# Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2008

United States
Environmental Protection
Agency

# Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2008

Compliance and Innovative Strategies Division
and
Transportation and Climate Division

Office of Transportation and Air Quality
U.S. Environmental Protection Agency

*NOTICE*

*This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments.*

EPA United States Environmental Protection Agency

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# I. Executive Summary

## Introduction

This report summarizes key trends in fuel economy and technology usage related to model year (MY) 1975 through 2008 light-duty vehicles sold in the United States. Light-duty vehicles are those vehicles that EPA classifies as cars or light-duty trucks (sport utility vehicles or SUVs, vans, and pickup trucks with less than 8500 pounds gross vehicle weight ratings). The data in this report supersede the data in previous reports in this series.

Since 1975, overall new light-duty vehicle fuel economy has moved through four phases:

1. a rapid increase from 1975 through the early 1980s,
2. a slower increase until reaching its peak in 1987,
3. a gradual decline until 2004, and
4. an increase beginning in 2005.

The projected fleetwide average MY2008 light-duty vehicle fuel economy is 20.8 miles per gallon (mpg). The fleetwide average MY2007 value is 20.6 mpg. There is greater confidence in the MY2007 value as the database for 2007 includes formal sales data for about 80% of the MY2007 fleet, while the projected MY2008 value is based on pre-model year sales projections provided by automakers. The 20.8 mpg value for model year 2008 represents a 1.5 mpg, or 8%, increase over the 19.3 mpg value for 2004, which was the lowest fuel economy value since 1980.

More so than in any other recent report, EPA believes that the pre-model year 2008 sales projections provided by automakers to EPA do not accurately reflect the actual light-duty vehicle market in MY2008. Automakers submitted MY2008 sales projections to EPA in the spring and summer of 2007 when average nationwide gasoline prices were in the $2.50 to $3.00 per gallon range. Actual gasoline prices have averaged about $3.50 per gallon during MY2008, or $0.50 to $1.00 per gallon higher than at the time automakers provided sales projections to EPA. Based on publicly available sales data, which are not part of the formal EPA database, it appears that higher gasoline prices have led to a 10 to 15 percent decrease in overall light-duty vehicle sales relative to automaker projections. Further, the sales data suggest that subcompact, compact, and midsize cars have been the only vehicle classes to have met or exceeded sales projections by automakers, while sales of midsize SUVs, large SUVs, and large pickup trucks are 15 to 25 percent lower than automaker projections. It also appears that 4-cylinder engines have gained market share from 6-cylinder and 8-cylinder engines. Accordingly, it is extremely likely that the projected fleetwide average MY2008 fuel economy value of 20.8 mpg is too low. EPA will provide a more accurate value for MY2008 in the 2009 report, based on formal end-of-year submissions to EPA by automakers.

The fuel economy values in this report are either *adjusted* (ADJ) EPA "real-world" estimates provided to consumers, or unadjusted EPA *laboratory* (LAB) values. Most of the data is presented in adjusted values. Either adjusted or laboratory fuel economy may be reported as city, highway, or, most commonly, as *composite* (combined city/highway, or COMP). In 2006, EPA revised the methodology by which EPA estimates adjusted fuel economy to better reflect changes in driving habits and other factors that affect fuel economy such as higher highway speeds, more aggressive driving, and greater use of air conditioning. This is the second report in this series to reflect this new real-world fuel economy methodology, and every adjusted fuel economy value in this report for 1986 and later model years is lower than values in pre-2007 reports in this series.  To reflect that these changes did not occur overnight, these new downward adjustments are phased in, gradually, beginning in 1986, and for 2005 and later model years the new adjusted composite values are, on average, about 6% lower than under the methodology used by EPA in older reports.  See Appendix A for more details.

