effect on light vehicles sales did not hit the U.S. market largely until May for Honda and Toyota. Nissan was affected in April due to low inventory supplies and high sales volume in March. The dotted red line shows the average monthly sales of all three companies in 2010, when there was no weather-related crisis.

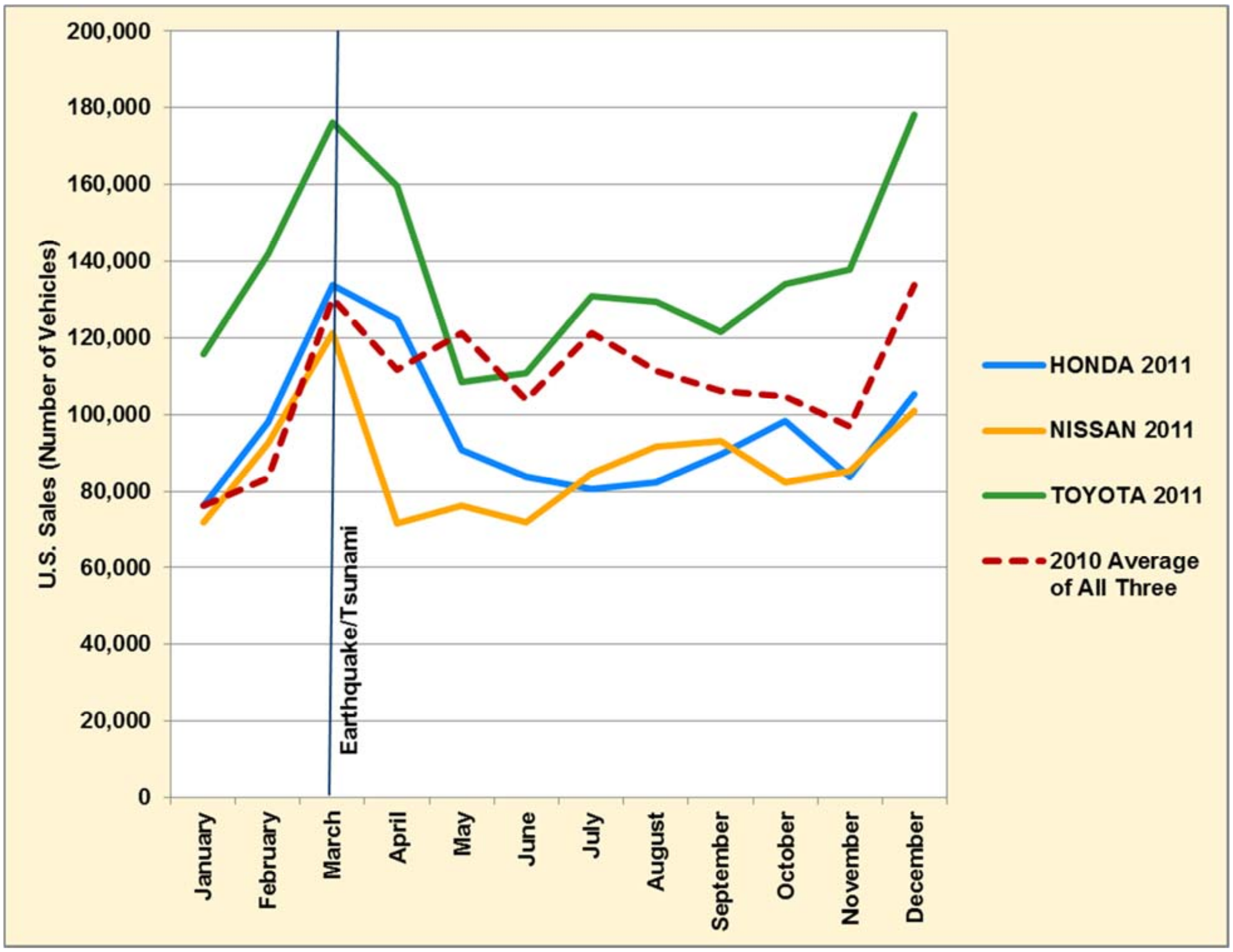


FIGURE 25. Light Vehicle Sales for Japanese Manufacturers by Month, 2011

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

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Chapter 2.

LIGHT VEHICLES

Page

Contents

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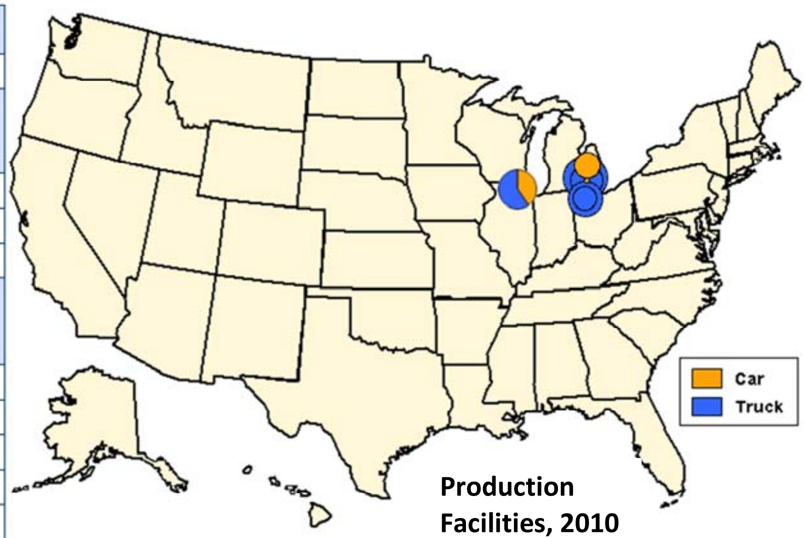
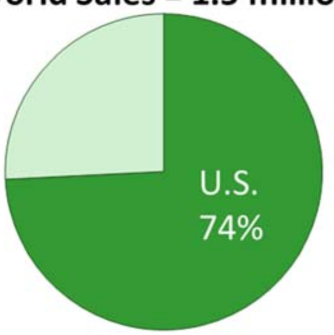
Chrysler Company Profile

Number of U.S. Employees	
18,300	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	29.9 mpg
Import Cars	None
Light Trucks	24.3 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	10
Natural Gas	0
Propane	0
Hybrid Electric	0
Plug-In Hybrid Electric	0
Electric	0



World Sales = 1.5 million



Chrysler Plants	Type	2010 Production
Warren, MI	Truck	197,449
Toledo, OH -Supplier Park	Truck	144,685
Detroit, MI -Jefferson North	Truck	134,153
Sterling Heights, MI	Car	101,353
Belvidere, IL	Truck	100,839
Toledo, OH -North	Truck	91,973
Belvidere, IL	Car	67,586
Detroit, MI -Connor Ave.	Car	459

FIGURE 26. Chrysler Company Profile

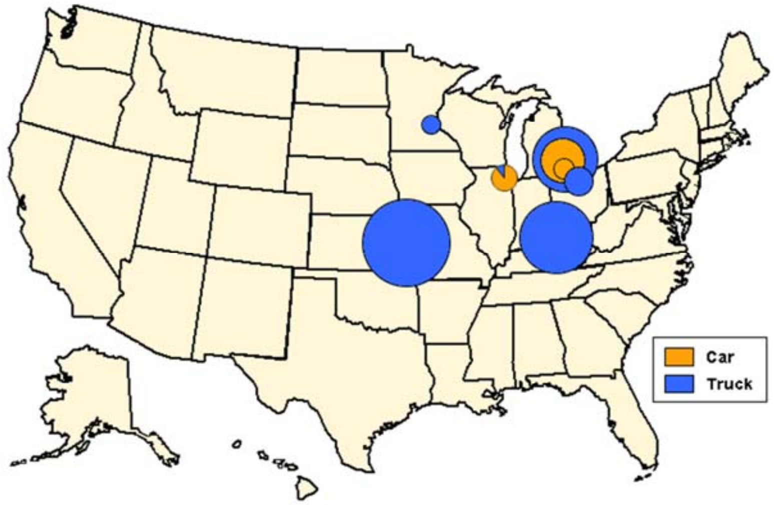
Fuel Saving Technologies

Chrysler emerged from bankruptcy in 2009, joined in an alliance with Fiat. By 2011, Fiat held a 58% share of Chrysler. This alliance brought some fuel savings technologies to Chrysler such as Fiat's Multiair technology that regulates the intake valves for the cylinders independently and increases power and torque while reducing emissions. Like other manufactures, Chrysler is increasing fuel economy throughout its' line-up by downsizing engines and shifting away from 8 cylinder and 6 cylinder engines in favor of more 4 cylinder engines. To meet consumer expectations for performance, Chrysler is also using turbocharging and direct injection to maximize engine output from their smaller engines while increasing efficiency.

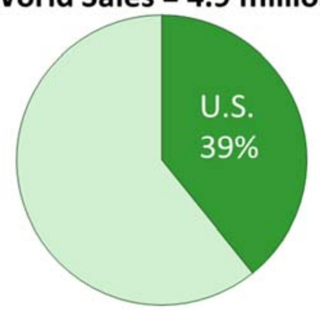
Chrysler has developed an 8 speed transmission for 2012 and is also working on a 9 speed transmission that is scheduled for 2013. Additionally, a 6 speed automatic double clutch transmission is being developed for 2012 which is mechanically similar to a manual transmission but with automatic shifting. An advantage of the double clutch transmission is that there is no loss of power between gearshifts. One clutch selects the odd gears (1, 3 & 5) while the other selects the even gears (2, 4 & 6) allowing for instantaneous shifts that maintain torque to the wheels at all times. Chrysler is also planning to bring an all-electric version of the Fiat 500 to market in 2012.

Ford Company Profile

Number of U.S. Employees	
75,000	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	32.4 mpg
Import Cars	None
Light Trucks	24.2 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	12
Natural Gas	1
Propane	1
Hybrid Electric	5
Plug-In Hybrid Electric	0
Electric	1



World Sales = 4.9 million



Ford Plants	Type	2010 Production
Kansas City, MO	Truck	427,282
Louisville, KY	Truck	351,286
Dearborn, MI	Truck	313,327
Wayne, MI	Car	199,502
Avon Lake, OH	Truck	121,471
Chicago, IL	Car	99,137
Flat Rock MI	Car	77,586
St. Paul, MN	Truck	70,666
Chicago, IL	Truck	11,905
Detroit, MI	Truck	7,143

FIGURE 27. Ford Company Profile

Fuel Saving Technologies

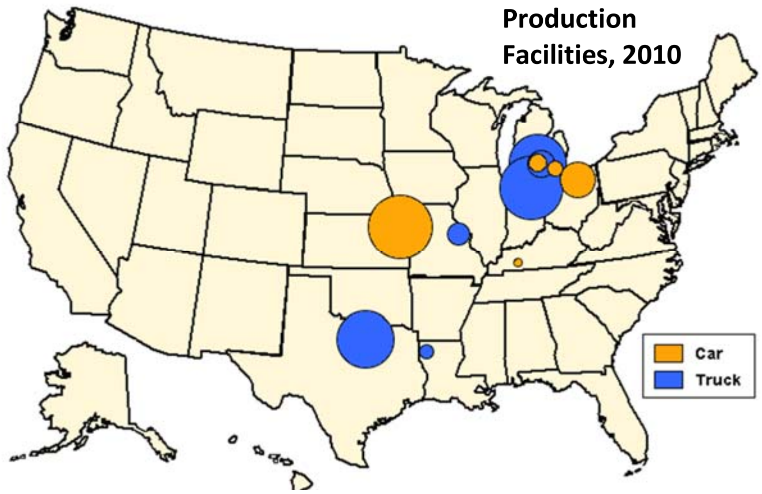
Ford has been very successful in developing and marketing their EcoBoost technology that uses gasoline direct injection combined with turbocharging to increase engine output while also increasing efficiency. This has allowed Ford to downsize their engine offerings while providing comparable performance. Consumers have embraced this technology, as evidenced by the V6 EcoBoost version of the F150 outselling the V8 option. The EcoBoost technology is being deployed throughout Ford's line-up of vehicles from work trucks down to their smallest entry-level passenger cars. Other engine technologies include twin independent variable camshaft timing (Ti-VCT) and aggressive deceleration fuel shut-off, as well as active grille shutters 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 used in the 2011 Fiesta SFE (Super Fuel Economy). This transmission shifts automatically but uses a dry double clutch similar to a manual transmission but without the loss of power between shifts which improves efficiency. Ford is also developing an 8 speed automatic to be used across their lineup to improve efficiency and facilitate the downsizing of their engines.

Ford has implemented full hybrid systems like those used in the Escape and Fusion hybrids and is planning to launch the Focus EV in 2012. Ford also worked with Azure Dynamics to produce the Transit Connect EV for 2011.

General Motors Company Profile

Number of U.S. Employees	
79,000	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	31.7 mpg
Import Cars	32.9 mpg
Light Trucks	23.1 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	21
Natural Gas	0
Propane	0
Hybrid Electric	5
Plug-In Hybrid Electric	1
Electric	0



GM Plants	Type	2010 Production
Kansas City, KS	Car	309,436
Fort Wayne, IN	Truck	304,679
Arlington, TX	Truck	282,029
Lansing, MI - Delta	Truck	277,696
Lordstown, OH	Car	158,099
Flint, MI	Truck	114,969
Wentzville, MO	Truck	91,016
Lansing, MI - Grand River	Car	65,480
Hamtramck, MI	Car	51,896
Shreveport, LA	Truck	48,449
Bowling Green, KY	Car	15,791

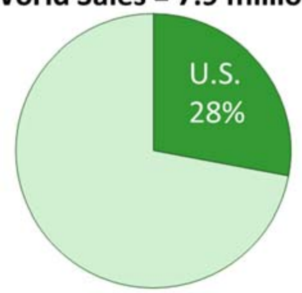


FIGURE 28. General Motors Company Profile

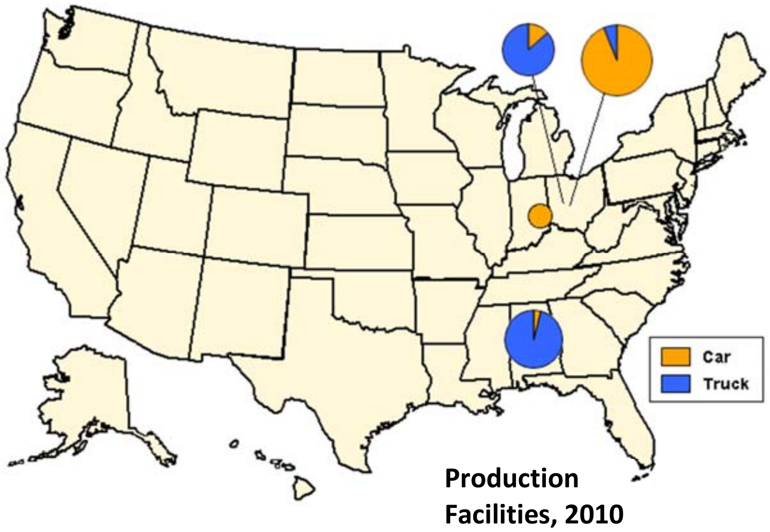
Fuel Saving Technologies

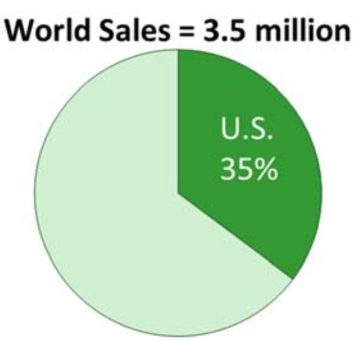
General Motors has implemented a wide range of technologies to achieve greater fuel efficiency. In late 2010, GM launched the Chevrolet Volt, which was the first commercially available plug-in hybrid to reach the market. On full-sized trucks and SUVs where towing is important, GM has offered a Two-Mode hybrid system beginning with the 2008 model year that provides the benefits of hybrid technology while still providing towing capability. In addition to these robust and costly hybrid drivetrain technologies, GM is also implementing lower cost “stop-start” hybrid technologies that it has termed eAssist. The eAssist technology was introduced in the Buick LaCrosse and Regal for 2011 and will be offered in the redesigned 2013 Chevrolet Malibu as well.

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 Chevrolet Sonic. Aerodynamics, both passive like air dams and underbody panels, as well as dynamic technologies like active shutters in the front grille that close at higher speed to improve aerodynamics, are increasingly used to boost efficiency. General Motors has also been a proponent of E85 flex-fuel vehicles and brought to market the first turbocharged E85 flex-fuel vehicle with 2011 Buick Regal. GM will also be introducing the all-electric Spark EV for the 2013 model year and will be introducing a diesel version of the Chevrolet Cruze that same year.

Honda Company Profile

Number of U.S. Employees	
25,000	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	34.9 mpg
Import Cars	42.8 mpg
Light Trucks	26.2 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	0
Natural Gas	1
Propane	0
Hybrid Electric	3
Plug-In Hybrid Electric	0
Electric	0





Honda Plants	Type	2010 Production
Marysville, OH	Car	320,011
Lincoln, AL	Truck	261,090
East Liberty, OH	Truck	213,543
Greensburg, IN	Car	95,116
East Liberty, OH	Car	33,200
Marysville, OH	Truck	20,550
Lincoln, AL	Car	10,992

FIGURE 29. Honda Company Profile

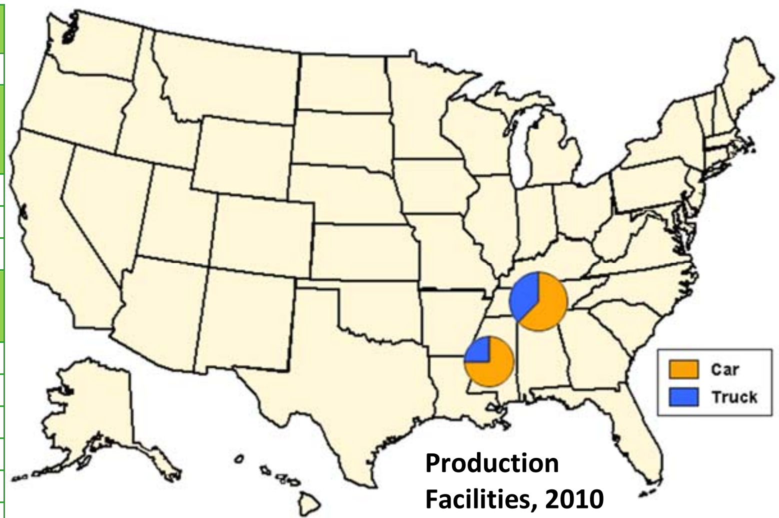
Fuel Saving Technologies

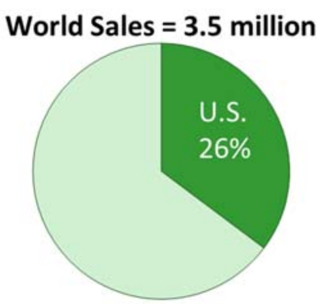
Honda began using cylinder deactivation or variable cylinder management (VCM) beginning with the top trim level of the 2005 Odyssey and it is now standard in the newly redesigned 2011 Odyssey. It has also been used in select trim levels of the Accord since 2008. This provides the power of a larger displacement engine while providing the efficiency of a smaller engine when power is not needed.

Honda is also actively developing and deploying hybrid technology. The Insight and CR-Z are hybrid-only models while the Civic Hybrid is based on the standard Civic model. Honda is pursuing hybrid technologies and spreading them across more of their lineup and a fully electric vehicle is planned for the U.S. market in the form of 2012 Honda Fit EV. 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 led to the development of the FCX Clarity. In 2008, the FCX Clarity became the first commercial fuel cell vehicle available to consumers – as a leased vehicle for those living in Southern California.

Nissan Company Profile

Number of U.S. Employees	
11,200	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	34.6 mpg
Import Cars	33.4 mpg
Light Trucks	24.8 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	2
Natural Gas	0
Propane	0
Hybrid Electric	1
Plug-In Hybrid Electric	0
Electric	1





Nissan Plants	Type	2010 Production
Smyrna, TN	Car	175,651
Canton, MS	Car	171,216
Smyrna, TN	Truck	105,623
Canton, MS	Truck	57,748

FIGURE 30. Nissan Company Profile

Fuel Saving Technologies

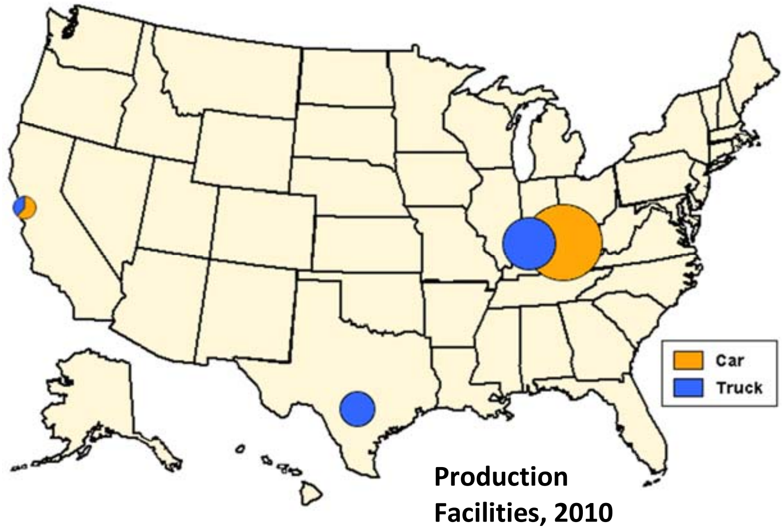
Of the major manufacturers, Nissan has been the most aggressive in promoting electric vehicles not only in the United States but also around the world. Nissan launched the 2011 Leaf EV in the U.S. market at the very end of calendar year 2010. Nissan has implemented full hybrid technology with the Altima Hybrid but has not spread this throughout their line-up.

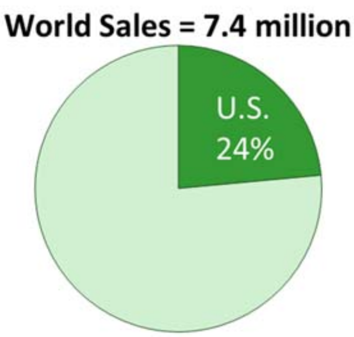
Though Nissan has employed gasoline direct injection with turbocharging, they have also developed a lower cost dual port injection system that produces similar benefits of better performance and an increase in fuel economy of about 4% over an engine with a single fuel injector. The 2012 Versa will be 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. CVTs are typically used on vehicles with small displacement engines with limited torque. However, Nissan was the first to offer the CVT for engines as large as 3.5 liters and now offers them throughout their line-up including high-powered luxury vehicles.

Toyota Company Profile

Number of U.S. Employees	
29,000	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	32.6 mpg
Import Cars	42.6 mpg
Light Trucks	25.5 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	2
Natural Gas	0
Propane	0
Hybrid Electric	8
Plug-In Hybrid Electric	0
Electric	0





Toyota Plants	Type	2010 Production
Georgetown, KY	Car	371,694
Princeton, IN	Truck	243,992
San Antonio, TX	Truck	150,098
Fremont, CA (NUMMI)	Car	63,318
Fremont, CA (NUMMI)	Truck	27,495

FIGURE 31. Toyota Company Profile

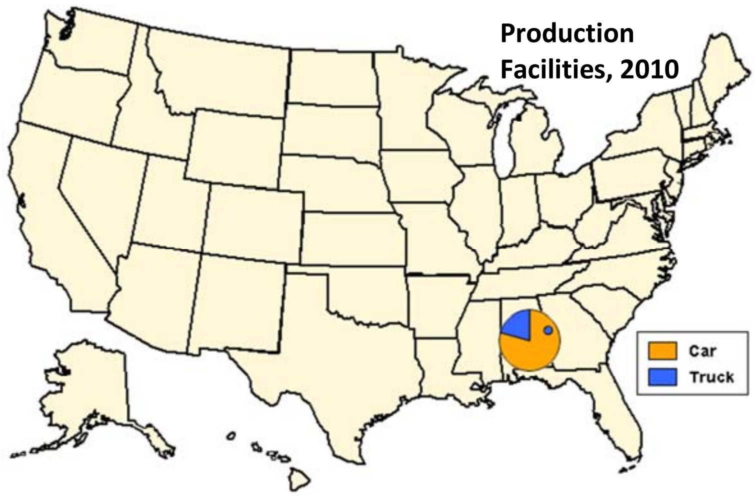
Fuel Saving Technologies

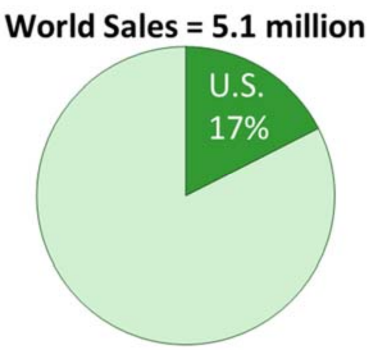
Toyota has been a dominant player in the development of hybrid technology and is expanding the Prius into a family of hybrid vehicles. The new Prius models will include a larger Prius that offers more cargo space called the Prius V as well as a smaller Prius that will get higher fuel economy than the current model that is referred to as the Prius C. A plug-in version of the standard Prius is also scheduled to arrive in the spring of 2012 with an all-electric range of about 15 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.

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 pursuing diesel engines for its larger vehicles like the Tundra and Sequoia where power, torque and towing capacity are particularly important. The 2012 Scion iQ EV will be Toyota's first all-electric vehicle for the U.S. market. Like other manufacturers, aerodynamics is an important part of Toyota's strategy for increasing fuel economy as evidenced by the standard Prius and plug-in Prius which have among the lowest coefficients of drag in the industry.

Hyundai Company Profile

Number of U.S. Employees	
5,000	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	None
Import Cars	35.7 mpg
Light Trucks	28.6 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	0
Natural Gas	0
Propane	0
Hybrid Electric	1
Plug-In Hybrid Electric	0
Electric	0





Hyundai Plants	Type	2010 Production
Montgomery, AL	Car	238,387
Montgomery, AL	Truck	62,113
West Point, GA	Truck	17,320

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 32. Hyundai Company Profile

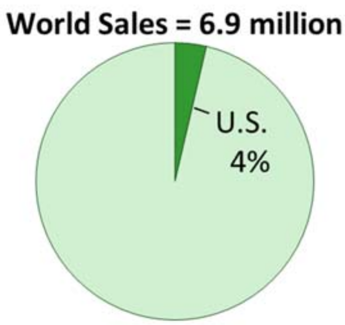
Fuel Saving Technologies

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 their engine offerings. In order to do this while still meeting consumer expectations for performance, Hyundai is combining weight reduction with high output turbocharged direct injection engines. The 2011 Hyundai Sonata is an example of this approach as Hyundai became the first manufacturer in the United States to offer a large sedan without a V6 option. The 2011 Sonata is offered with a base 2.4 liter gasoline direct injection (GDI) 4 cylinder engine that produces 200 horsepower or an optional 2.0 liter turbocharged engine that delivers 274 horsepower. The overall vehicle weight of the 2011 Sonata is 130 lbs. less than the outgoing model.

Aside from smaller high output engines and weight reduction, Hyundai is implementing a range of other technologies as well – from aerodynamics to hybrid drive trains. For example, the 2011 Sonata is also offered as a hybrid. These technologies are being deployed throughout their model line-up. In addition, Hyundai is developing diesel and fuel cell technology.

Volkswagen Company Profile

Number of U.S. Employees	
4,500	
Corporate Average Fuel Economy, Model Year 2010	
Domestic Cars	None
Import Cars	33.4 mpg
Light Trucks	27.2 mpg
Number of Alternative Fuel Models, Model Year 2011	
Flex Fuel	3
Natural Gas	0
Propane	0
Hybrid Electric	1
Plug-In Hybrid Electric	0
Electric	0



Volkswagen Plants	Type	2010 Production
Chattanooga, TN	Car	None

FIGURE 33. Volkswagen Company Profile

Fuel Saving Technologies

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

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

Volkswagen has been developing hybrid systems for passenger vehicles and will be introducing a gas-electric hybrid Jetta model to the U.S. market in 2012. Also under development are pure electric models like the Volkswagen E-Up! and Audi e-Tron.

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

The companies that made 90% of all vehicles produced in the United States in 2010 are together responsible for only about half of the vehicles produced worldwide. VW, which did not produce vehicles in the United States until 2011, held 8% of World production in 2010. Hyundai produced 6% of the World's vehicles and only 4% of U.S. vehicles. Toyota had a consistent producer share of 10% in the United States and the World. Many companies, like recent upstarts in China and India, comprise the other 50% of world production. The U.S. produces about 10% of the world's vehicles.

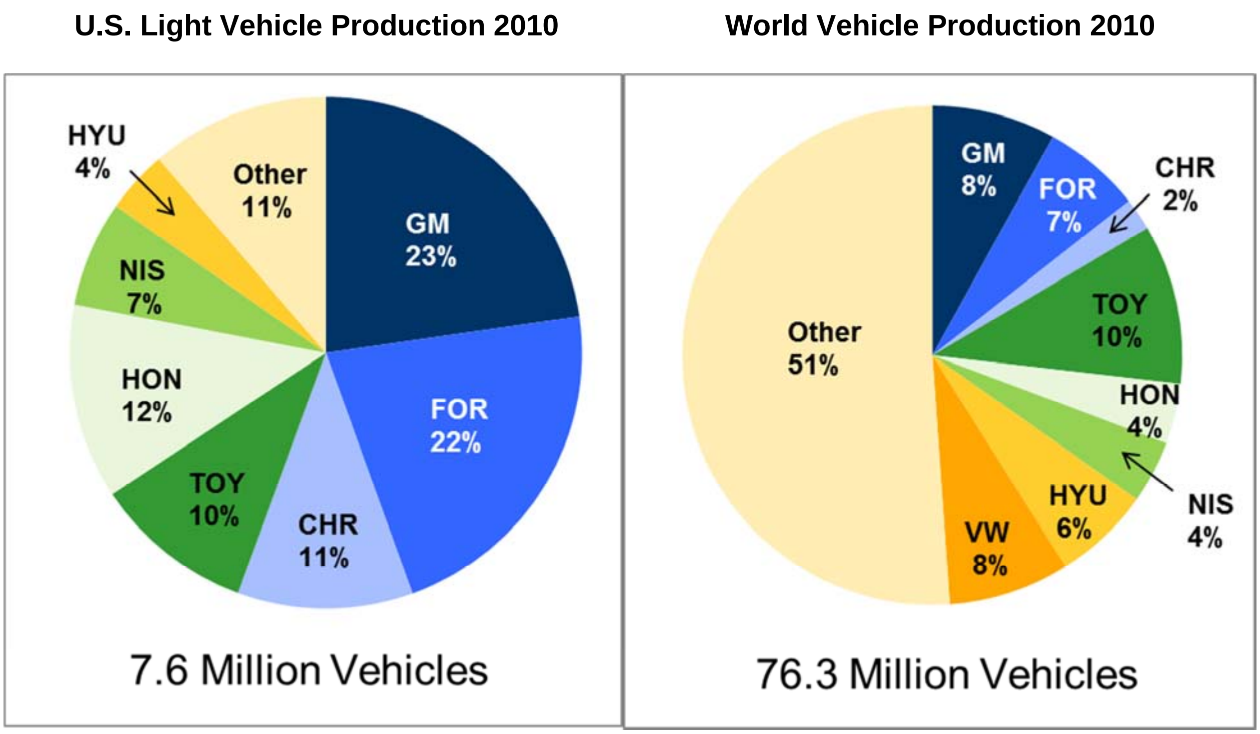


FIGURE 34. Production of U.S. and World Vehicles in 2010 by Manufacturer

Note: World production includes heavy vehicles, which are a small share of total production.

Source:
Wards AutoInfoBank.

U.S. Sales Volumes Rose in 2010, Reversing Downward Trend

From 2006 to 2009, car and light truck sales declined each year. The trend reversed in 2010, with sales climbing slightly over 2009 levels. Even with the increase, about 30% fewer cars and light trucks were sold in 2010 than in 2006. Most of the major manufacturers experienced drastic sales declines over this period. The exceptions are Hyundai and Nissan. Hyundai sold 24% more cars in 2010 than in 2006. Nissan also experienced a small increase (7%) in car sales.

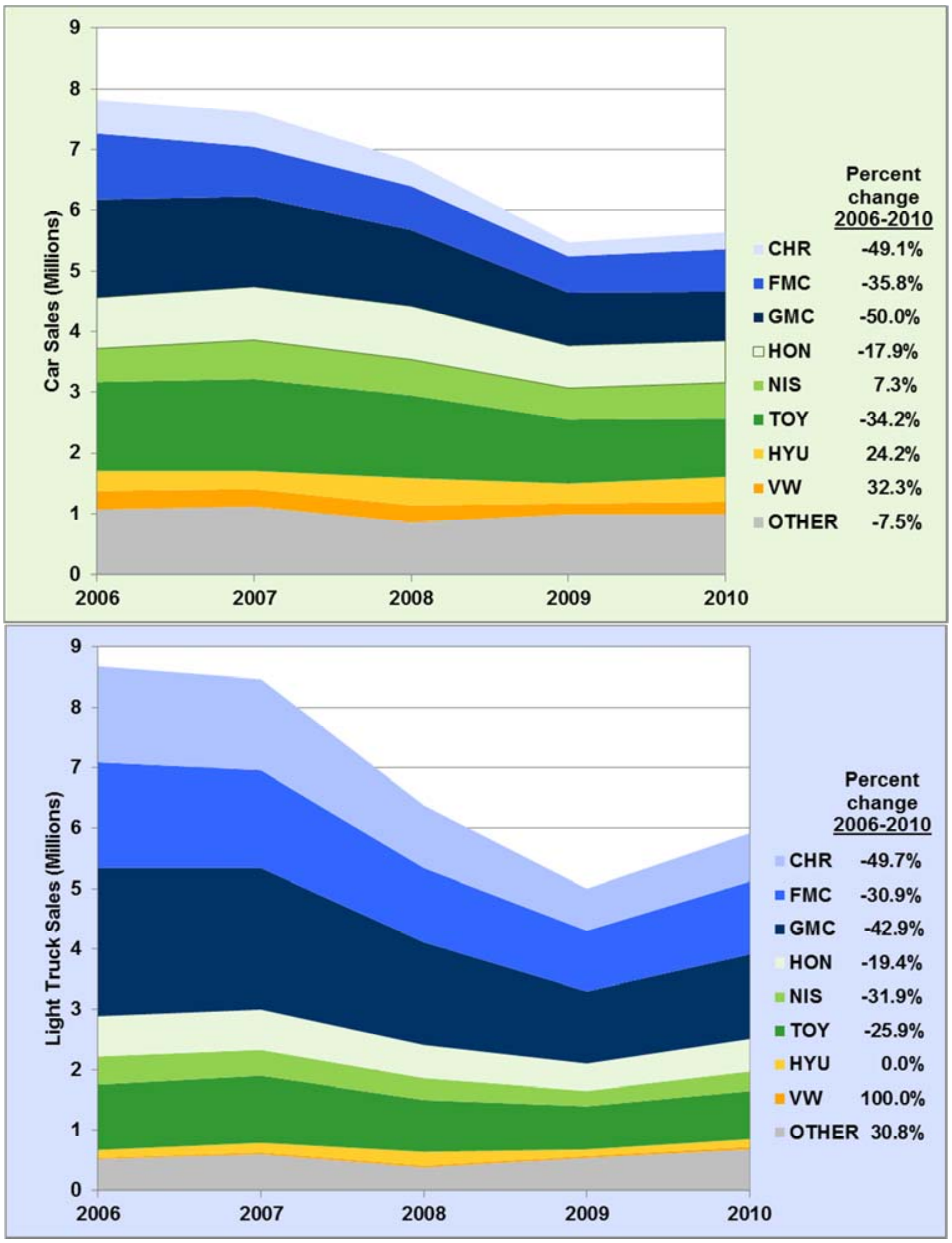


FIGURE 35. New Light Vehicle Sales by Manufacturer, 2006-2010

Source:
Wards AutoInfoBank.

Market Share Shifted Among Manufacturers

Smaller manufacturers are gaining market share. In the car market, General Motors, Ford, Chrysler, and Toyota all lost market share from 2006 to 2010, while Hyundai, Nissan, and Honda gained. The three domestic manufacturers accounted for two-thirds of light truck market share in 2006, but only 58% in 2010.