Because the underlying methodology for generating unadjusted laboratory fuel economy values has not changed since this series began in the mid-1970s, they provide an excellent basis for comparing long-term fuel economy trends from the perspective of vehicle design, apart from the factors that affect real-world fuel economy that are reflected in the adjusted fuel economy values.  Laboratory composite values represent a harmonic average of 55 percent city fuel economy and 45 percent highway fuel economy, or "55/45."  For 2005 and later model years, unadjusted laboratory composite fuel economy values are, on average, about 25% greater than adjusted composite fuel economy values.  The projected fleetwide average 26.0 mpg unadjusted laboratory composite fuel economy value for MY2008 is an all-time high.

The Department of Transportation's National Highway Traffic Safety Administration (NHTSA) has the overall responsibility for the Corporate Average Fuel Economy (CAFE) program.  For 2008, the CAFE standards are 27.5 mpg for cars and 22.5 mpg for light trucks (for light trucks, individual manufacturers can choose between the fixed, unreformed 22.5 mpg standard and a reformed vehicle footprint-based standard which yields different compliance levels for each manufacturer).  EPA provides laboratory composite fuel economy data, along with alternative fuel vehicle credits and test procedure adjustments, to NHTSA for CAFE enforcement.  Accordingly, current NHTSA CAFE values are a minimum of 25% higher than EPA adjusted fuel economy value.

**Importance of Fuel Economy**

Fuel economy continues to be a major area of public and policy interest for several reasons, including:

1. Fuel economy is directly related to energy security because light-duty vehicles account for approximately 40 percent of all U.S. oil consumption, and much of this oil is imported.

2. Fuel economy is directly related to the cost of fueling a vehicle and is of great interest when crude oil and gasoline prices rise.

3. Fuel economy is directly related to emissions of greenhouse gases (i.e., carbon dioxide). Light-duty vehicles contribute about 20 percent of all U.S. carbon dioxide emissions.

**Characteristics of Light Duty Vehicles for Four Model Years**

| | 1975 | 1987 | 1998 | 2008 |
|---|---|---|---|---|
| Adjusted Fuel Economy (mpg) | 13.1 | 22.0 | 20.1 | 20.8 |
| Weight (lbs.) | 4060 | 3220 | 3744 | 4117 |
| Horsepower | 137 | 118 | 171 | 222 |
| 0 to 60 Time (sec.) | 14.1 | 13.1 | 10.9 | 9.6 |
| Percent Truck Sales | 19% | 28% | 45% | 48% |
| Percent Front-Wheel Drive | 5% | 58% | 56% | 53% |
| Percent Four-Wheel Drive | 3% | 10% | 20% | 28% |
| Percent Multi-Valve Engine | - | - | 40% | 77% |
| Percent Variable Valve Timing | - | - | - | 58% |
| Percent Cylinder Deactivation | - | - | - | 7% |
| Percent Gasoline Direct Injection | - | - | - | 2.3% |
| Percent Turbocharger | - | - | 1.4% | 2.5% |
| Percent Manual Trans | 23% | 29% | 13% | 7% |
| Percent Continuously Variable Trans | - | - | - | 8% |
| Percent Hybrid | - | - | - | 2.5% |
| Percent Diesel | 0.2% | 0.2% | 0.1% | 0.1% |

**Highlight #1: Fuel Economy Increases Beginning in 2005 Reverse the Long-Term Trend of Declining Fuel Economy From 1987 through 2004.**

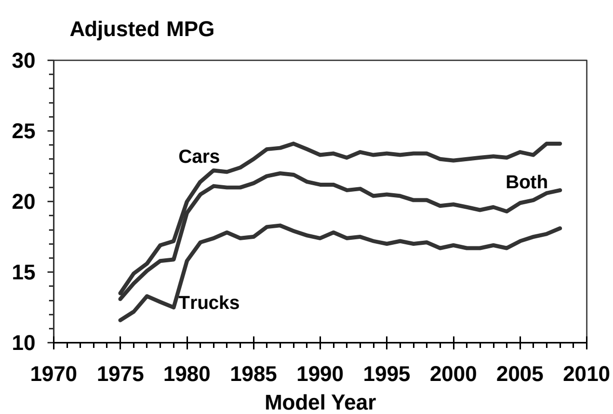
*Overall average fuel economy is projected to increase by 1.5 mpg, or 8%, from 19.3 mpg in MY2004 to 20.8 mpg in MY2008. The actual fuel economy performance for MY2008 will likely exceed 20.8 mpg as this value is based on pre-model year sales projections made by automakers at a time when gasoline prices were considerably lower. The fuel economy increases beginning in MY2005 reverse a long trend of slowly declining fuel economy since 1987. The projected MY2008 unadjusted laboratory fuel economy value of 26.0 mpg, which does not account for real world fuel economy performance, represents an all-time high.*

Since 1975, the fuel economy of the combined car and light truck fleet has moved through several phases: (1) a rapid increase from 1975 to the early 1980s, (2) a slow increase to the fuel economy peak of 22.0 mpg in 1987, (3) a gradual decline from the peak to 19.3 mpg in 2004, and (4) consecutive annual increases beginning in 2005, growing to 20.8 mpg in 2008.

The 20.8 mpg value for model year 2008 is 1.2 mpg below the peak of 22.0 mpg in MY1987. But it is important to note that this difference is due to the new methodology for calculating adjusted fuel economy values that is gradually phased in over the 1986 to 2005 timeframe. Based on the laboratory composite fuel economy values, which are not affected by the new methodology for calculating adjusted fuel economy values, the projected MY2008 value of 26.0 mpg is 0.1 mpg higher than the previous peak of 25.9 mpg in 1987.

MY2008 cars are projected to average 24.1 mpg and MY2008 light trucks are estimated to average 18.1 mpg. Since 2004, light truck fuel economy has increased by 1.4 mpg, while car fuel economy has increased by 1.0 mpg (car market share has also increased). The recent increase in truck fuel economy is due, in part, to higher truck CAFE standards, which have risen from 20.7 mpg in 2004 to 22.5 mpg in 2008.

**Adjusted Fuel Economy by Model Year**
**(Annual Data)**



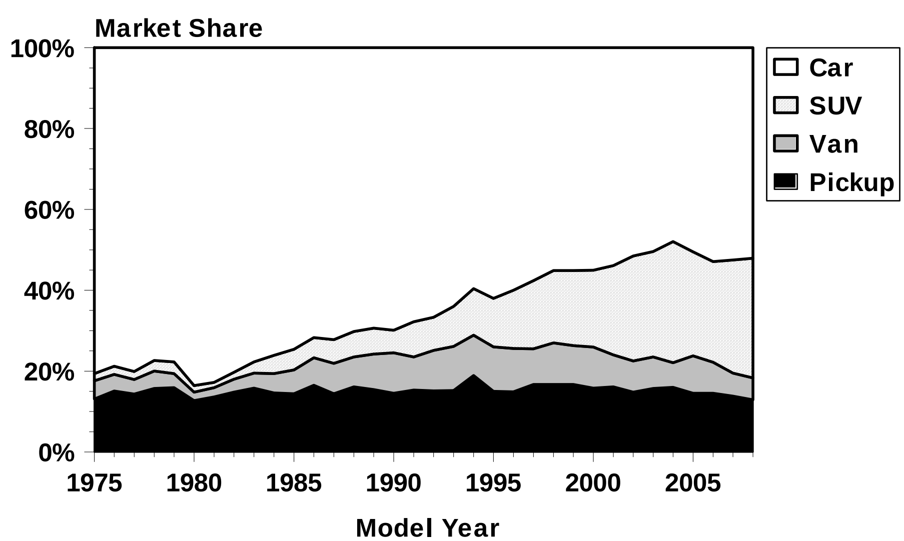
**Highlight #2: Trucks Continue To Represent About Half of New Vehicle Sales.**