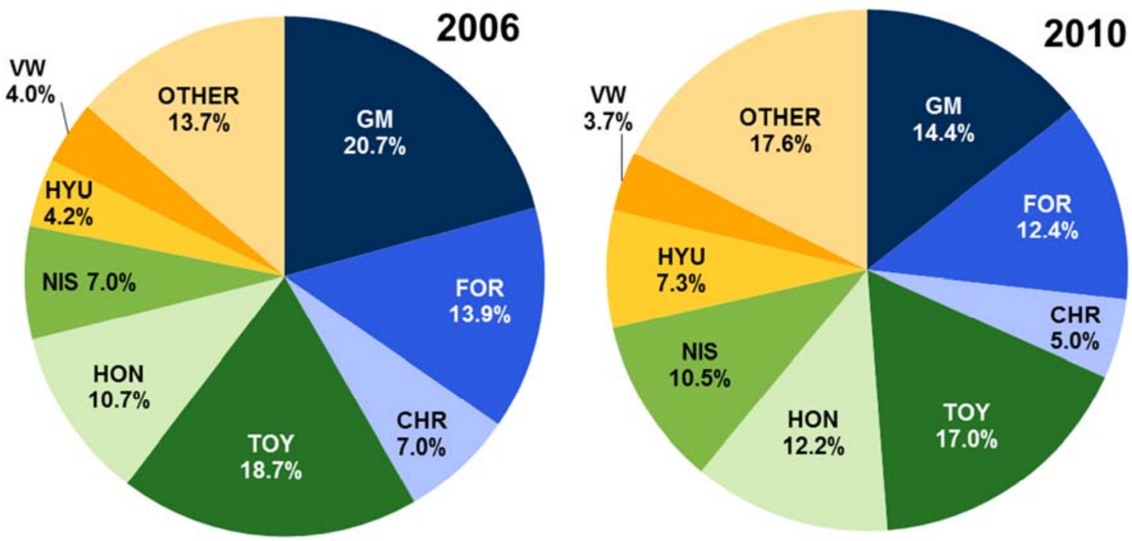


FIGURE 36. New Car Market Share by Manufacturer, 2006 and 2010

Source:
Ward's AutoInfoBank

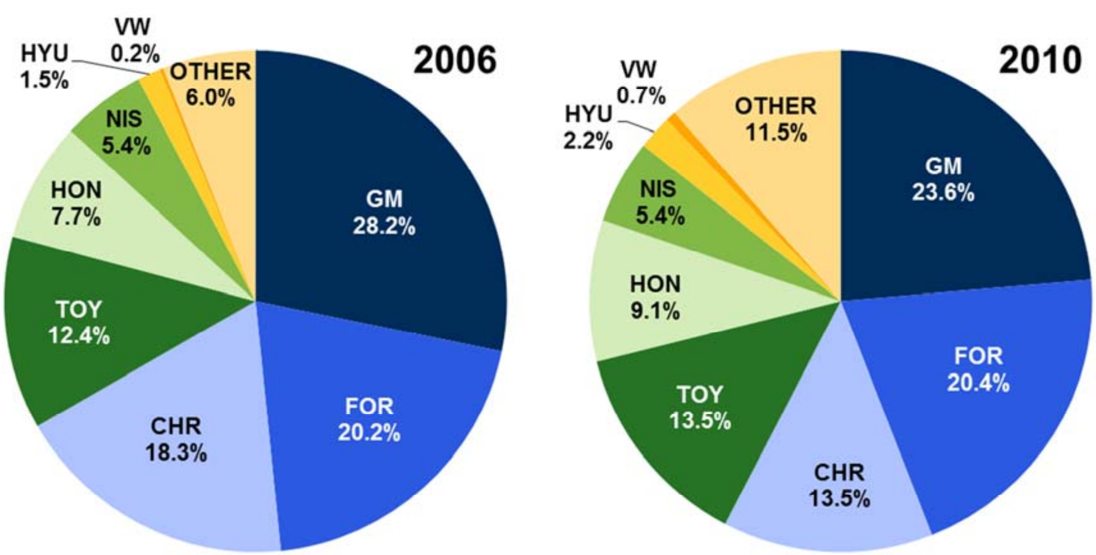


FIGURE 37. New Light Truck Market Share by Manufacturer, 2006 and 2010

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, GM, Ford 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.

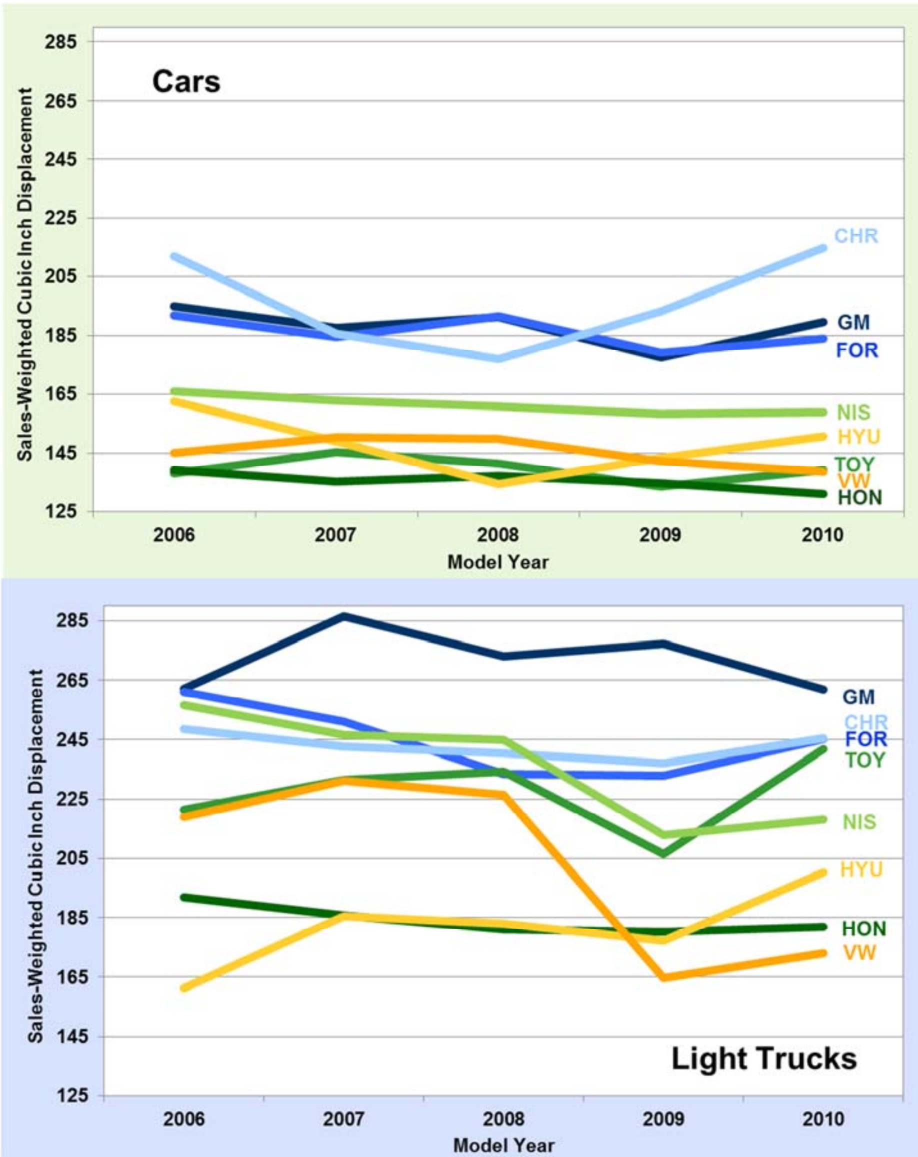


FIGURE 38. Car and Light Truck Engine Size by Manufacturer

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Horsepower is Up in 2010

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, GM, Ford, Toyota, and Hyundai have increased average sales-weighted horsepower in 2010 model year (MY) cars. In light trucks, Toyota and Hyundai have increased horsepower significantly from 2009 to 2010. Nissan and VW had a large decline in light truck horsepower between 2008 and 2009.

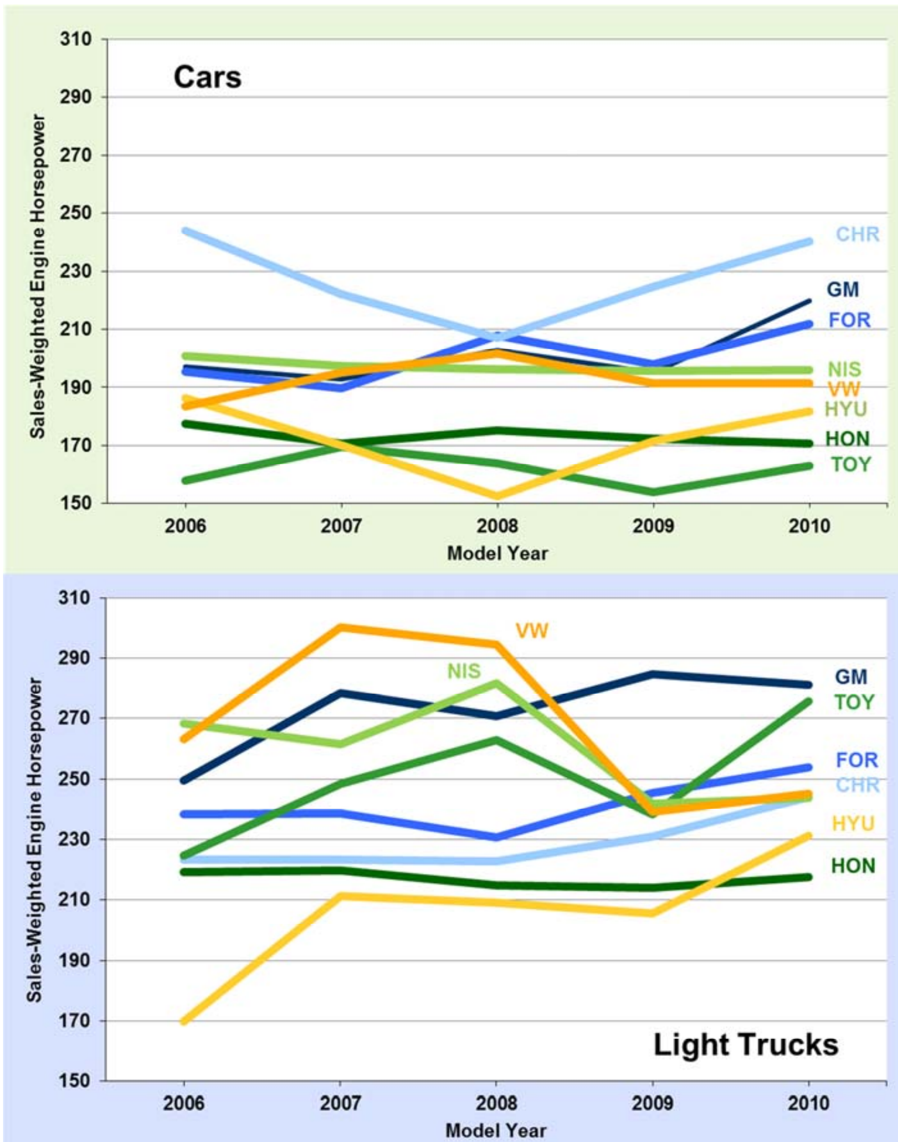


FIGURE 39. Car and Light Truck Horsepower by Manufacturer

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Fuel Economy Improvement is Small Compared to Increase in Horsepower

Despite a 110% increase in horsepower and 34% decrease in 0-60 time from 1980 to 2010, the fuel economy of vehicles improved 17.2%. All of these data series are sales-weighted averages. The weight of the vehicle appears to have an inverse relationship with fuel economy.

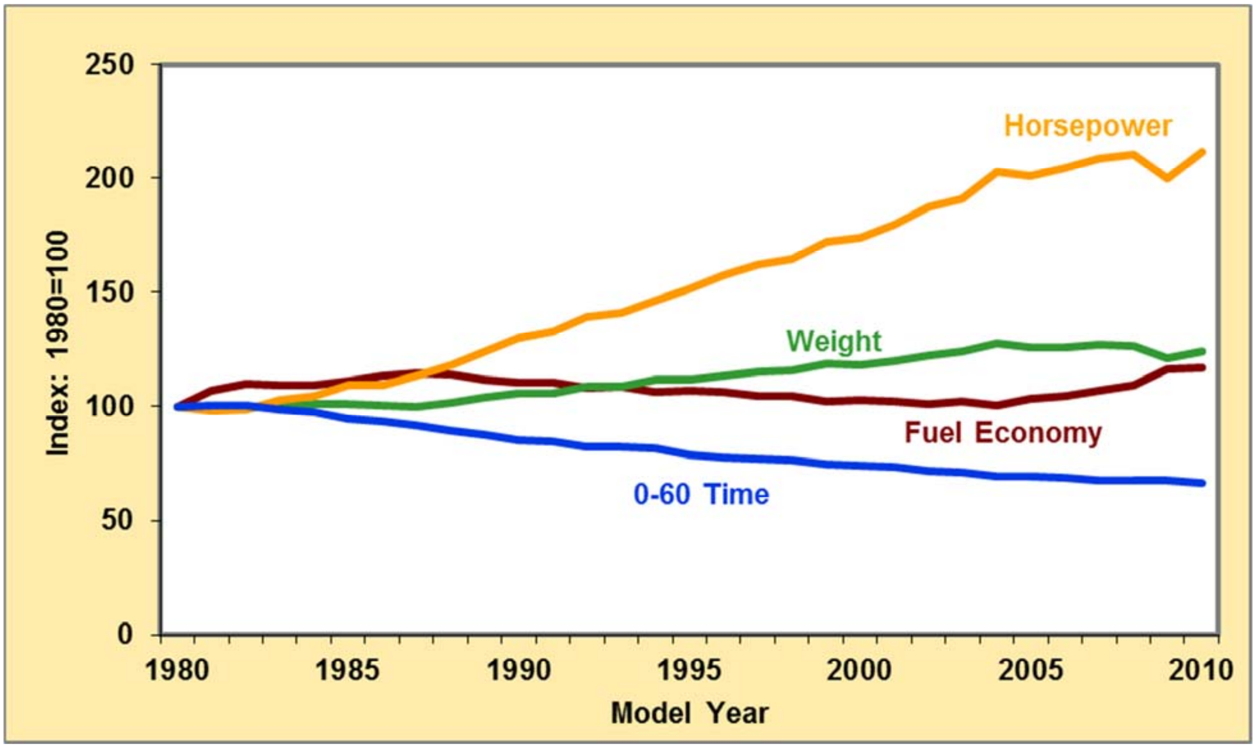
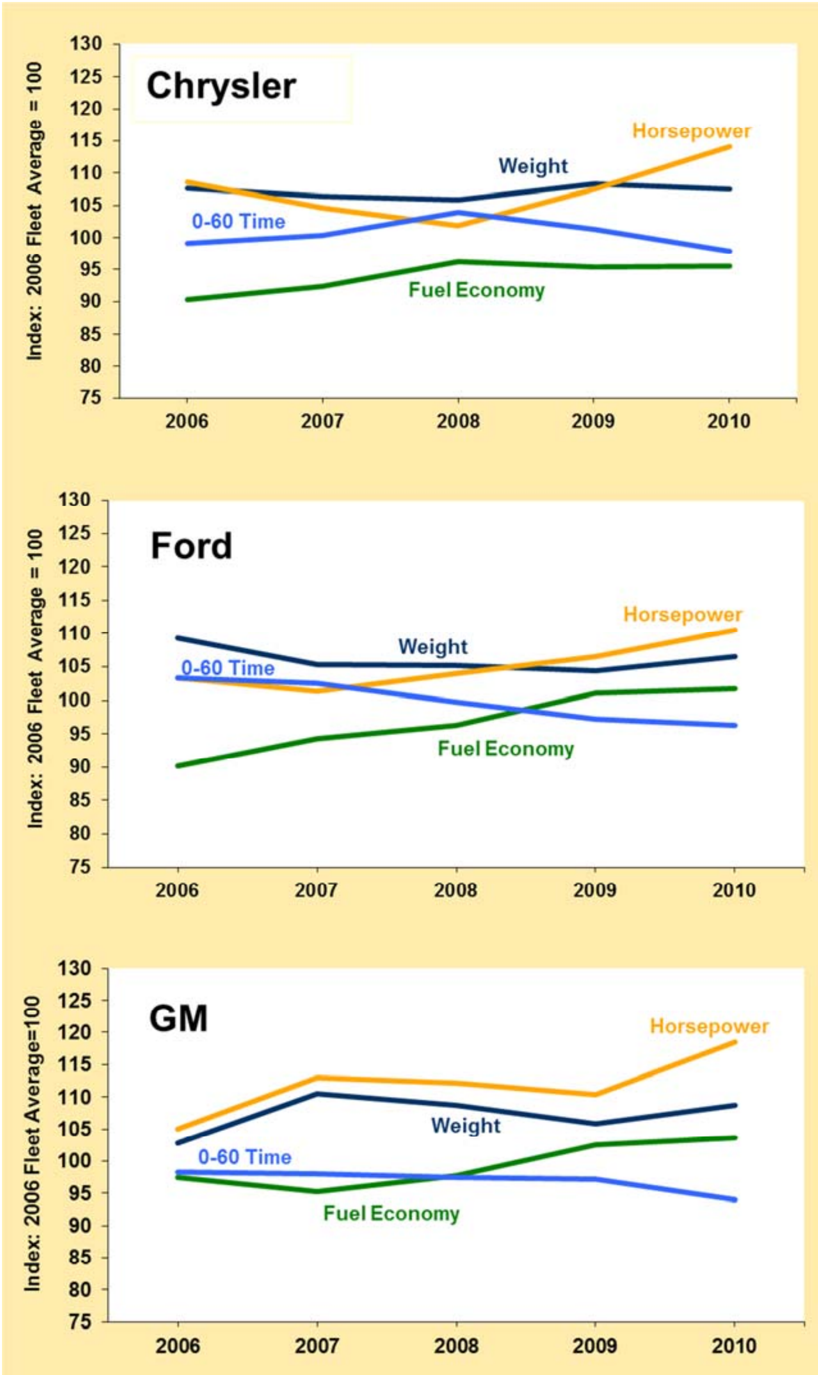


FIGURE 40. Characteristics of Light Vehicles Sold, 1980-2010

Note: Data are sales-weighted.

Source:
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

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



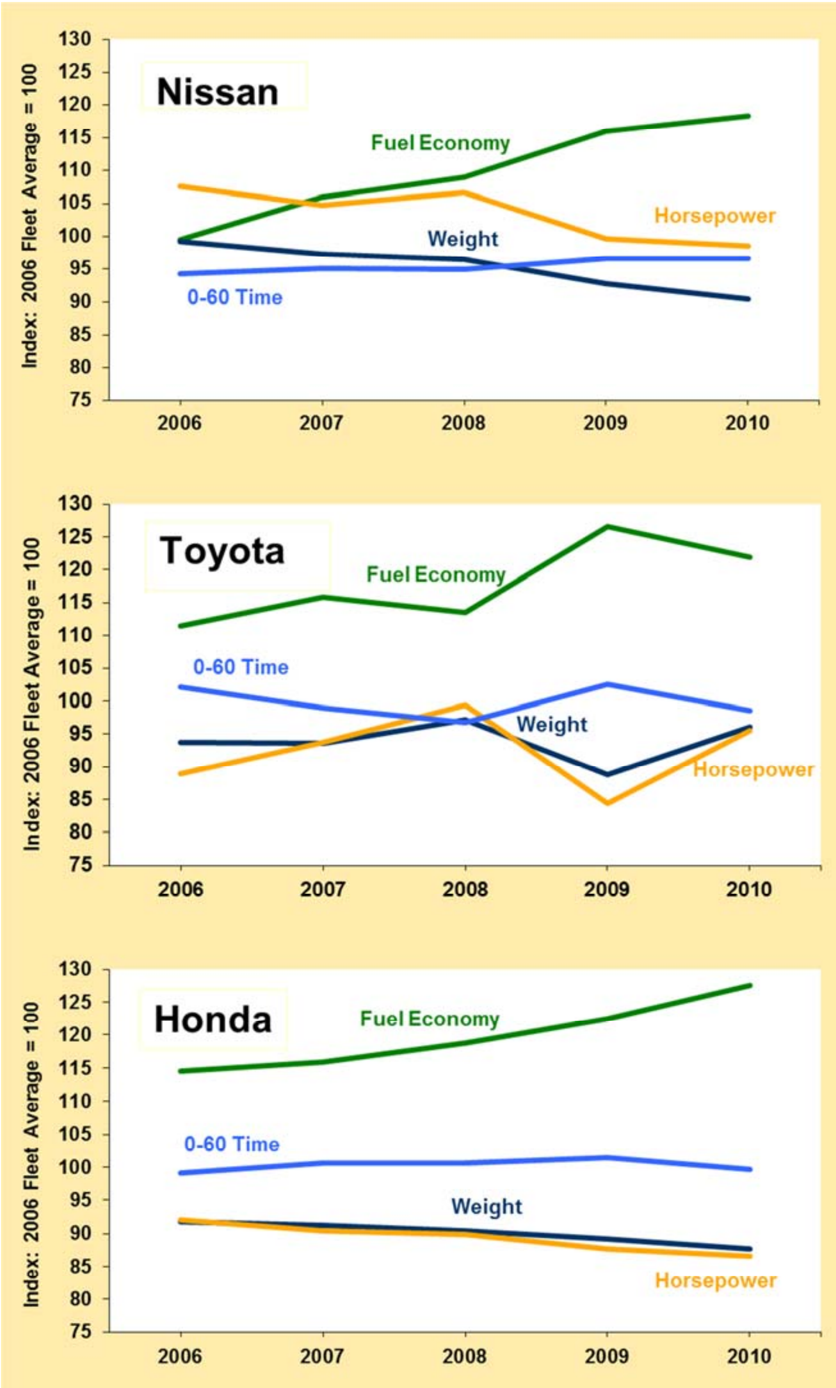
These sales-weighted averages show that all of the Detroit 3 manufacturers are increasing the horsepower and decreasing the 0-60 times of the light vehicles they sell. Vehicle weight for all three has fluctuated slightly up and down as they try to use more lightweight materials while adding additional features on the vehicles. Ford made the biggest improvement in fuel economy over the five year period – a 13% improvement from 2006 to 2010. In the same time frame, Chrysler and GM both had a 6% improvement in fuel economy. Fuel economy in 2006 was below the fleet average (below 100 on the graph) for all three manufacturers.

FIGURE 41. Characteristics of Detroit 3 Light Vehicles Sold, 2006-2010

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Fuel Economy Above Fleet Average and Weight Below Fleet Average for Japanese Manufacturers



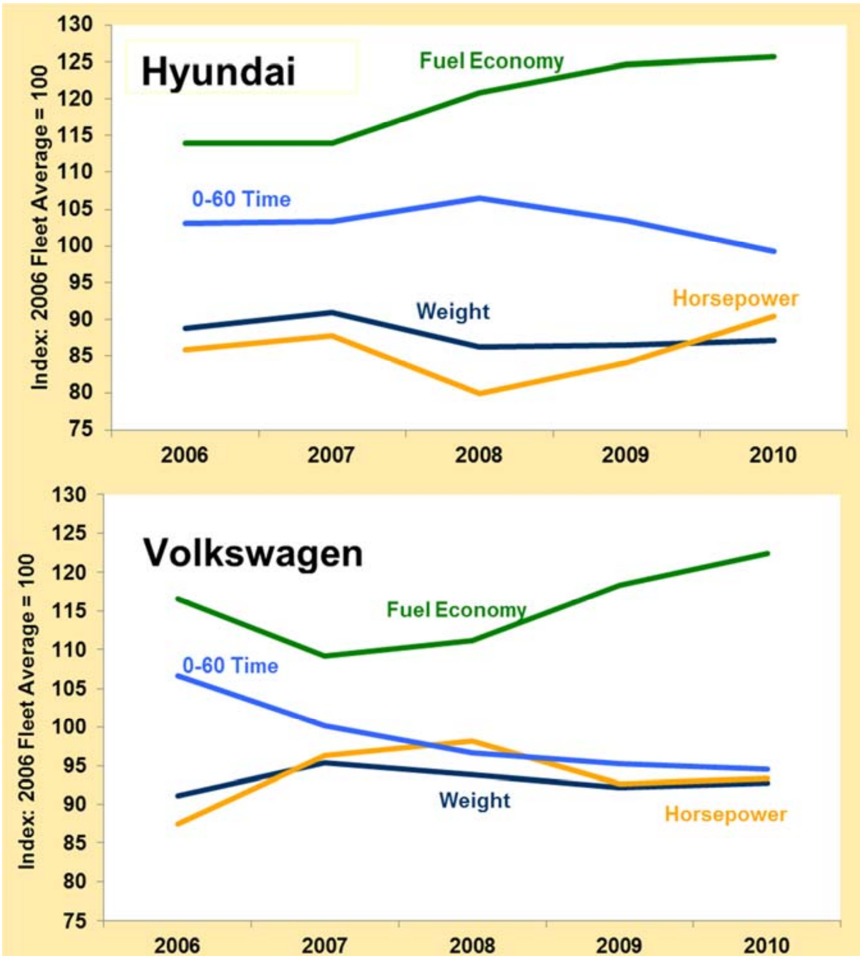
These sales-weighted averages show that the fuel economy of these Japanese manufacturers has been at or above the fleet average (above 100 on the graph) over the last five years. Nissan had the greatest fuel economy improvement of any manufacturer – 13% over the five year period. Unlike the Detroit 3, these Japanese manufacturers have not increased horsepower or 0-60 times in the last five years. In fact, horsepower is lower for Nissan and Honda, and up by 7% for Toyota. Weight for all three manufacturers was below fleet average.

FIGURE 42. Characteristics of Japanese Light Vehicles Sold, 2006-2010

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

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



These sales-weighted averages show that both Hyundai and Volkswagen have improved fuel economy since 2007. Even in 2006 the fuel economy for both companies' light vehicles was higher than the fleet average (higher than 100 on the graph). Volkswagen decreased 0-60 time by 11% from 2006 to 2008, while horsepower rose 7% overall in the five year period. Despite that increase, horsepower was below the fleet average for both manufacturers.

FIGURE 43. Characteristics of Light Vehicles Sold by Other Large Manufacturers, 2006-2010

Source:
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. 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 15.3% of car and 5.3% 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 2010 that were equipped with CVT.

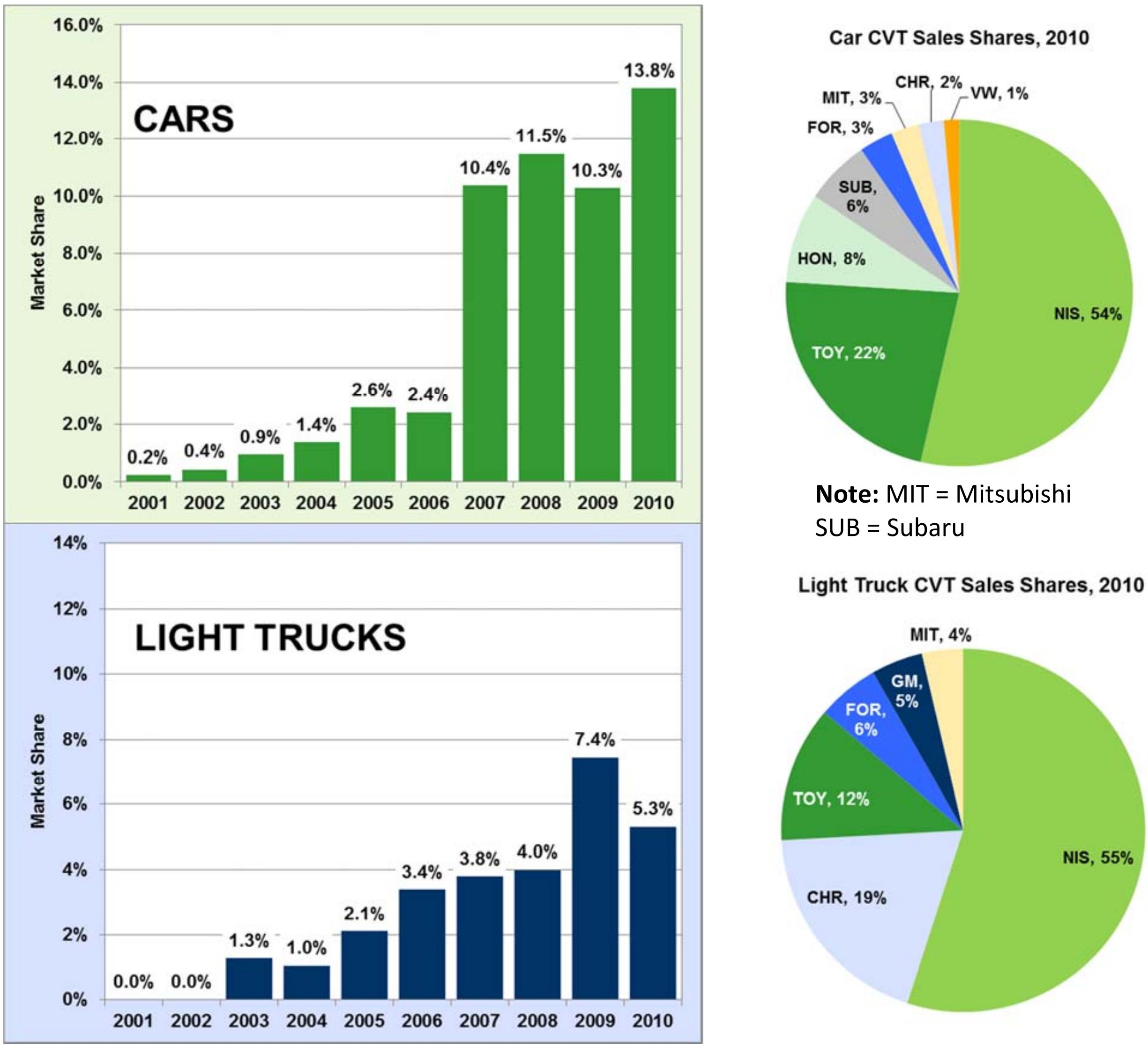


FIGURE 44. CVT Market Share, 2003-2010 and CVT Manufacturer's Share, 2010

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. 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 5 speeds or more began dominating the market. The market share grew for 6 and 7-speed cars and light trucks in 2010. Continuously variable transmissions (CVT) are also making their way into the market.

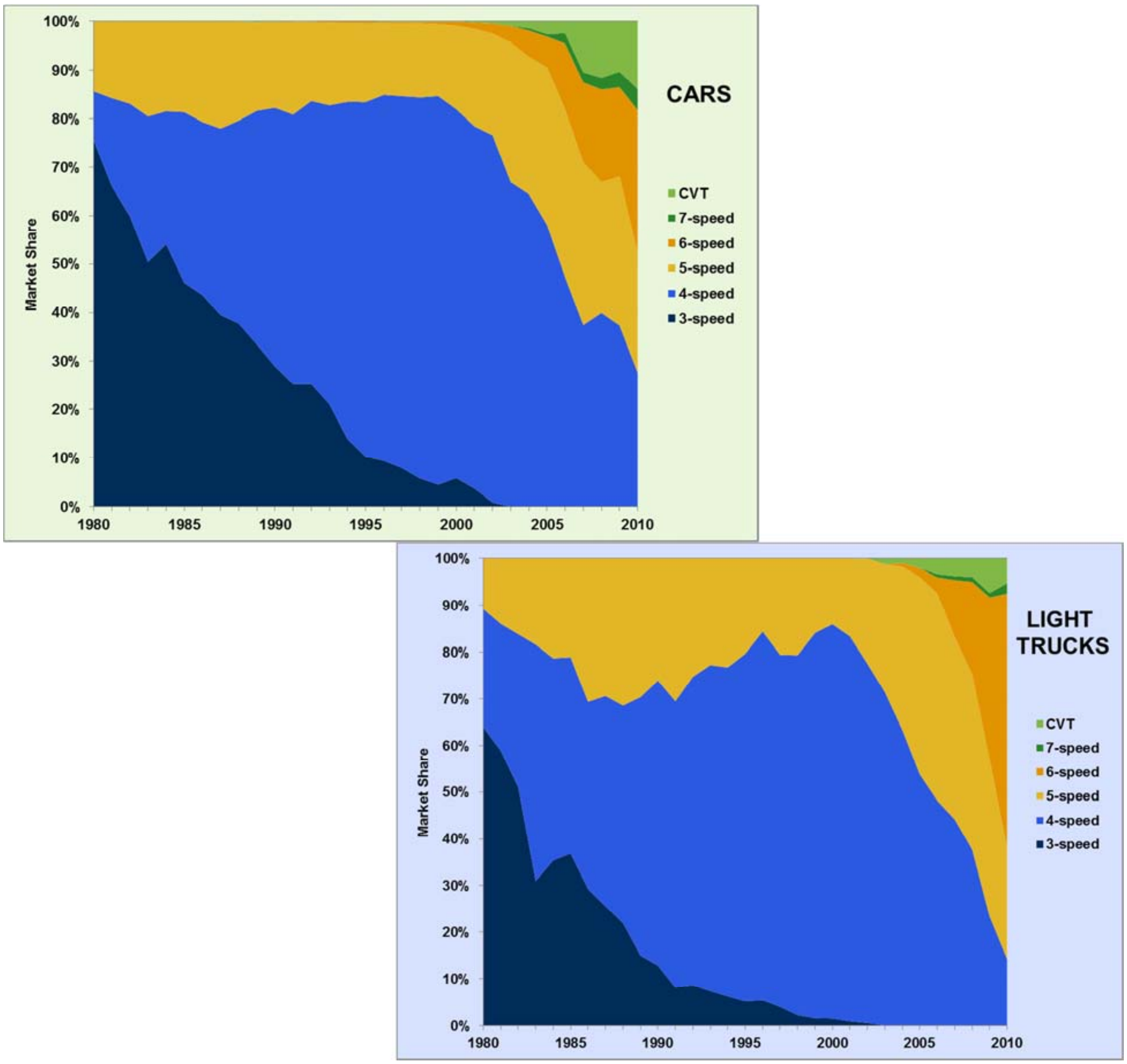


FIGURE 45. Market Share of Transmission Speeds, 1980-2010

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

VW, Toyota, GM, and Ford Use Gasoline Direct Injection in Cars

> VW began using gasoline direct injection (GDI) in cars in model year (MY) 2008 and nearly 50% of the cars it sold in MY 2010 were GDI. Chrysler, Nissan, Honda, and Hyundai (not pictured) have used port fuel injection exclusively since the mid-1990's. VW also sold diesel cars over the years, while the other large manufacturers have not sold diesels since the 1980's.

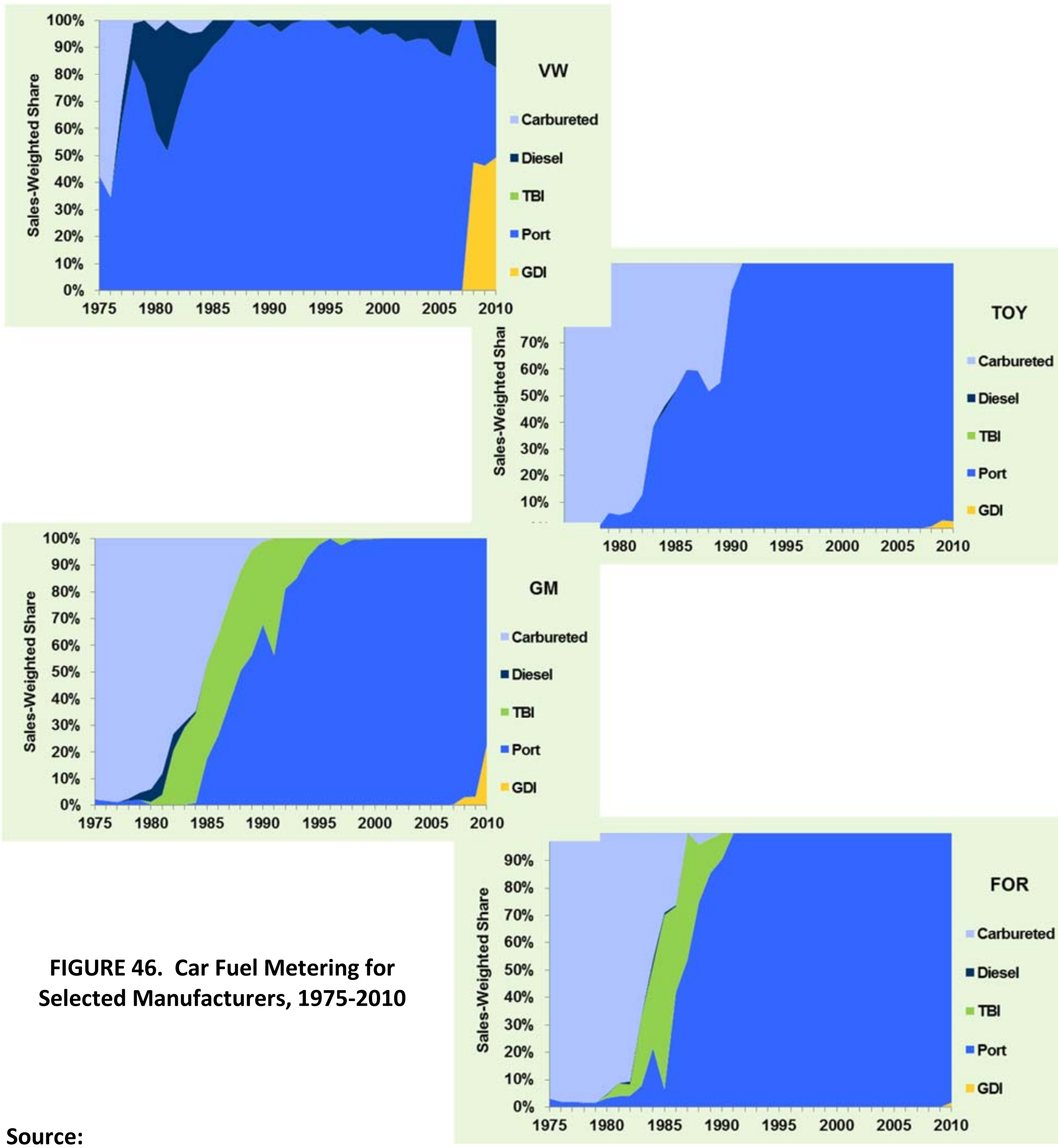


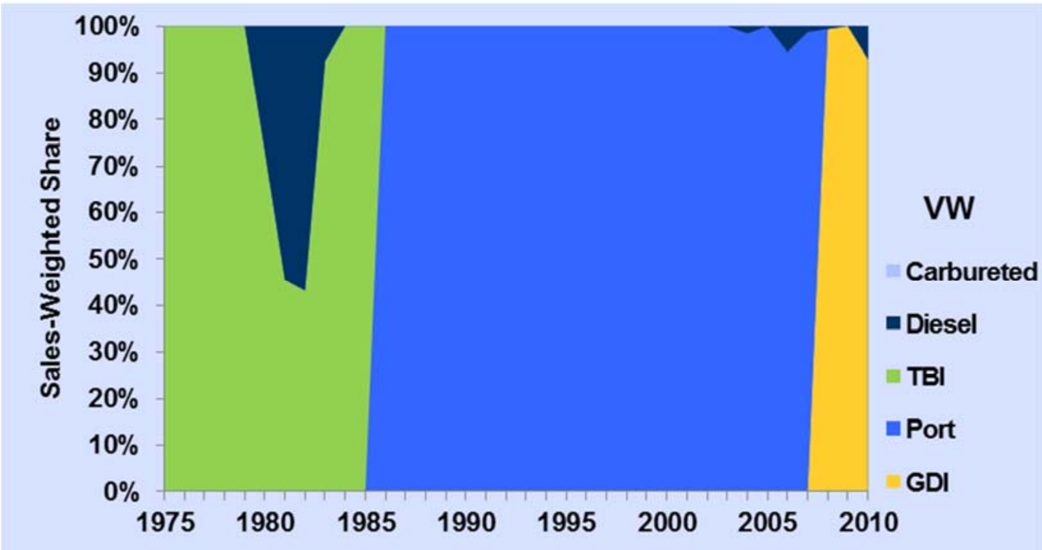
FIGURE 46. Car Fuel Metering for Selected Manufacturers, 1975-2010

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

VW and GM Use Gasoline Direct Injection in Light Trucks

VW has used gasoline direct injection (GDI) in more than 92% of trucks since model year (MY) 2008. Diesels make up the remainder of VW trucks. GM used GDI in 9% of trucks in 2009 and 41% in 2010. All other manufacturers have sold port fuel injected trucks exclusively since the mid- 1990s with throttle body injection (TBI) or carbureted engines before that time.