*Sales of light trucks, which include SUVs, vans, and pickup trucks, have accounted for about 50 percent of the U.S. light-duty vehicle market since MY2002. After two decades of constant growth, light truck market share has been relatively stable from 2002 through 2007. While projected MY2008 truck market share is relatively stable, it is likely that actual truck market share in MY2008 will be less than the projected value, which is based on pre-model year sales projections, given higher gasoline prices.*

Historically, growth in the light truck market was primarily driven by the explosive increase in the market share of SUVs (EPA does not have a separate category for crossover vehicles and classifies many crossover vehicles as SUVs). The SUV market share increased from less than 10 percent of the overall new light-duty vehicle market in MY1990 to about 30 percent of vehicles built each year since 2003. By comparison, market shares for both vans and pickup trucks have declined slightly since 1990. The increased overall market share of light trucks, which in recent years have averaged 5-7 mpg lower than cars, accounted for much of the decline in fuel economy of the overall new light-duty vehicle fleet from MY1987 through MY2004.

The MY2008 light truck market share is projected to be 48 percent, based on pre-model year sales projections by automakers. It is likely that actual light truck market share will be less than 48 percent, due to the impact of high gasoline prices on consumers.

**Sales Fraction by Vehicle Type**
**(Annual Data)**



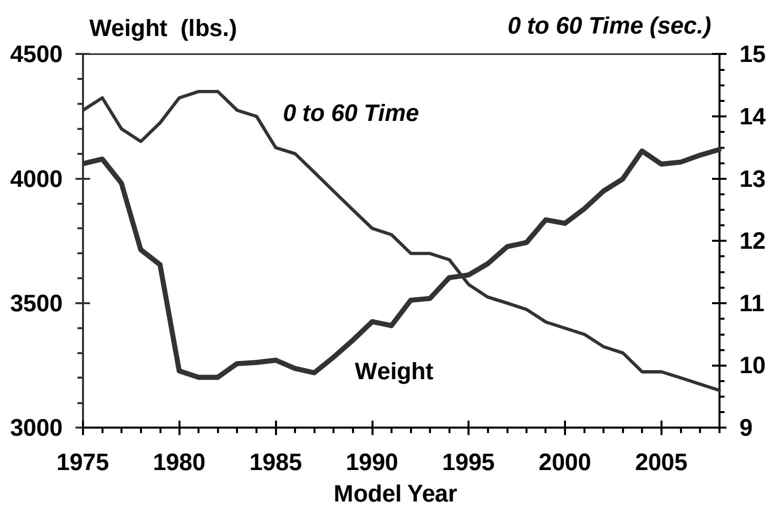
**Highlight #3: Technological Innovation Since 2005 Is Being Used for Higher Fuel Economy and Performance.**

*Automotive engineers are constantly developing more advanced and efficient vehicle technologies. From 1987 through 2004, on a fleetwide basis, this technology innovation was utilized exclusively to support market-driven attributes other than fuel economy, such as vehicle weight (which supports vehicle content and features), performance, and utility. Beginning in MY2005, technology has been used to increase both fuel economy and performance, while keeping vehicle weight relatively constant.*

Vehicle weight and performance are two of the most important engineering parameters that help determine a vehicle's fuel economy. All other factors being equal, higher vehicle weight (which supports new options and features) and faster acceleration performance (e.g., lower 0-to-60 mile-per-hour acceleration time), both decrease a vehicle's fuel economy. Average vehicle weight and performance had increased steadily from the mid-1980s through 2004.

Average light-duty vehicle weight has been fairly constant since 2004, with a small increase in weight of cars offset by a small decrease in truck market share. Average fleetwide performance has improved slightly in MY2006 and MY2007. The projection for MY2008 is for a small increase in both vehicle performance and weight, but it is likely that weight, and possibly performance as well, will be lower in MY2008 once we get final sales data.

**Weight and Performance (Annual Data)**

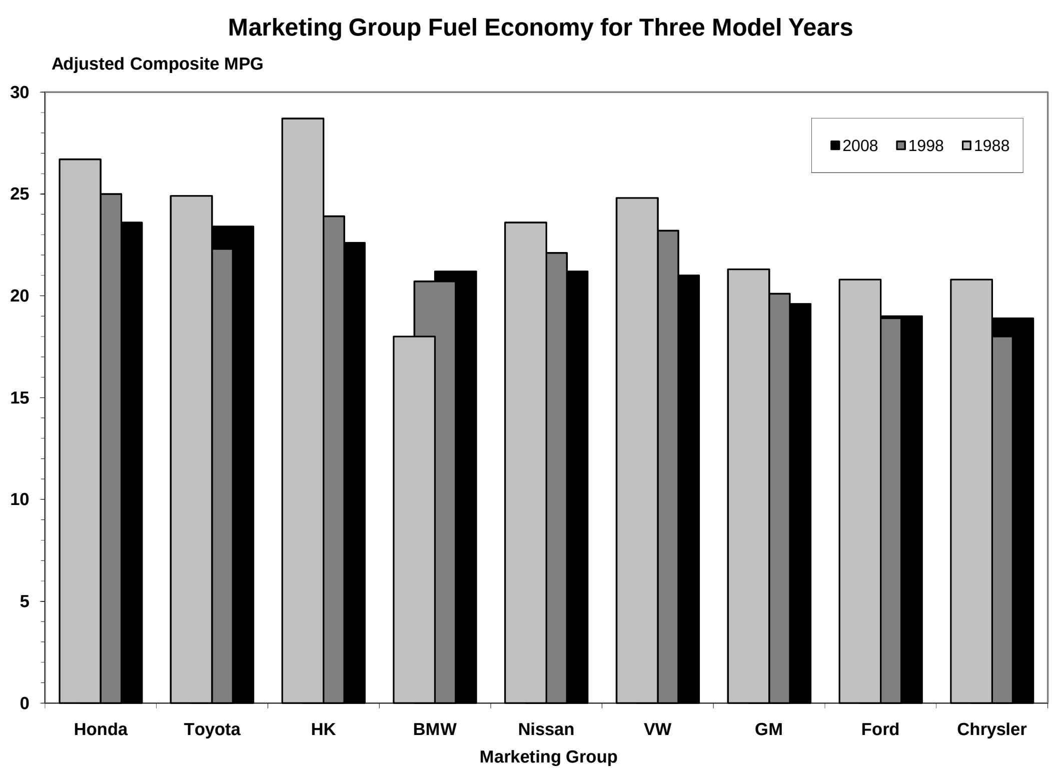


**Highlight #4: Differences between Marketing Group Fuel Economies Are Narrowing.**

*In 1987, when industry-wide fuel economy peaked, some major marketing groups had average fuel economies 6 to 8 mpg higher than other top marketing groups. The typical difference between higher and lower fuel economy marketing groups is now 3 to 4 mpg. Most, if not all, of these marketing groups will likely have higher MY2008 fuel economy values when final sales data is reported, due to higher gasoline prices.*

For MY2008, the nine highest-selling marketing groups (that account for over 95 percent of all sales) fall into three fuel economy groupings: Honda, Toyota, and Hyundai-Kia (HK) have estimated fuel economies of 22.6 to 23.6 mpg; BMW, Nissan, and Volkswagen have projected fuel economies of 21.0 to 21.2 mpg; and General Motors, Ford, and DaimlerChrysler have estimated fuel economies of 18.9 to 19.6 mpg. Note that these adjusted fuel economy values for marketing groups can not be directly compared to those in reports in this series prior to 2007, since this year's report uses the new methodology where adjusted fuel economy values since 2005 are, on average, about 6% lower than in previous reports.