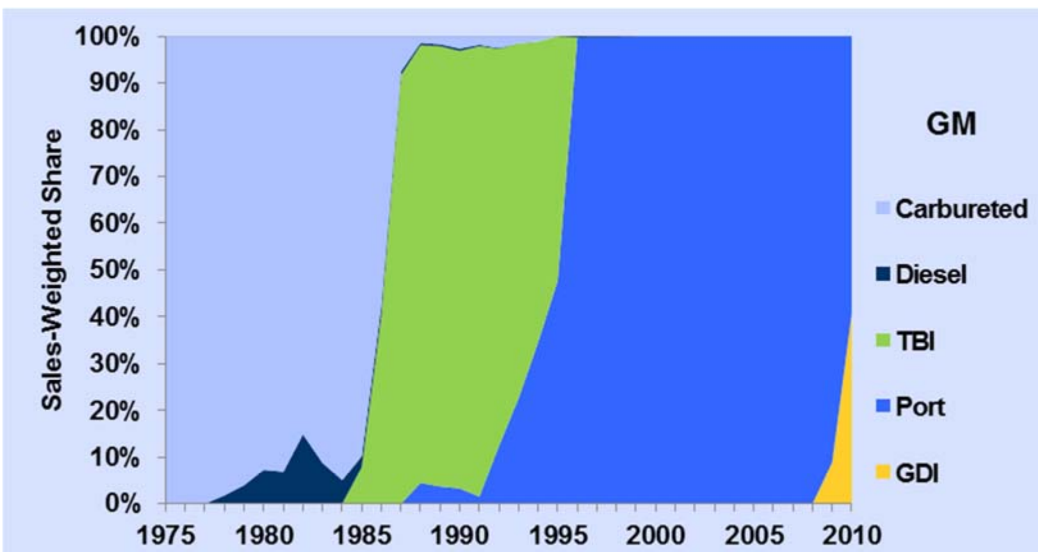


FIGURE 47. Light Truck Fuel Metering for Selected Manufacturers, 1975-2010

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

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Number of Light Vehicle Diesel Models Increase

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 2011, five different manufacturers have thirteen light vehicle models for sale with clean diesel engines that meet current emission standards.

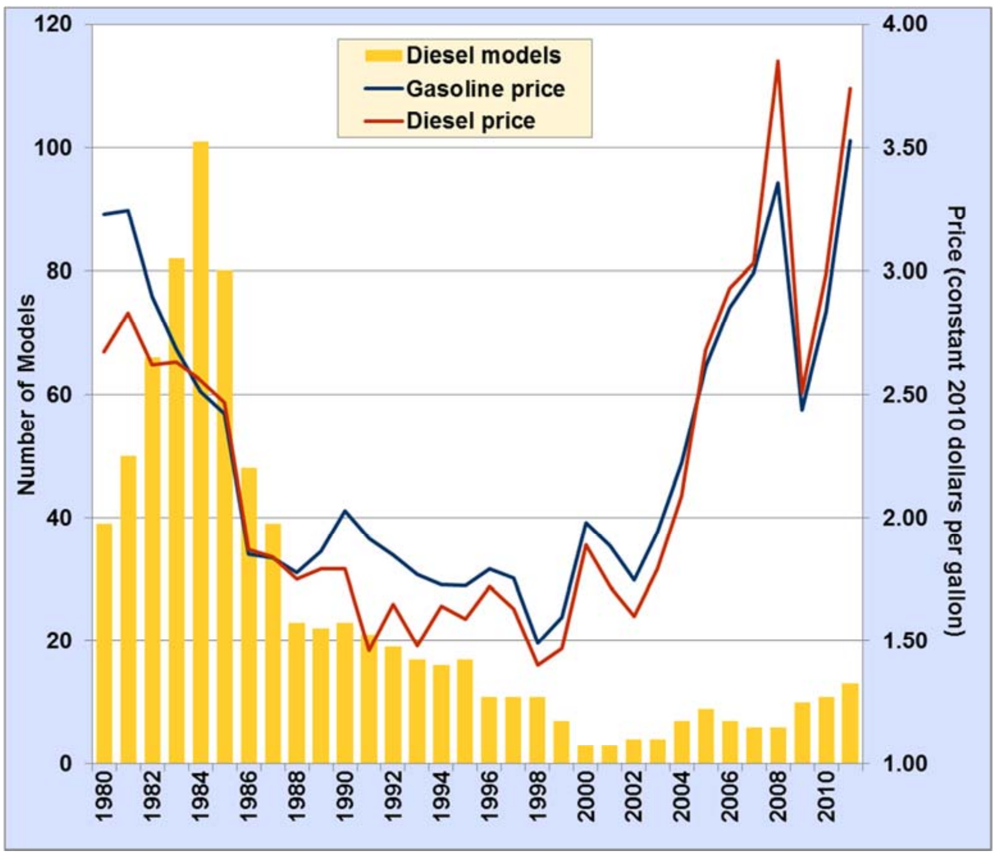


FIGURE 48. Number of Diesel Models and the Price of a Gallon of Gasoline and Diesel, 1980-2011

Sources:

U.S. Department of Energy and U.S. Environmental Protection Agency, Fuel Economy Guide website, June 2011. http://www.fueleconomy.gov

Energy Information Administration, "Gasoline and Diesel Fuel Update," http://www.eia.gov/oog/info/gdu/gasdiesel.asp

GM, Ford, Chrysler and Hyundai Sell Small, Medium, and Large Cars

GM has had a fairly consistent mix of small, medium and large cars over the years. The large car market share for Ford has been declining in recent model years, while the mid-size car market has increased. Chrysler's large and medium car markets increased from MY 2008 to 2010. Hyundai entered the large car market in 2006 when 58% of Hyundai cars sold were large.

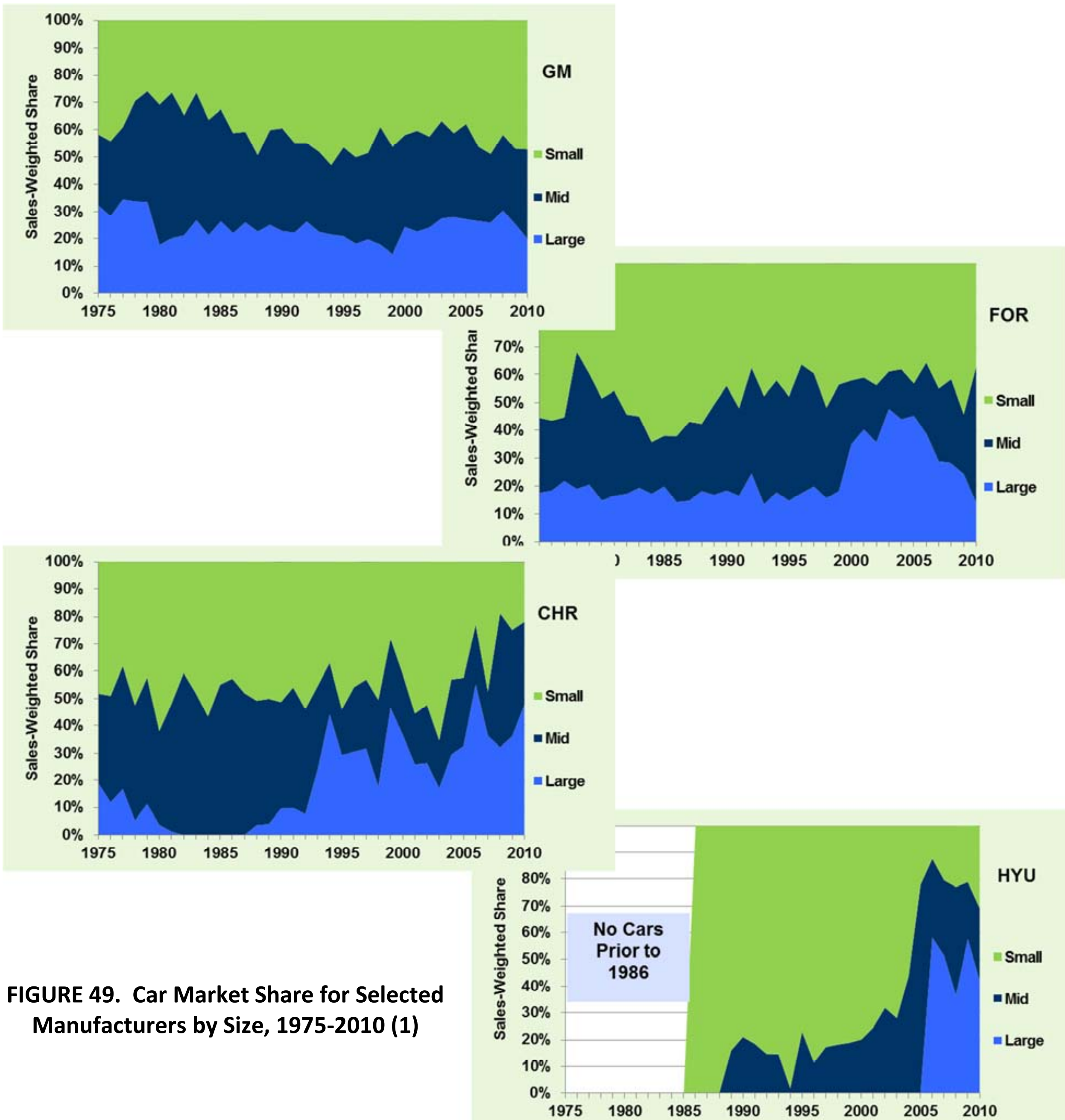


FIGURE 49. Car Market Share for Selected Manufacturers by Size, 1975-2010 (1)

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Toyota, Honda, Nissan and VW Sell Mainly Small and Mid-Size Cars

In model year (MY) 2010 VW's small cars made up more than 91% of their market. Toyota's market in MY 2010 was about half and half for small and mid-size cars, with about 1% large cars. Honda began selling large cars in MY 2008 when the Accord was redesigned and classified as large instead of mid-size. Nissan moved from selling nearly all small cars to selling nearly all mid-size cars.

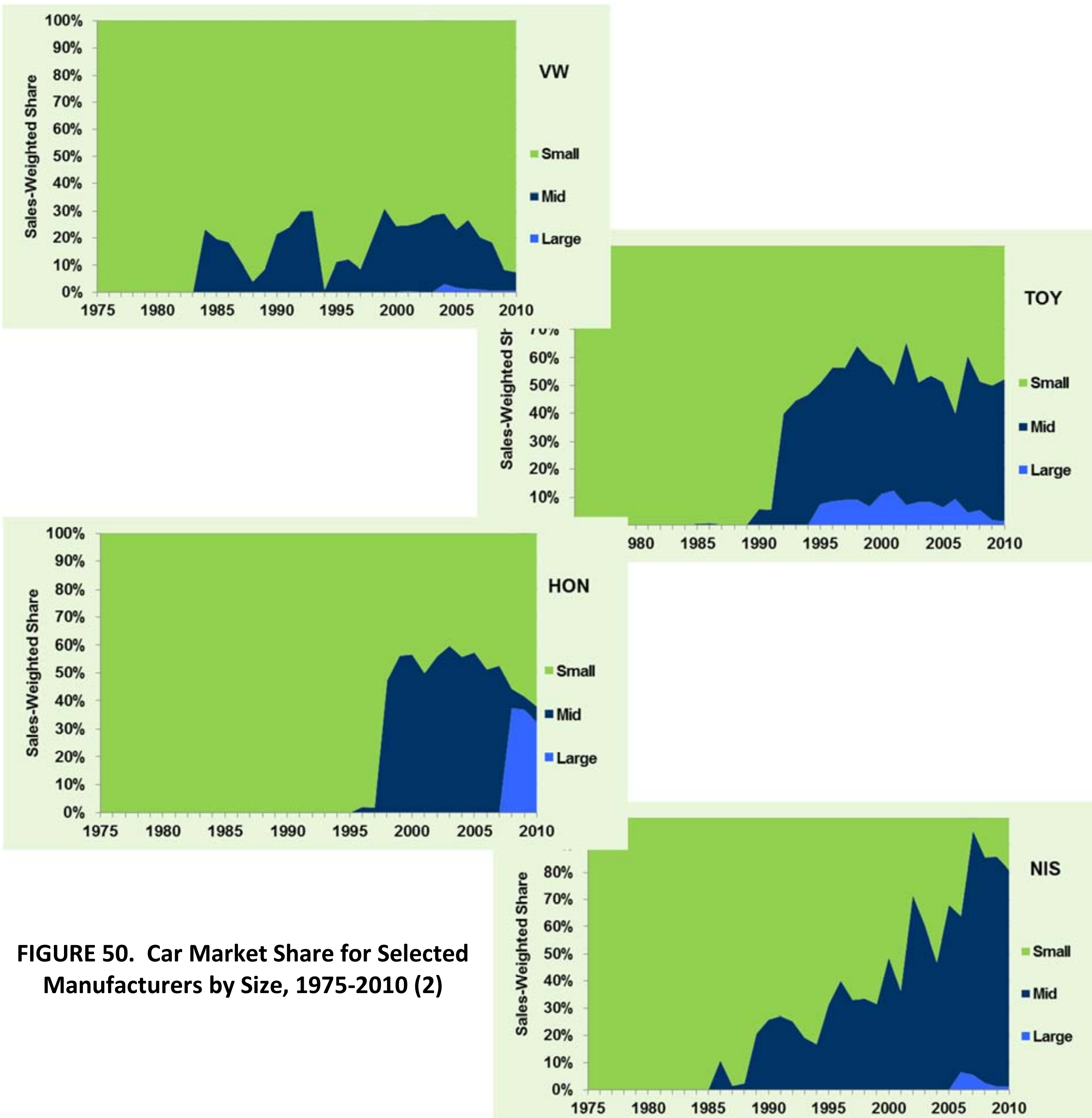


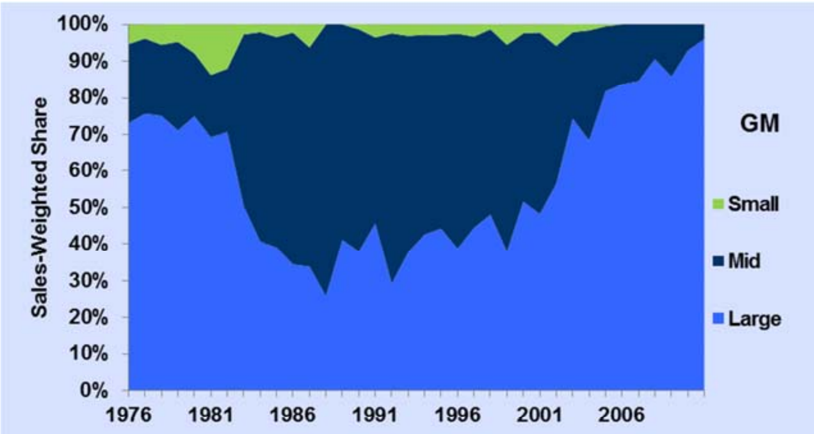
FIGURE 50. Car Market Share for Selected Manufacturers by Size, 1975-2010 (2)

Source:

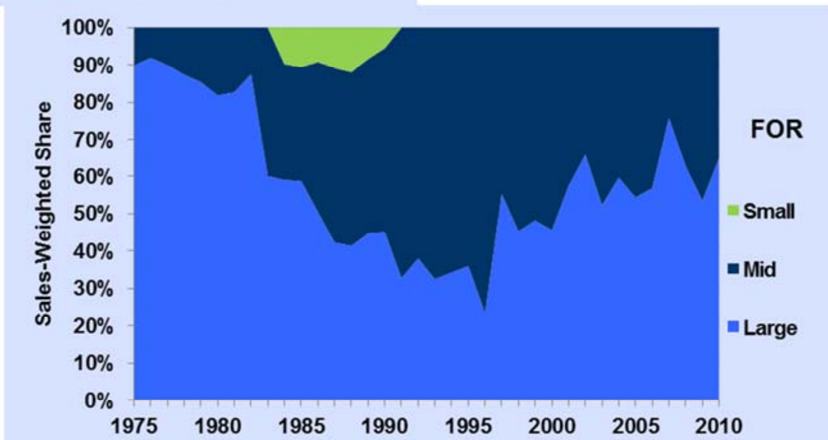
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

GM and Ford Have High Market Share for Large Light Trucks

Large trucks were 96% of GM's light truck market in model year (MY) 2010 and 65% 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.



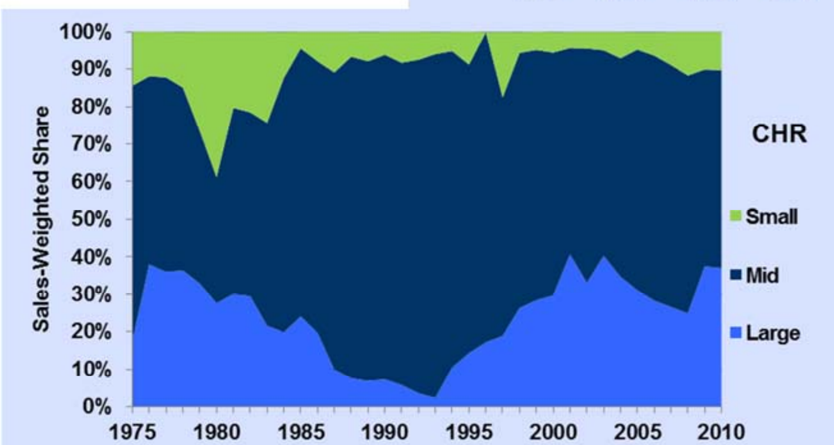
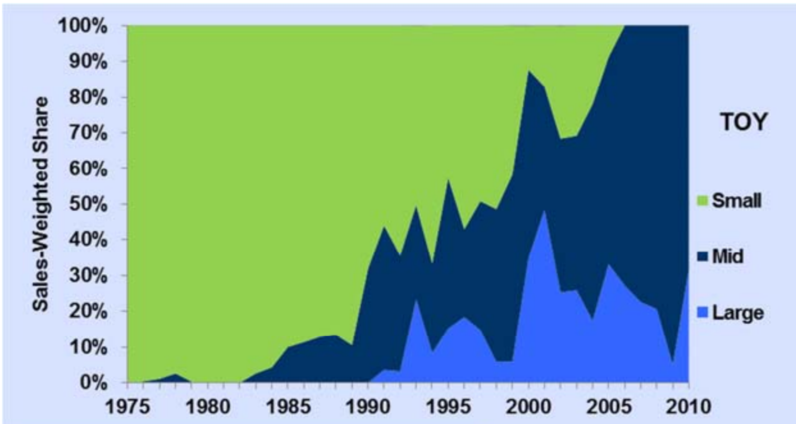


FIGURE 51. Light Truck Market Share for Selected Manufacturers by Size, 1975-2010 (1)

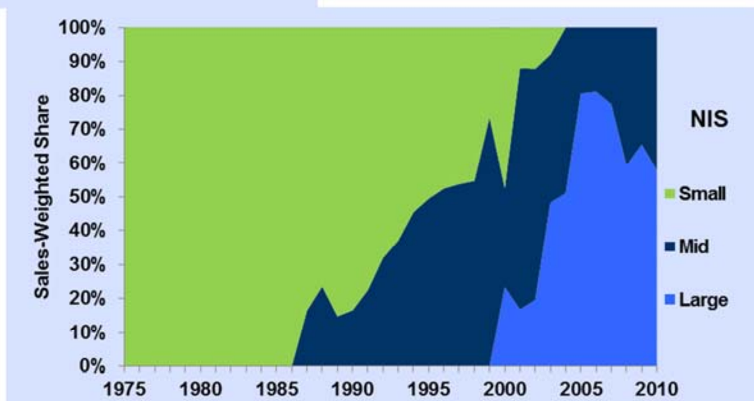
Source:
U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Toyota, Nissan and VW Moved to Larger Light Trucks

Toyota, Nissan and VW predominantly sold small light trucks until the 1990's. Toyota now sells mostly mid-size pickups. More than half of Nissan and VW light truck sales in model year (MY) 2010 are large, with the others being mid-size trucks. Hyundai and Honda (not pictured) both 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.



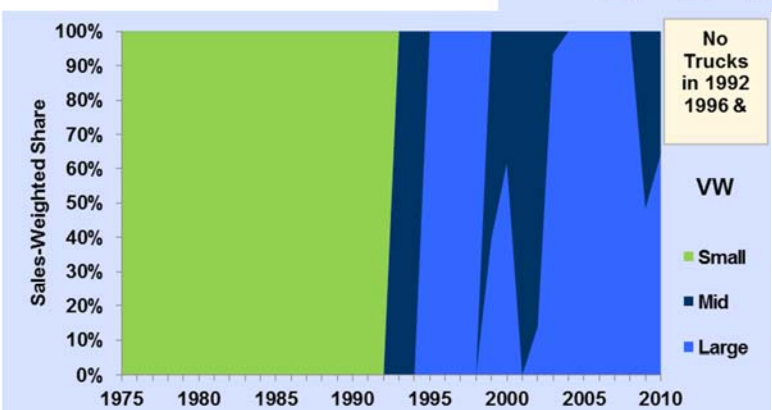
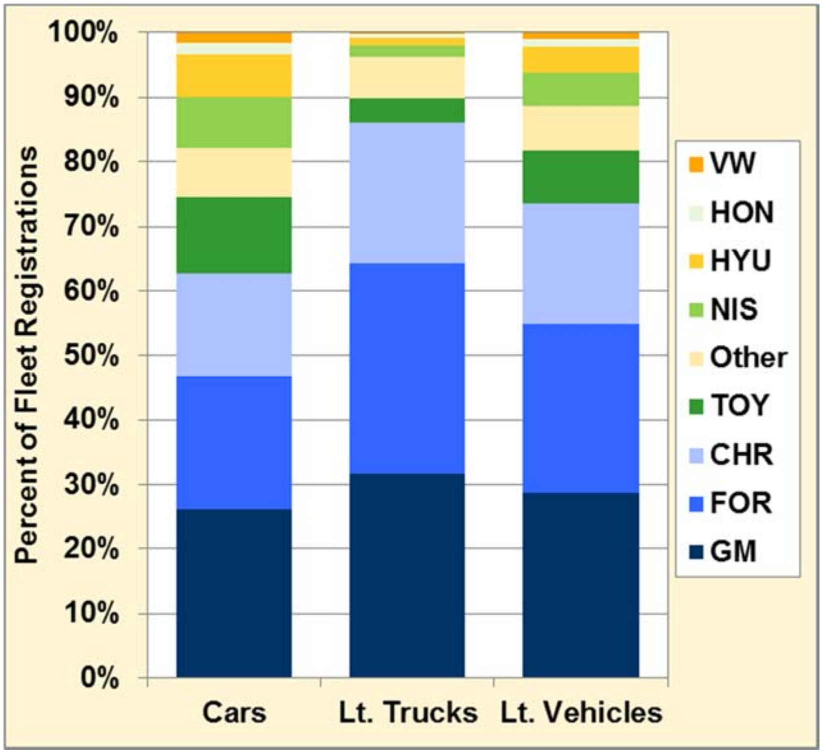


FIGURE 52. Light Truck Market Share for Selected Manufacturers by Size, 1975-2010 (2)

Source:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Detroit 3 Dominate New Fleet Registrations in 2010



Ford, GM, and Chrysler together accounted for 63% of new fleet car registrations and 86% of the new fleet light truck registrations in 2010. New registrations are often used as a proxy for sales. Of the top eight manufacturers, Honda and VW had the smallest share of new fleet registrations and GM had the largest share.

Though GM and Ford had more new fleet registrations in 2010 than Chrysler, Chrysler had the largest proportion of fleet vehicles vs. total – total being the sum of fleet vehicles and retail vehicles. Over 60% of the new Chrysler cars registered in 2010 were registered to fleets. Honda had only 2.5% of total new vehicles registered to fleets.

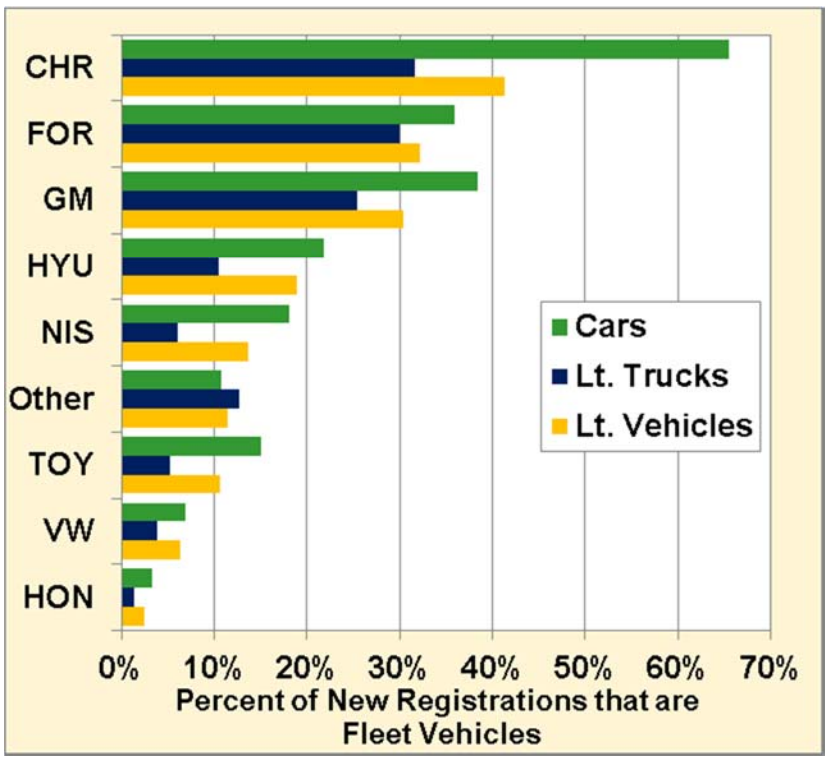


FIGURE 53. New Fleet Registration Data by Manufacturer

Source:

Bobit Publishing Company, *Automotive Fleet Factbook 2010*.
http://www.automotive-fleet.com/statistics

Chevrolet Impala Was the Top New Fleet Car in 2010

The Chevrolet Impala topped the list of new cars which were registered to fleets in 2010. New registrations are often used as a proxy for sales. Over sixty-seven percent of the new Impalas registered in 2010 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 4. Top 25 New Registrations of Cars in Fleets in 2010

Make	Model	Commercial	Government	Rental	Total Fleet	Total Retail	Total	% Fleet vs Total
Chevrolet	Impala	13,231	11,016	91,641	115,888	54,794	170,682	67.9%
Chevrolet	Malibu	10,396	4,353	57,234	71,983	129,997	201,980	35.6%
Dodge	Charger	1,701	8,324	53,336	63,361	18,074	81,435	77.8%
Ford	Fusion	33,609	3,035	26,312	62,956	122,269	185,225	34.0%
Toyota	Camry	7,157	225	52,206	59,588	259,710	319,298	18.7%
Ford	Focus	5,176	2,739	44,130	52,045	115,164	167,209	31.1%
Toyota	Corolla	4,308	142	47,403	51,853	215,545	267,398	19.4%
Chevrolet	Cobalt	1,434	262	49,746	51,442	61,368	112,810	45.6%
Dodge	Avenger	713	5,246	33,238	39,197	13,448	52,645	74.5%
Nissan	Versa	2,343	36	36,057	38,436	55,280	93,716	41.0%
Chrysler	Sebring	1,358	25	32,145	33,528	9,686	43,214	77.6%
Nissan	Altima	3,143	106	28,522	31,771	173,711	205,482	15.5%
Hyundai	Sonata	871	59	29,720	30,650	138,406	169,056	18.1%
Ford	Crown Victoria	951	29,576	13	30,540	2,078	32,618	93.6%
Hyundai	Elantra	567	19	29,081	29,667	83,848	113,515	26.1%
Ford	Taurus	16,051	1,249	11,650	28,950	39,728	68,678	42.2%
Dodge	Caliber	502	56	27,948	28,506	13,455	41,961	67.9%
Chrysler	300	1,035	65	22,410	23,510	15,238	38,748	60.7%
Mercury	Grand Marquis	218	31	23,092	23,341	6,629	29,970	77.9%
Chevrolet	Aveo	527	37	21,455	22,019	19,900	41,919	52.5%
Hyundai	Accent	564	13	17,299	17,876	32,507	50,383	35.5%
Nissan	Sentra	1,347	42	15,431	16,820	70,755	87,575	19.2%
Ford	Mustang	425	58	14,594	15,077	55,738	70,815	21.3%
Pontiac	G6	91	858	12,646	13,595	6,438	20,033	67.9%
KIA	Forte	133	8	13,405	13,546	51,387	64,933	20.9%

Source:

Bobit Publishing Company, *Automotive Fleet Factbook 2010*.
http://www.automotive-fleet.com/statistics

Ford F-Series Was the Top New Fleet Truck in 2010

The Ford F-series topped the list of new light trucks which were registered to fleets in 2010. New registrations are often used as a proxy for sales. About 22% percent of the new Impalas registered in 2010 were fleet vehicles, the majority of them in commercial fleets. The F-Series was also the top model for government fleets. The Chevrolet HHR and the Chrysler Town & Country were the models with the most new registrations in rental fleets.

TABLE 5. Top 25 New Registrations of Trucks in Fleets in 2010

Make	Model	Commercial	Government	Rental	Total Fleet	Total Retail	Total	% Fleet vs Total
Ford	F Series	62,440	25,817	15,986	104,243	366,586	470,829	22.10%
Ford	Econoline	32,284	14,136	28,042	74,462	21,018	95,480	78.00%
Chevrolet	Silverado	37,614	9,575	20,099	67,288	279,669	346,957	19.40%
Dodge	Caravan	15,380	8,357	35,716	59,453	40,322	99,775	59.60%
Chevrolet	HHR	4,769	505	51,443	56,717	20,924	77,641	73.10%
Ford	Escape	26,283	3,057	25,224	54,564	121,584	176,148	31.00%
Chrysler	Town & Country	2,070	88	50,387	52,545	56,258	108,803	48.30%
Chevrolet	Express	22,511	7,833	9,797	40,141	14,869	55,010	73.00%
Chevrolet	Tahoe	2,444	7,910	16,932	27,286	48,217	75,503	36.10%
Ford	Explorer	5,031	5,482	16,699	27,212	21,020	48,232	56.40%
Chevrolet	Traverse	3,635	266	21,623	25,524	76,535	102,059	25.00%
Dodge	Ram	10,049	2,819	11,892	24,760	142,687	167,447	14.80%
Dodge	Journey	4,194	197	16,400	20,791	32,387	53,178	39.10%
Chevrolet	Suburban	1,689	2,300	16,679	20,668	24,290	44,958	46.00%
Ford	Ranger	17,195	3,013	351	20,559	32,318	52,877	38.90%
Ford	Edge	5,624	341	14,304	20,269	86,722	106,991	18.90%
Chevrolet	Equinox	9,670	263	8,789	18,722	108,246	126,968	14.70%
Jeep	Grand Cherokee	1,582	219	15,105	16,906	39,966	56,872	29.70%
Toyota	Sienna	6,140	396	8,794	15,330	76,340	91,670	16.70%
KIA	Sorento	720	19	12,049	12,788	68,978	81,766	15.60%
Hyundai	Santa Fe	637	19	12,125	12,781	71,233	84,014	15.20%
Jeep	Patriot	3,412	97	8,695	12,204	20,650	32,854	37.10%
Jeep	Liberty	1,596	709	9,243	11,548	35,813	47,361	24.40%
Ford	Expedition	2,096	4,013	4,611	10,720	25,618	36,338	29.50%
KIA	Soul	301	2	10,078	10,381	45,156	55,537	18.70%

Source:

Bobit Publishing Company, *Automotive Fleet Factbook 2010*.

http://www.automotive-fleet.com/statistics

Fleet Management Companies Remarket Vehicles On-Line

The top ten fleet management companies owned or managed over 3 million vehicles in 2010. 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-six percent of the vehicles remarketed by the top ten fleet management companies were remarketed on-line. Donlan and Emkay remarketed over 80% of their vehicles on-line.

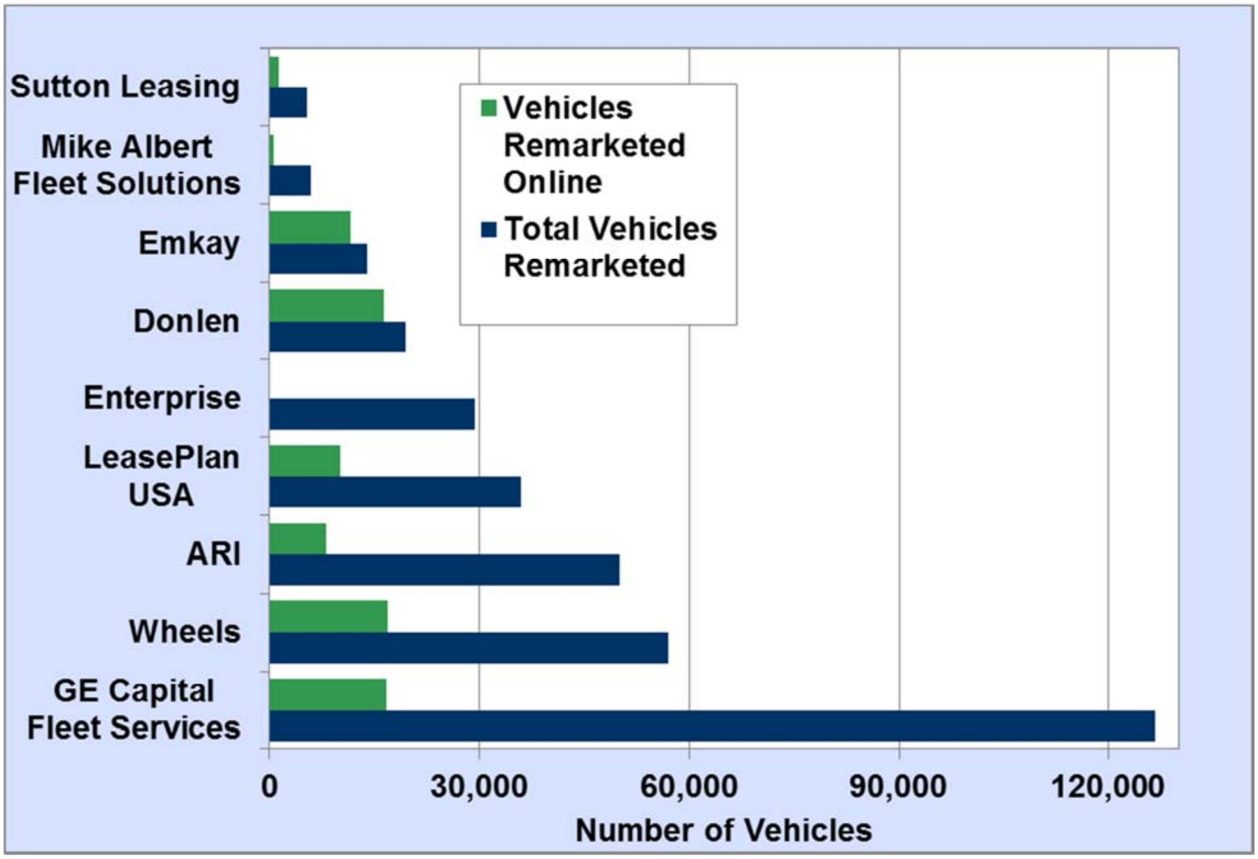


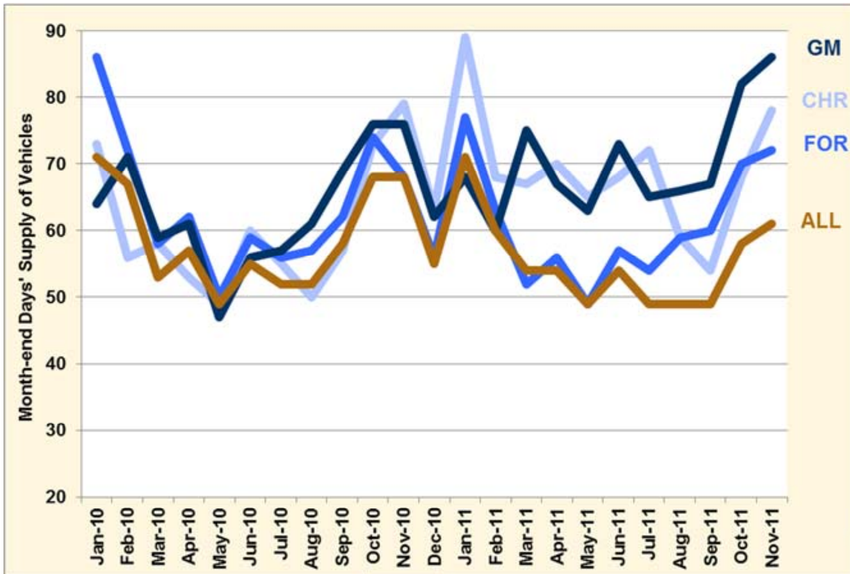
FIGURE 54. Vehicles Remarketed by the Top Ten Fleet Management Companies, 2010

Note: Data for PHH Arval remarketing and data for Enterprise on-line remarketing were not available.

Source:

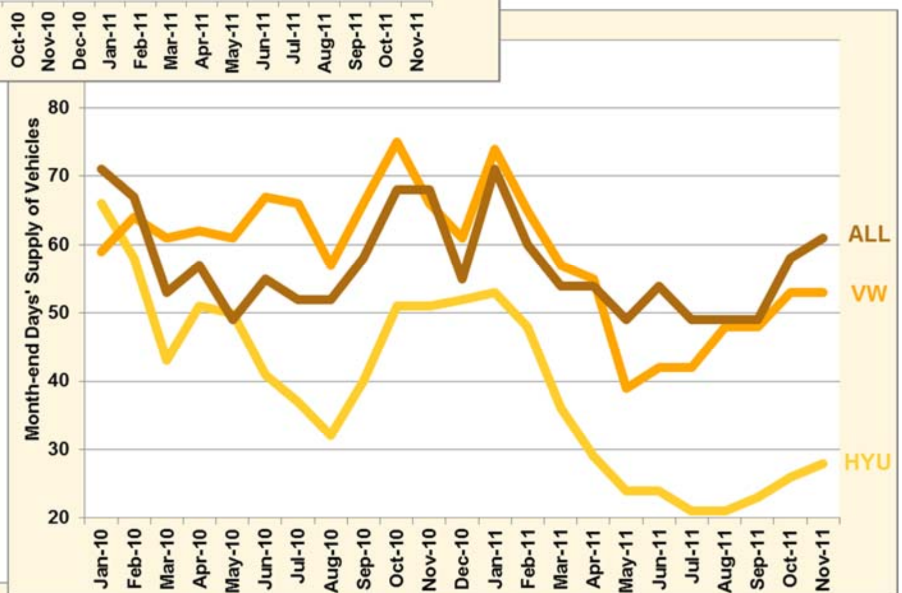
Bobit Publishing Company, *Automotive Fleet Factbook 2010*.
http://www.automotive-fleet.com/statistics

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.

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



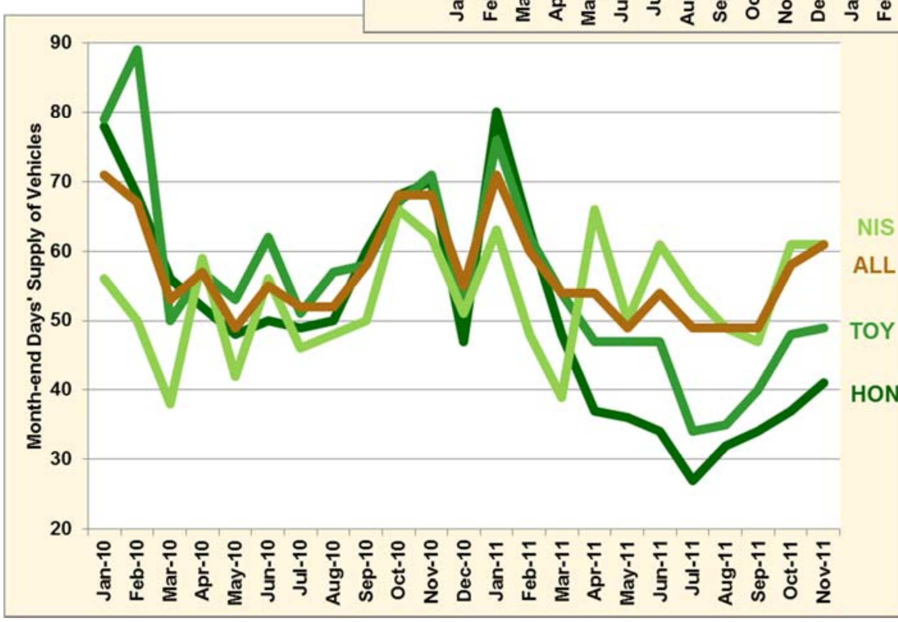


FIGURE 55. Monthly Inventory Supplies by Manufacturer, 2010-2011

Note: ALL = Average of all manufacturers.

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

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 $34 billion in parts sales to OEMs in 2010. 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 6. List of Top Ten Tier 1 Global Suppliers

			Market Share				
Rank	Company	Company Headquarters	North America	Europe	Asia	Rest of World	Total
1	Robert Bosch GmbH	Germany	14%	53%	27%	6%	100%
2	Denso Corp	Japan	17%	13%	68%	2%	100%
3	Continental AG	Germany	19%	58%	19%	4%	100%
4	Aisin Seiki Co.	Japan	13%	8%	78%	1%	100%
5	Magna International, Inc.	Canada	52%	43%	0%	5%	100%
6	Faurecia	France	18%	66%	9%	7%	100%
7	Johnson Controls, Inc.	United States	41%	49%	10%	0%	100%
8	ZF Friedrichshafen AG	Germany	12%	61%	19%	8%	100%
9	LG Chem	South Korea	1%	6%	84%	9%	100%
10	Hyundai Mobis	South Korea	19%	10%	71%	0%	100%

Note: Rank based on total global OEM automotive parts sales in 2010.

Source:
Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2011. http://www.autonews.com/

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

There are 11 U.S.-based companies in the top 50 automotive global suppliers. Of these companies, none has more than half of its parts sales in North America.

TABLE 7. U.S.-based Tier 1 Suppliers in the Top 50

Rank	Company	Percent North America Sales	Products
7	Johnson Controls, Inc.	41%	Seat systems, interior electronics, door panels, instrument panels, center and floor consoles, lead-acid and hybrid vehicle batteries
11	TRW Automotive Holdings Corp.	30%	Steering, suspension, braking and engine components; fasteners, occupant-restraint systems, electronic safety and security systems
12	Delphi Automotive	33%	Mobile electronics; powertrain, safety, steering, thermal controls and security systems; electrical/electronic architecture; in-car entertainment technologies
14	Lear Corp.	34%	Seating and electrical power management systems
22	Visteon Corp.	17%	Climate-control systems, electronics, interiors and lighting
27	Dana Corp.	49%	Axles, driveshafts, sealing and thermal management products; off-highway vehicle transmissions, tire management products
29	Cummins, Inc.	40%	Diesel engines
30	DuPont	30%	Paint and coatings, high-performance polymers, elastomers, renewable sourced polymers, fibers and fluoropolymers; battery separator and electronic material technologies, fabricated products, advanced composite materials, specialty chemicals, lubricants, refrigerants, films, bio-based fuels
31	BorgWarner	25%	Turbochargers, engine valve-timing and ignitions systems; emissions thermal and transmission-clutch systems; transmission-control and all-wheel-drive systems
36	Tenneco, Inc.	46%	Emission-control systems, manifolds, catalytic converters, diesel aftertreatment system, catalytic reduction mufflers, shock absorbers, struts, electronic suspension products and systems
44	Federal-Mogul Corp.	28%	Pistons, rings, cylinder liners, piston pins, bearings, valve seats and guides, gaskets, seals, heat shields, friction materials, systems protection

Note: Rank based on total global OEM automotive parts sales in 2010.

Source:

Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2011 and June 2007. http://www.autonews.com/

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

There are nine U.S. automotive parts suppliers that sold more than $5 billion in parts to original equipment manufacturers (OEM) in 2010. These nine companies have been diversifying their customer base over the last five years; every one of them increased their share of sales to Asia and decreased their share of sales to the United States from 2006 to 2010. Likely, China and India are the growing Asian markets.

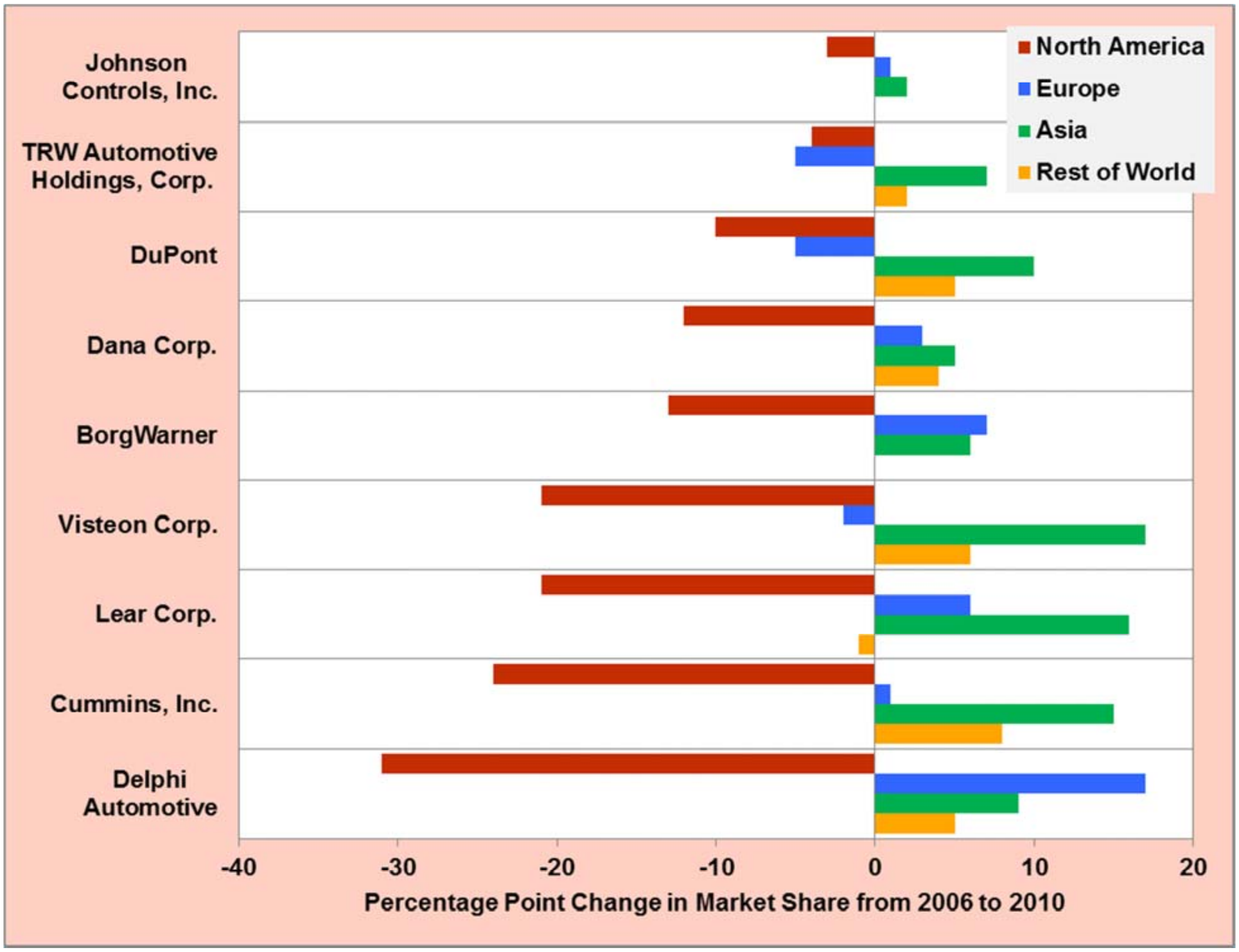


FIGURE 56. Change in Market Share of Top U.S.-based Tier 1 Suppliers, 2006-2010

Source:

Crain Communications, *Automotive News Supplement,* "Top 100 Global Suppliers," June 2011 and June 2007. http://www.autonews.com/

Chapter 3.

HEAVY TRUCKS

Page

Contents

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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 (GVWR) 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.

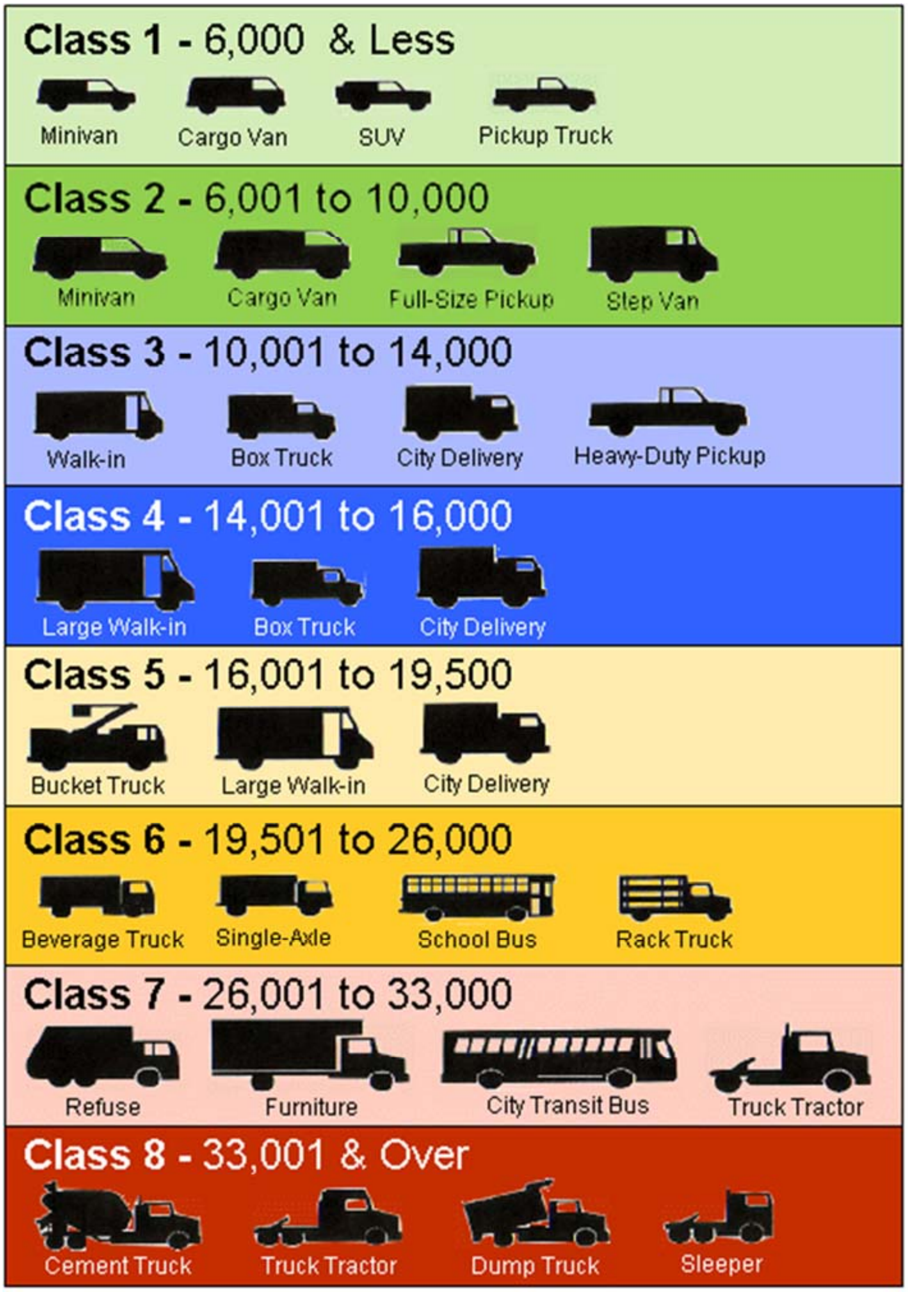

FIGURE 57. Examples of Trucks in Each Truck Class

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 GWVR. Class 8a and 8b are subdivided based on the truck design (straight truck vs. combination truck).

TABLE 8. 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 Can, 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

Heavy Truck Assembly Plants are Located throughout the United States

The top seven manufacturers of heavy trucks have assembly plants mainly in the East and the Northwest, with the exception of Peterbilt's plant in Texas. These manufacturers produce class 7 and 8 trucks at these facilities, though Freightliner produces medium-duty trucks (classes 3-6) at the Mount Holly, North Carolina plant.

TABLE 9. Heavy Truck Manufacturers by Location, 2010

Freightliner Trucks	Western Star Trucks	International Trucks	Kenworth Truck	Peterbilt Motors	Volvo Trucks North America	Mack Trucks, Inc.
Cleveland, NC Mount Holly, NC	Portland, OR	Springfield, OH	Renton, WA Chillicothe, OH	Denton, TX	Dublin, VA	Macungie, PA

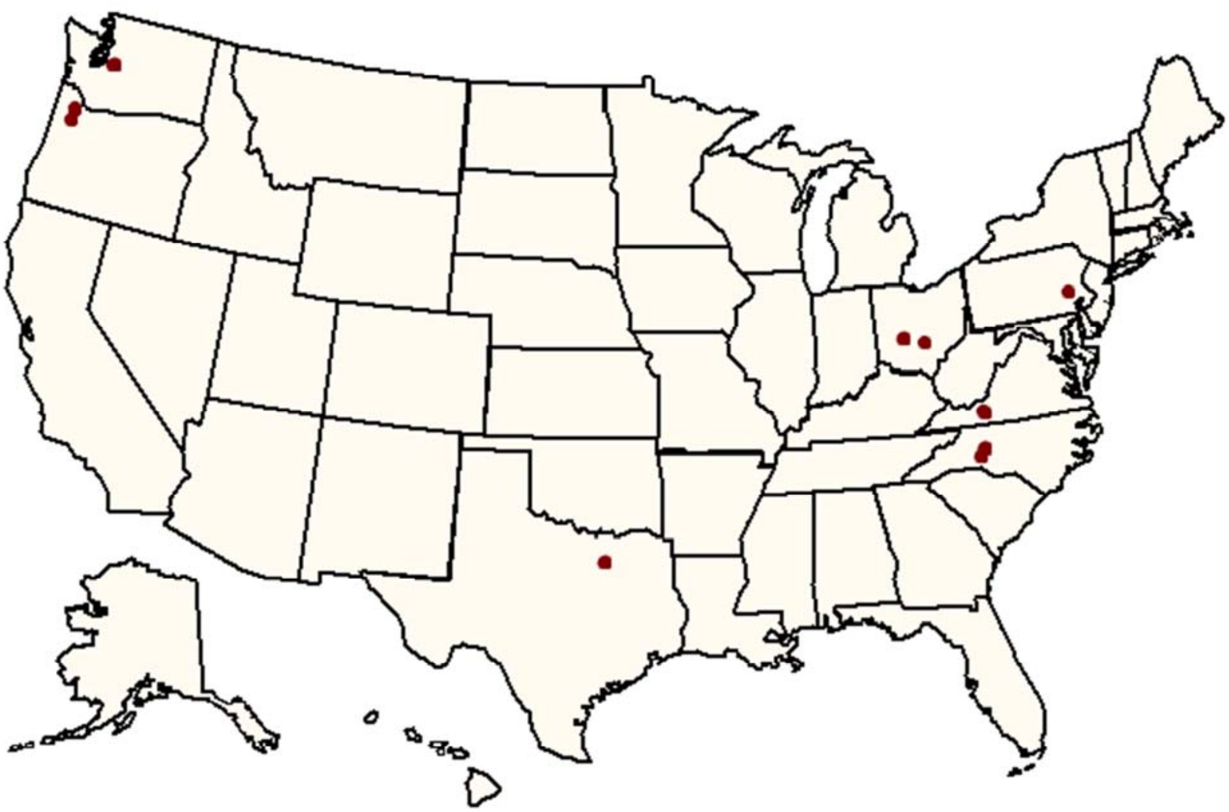

FIGURE 58. Heavy Truck Manufacturing Plants by Location, 2010

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

Class 3 Truck Sales Rebound in 2010

Class 3 truck sales fell with the economy in 2008 and 2009, but have recovered to pre-recession levels in 2010. The sales of all class 3 trucks in 2010 are 8% above 2006 sales, but 45% above 2009 sales. The primary manufacturers of these trucks are Ford, Chrysler, and General Motors. In 2006, Ford and Chrysler together held 95% of the class 3 market. General Motors began selling a larger portion of trucks in this weight class in 2007 and in 2010 sold 15% of class 3 trucks. Chrysler's share of the class 3 market increased to 50% in 2010, mainly at the expense of Ford, whose market share declined from 70% in 2006 to 33% in 2010.

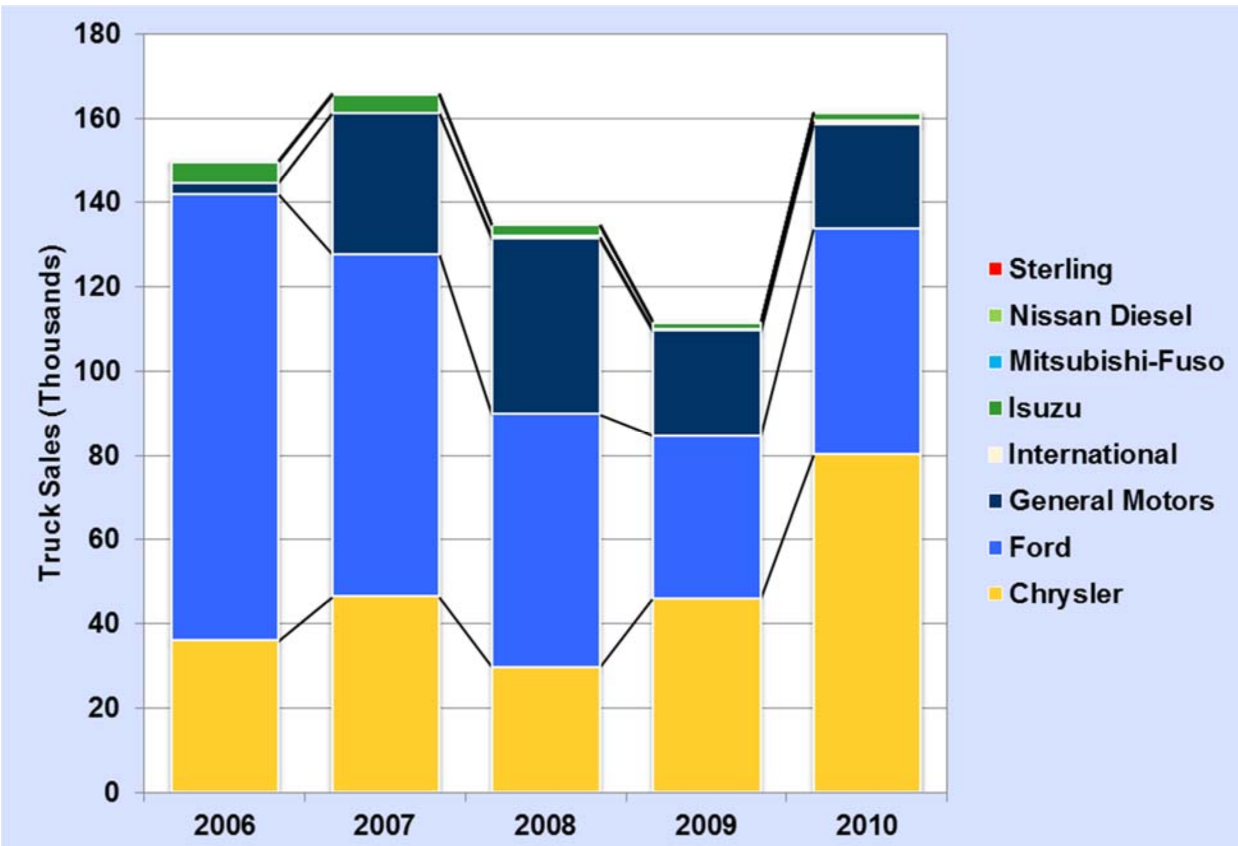

FIGURE 59. Class 3 Truck Sales by Manufacturer, 2006-2010

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2011*, Southfield, MI, 2011.
http://wardsauto.com

Class 4-7 Truck Sales Continue to be Low

Though the sales of class 4-7 trucks were up slightly in 2010, they were 60% below the 2006 level. However, most companies kept their market share of the significantly lower market, with General Motors being the notable exception. In 2006 (pre-bankruptcy) GM sold over 41,000 class 4-7 trucks, while in 2010 they sold just 3,000. Ford, Freightliner, Hino, Isuzu, and Kenworth, all gained one or two percent of the market share after GM's decline. International gained four percent from 2006 to 2010.

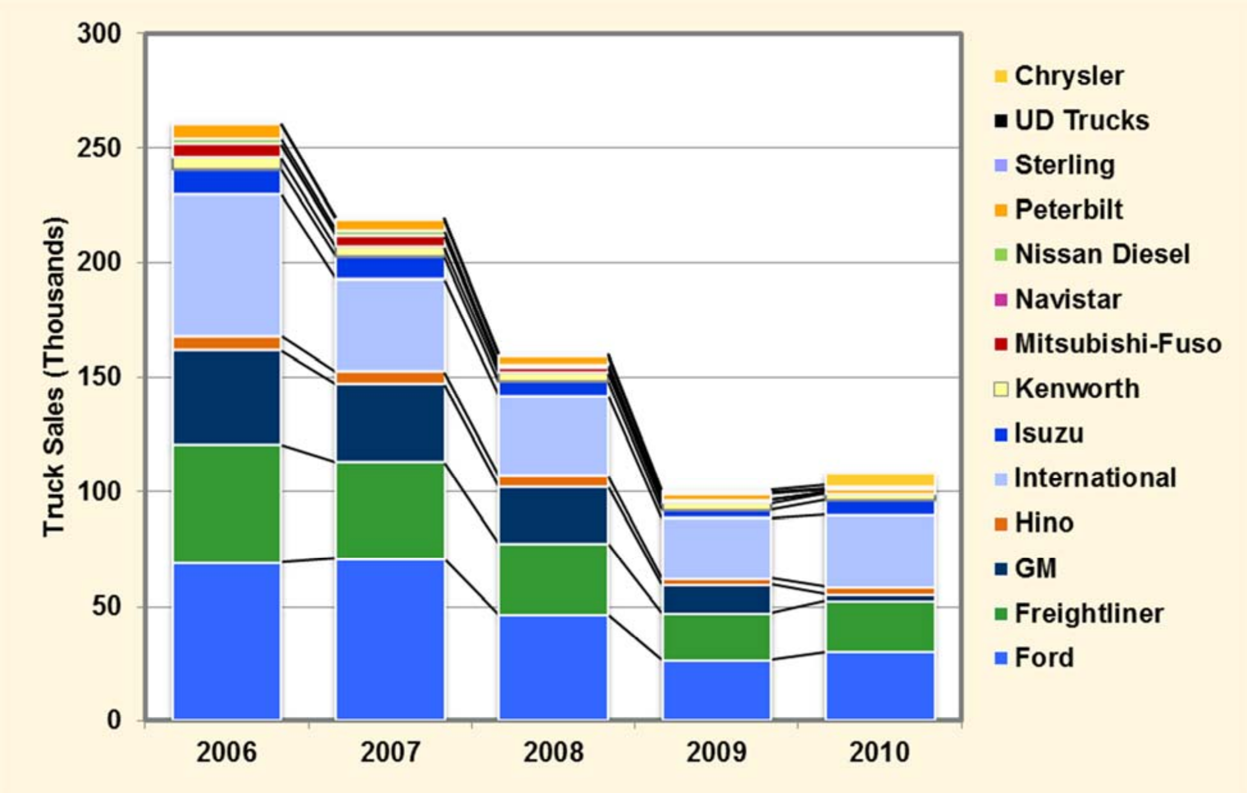

FIGURE 60. Class 4-7 Truck Sales by Manufacturer, 2006-2010

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

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2011*, Southfield, MI, 2011.
http://wardsauto.com

Class 8 Truck Sales are Less than Half of 2006 Sales

Mainly due to the economic recession, class 8 truck sales since 2008 have been less than half of what they were in 2006. There was not a large shift in market share among the manufacturers during this time period. International held 19% of the class 8 market in 2006 and increased to 25% of the market in 2010. Each of the other companies listed lost about 1%.

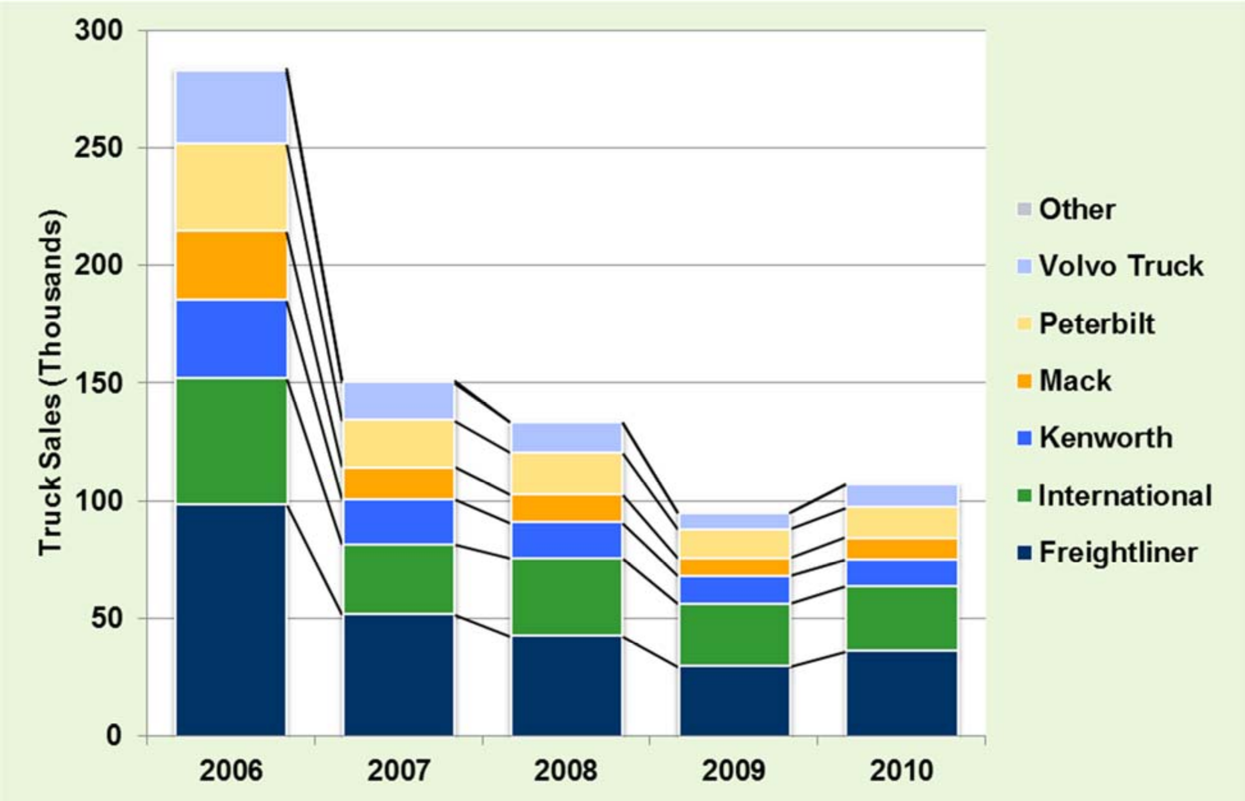

FIGURE 61. Class 8 Truck Sales by Manufacturer, 2006-2010

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2011*, Southfield, MI, 2011.
http://wardsauto.com

Diesel Engine Use Increases for Medium Trucks

For class 4-6 trucks, the share of engines that were diesel increased over the last five years, while the diesel share of class 3 and class 7 declined. Class 8 trucks have always been near 100% diesel and that has not changed. Over all, diesel comprised 73% of the class 3-8 trucks sold in 2010, down from 84% in 2006.

FIGURE 62. Share of Diesel Trucks by Class, 2006 and 2010

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

Source:

Ward's Automotive Group, *Motor Vehicle Facts and Figures 2011*, Southfield, MI, 2011. 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 10. Diesel Engine Suppliers by Manufacturer, 2010

Make	Engine Manufacturer	Share
Freightliner	Cummins	49.3%
	Detroit Diesel	48.3%
	Mercedes Benz	2.4%
	Total	**100.0%**
International	Caterpillar	0.4%
	Cummins	10.8%
	International	88.8%
	Total	**100.0%**
Kenworth	Caterpillar	23.3%
	Cummins	64.3%
	PACCAR	12.4%
	Total	**100.0%**
Peterbilt	Caterpillar	21.7%
	Cummins	65.6%
	PACCAR	12.7%
	Total	100.0%
Volvo	Cummins	24.7%
	Volvo	75.3%
	Total	**100.0%**
Western Star	Caterpillar	1.7%
	Cummins	12.8%
	Detroit Diesel	79.9%
	Mercedes Benz	5.6%
	Total	**100.0%**
Hino	Hino	100.0%
Mack	Mack	100.0%
Other	Cummins	100.0%

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

Cummins and International Lead Heavy Truck Diesel Engine Market

Cummins with 38% of the market and International (also known as Navistar) with 23% of the market were leaders in heavy truck diesel engines.

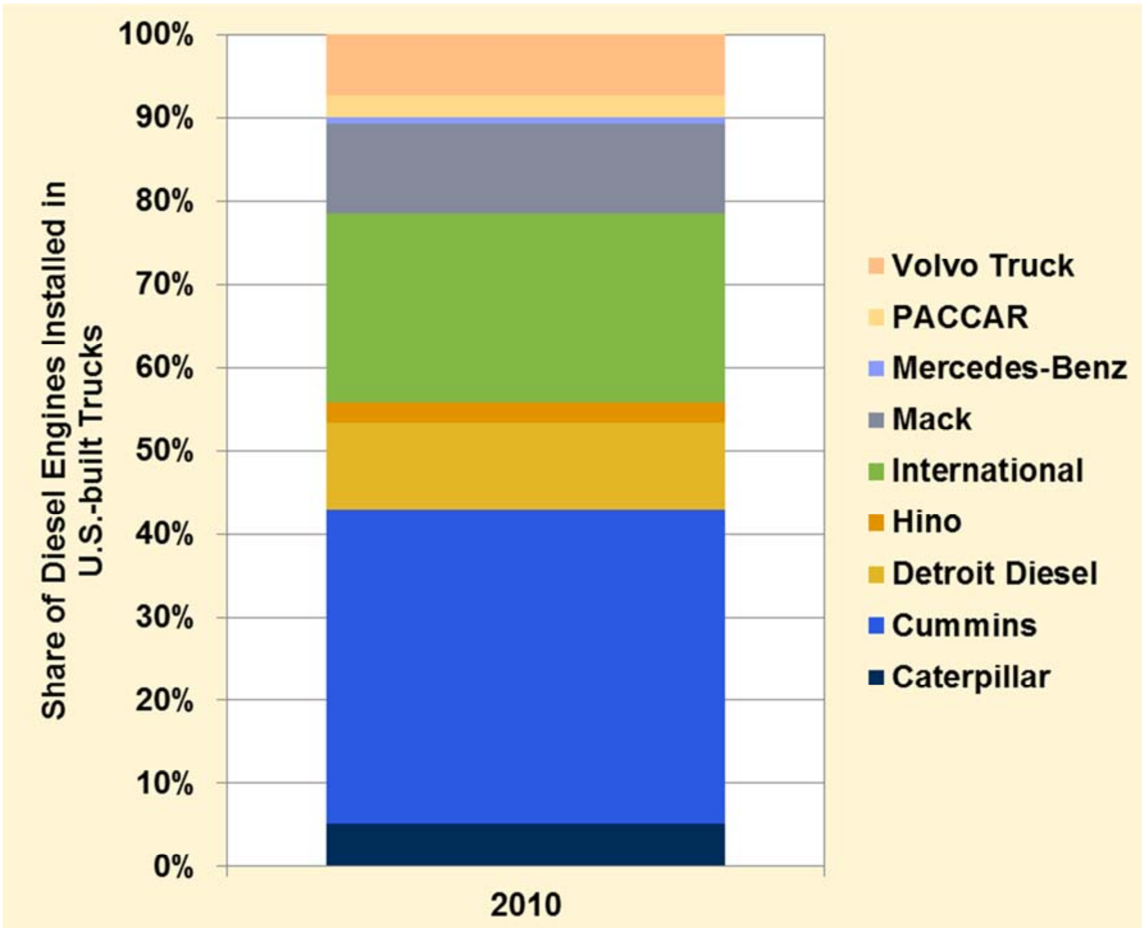

FIGURE 63. Diesel Engine Manufacturers Market Share, 2010

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

Combination Trucks Average Over 60,000 Miles per Year

According to the latest Federal Highway Administration estimates, the average miles traveled per truck was over 60,000 miles for a combination truck in 2009, 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 7.4 miles per gallon (mpg) in 2009 while the combination truck fuel economy was 6 mpg. The combination trucks typically have larger engines to carry heavier loads than the single-unit trucks.