Each of these marketing groups has lower average fuel economy today than in 1988, with the exception of BMW. Since then, the differences between marketing group fuel economies have narrowed considerably, with some of the higher mpg marketing groups in 1988 showing larger fuel economy decreases since 1988. Three of the marketing groups show a slight increase in average fuel economy since 1998: Toyota, BMW, and Chrysler. For MY2008, Volkswagen and BMW are the only two of the nine highest-selling marketing groups to have a projected truck market share of less than 39 percent.



## Important Notes with Respect to the Data Used in This Report

Most of the fuel economy values in this report are a single *adjusted* composite (combined city/highway) fuel economy value, based on the real-world estimates for city and highway fuel economy provided to consumers on new vehicle labels, in the EPA/DOE *Fuel Economy Guide*, and in EPA's *Green Vehicle Guide*.

This 2008 report supersedes all previous reports in this series, which date back to the early 1970s. In general, users of this report should rely exclusively on data in this 2008 report, which covers the years 1975 through 2008, and not try to make comparisons to data in previous reports in this series. There are at least two reasons for this.

One, EPA revised the methodology for estimating real-world fuel economy values in December 2006. This is the second report in this series to reflect this new real-world fuel economy methodology, and every adjusted (ADJ) fuel economy value in this report for 1986 and later model years is lower than given in reports in this series prior to the 2007 report. Accordingly, adjusted fuel economy values for 1986 and later model years should not be compared with the corresponding values from pre-2007 reports. These new downward adjustments are phased in, linearly, beginning in 1986, and for 2005 and later model years the new adjusted composite (combined city/highway) values are, on average, about 6% lower than under the methodology previously used by EPA. See Appendix A for more in-depth discussion of this new methodology and how it affects both the adjusted fuel economy values for individual models and the historical fuel economy trends database.

Two, when EPA changes a marketing group definition to reflect a change in the industry's financial arrangements, EPA makes the same adjustment in marketing group composition in the historical database as well. This maintains a consistent marketing group definition over time, which allows the identification of trends over time. On the other hand, it means that the database does not necessarily reflect actual past financial arrangements. For example, the 2008 database no longer reflects the fact that Chrysler was combined with Daimler for several years.

In some tables and figures in this report, a single *laboratory* composite (combined city/highway) value is also shown. Because the underlying methodology for generating and reporting laboratory fuel economy values has not changed since this series began in the mid-1970s, these laboratory fuel economy values provide an excellent basis for comparing long-term fuel economy trends from the perspective of vehicle design, apart from the factors that affect real-world fuel economy that are reflected in the adjusted fuel economy values. For 2005 and later model years, laboratory composite fuel economy values are, on average, about 25% greater than adjusted composite fuel economy values.

Formal Corporate Average Fuel Economy (CAFE) compliance data as reported by the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) do not correlate precisely with either the adjusted or laboratory fuel economy values in this report. While EPA's laboratory composite fuel economy data form the cornerstone of the CAFE compliance database, NHTSA must also include credits for alternative fuel vehicles and test procedure adjustments (for cars only) in the official CAFE calculations. Accordingly, NHTSA CAFE values are at least 25% higher than EPA adjusted fuel economy values for model years 2005 through 2008.

In general, car/truck classifications in this database parallel classifications made by NHTSA for CAFE purposes and EPA for vehicle emissions standards. However, this report relies on engineering judgment, and typically there are a few cases each model year where the methodology used for classifying vehicles for this report results in differences in the determination of whether a given vehicle is classified as a car or a light truck. See Appendix A for a list of these exceptions.

The data presented in this report were tabulated on a model year basis, but many of the figures in this report use three-year moving averages that effectively smooth the trends, and these three-year moving averages are tabulated at the midpoint. For example, the midpoint for model years 2006, 2007, and 2008 is MY2007. Figures are based on annual data unless otherwise noted.

All of the data in this report are from vehicles certified to operate on gasoline or diesel fuel. There are no data from the very small number of vehicles that are certified to operate only on alternative fuels. The data from ethanol flexible fuel vehicles, which can operate on both an 85 percent ethanol/15 percent gasoline blend or gasoline, are from gasoline operation.