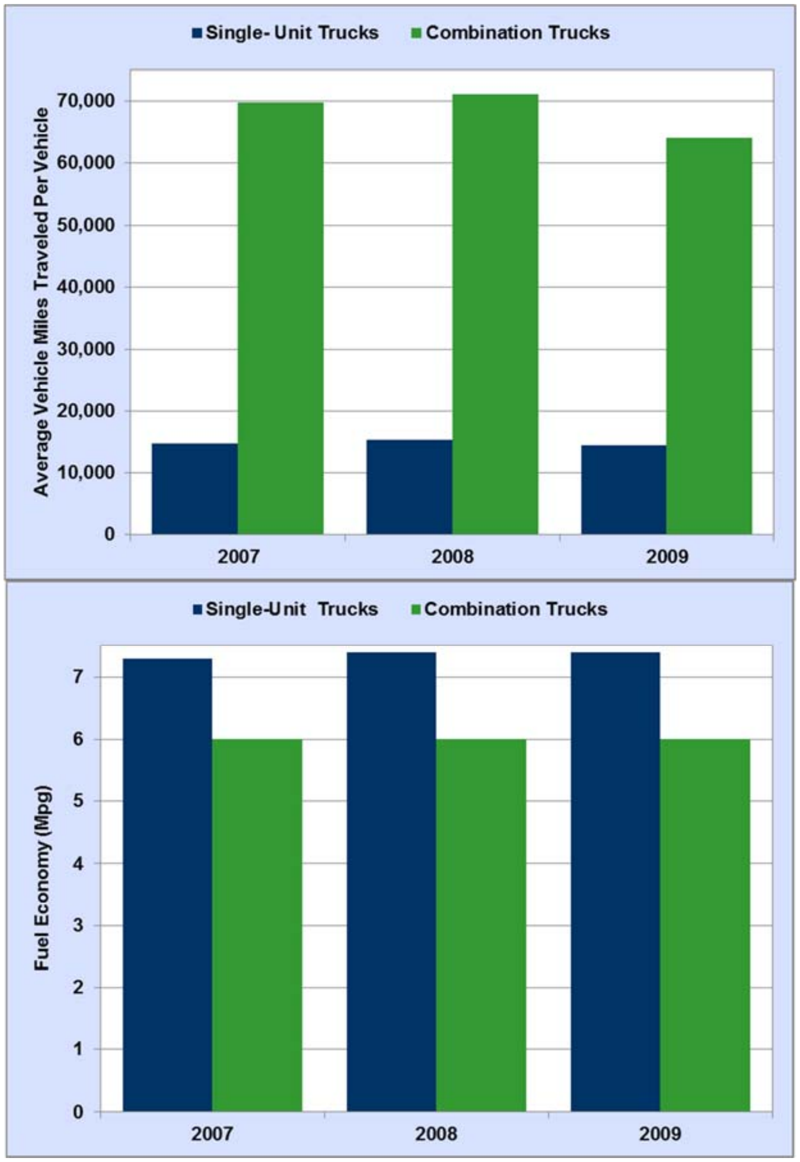

FIGURE 64. Vehicle Miles of Travel and Fuel Economy for Heavy Trucks, 2007-2009

Source:

U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 2009*, Table VM-1, April 2010. http://www.fhwa.dot.gov/policyinformation/statistics/2009/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 mph.

TABLE 11. 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 (Miles per Hour)
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.

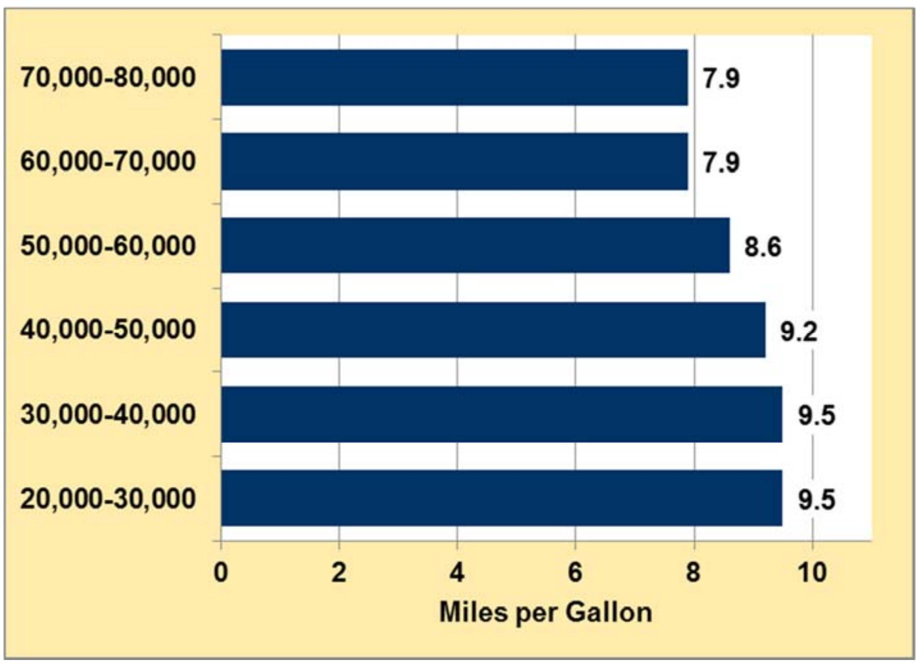

FIGURE 65. Fuel Efficiency of Class 8 Trucks by Vehicle Weight Range on Flat Terrain

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.

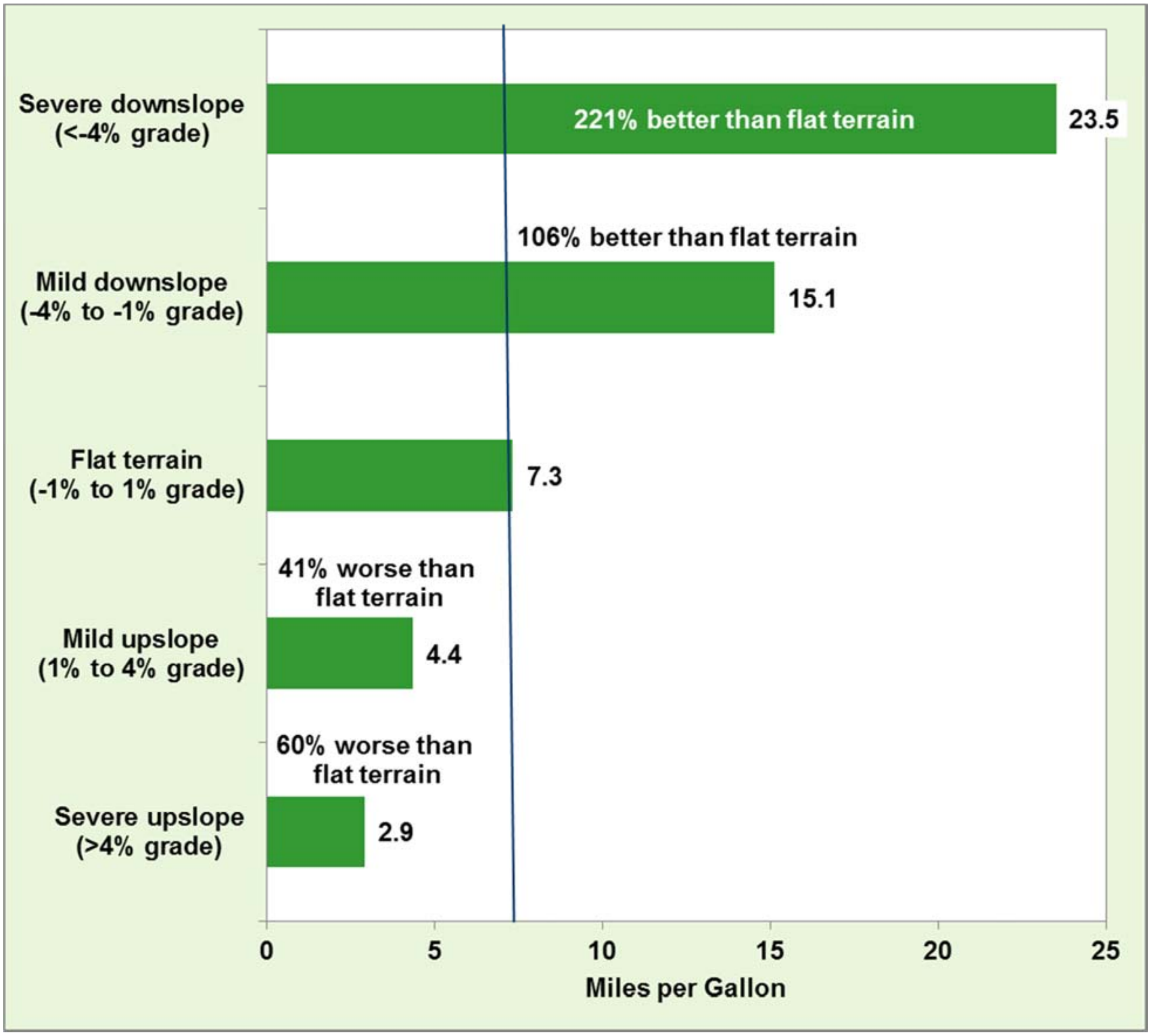

FIGURE 66. Fuel Efficiency of Class 8 Trucks by Roadway Grade

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. The driver of the truck controls the speed at which the truck idles.

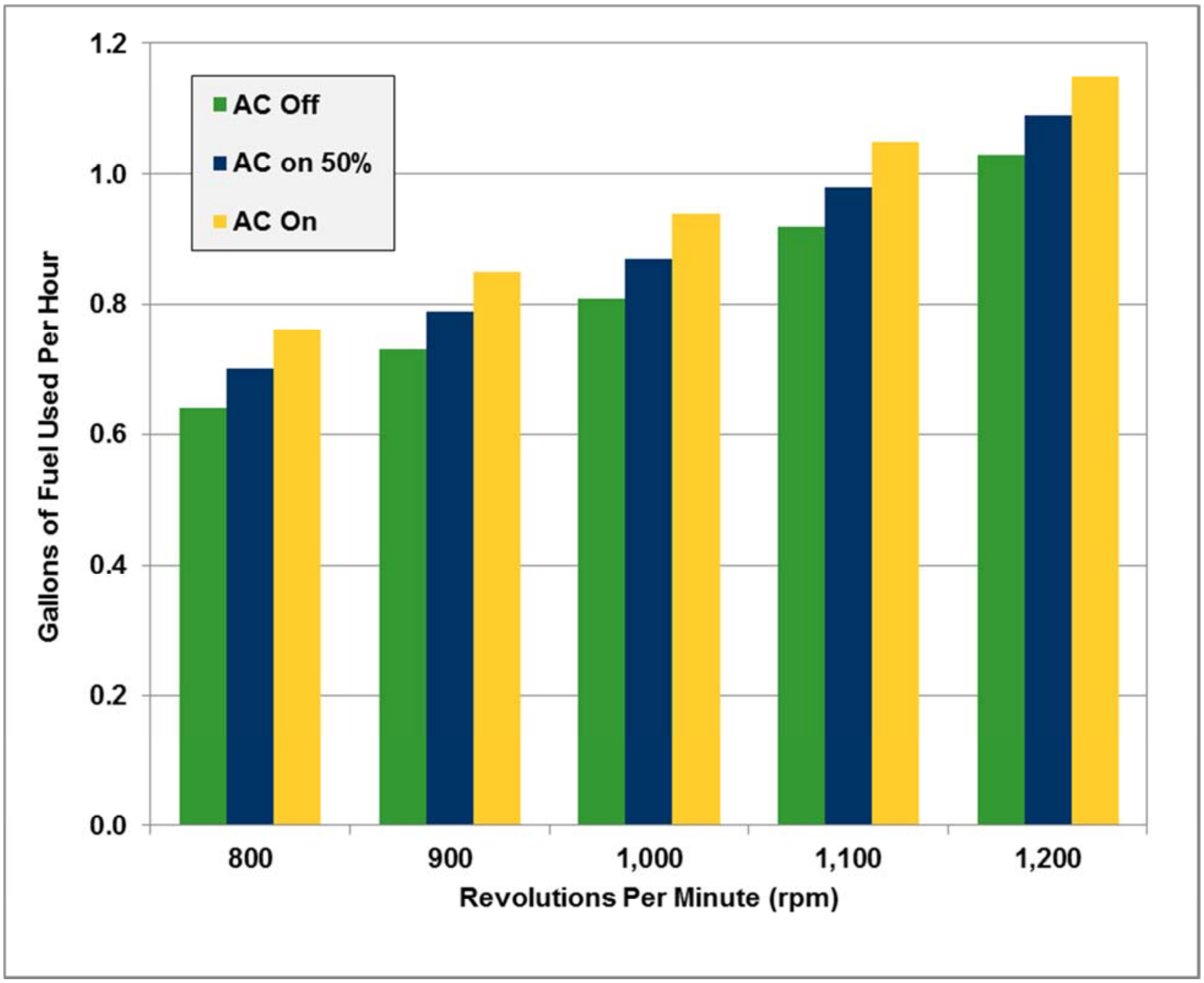

FIGURE 67. Average Amount of Fuel Used for Idling a Truck-Tractor

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

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Chapter 4.

TECHNOLOGIES

Page

Contents

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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 2010 there were 32 different HEVs sold. Likely due to the economic recession and relatively low gasoline prices, the total sales of HEVs peaked in 2007 at just over 350 thousand vehicles.

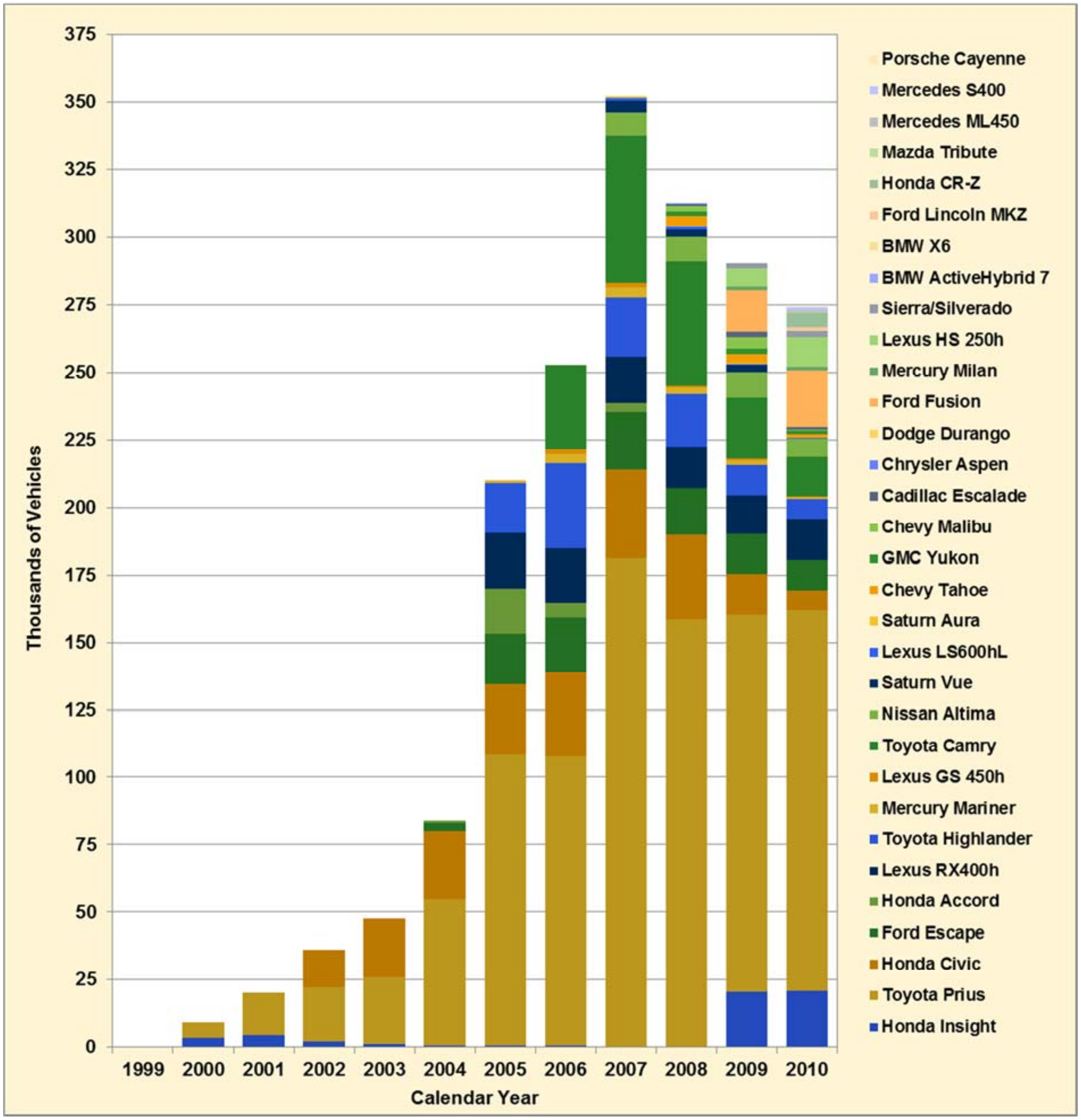


FIGURE 68. Hybrid-Electric Vehicle Sales, 1999-2010

Source:

U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/afdc/data/docs/hev_sales.xls

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.

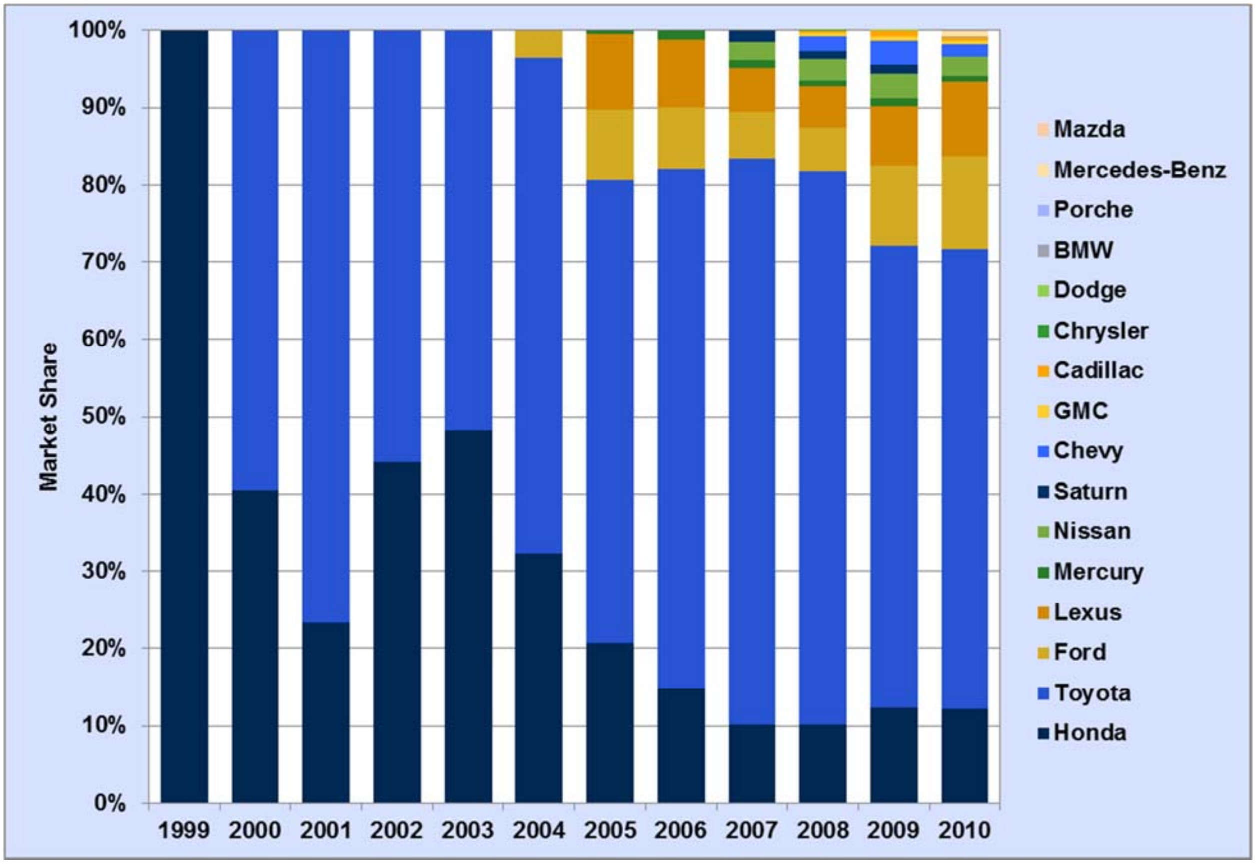


FIGURE 69. Hybrid-Electric Vehicle Market Share, 1999-2010

Source:

U.S. Department of Energy, Alternative Fuels and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/afdc/data/docs/hev_sales.xls

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
GMC	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

The recent debut of the Chevrolet Volt and the Nissan Leaf is just the beginning of cars that plug into electric outlets. There are already several other plug-ins currently available from Tesla, Ford, and Smart, with more models planned by various manufacturers for 2012 - 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
Chevrolet	Volt	Available	40 miles	1.4-liter engine, 16 kWh lithion ion battery, 150-hp electric motor
Ford	Transit Connect	Available	80 miles	2.0L Duratec 1-4 Engine, 28 kWh lithium-ion battery
Nissan	Leaf	Available	100 miles	24 kWh lithium-ion battery
Smart	ED	Available	70 miles	16 kWh lithion-ion battery, 55 kW electric motor
Tesla	Roadster	Available	200 miles	53 kWh battery, 185 kWh, 248 hp electric motor
Think	City	Available	120 miles	24 KWh battery
BMW	ActiveE	2012	100 miles	32 kWh lithium-ion battery
BYD	e6 Wagon	2012	200 miles	1.0-liter engine, iron-phosphate Fe battery, 75kW motor
BYD	F3DM	2012	60 miles	1.0-liter engine, 16 kWh lithium-ion battery, 50kW traction motor
Coda	Electric Sedan	2012	120 miles	34 kWh lithium-ion battery
Ford	Focus Electric	2012	100 miles	23 kWh lithium-ion battery
Fisker	Karma	2012	50 miles	2.0-liter engine, 22 kWh lithion-ion battery, 400-hp electric motors (2)
Honda	Fit EV	2012	75 miles	6 kW lithium-ion battery, 120 kW electric motor
Mitsubishi	i	2012	75 miles	16 kWh lithium-ion battery, 47 kW motor
Tesla	Model S	2012	150 miles	80 kWh litium-ion battery,
Toyota	FT-EV	2012	50 miles	all electric
Toyota	Prius Plug-In Hybrid	2012	13 miles	lithium-ion battery, 1.8-liter aluminum 4-cyl engine
Toyota	Rav4 EV	2012	100 miles	
Volvo	V70 Plug-In Hybrid	2012	30 miles	11.3 kWh battery
BMW	i3	2013	100 miles	22 kWh lithium-ion battery, 170 hp electric motor
BMW	Vision	2013	30 miles	11 kWh lithium-ion battery, 3 cyl diesel engine
Volkswagen	E-Up!	2013	80 miles	18 kWh battery, 80 hp electric motor
Volkswagen	E-Golf	2014	95 miles	26.5 kWh battery, 85kW electric motor
Audi	A1 E-Tron	Concept	30 miles	12 kWh lithium-ion battery, 102 hp electric motor, 252cc Wankel rotary engine
Misubishi	PX-MiEV	Concept	30 miles	10 kWh lithium-ion battery, 1.6-liter 114 hp 4-cyl engine
Vision	S500	Concept	18 miles	4 kW 60 hp V6 gas engine, 10 kWh lithium-ion battery, 4 15 kW electric motor
Volvo	C30	Concept	90 miles	24 kWh battery

Source:

Plugincars.Com. http://www.plugincars.com/cars

PrimeEarth EV Energy was the Largest Hybrid-Electric Battery Supplier in 2010

PrimeEarth EV Energy, a joint venture of Panasonic and Toyota, is the supplier for Toyota, Nissan, and GM hybrid trucks. Nearly 75% of the hybrid vehicles sold in model year 2010 run on PrimeEarth batteries. Sanyo is the other large battery supplier, supplying batteries to Ford and Honda. Two other companies, Johnson Controls-Saft and SB LiMotive supply batteries for other manufacturers with low hybrid sales. In 2011, the partnership between Johnson Controls and Saft came to an end.

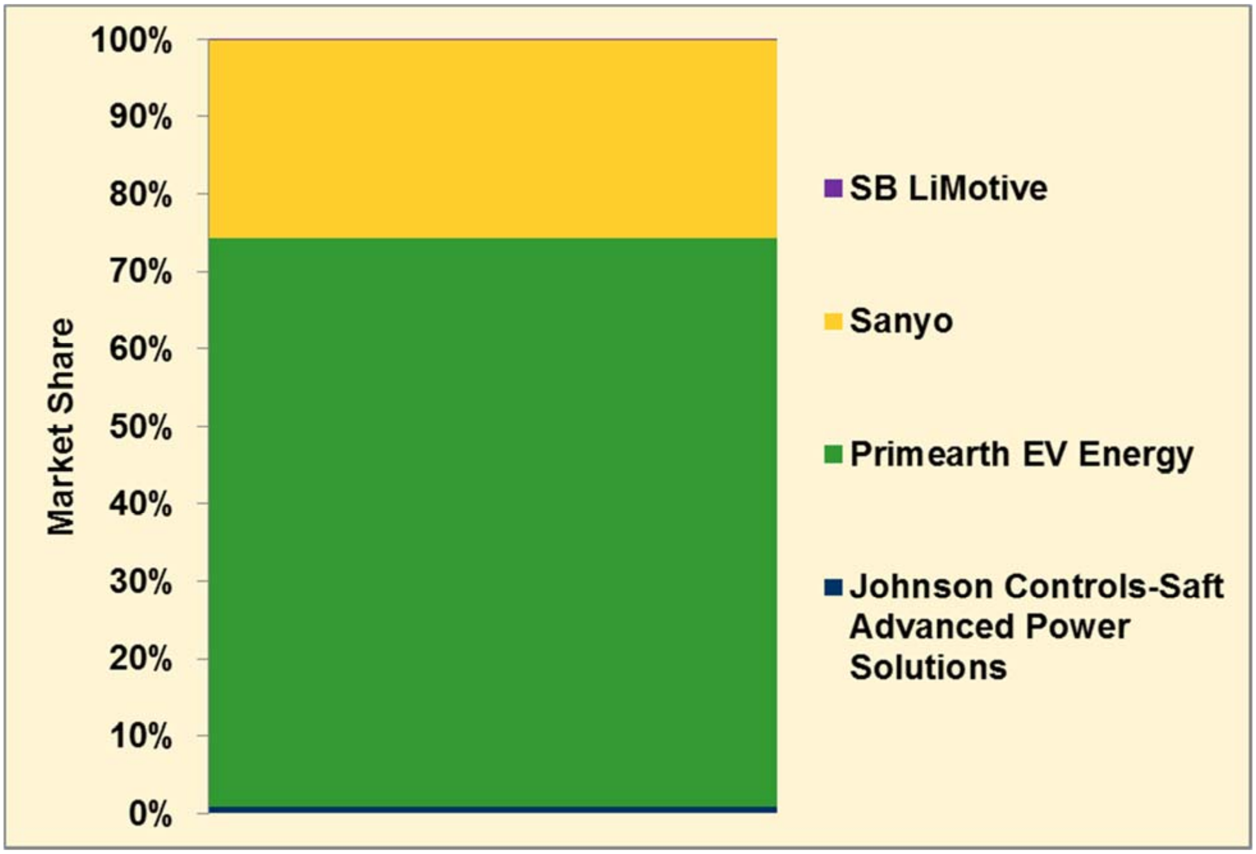


FIGURE 70. Battery Market Share, 2010

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

Sources:
Estimated using hybrid vehicle sales in 2010 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/afdc/data/docs/hev_sales.xls
Battery supplier for each vehicle – compiled from various public sources, Oak Ridge National Laboratory.

Batteries for Upcoming Electric and Hybrid-Electric Vehicles

There are new models of battery-electric vehicles (BEV) and hybrid-electric vehicles (HEV) in the market in model years 2011 and 2012. The first HEVs used nickel-metal hydride (NiMH) batteries, but many of the new HEVs and BEVs use lithium-ion (Li-ion) batteries.

TABLE 14. Batteries for Selected Upcoming Electric and Hybrid-Electric Vehicles

Vehicle	Model Year	Vehicle type	Battery type	Supplier
Chrysler Fiat 500EV (expected)	2012	BEV	Li-ion	SB LiMotive
Ford Fusion/Mariner/MKZ Hybrid	2011	HEV	NiMH	Sanyo
Ford Escape Hybrid (discontinued for 2012)	2011	HEV	NiMH	Sanyo
Ford Focus Electric (expected)	2012	BEV	Li-ion	LG Chem/ Compact Power
GM Volt	2011	PHEV	Li-ion	LG Chem/ Compact Power
GM Silverado/Sierra Hybrid, Yukon/Tahoe/Escalade Hybrid	2012	HEV	NiMH	Primearth EV Energy
GM Buick Lacrosse/Regal eAssist	2012	start/ stop	Li-ion	Hitachi
Honda Insight, CR-Z, Civic Hybrid	2011	HEV	NiMH	Sanyo
Honda Civic Hybrid	2012	HEV	Li-ion	Not available
Hyundai Sonata/Optima Hybrid	2011	HEV	Li-ion	LG Chem
Mitsubishi MiEV	2012	BEV	Li-ion	Toshiba
Nissan Leaf	2011	BEV	Li-ion	Automotive Energy Supply Corp
Nissan Infinti M35h	2012	HEV	Li-ion	Automotive Energy Supply Corp
Toyota Camry/Highlander/Lexus hybrids	2011	HEV	NiMH	Primearth EV Energy
Toyota Prius Hybrids	2011	HEV	NiMH	Primearth EV Energy
Toyota Prius Plug-in	2012	PHEV	Li-ion	Sanyo
VW Touareg Hybrid	2011	HEV	NiMH	Sanyo

Note: Compact Power is a wholly owned U.S. subsidiary of LG Chem.

Sanyo is now owned by Panasonic.

Primearth EV Energy was formerly known as Panasonic EV Energy, a joint venture between Toyota and Panasonic. Majority owned by Toyota at present.

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

SB LiMotive is a joint venture between Bosch and Samsung SDI that recently purchased Cobasys, LLC (joint venture between ECD Ovonics and Chevron Texaco).

Source:

Compiled from public sources by Josh Pihl, Oak Ridge National Laboratory, December 2011.

Flex-Fuel Vehicle Offerings Double in MY 2011

In the last five years, GM 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, such that there were 68 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.

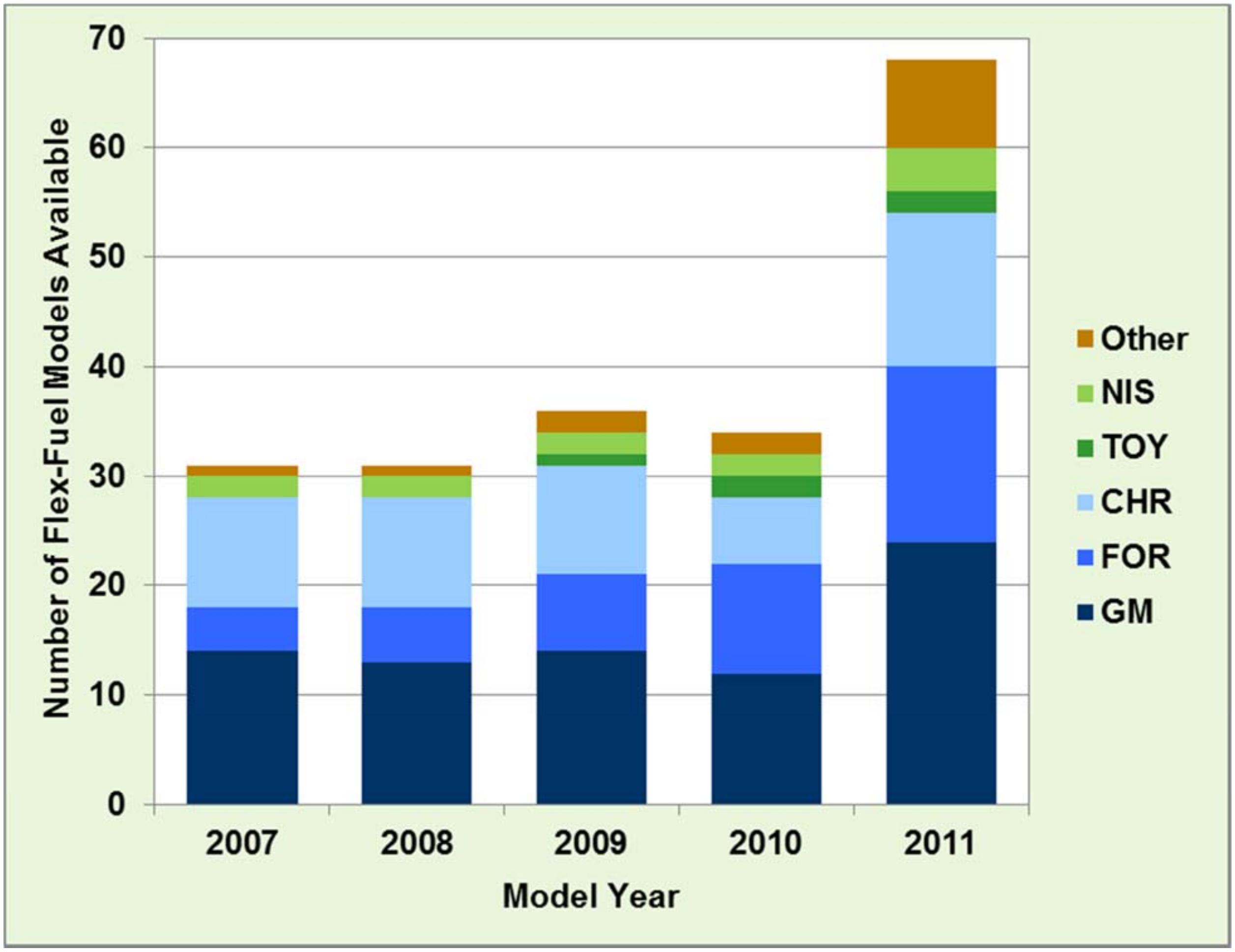
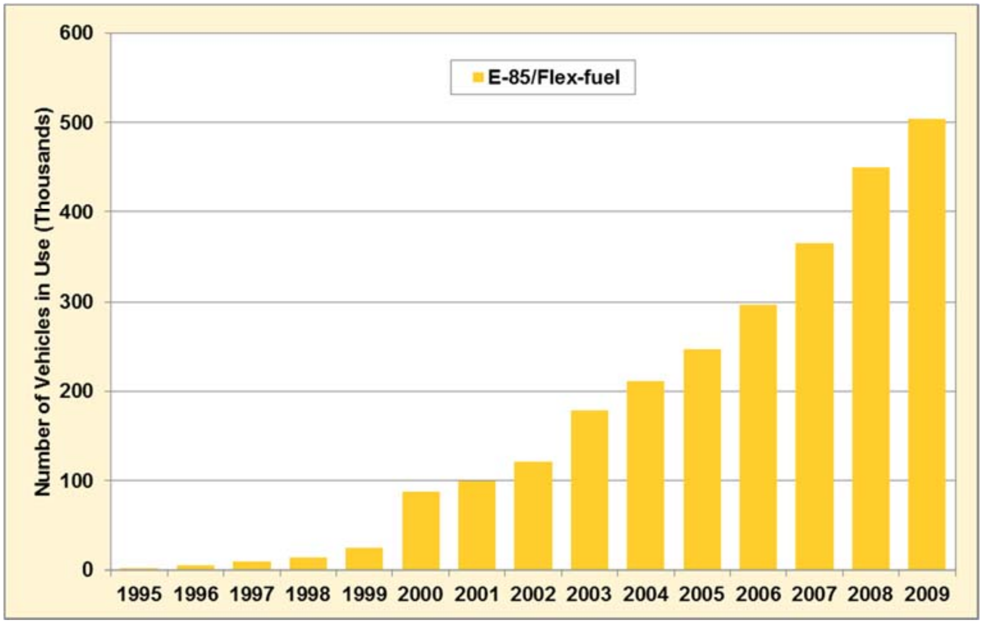


FIGURE 71. Number of Flex-Fuel Models Available

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 500 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 electric vehicles (not including hybrids) have increased.



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

Note:
Electricity does not include hybrid vehicles. LPG = Liquefied petroleum gas. CNG = Compressed natural gas. LNG = Liquefied natural gas.

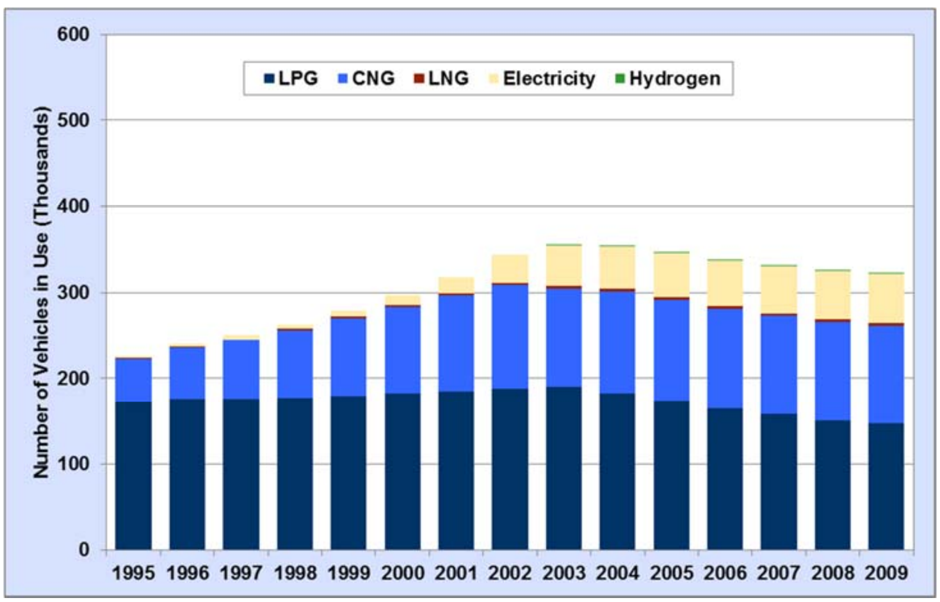


FIGURE 72. Number of Alternative Fuel Vehicles in Use, 1995-2010

Source:

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

Biofuel Stations Spread Beyond the Mid-West

E-85, which is 85% ethanol and 15% gasoline, is sold at 2,468 stations nationwide. Many stations are located in the Mid-West 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 631 stations across the country, with the predominance of stations in the Southeast. Data are as of October 31, 2011.

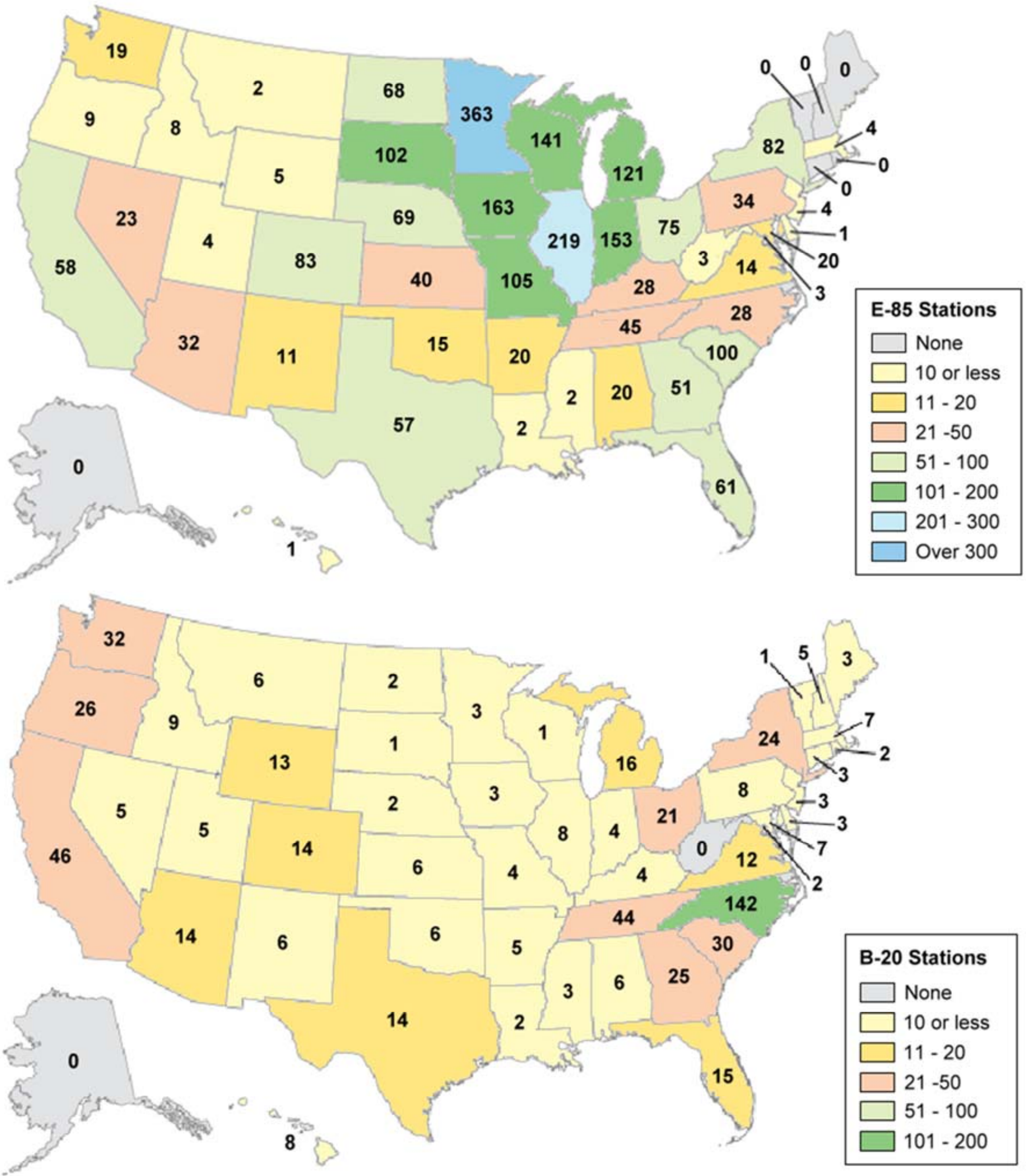


FIGURE 73. Number of E-85 (top) and B-20 Stations by State

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 2,563 propane stations across the county. Texas and California together comprise 28% of the propane stations. Natural gas, compressed or liquefied, is not as widely available as many other alternative fuels. There are 978 stations nationwide. New York and California have the most natural gas stations. Data are as of October 31, 2011.

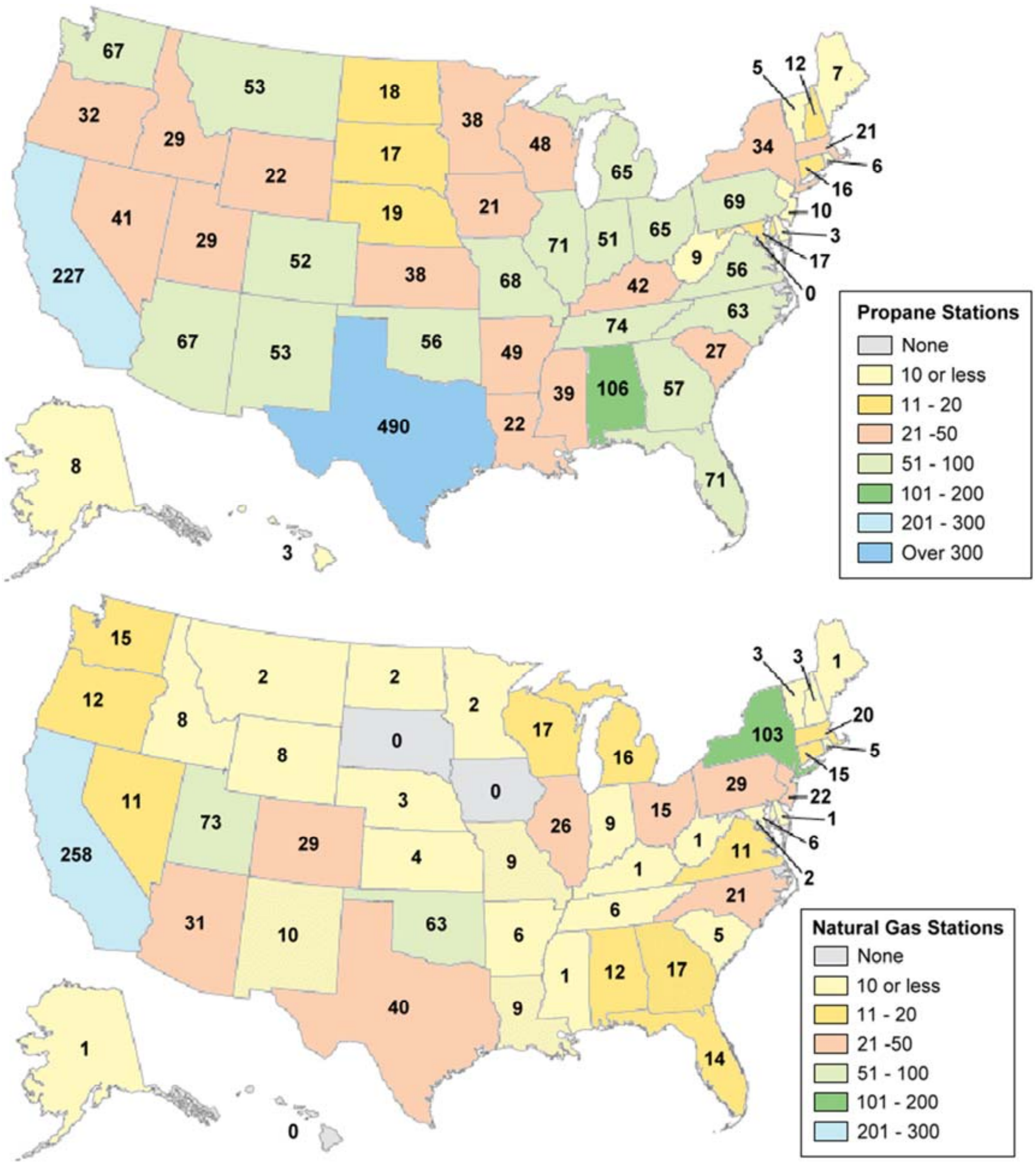


FIGURE 74. Number of Propane (top) and Natural Gas Stations by State

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 (4,420 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 October 31, 2011.

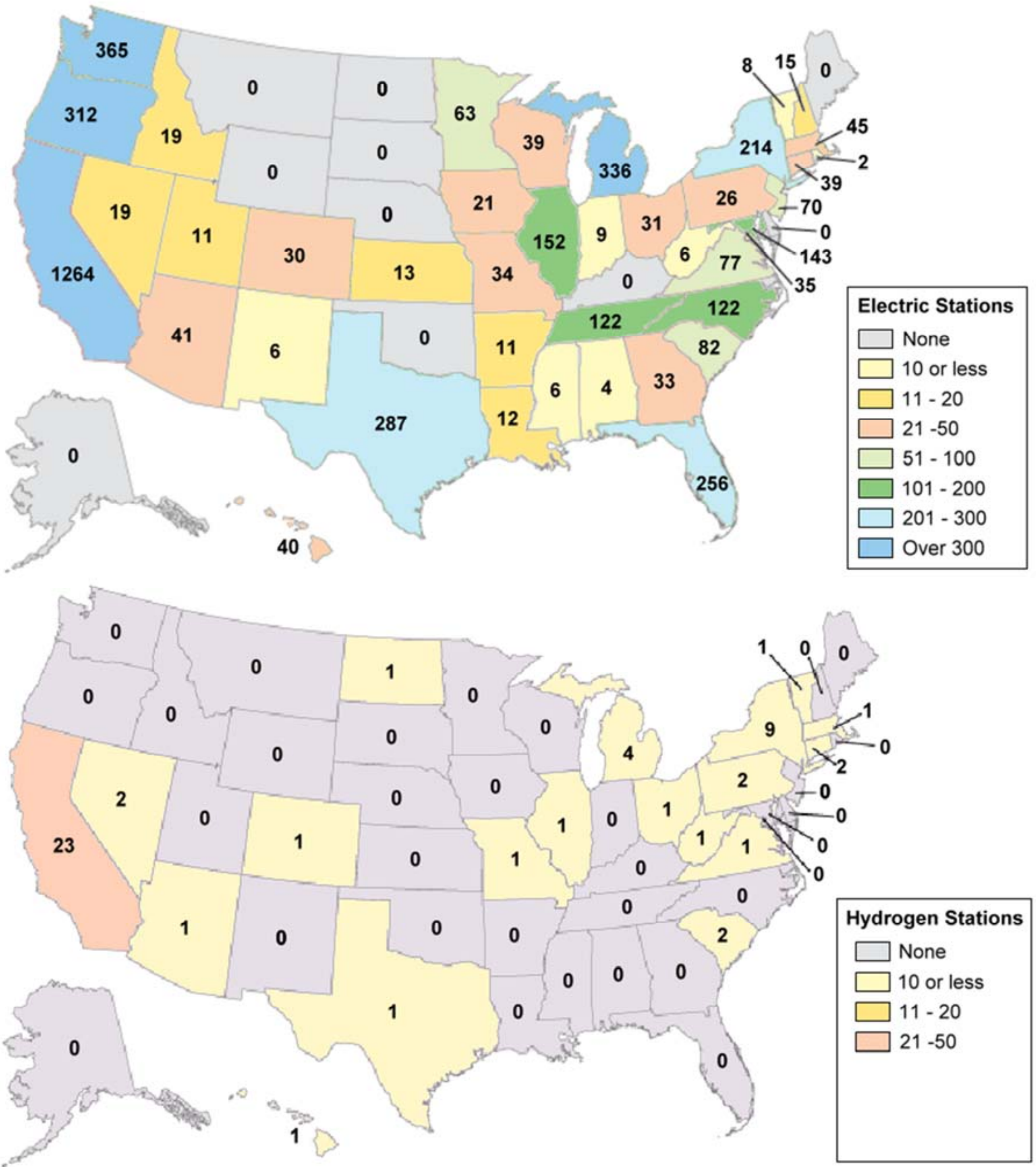


FIGURE 75. Number of Electric (top) and Hydrogen Stations by State

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 2010. Federal use of other alternative fuels has been less than one million GGEs combined in 2009 and 2010. Note the large difference in the scales of the two graphs.

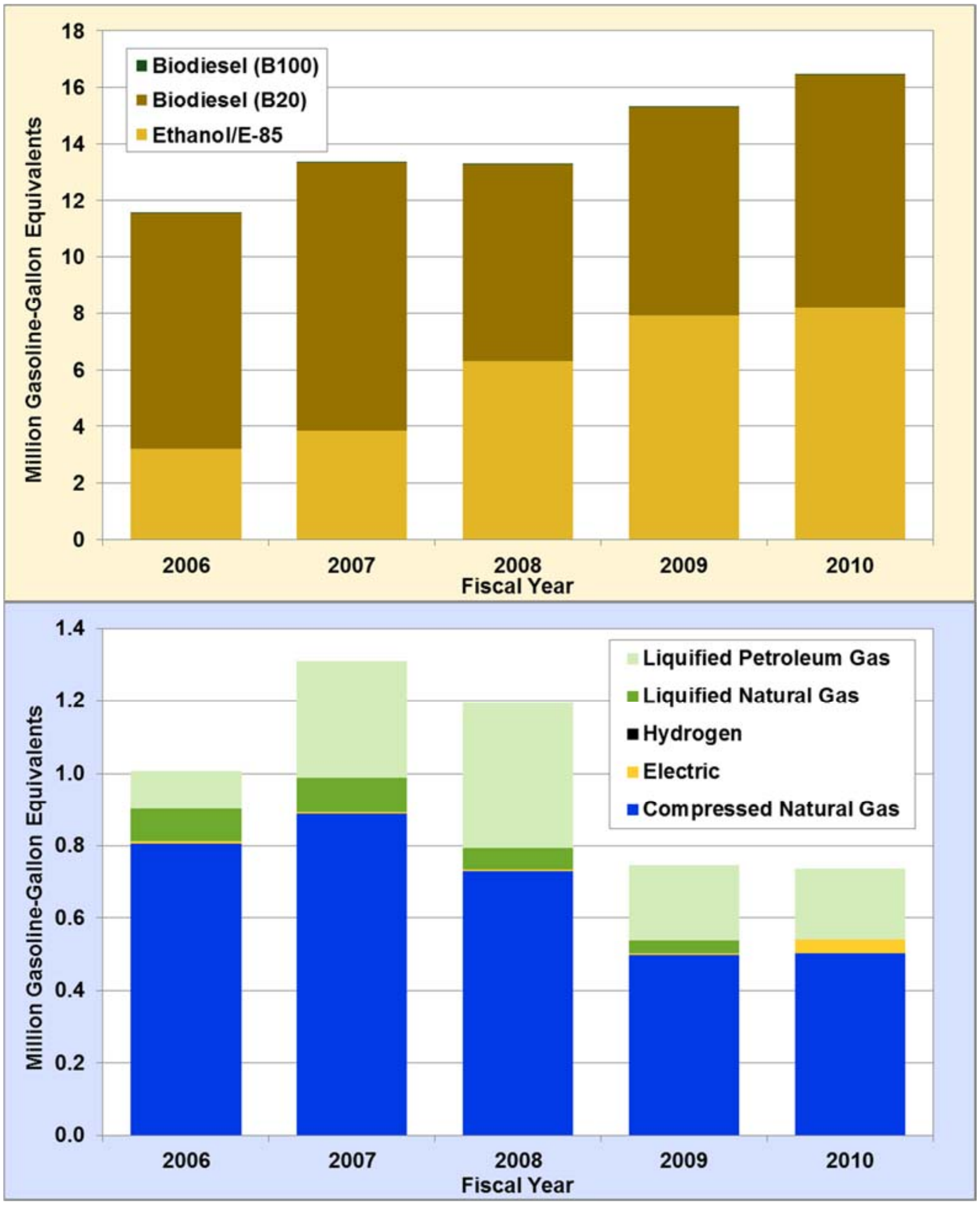


FIGURE 76. Alternative Fuel Use by the Federal Government

Source:

U.S. General Services Administration, *FY 2010 Federal Fleet Report*, Washington, DC, 2011. http://www.gsa.gov/portal/content/102943

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 2010.

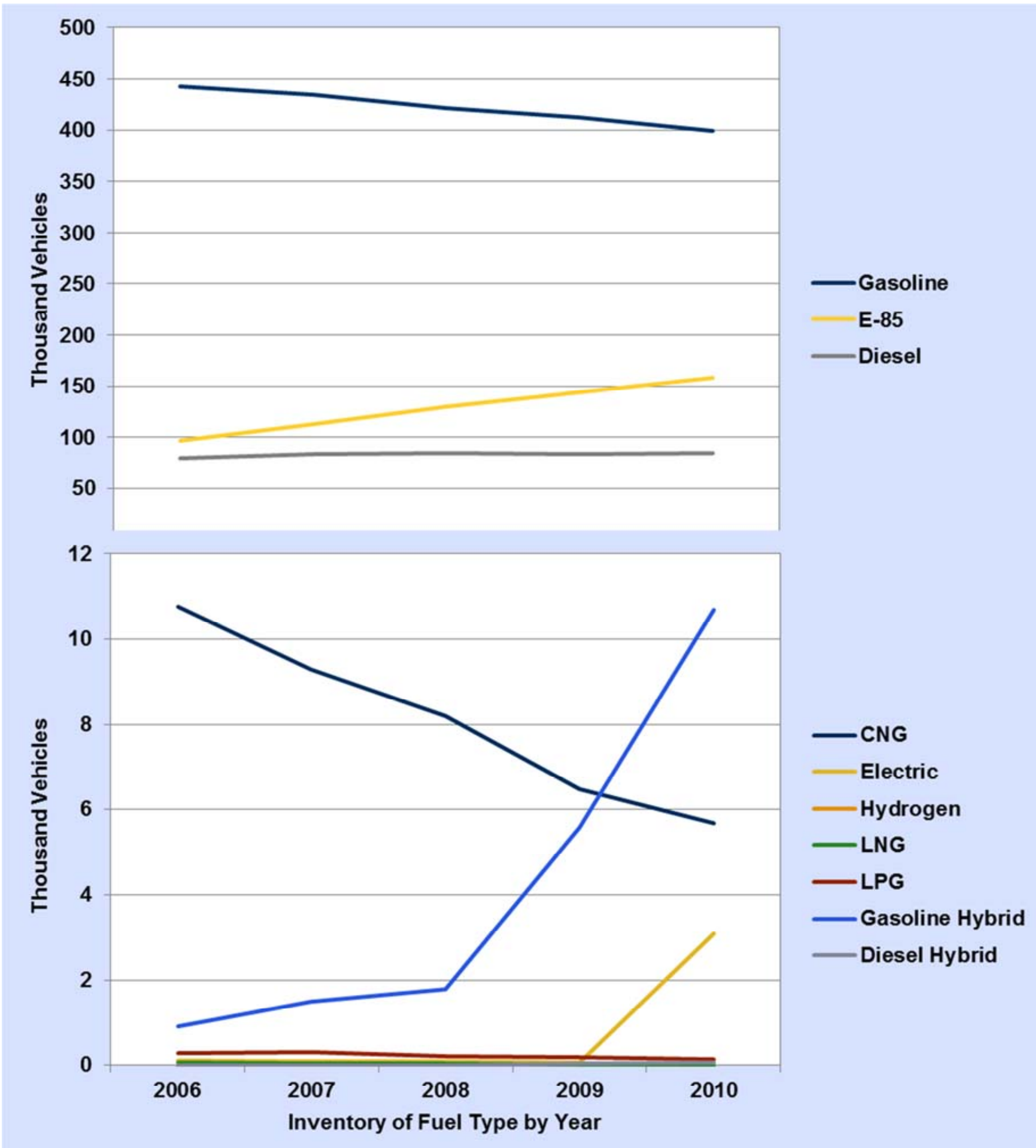


FIGURE 77. Federal Government Vehicles by Fuel Type, 2006-2010

Source:

U.S. General Services Administration, FY 2010 Federal Fleet Report, Washington, DC, 2011. 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 Merck & Co. has just under 6,000 alternative fuel vehicles, most of them flex-fuel. Ninety-five percent of Schwan's Home Service vehicles and Ferrellgas vehicles run on propane.

TABLE 15. Top 25 Commercial Fleets Using Alternative Fuel and Advanced Technology Vehicles, 2009

	Company	Total Alt Fuel	CNG*	Propane*	Flex-Fuel	Biodiesel	Hybrid/ Electric*	Total Vehicles	Percent Alt Fuel	Percent Hybrid/Electric
1	Merck & Co., Inc.	5,849			5,800		49	7,317	80%	1%
2	Schwan's Home Service Inc.	5,800		5,800				6,094	95%	0%
3	State Farm Mutual Auto Insurance Company	4,471			4,339	1	131	14,376	31%	1%
4	GE Healthcare	3,875			3,875			5,614	69%	0%
5	Xerox Corp.	3,825			3,675		150	10,450	37%	1%
6	Bristol-Myers Squibb Co.	3,562			3,550		12	5,557	64%	0%
7	Ferrellgas	3,530		3,530				3,733	95%	0%
8	Eli Lilly & Co.	3,174			3,000	174		5,113	62%	0%
9	Johnson & Johnson Services Inc.	3,037			912		2,125	9,850	31%	22%
10	Honeywell International Inc.	2,319			2,319			4,189	55%	0%
11	Consolidated Edison Company of New York	1,804	20			1,761	23	3,608	50%	1%
12	Florida Power & Light	1,524			10	1,251	263	1,851	82%	14%
13	United Parcel Service (UPS)	1,448	725	720			3	72,633	2%	0%
14	DSWaters of America	1,236		1,131			105	1,573	78%	7%
15	Monsanto Co.	1,131			1,125		6	3,365	34%	0%
16	Liberty Mutual Insurance	1,018			1,018			3,505	29%	0%
17	Delta Airlines	861	4	124	0		733	1,546	56%	47%
18	Comcast Corp.	852			756		96	40,158	2%	0%
19	National Grid	832	730	15	52		35	3,000	28%	1%
20	Ecolab Inc.	809			809			7,311	11%	0%
21	Alliant Energy	804			4	800		1,837	44%	0%
22	Novartis Pharmaceuticals	797					797	8,102	10%	10%
23	Federal Express Corp.	786	90	696				36,701	2%	0%
24	Schneider Electric/Square D	770			750		20	1,535	50%	1%
25	BMHC (BMC West/SelectBuild)	738		418	315		5	2,670	28%	0%

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

Source:

Bobit Publishing, *Automotive Fleet 500*, "Top 50 Green Commercial Fleets," 2009. http://www.fleet-central.com/TopFleets/pdf/top50green_09.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 129 pounds per vehicle from 1995 to 2009 while the use of high and medium strength steels has increased by 200 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 43% 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.

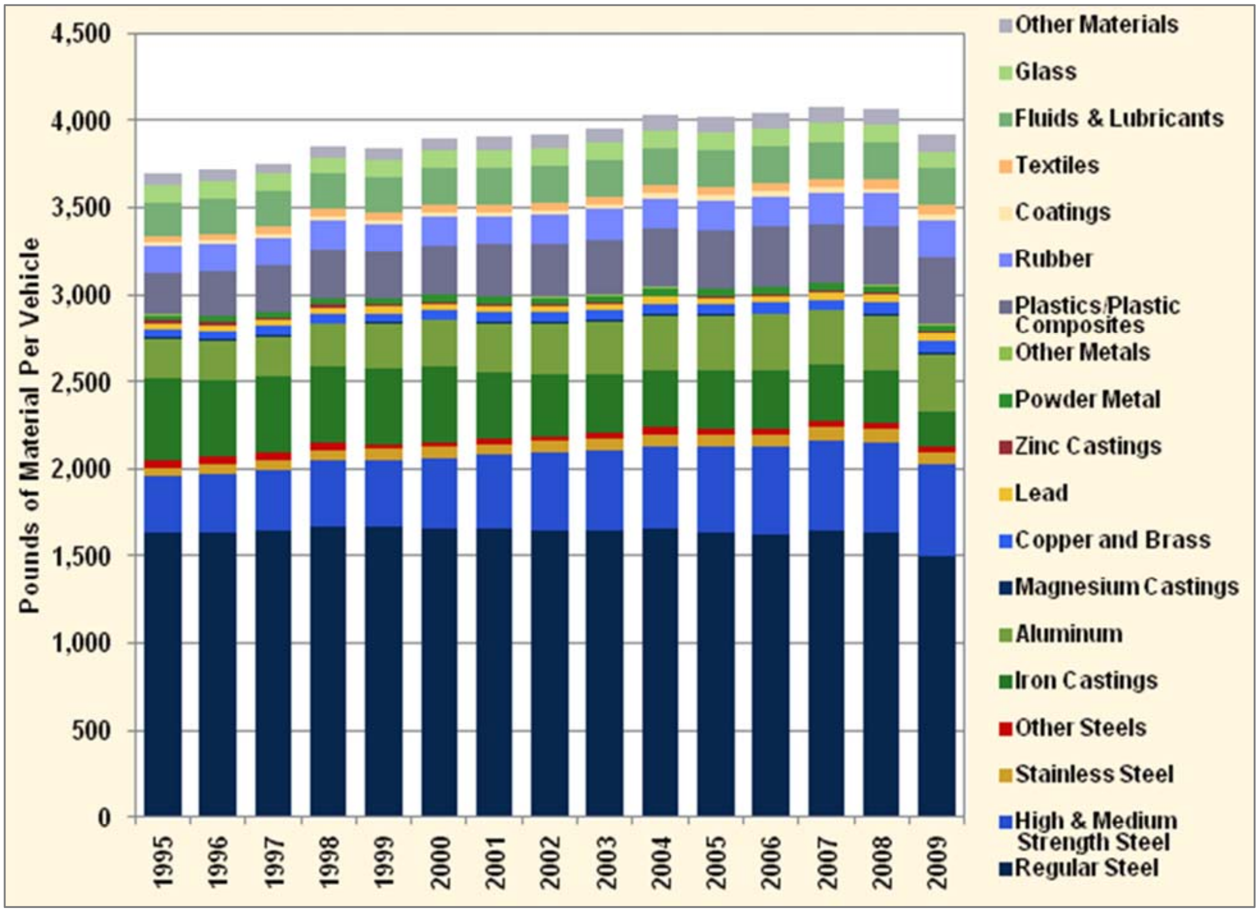


FIGURE 78. Average Materials Content of Light Vehicles, 1995-2009

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

How Can Fuel Consumption be Reduced for 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 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.

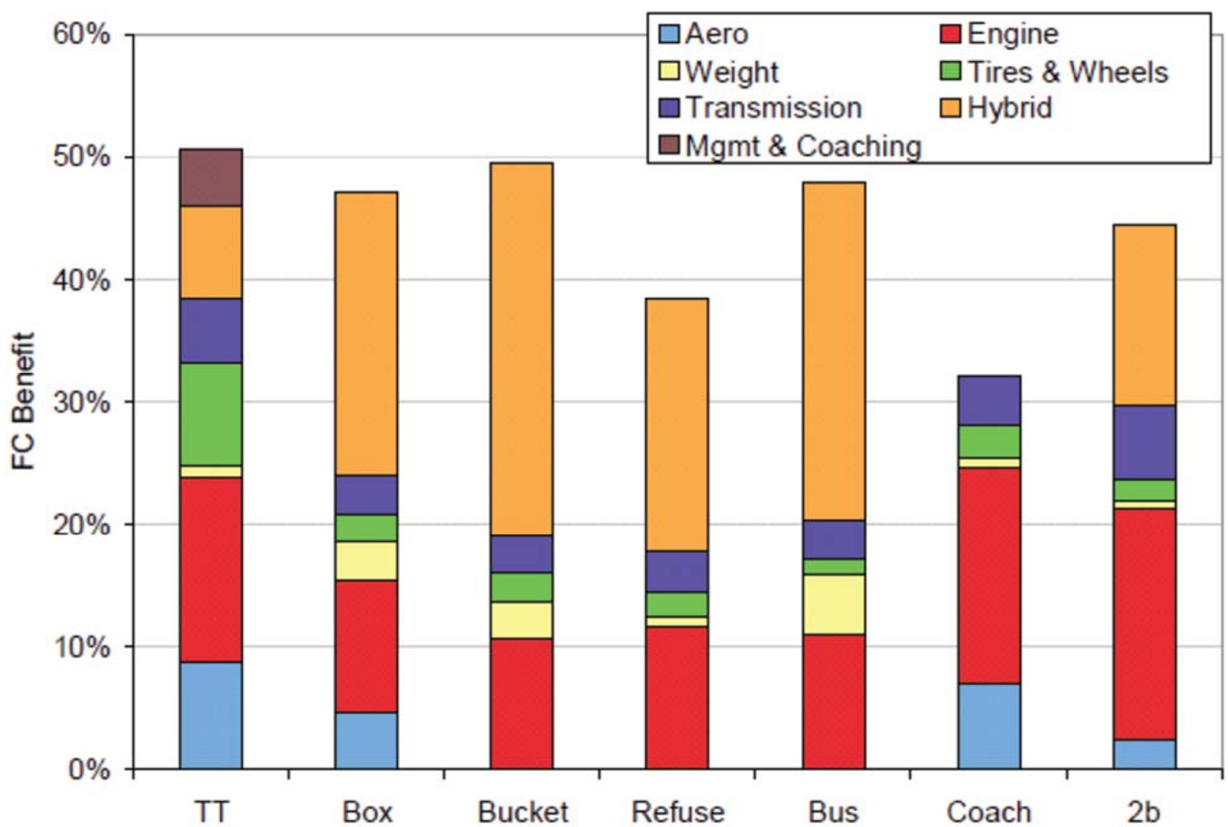


FIGURE 79. Comparison of 2015-2020 New Vehicle Potential Fuel Saving Technologies

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 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 16. SmartWay Certified Manufacturers

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

Source:
U.S. Environmental Protection Agency, SmartWay Technology Program.
http://www.epa.gov/smartway/technology/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 17. 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.
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.
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.
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 air flow 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 NO_X after combustion. Other systems compromise the combustion process to limit the formation of NO_X 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.
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, 2011.

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 18. 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.
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.
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 manufactures continue to develop transmissions with even more gear ratios.

Source:

Compiled from published sources by Bob Boundy, Roltek, Inc., Clinton, TN, 2011.

Heavy Vehicles Use Hybrid Technologies in Different Ways

FIGURE 80. 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 81. Hybrid Bus

FIGURE 82. 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.

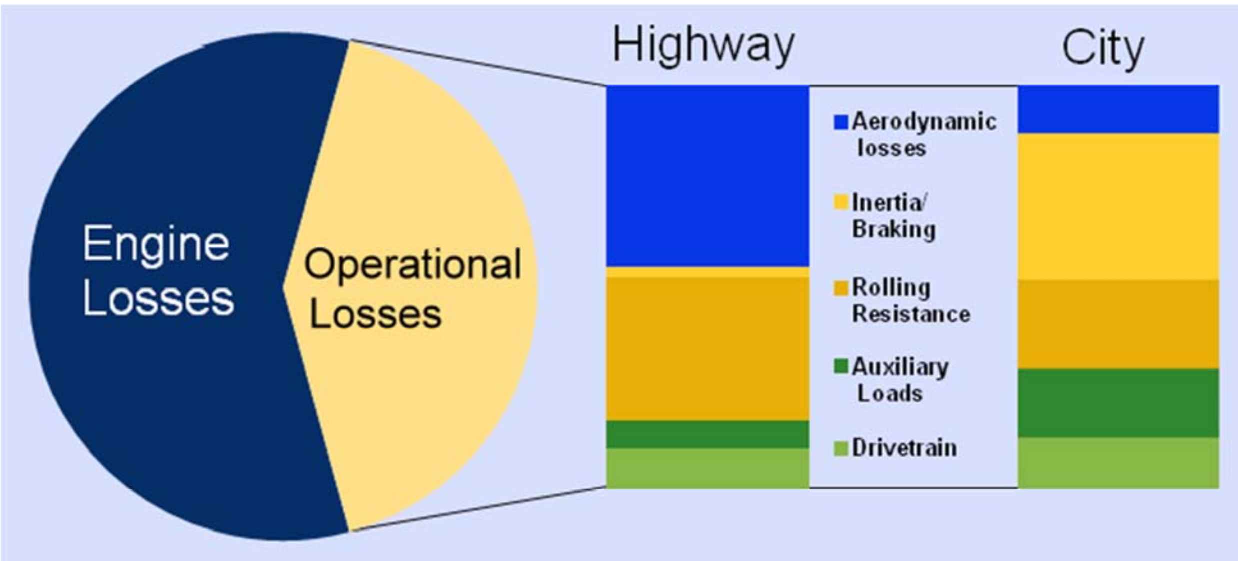


FIGURE 83. Class 8 Truck-Tractor Energy Losses

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

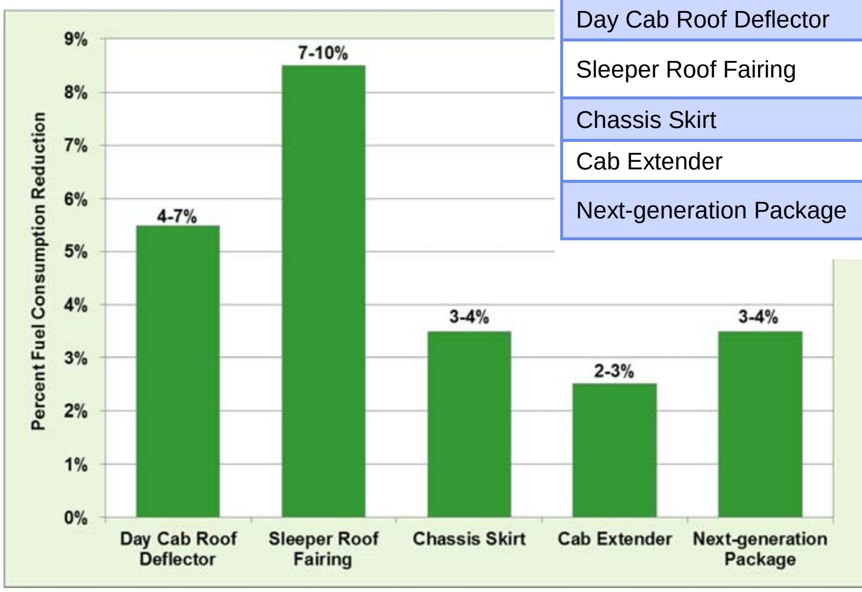


FIGURE 84. Fuel Consumption Reduction Rate, Approximate Cost, and Industry Adoption Rate for Aerodynamic Technologies

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.

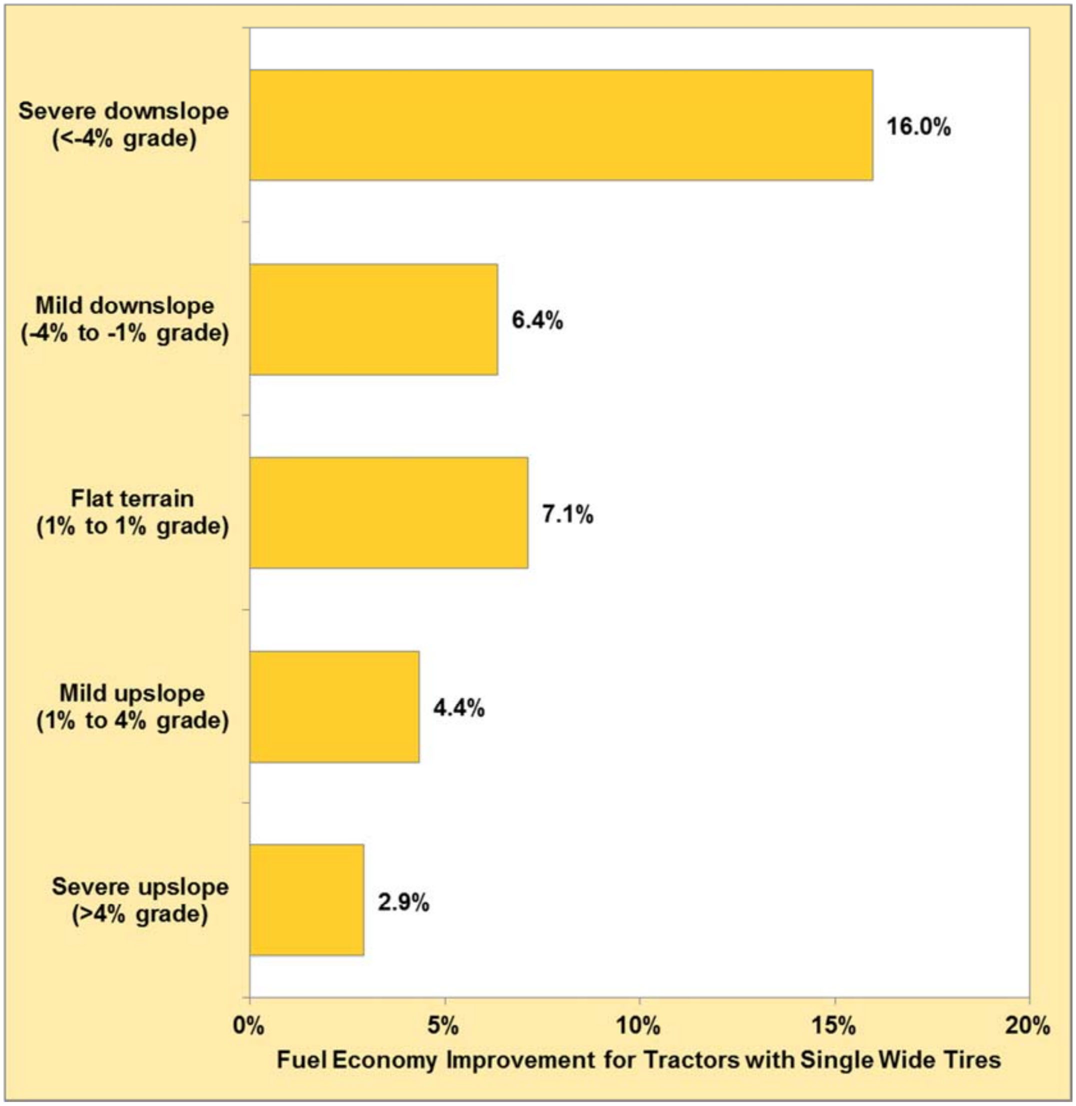


FIGURE 85. Fuel Economy Improvement for Class 8 Tractors with Single Wide Tires

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

Truck Stop Electrification Reduces Idle Fuel Consumption

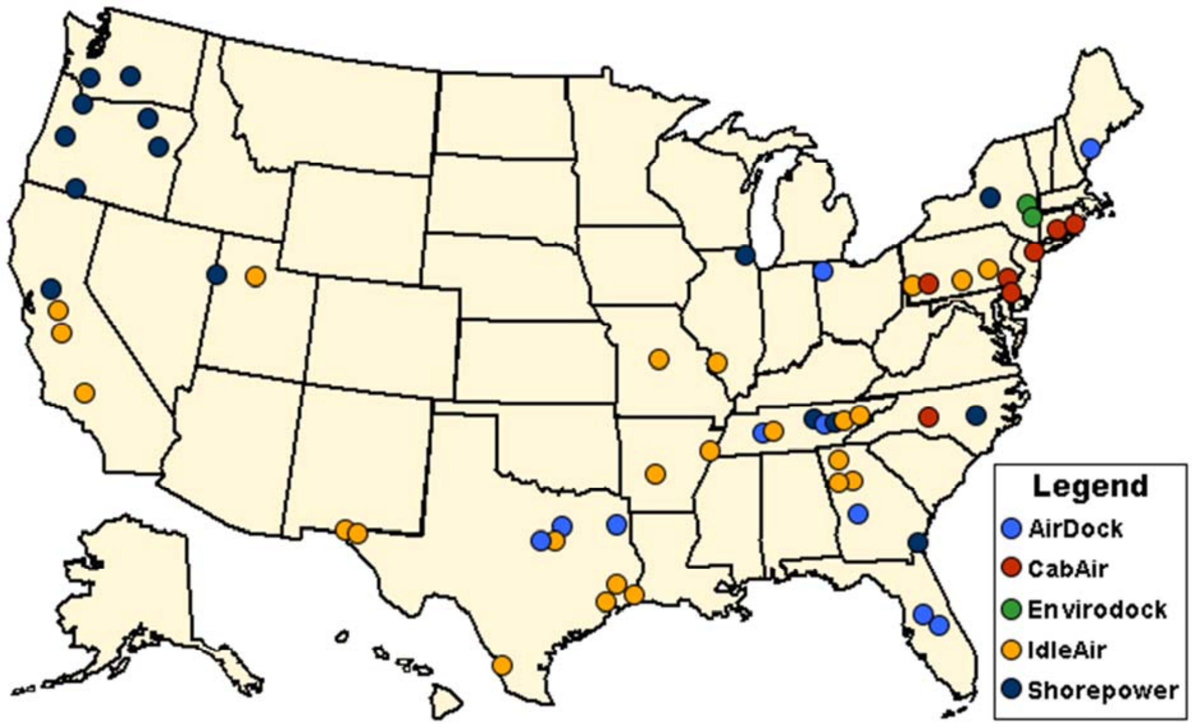


FIGURE 86. Map of Truck Stop Electrification Sites

TABLE 19. Number of Truck Stop Electrification Sites by State

State	Number of Sites
Arkansas	2
California	4
Connecticut	2
Delaware	2
Florida	2
Georgia	5
Illinois	2
Maine	1
Missouri	1
North Carolina	2
New Jersey	1
New York	3
Ohio	1
Oregon	5
Pennsylvania	4
Tennessee	7
Texas	10
Utah	2
Washington	2
Total	**58**

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 58 publicly accessible electrification sites across the nation. Some of these sites require special equipment to be installed on the truck and others do not. Presently, five companies equip electrification sites: Shorepower, CabAire, EnviroDock, AireDock, and IdleAir.

Source:
Alternative Fuels and Advanced Vehicles Data Center.
http://www.afdc.energy.gov/afdc/progs/tse_listings.php

Chapter 5.

POLICY

Page

Contents

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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. Traditional (non-plug-in) hybrid vehicles were eligible for a tax credit of up to $3,400 from 2005 through 2010. Diesels, which are more efficient than gasoline vehicles, were eligible for a similar tax credit, as were alternative-fuel vehicles. All of those credits were discontinued at the end of calendar year 2010. 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.

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 Chevrolet Volt
Electric Vehicles (Requirements for this credit changed between 2009 and 2010.)	2009 - on	$7,500	     	2010 Coda Sedan 2011 Ford Transit Connect EV 2011 Nissan Leaf 2011 Smart ForTwo EV 2008-2010 Tesla Roadster 2011 Wheego LiFe
Hybrids	2005 - 2010	$3,400	Purchases made after December 31, 2010 are not eligible for the tax credit.	
Diesels	2005 - 2010	$3,400		
Compressed Natural Gas	2005 - 2010	$3,400		
Liquefied Natural Gas	2005 - 2010	$3,400		
Liquefied Petroleum Gas	2005 - 2010	$3,400		
Hydrogen	2005 - 2010	$3,400		
M85 (85% Methanol)	2005 - 2010	$3,400		

Source:

U.S. Department of Energy and U.S. Environmental Protection Agency, www.fueleconomy.gov website, June 2011. http://www.fueleconomy.gov/feg/taxcenter.shtml

The Cash for Clunkers Program Took Inefficient Vehicles off the Road

The Car Allowance Rebate System, also known as Cash for Clunkers, provided Federal rebate money for consumers who traded old vehicles with an EPA combined fuel economy rating of 18 miles per gallon or less for brand new vehicles with improved fuel economy. The program was active from July 1 to August 24, 2009 and handled more than 677,000 transactions for a total of $2.85 billion.

TABLE 21. Top Ten List of Trade-in and Purchased Vehicles in the Cash for Clunkers Program

Top 10 Trade-in Vehicles
1. Ford Explorer 4WD
2. Ford F150 Pickup 2WD
3. Jeep Grand Cherokee 4WD
4. Ford Explorer 2WD
5. Dodge Caravan/Grand Caravan 2WD
6. Jeep Cherokee 4WD
7. Chevrolet Blazer 4WD
8. Ford F150 Pickup 4WD
9. Chevrolet C1500 Pickup 2WD
10. Ford Windstar FWD Van

Top 10 New Vehicles Purchased
1. Toyota Corolla
2. Honda Civic
3. Toyota Camry
4. Ford Focus FWD
5. Hyundai Elantra
6. Nissan Versa
7. Toyota Prius
8. Honda Accord
9. Honda Fit
10. Ford Escape FWD

Vehicles purchased under the program are, on average, 19% above the average fuel economy of all new vehicles at that time, and 59% above the average fuel economy of vehicles that were traded in.

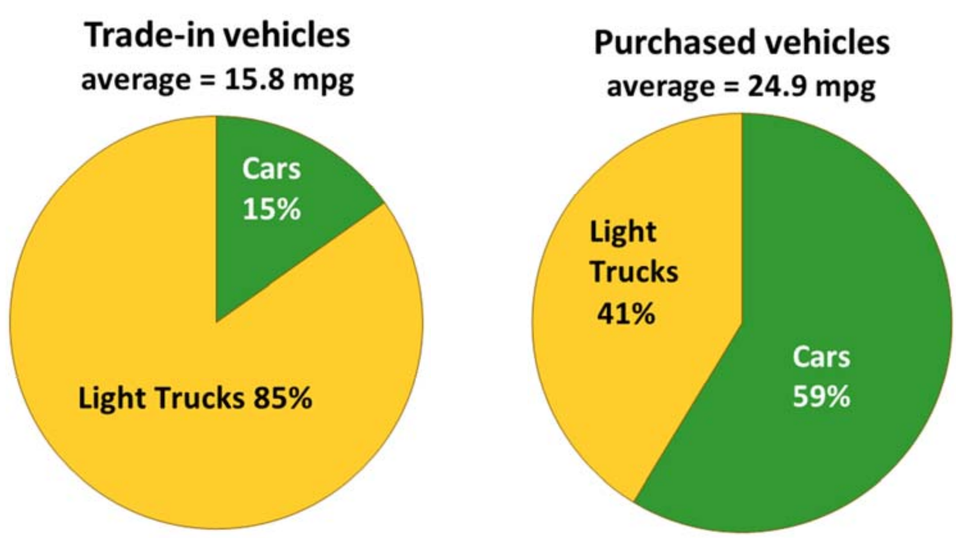


FIGURE 87. Share of Cars and Light Trucks Traded and Purchased under the Cash for Clunkers Program

Source:
National Highway Traffic Safety Administration, http://www.cars.gov

The Cash for Clunkers Program Raised the Nation's Fuel Economy

The Car Allowance Rebate System, also known as Cash for Clunkers, was successful in taking inefficient vehicles off of the road and replacing them with new, more fuel efficient vehicles. The average difference between the fuel economy of the vehicles traded-in and the fuel economy of the vehicles purchased under the program is shown in the map below. In California where the price of fuel is typically high, consumers purchased vehicles that averaged more than 10 miles per gallon (mpg) over what they traded.

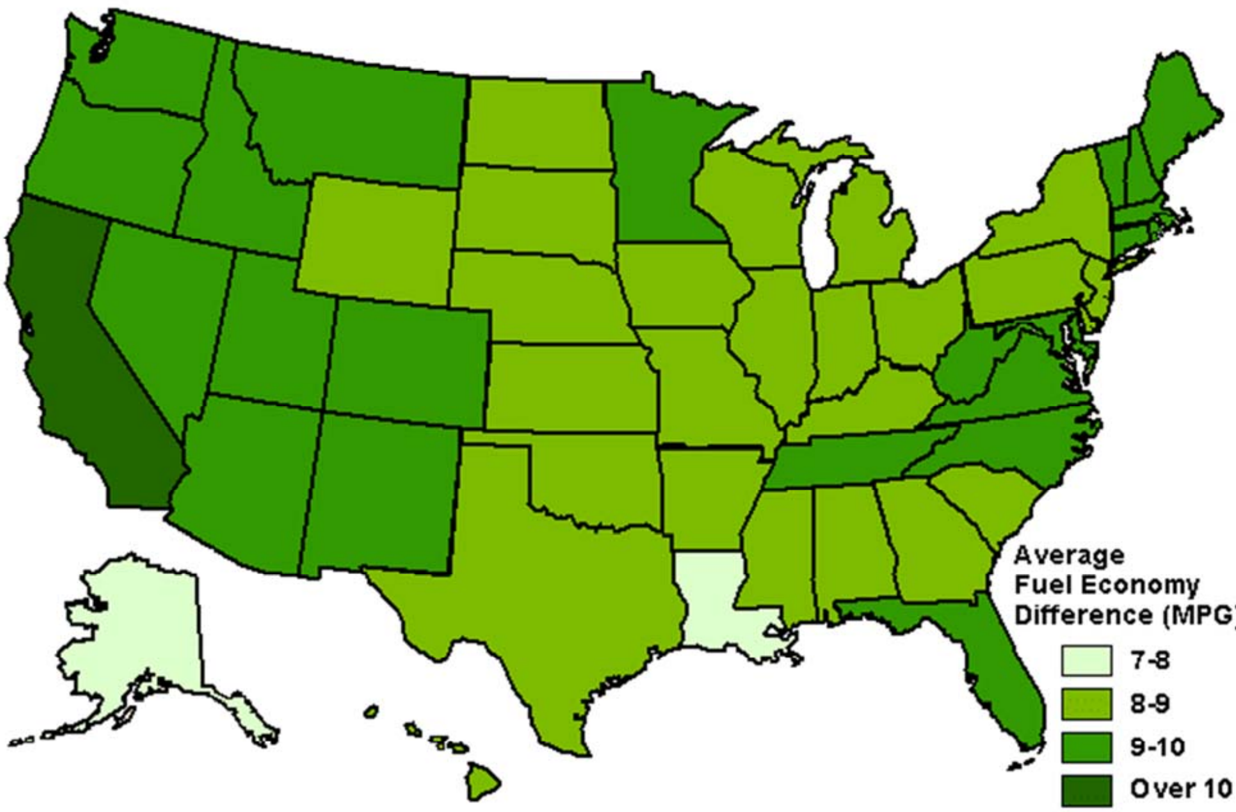


FIGURE 88. Average Fuel Economy Difference between Vehicles Traded and Vehicles Purchased in the Cash for Clunkers Program

Source:
National Highway Traffic Safety Administration, http://www.cars.gov

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 will be mandatory for the 2013 model year; however, automakers may voluntarily begin using the new labels for the 2012 model year.

FIGURE 89. Window Stickers for Model Year 2013 Cars and Light Trucks

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.

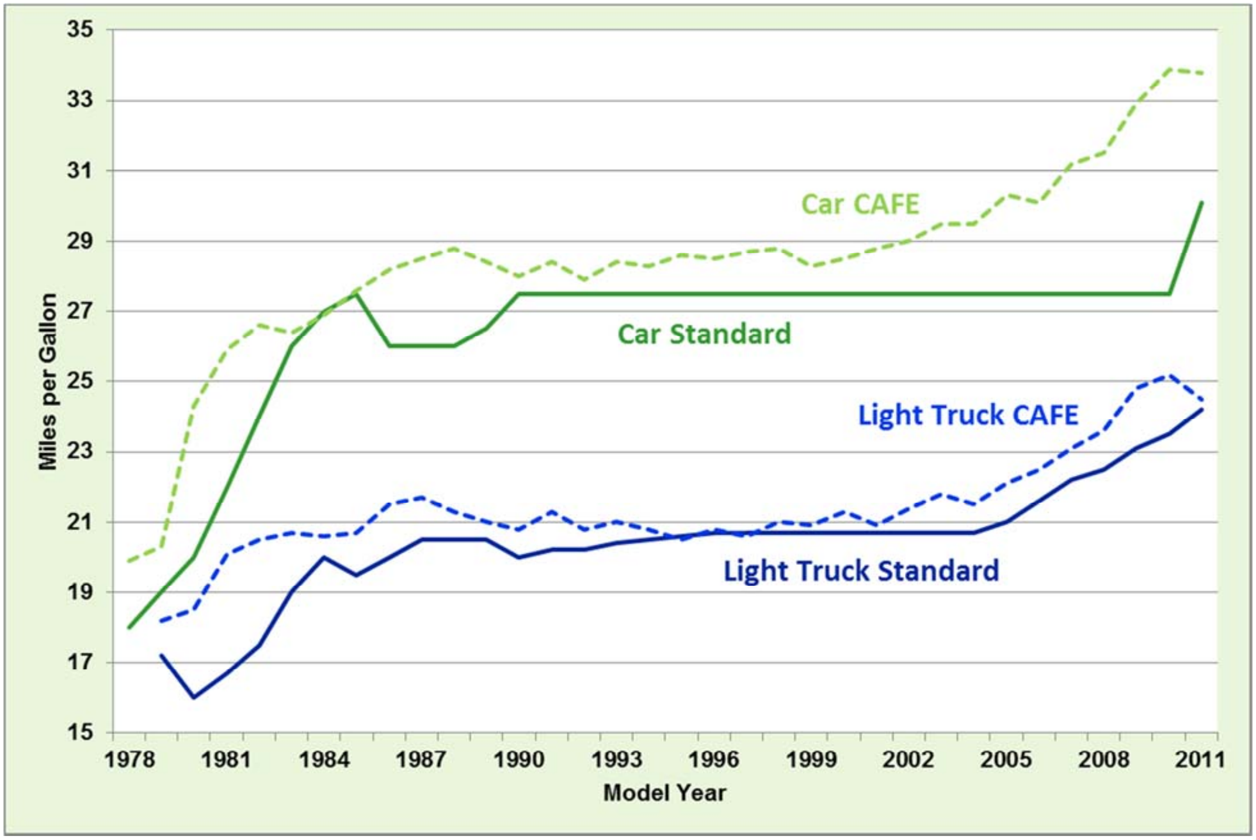


FIGURE 90. Corporate Average Fuel Economy for Cars and Light Trucks, 1978-2011

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

Source:

National Highway Traffic Safety Administration, "Summary of Fuel Economy Performance," October 2011. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/October_2011_Public.pdf

Corporate Average Fuel Economy: Manufacturers' Ups and Downs

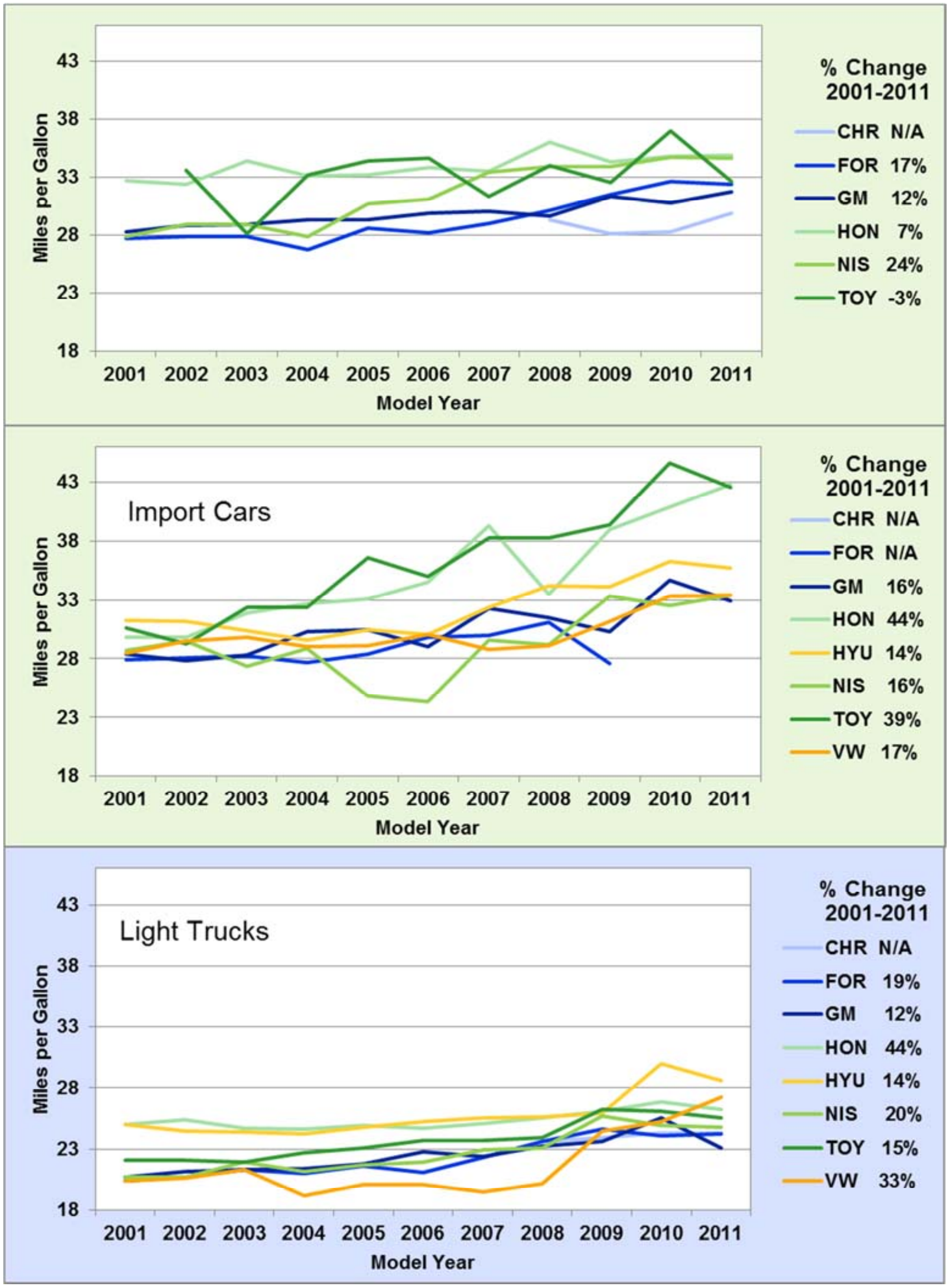


FIGURE 91. CAFE for Domestic and Import Cars and Light Trucks by Manufacturer, 2001-2011

Note: Data for Chrysler begin in 2008 after the merger with Daimler ended. Percent change for Toyota domestic cars is for 2002 – 2011. Ford has no import cars past 2009.

Source:

National Highway Traffic Safety Administration, "Summary of Fuel Economy Performance," October 2011. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/cafe/October_2011_Public.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 has taken full advantage of the credit in both cars and light trucks for the last five years. Ford received the full credit beginning in model year (MY) 2008 for both cars and light trucks. Chrysler received full credit for light trucks beginning in MY 2008, but never received full credit for cars until MY 2011. Nissan is the only other manufacturer to receive AMFA credits. In MY 2008 and 2011 Nissan received full credit for light trucks.

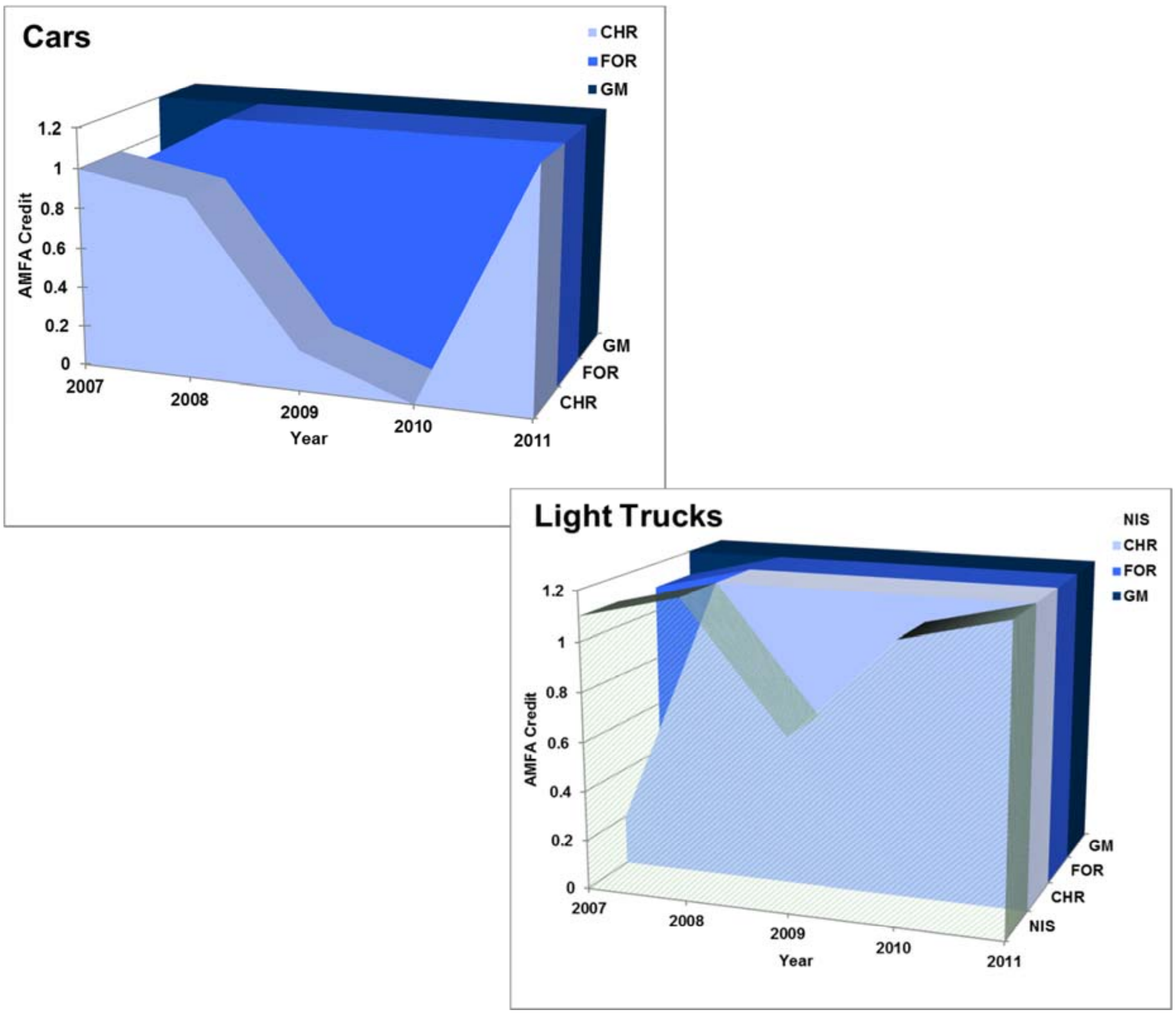


Figure 92. Flex Fuel Vehicle CAFE Credits

Source:

National Highway Traffic Safety Administration, "Fuel Economy Performance With and Without AMFA," April 2011. http://www.nhtsa.gov/staticfiles/rulemaking/pdf/Flexible_Fuel_Credits_2003_2010.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 November 2011, the National Highway Traffic Safety Administration proposed standards for MY 2017 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.

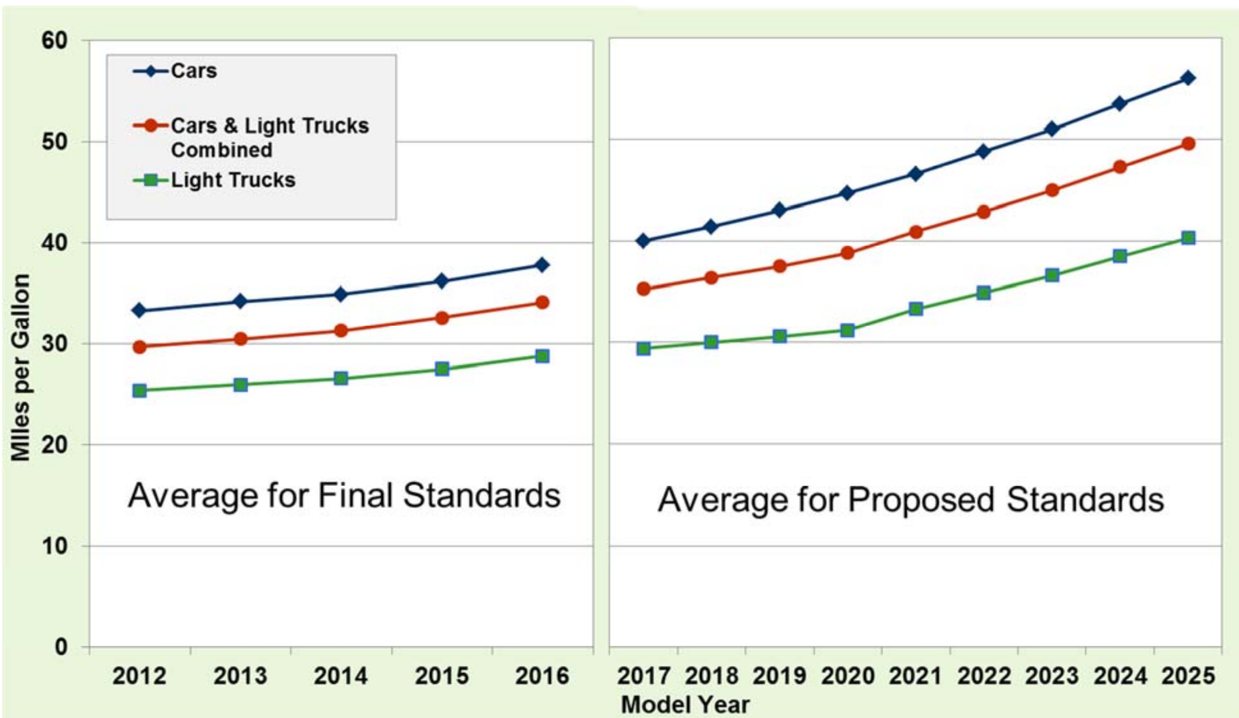


FIGURE 93. Average CAFE Standards for MY 2012-2025

Sources:

Federal Register, Vol. 75, No. 88, May 7, 2010, pp. 25324-25728.

Notice of Proposed Rulemaking, Docket No. NHTSA-2010-0131, November 16, 2011.

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 2017 to 2025 are proposed standards.

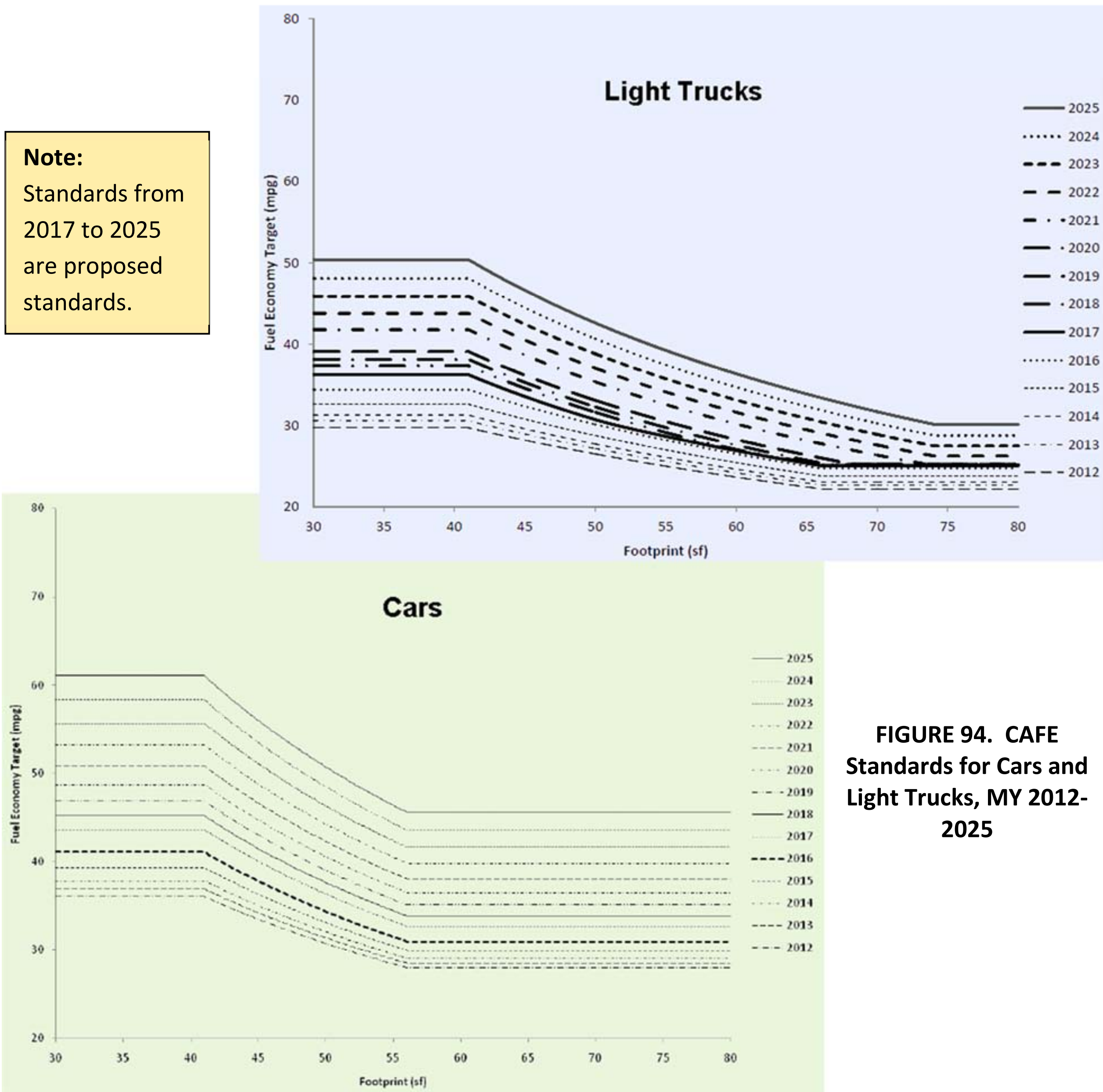


FIGURE 94. CAFE Standards for Cars and Light Trucks, MY 2012-2025

Source:
Notice of Proposed Rulemaking, Docket No. NHTSA-2010-0131, November 16, 2011.

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 (CAFE) Standards have fuel economy targets based on the vehicle footprint. The average footprint for all cars sold in model year (MY) 2010 was 45.2 square feet (sq. ft.), down just 0.2 sq. ft. from MY 2008. The average footprint for light trucks was higher – 54.0 in 2010. The table shows selected vehicles and their MY 2008 footprint.

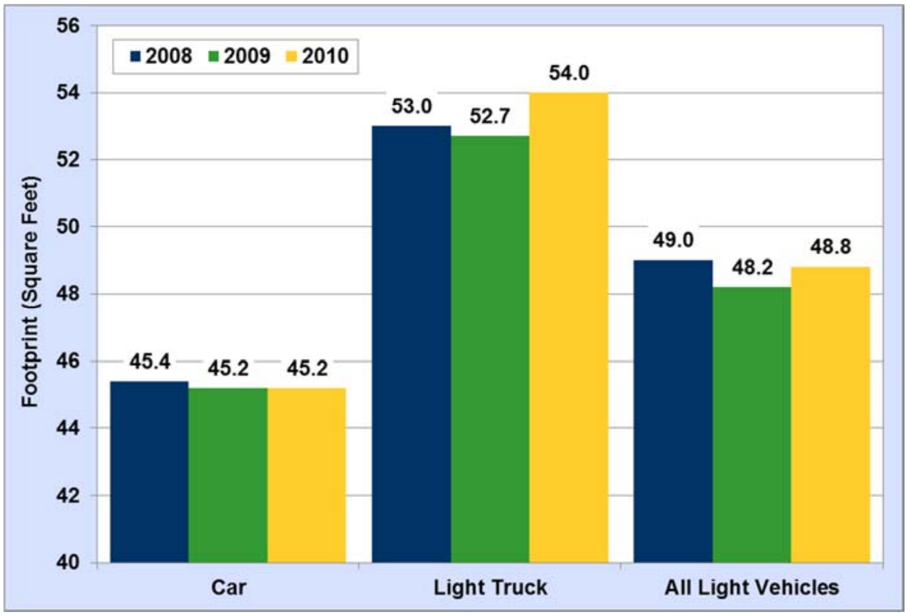


FIGURE 95. Average Vehicle Footprint, MY 2008-2010

TABLE 22. Vehicle Footprint and Fuel Economy Target, MY 2008

Vehicle Type	Example Model (MY 2008 Vehicles)	Footprint (Sq. Ft.)	MY 2016 Fuel Economy Target (mpg)
Cars			
Compact	Honda Fit	40	41.1
Midsize	Ford Fusion	46	37.1
Fullsize	Chrysler 300	53	32.6
Light Trucks			
Small Sport Utility	Ford Escape 4WD	44	32.9
Midsize Crossover	Nissan Murano	49	30.6
Minivan	Toyota Sienna	55	28.2
Large Pickup Truck	Chevrolet Silverado	67	24.7

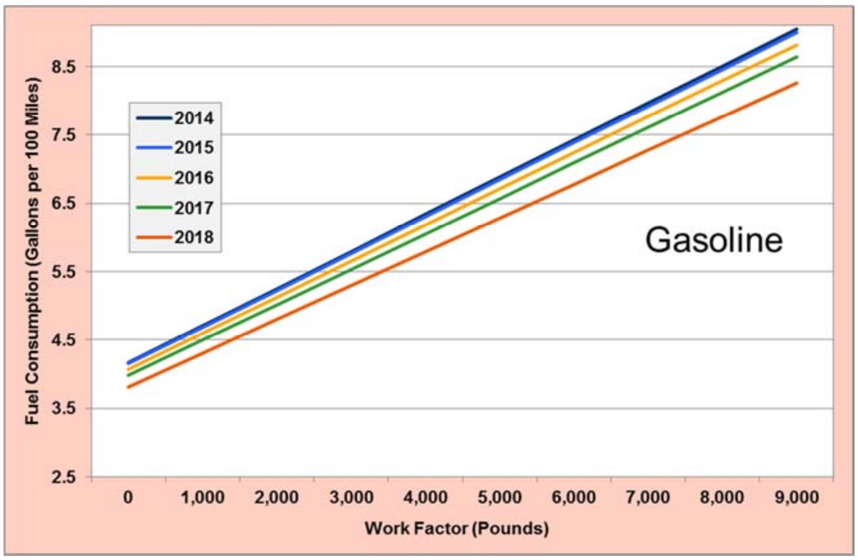
Sources:

U.S. Environmental Protection Agency, *Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010*, EPA420-R-10-023, November 2010. http://www.epa.gov/otaq/fetrends.htm

Federal Register, Vol. 75, No. 88, May 7, 2010, p. 25338.

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.

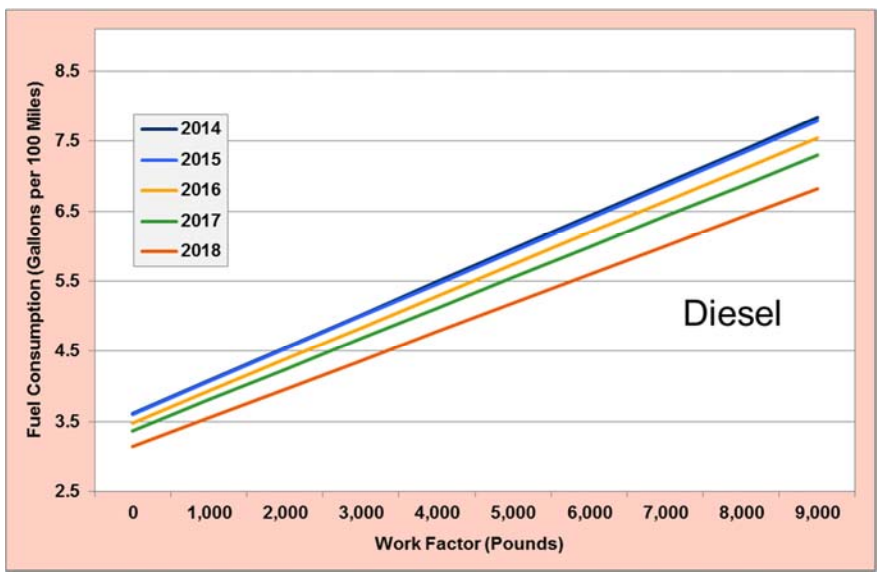


FIGURE 96. Fuel Consumption Target Standards for Gasoline and Diesel Heavy Pickups and Vans

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).

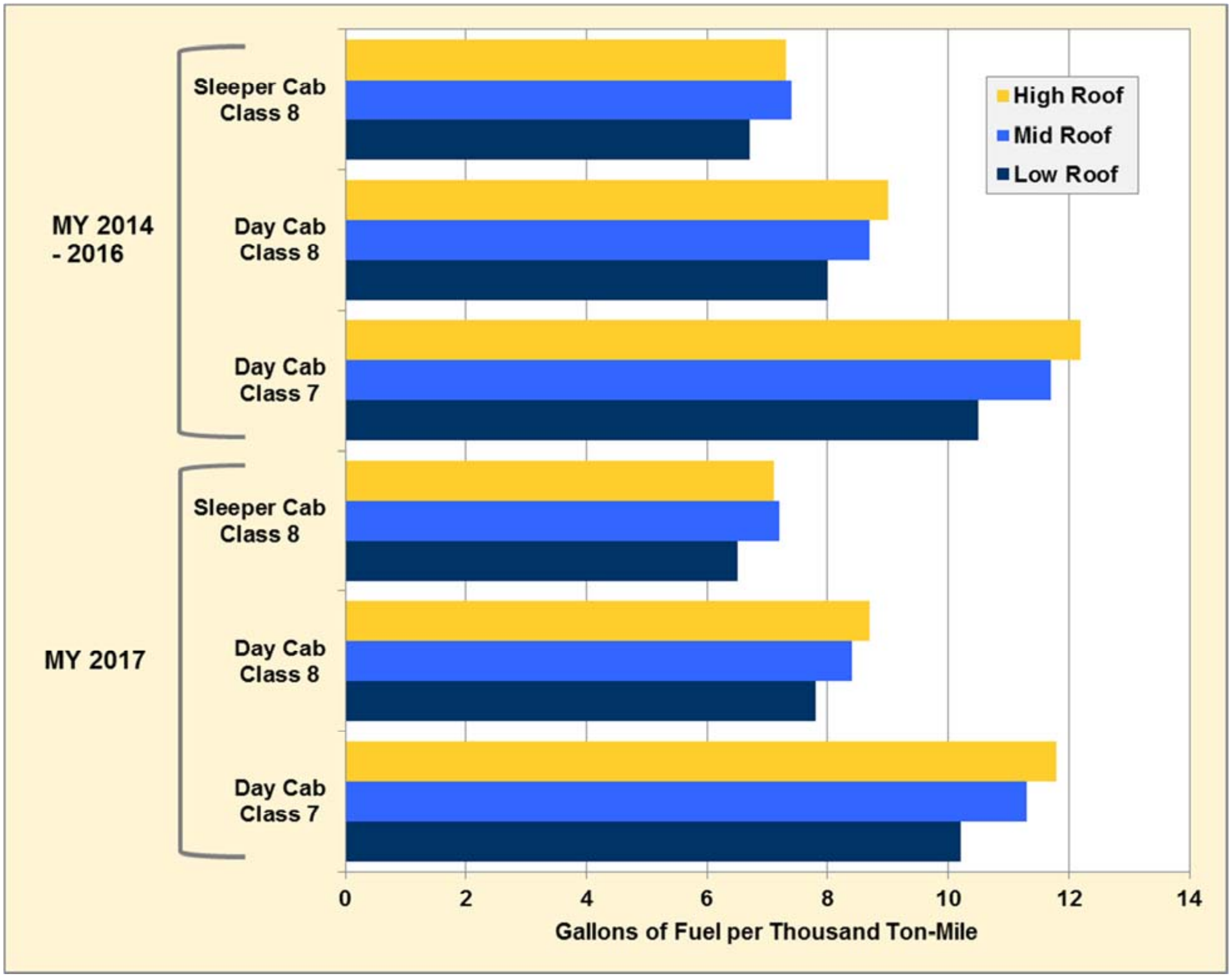


FIGURE 97. Fuel Consumption Standards for Combination Tractors

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 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).

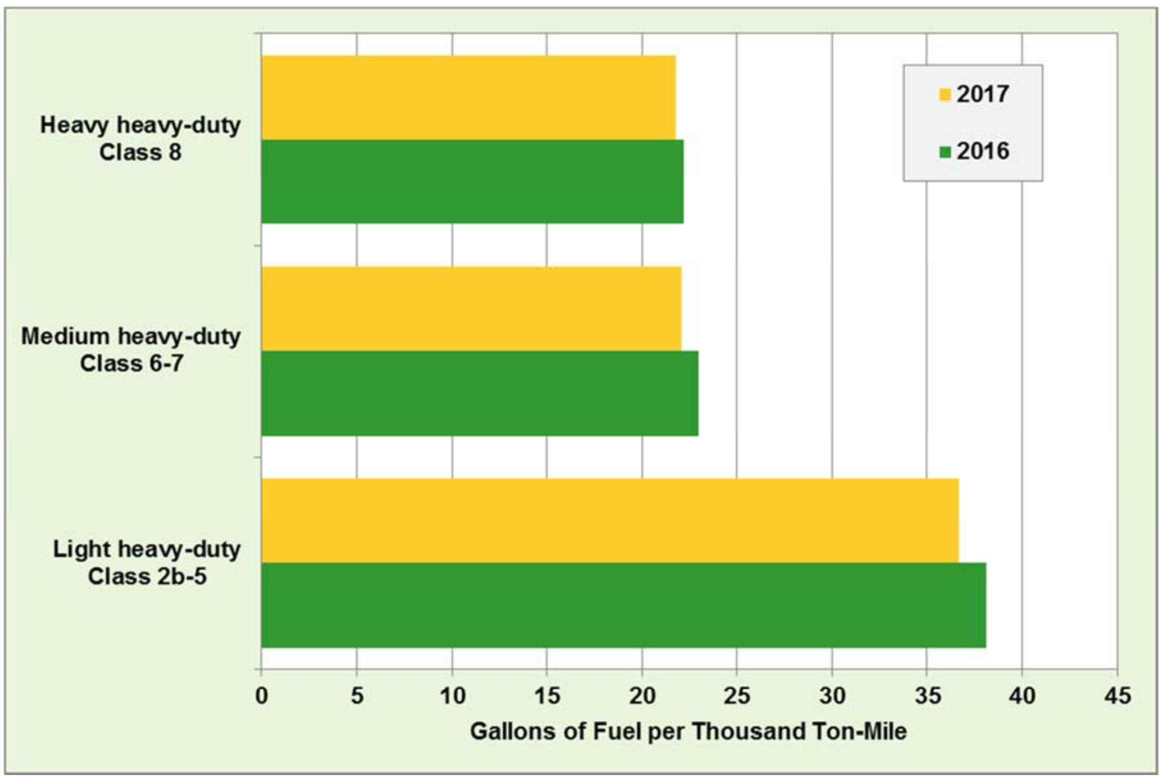


FIGURE 98. Vocational Vehicle Fuel Consumption Standards

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 (NHTSA) 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.

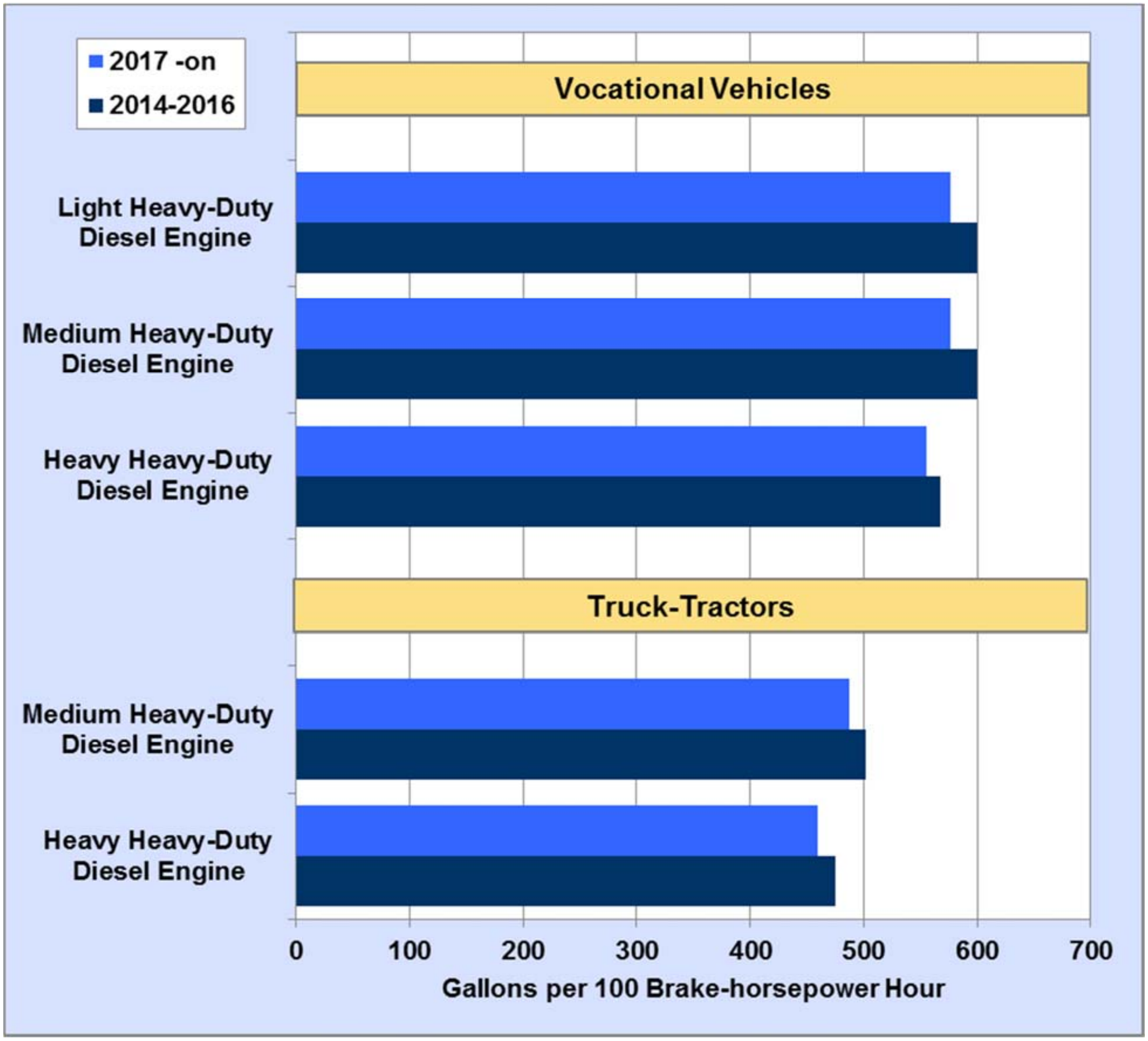


FIGURE 99. Fuel Standards for New Diesel Engines

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 five States plus the District of Columbia have not adopted the weight exemption (gold).

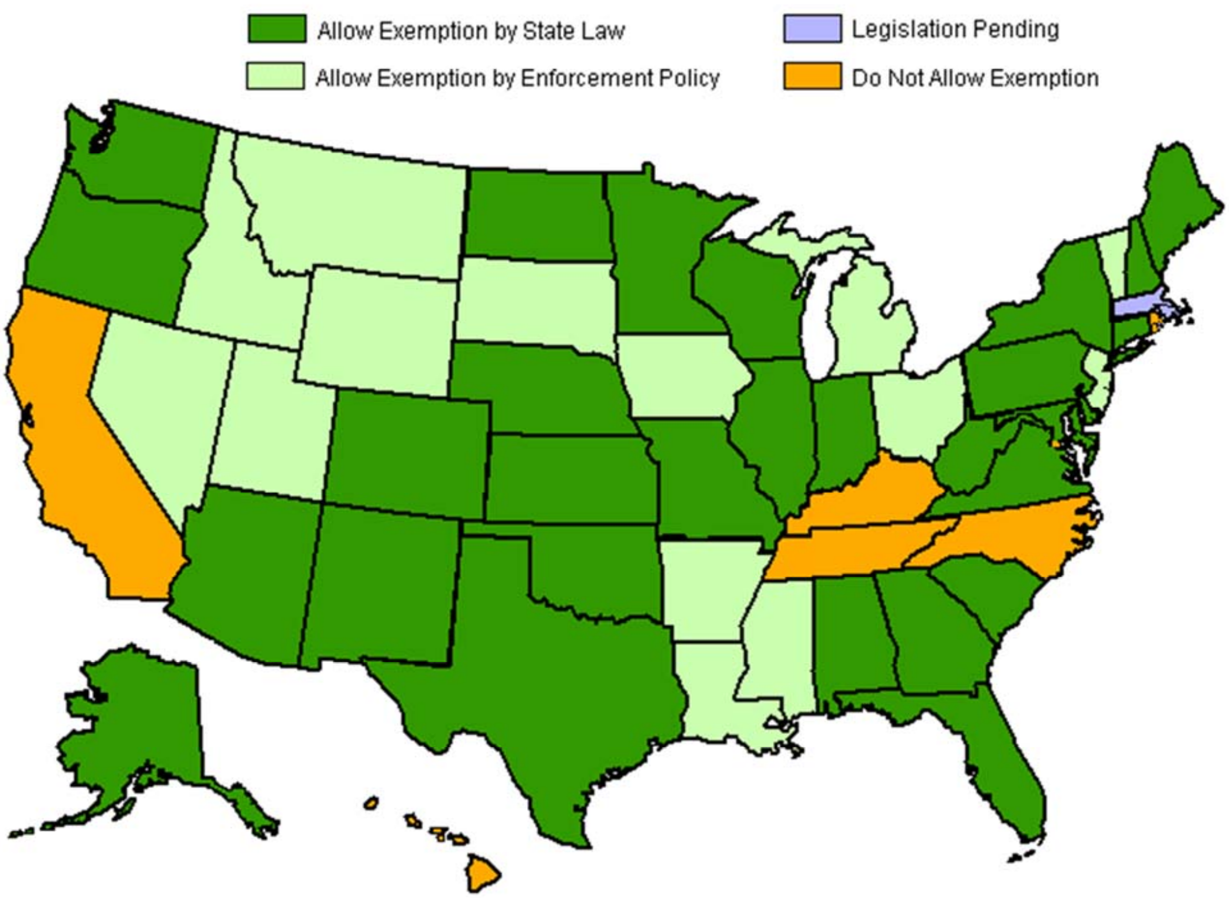


FIGURE 100. States Adopting 400-Pound Weight Exemption for Idling Reduction Devices, 2011

Source:

U.S. Department of Energy, Energy Efficiency & Renewable Energy, *National Idling Reduction News*, October 2011.
http://www1.eere.energy.gov/vehiclesandfuels/pdfs/idling_news/oct11_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

- Aux Generators Inc.
- Auxiliary Power Dynamics, LLC
- Black Rock Systems
- Carrier Transicold
- Centramatics
- Comfort Master
- Cummins
- Diamond Power
- Double Eagle Industries
- Dunamis Power Systems
- Flying J Inc
- Frigette Truck Systems
- Gates Corporation
- Hodyon LP
- Idle Solutions
- Idlebuster
- Kohler
- Kool-Gen
- Mantis Metalworks, LLC
- Mechron Power Systems
- Midwest Power Generators
- Navistar
- Parks Industries
- Pony Pack
- Power Technology Southeast
- RigMaster Power Systems, Inc
- Star Class
- Thermo King
- TRIDAKO Energy Systems
- Truck Gen
- Volvo
- Willis Power Systems

Thermal Storage Systems

- Autotherm Division Enthal Sys, Inc
- Webasto

Shore Connection Systems

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

Fuel Operated Heaters

- Espar
- Teleflex
- Volvo
- Webasto

Battery Air Conditioning/ Heating Systems

- AuraGen
- Bergstrom, Inc
- DC Power Systems APU
- Dometic Corporation
- Driver Comfort System
- EnergyXtreme
- Freightliner
- Glacier Bay
- Hammond Air Conditioning, LTD
- Indel B Sleeping Well
- Idle Free Systems
- Kenworth Truck Company
- Navistar
- Paddock Solar
- Peterbuilt
- Safer Corporation
- Sun Power Technologies
- Volvo

Figure 101. Idle Reduction Technologies Which are Granted Exemption from Federal Excise Taxes

Source:

U.S. Environmental Protection Agency, SmartWay Technology Program. August 2011.
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.

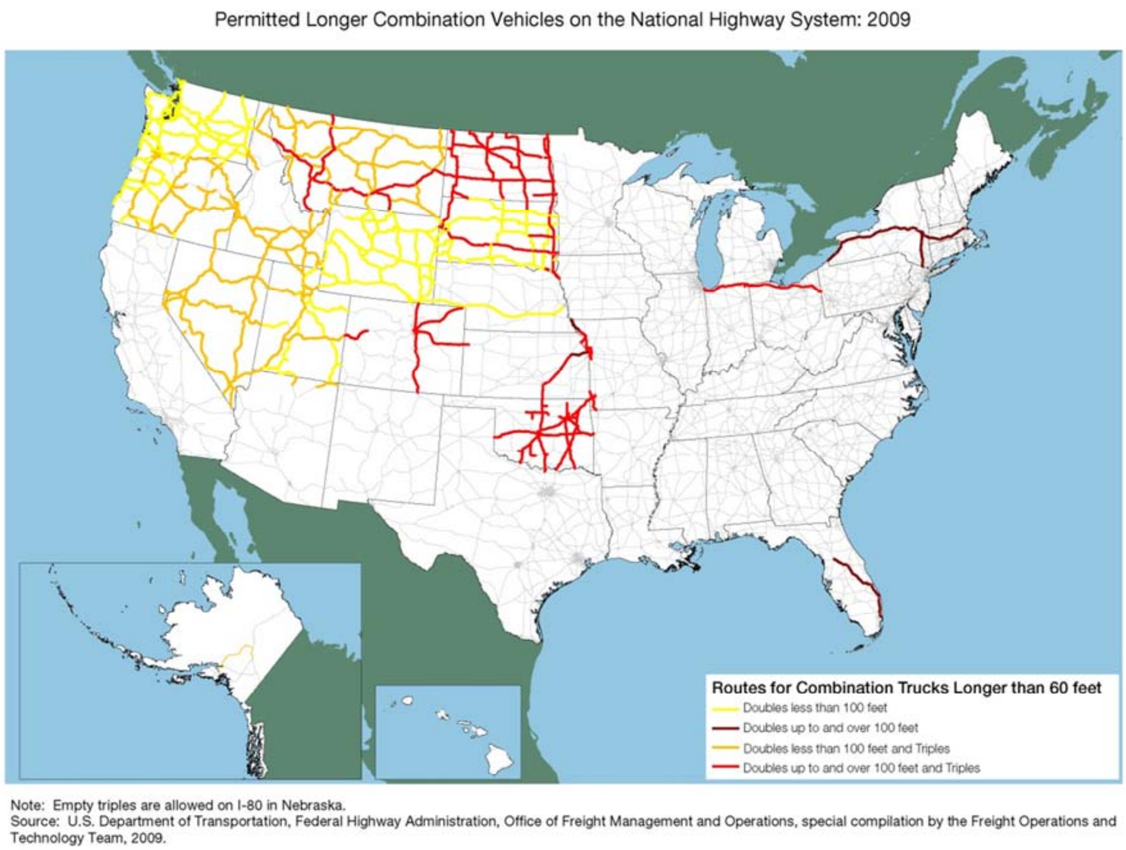


FIGURE 102. Routes where Longer Combination Vehicles are Permitted, 2009

Source:

U.S. Department of Transportation, Federal Highway Administration, *Freight Facts and Figures 2010,* FHWA-HOP-10-058, November 2010. http://ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/10factsfigures

Heavy Truck Speed Limits are Inconsistent

Ranging from a speed limit of 55 miles per hour (mph) to 80 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 – 55 mph. At the other end of the spectrum, Utah and Texas both have some roads where the truck speed limit is 80 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.

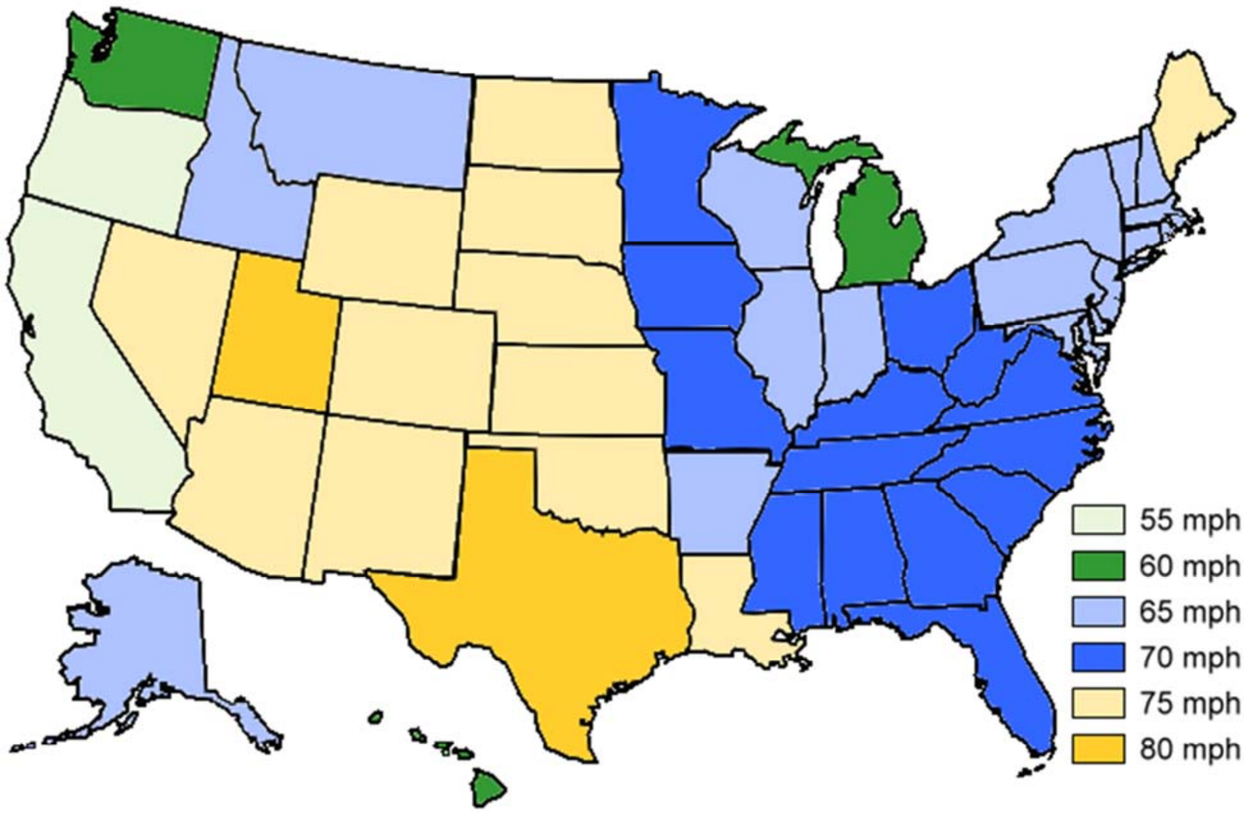


FIGURE 103. Maximum Daytime Truck Speed Limits by State

Source:

Insurance Institute for Highway Safety, Highway Loss Data Institute, November 2011.
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.

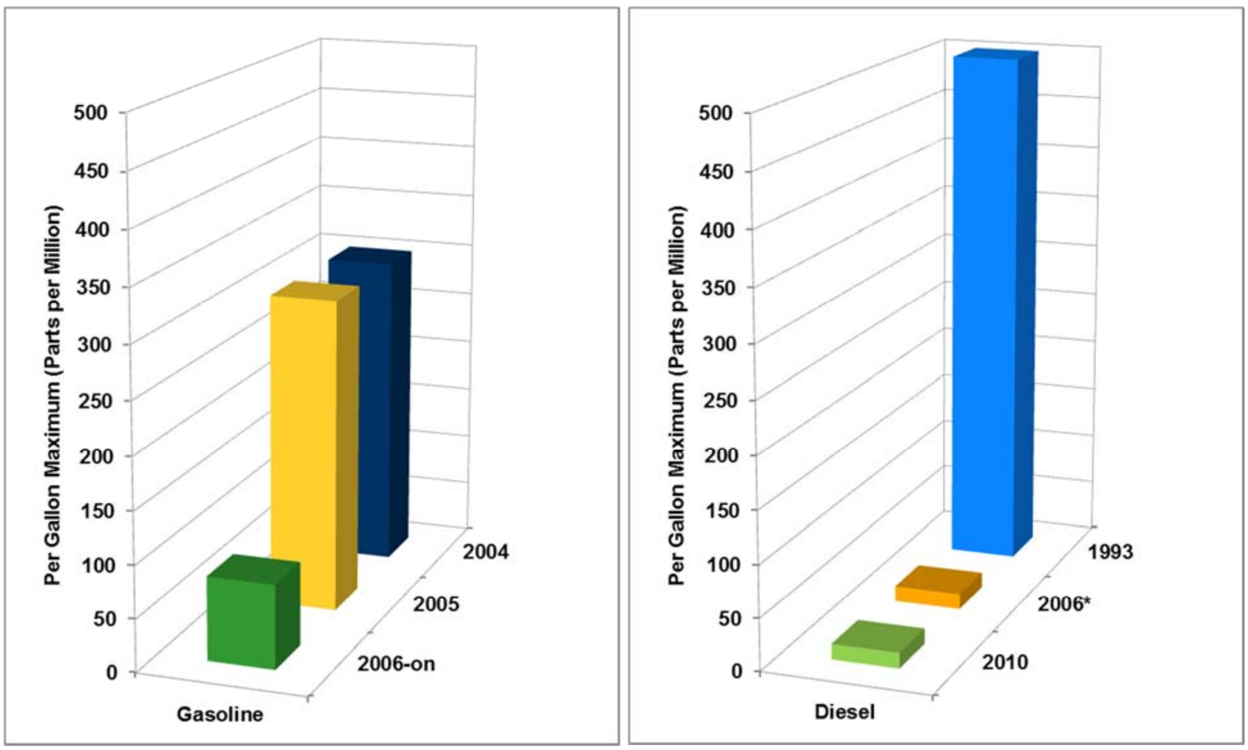


FIGURE 104. Gasoline and Diesel Sulfur Standards

***** 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.

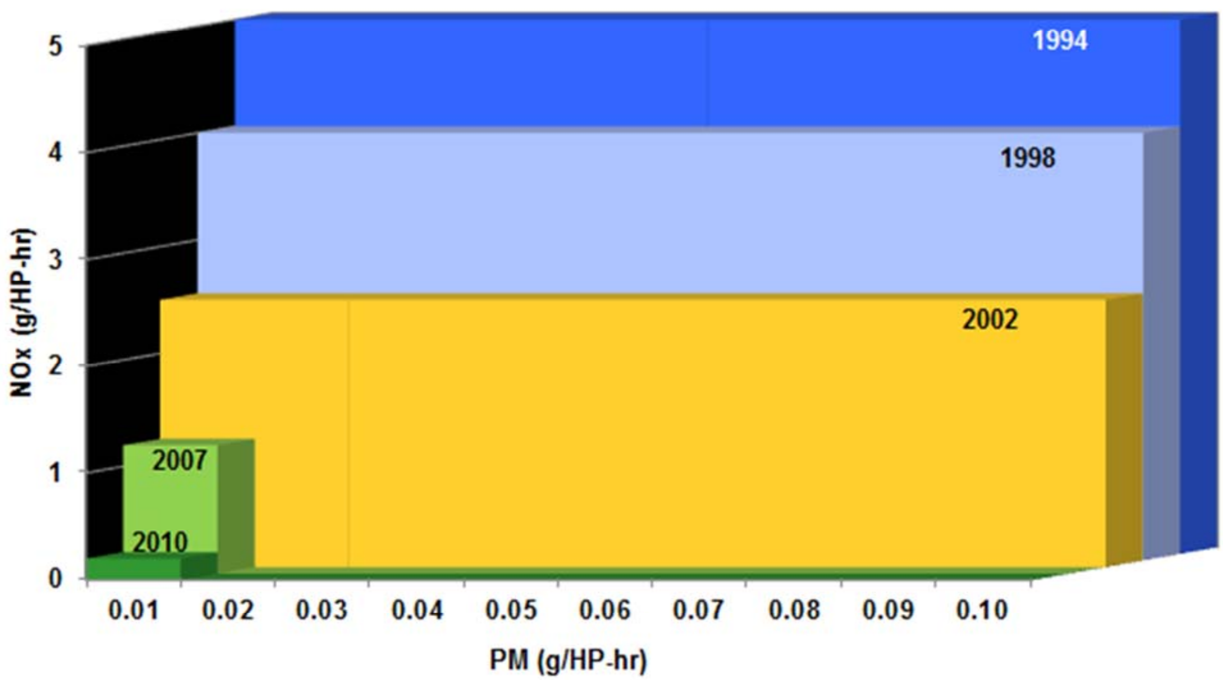


FIGURE 105. Diesel Emission Standards, 1994-2010

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.

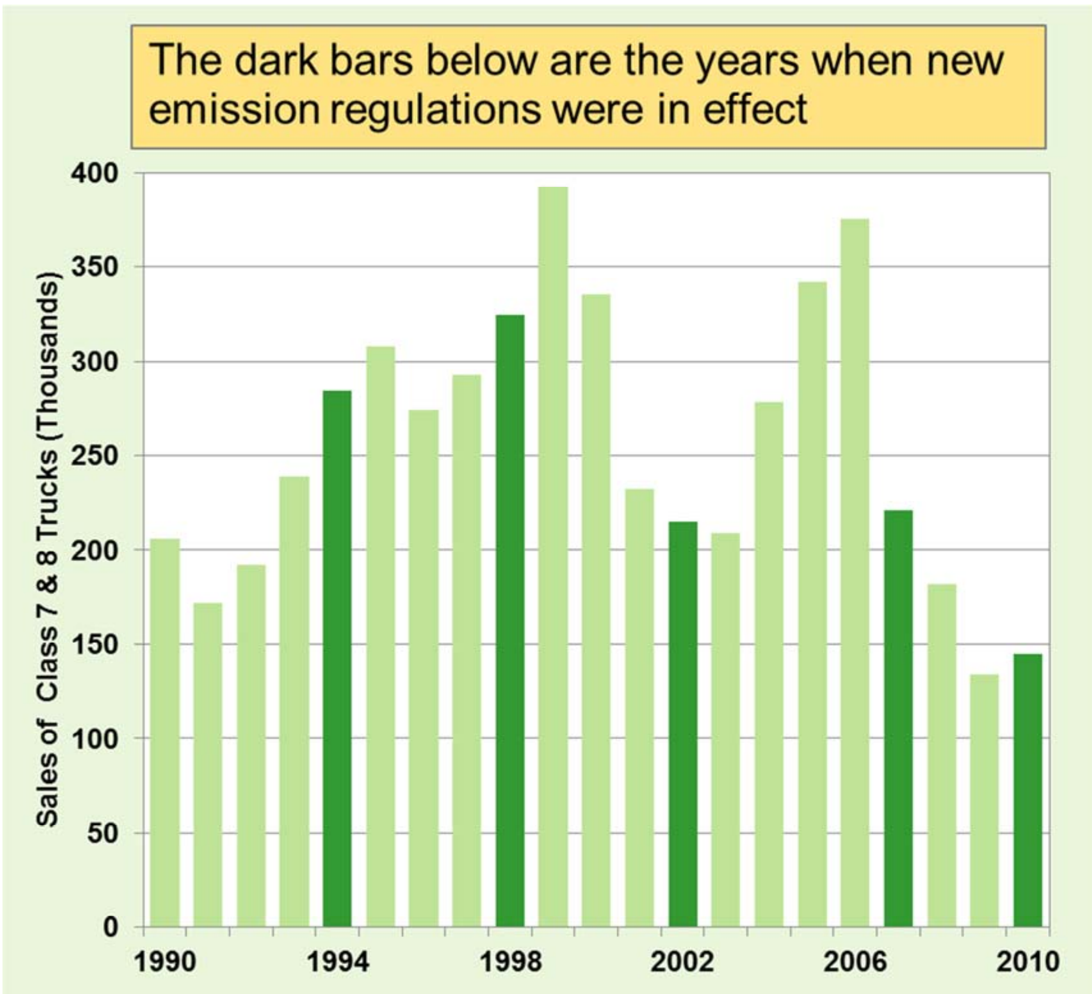


FIGURE 106. Class 7 and 8 Truck Sales, 1990-2010

Source:
Ward's Automotive Group, *Motor Vehicle Facts and Figures 2011*, Southfield, MI, 2011.
http://wardsauto.com