All average fuel economy values were calculated using harmonic rather than arithmetical averaging, in order to maintain mathematical integrity. See Appendix A.

The EPA fuel economy database used to generate the fuel economy trends database in this report was frozen in January 2008, yielding additional data beyond that used in last year's report for model years beginning in 2005, although additional data for MY2007 was added in April 2008.

Through MY2006, the fuel economy, vehicle characteristics, and sales data used for this report were from the formal end-of-year submissions from automakers obtained from EPA's fuel economy database that is used for CAFE compliance purposes. Accordingly, values for all model years up to 2006 can be considered final.

For MY2007, the data used in this report are based on a database where about 80 percent of the total sales are from formal end-of-year CAFE submissions by automakers, and about 20 percent are from confidential pre-model year sales projections submitted to the Agency by the automakers, with these latter projections updated based on actual 2007 sales data reported in trade publications. EPA has a high level of confidence in the data for MY2007, given that 80 percent of the 2007 data is based on actual CAFE reports. It is noteworthy that the 20.6 mpg adjusted fuel economy value for MY2007 in this report is 0.4 mpg higher than the projected 20.2 mpg adjusted fuel economy value for MY2007 in the 2007 report. This suggests that higher gasoline prices have led to actual 2007 sales that differ from the projected 2007 sales provided to EPA by automakers in 2006.

For MY2008, EPA has exclusively used confidential pre-model year sales projections. Accordingly, MY2008 projections are much more uncertain, particularly given the changes in the automotive marketplace driven by higher fuel prices. For model years 1998 through 2005, the final laboratory fuel economy values for a given model year have varied from 0.4 mpg lower to 0.4 mpg higher compared to original estimates for the same model year that were based exclusively on projected sales.

**For More Information**

*Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 200*8 (EPA420-R-08-015) is available on the Office of Transportation and Air Quality's (OTAQ) Web site at:

www.epa.gov/otaq/fetrends.htm

Printed copies are available from the OTAQ library at:

U.S. Environmental Protection Agency
Office of Transportation and Air Quality Library
2000 Traverwood Drive
Ann Arbor, MI 48105
(734) 214-4311

A copy of the *Fuel Economy Guide* giving city and highway fuel economy data for individual models is available at:

www.fueleconomy.gov

or by calling the U.S. Department of Energy at (800) 423-1363.

EPA's *Green Vehicle Guide* providing information about the air pollution emissions and fuel economy performance of individual models is available on EPA's web site at:

www.epa.gov/greenvehicles

For information about the Department of Transportation (DOT) Corporate Average Fuel Economy (CAFE) program, including a program overview, related rulemaking activities, and summaries of the fuel economy performance of individual manufacturers since 1978, see:

www.nhtsa.dot.gov and click on "Fuel Economy"

## II. Introduction

Light-duty automotive technology and fuel economy trends are examined here, as in the preceding reports in this series [1-34]*, using the latest and most complete EPA data available.

When comparing data in this and previous reports, please note that revisions are made for some prior model years for which more complete and accurate sales and fuel economy data have become available. In addition, changes have been made periodically in the way EPA calculates adjusted fuel economy values which means it is not appropriate to compare adjusted fuel economy values from this report with others in this series. Finally, the grouping of individual manufacturers into broader marketing groups also changes over time to reflect changes in the financial arrangements within the automobile industry.

The EPA fuel economy database used to generate the fuel economy trends database in this report was frozen in January 2008, yielding additional data beyond that used in last year's report for model years 2005 through 2008, though additional data for MY2007 was added in April 2008.

Through MY2006, the fuel economy, vehicle characteristics, and sales data used for this report were from the formal end-of-year submissions from automakers obtained from EPA's fuel economy database that is used for CAFE compliance purposes. For MY2007, the data used in this report is based on a database where about 80% of the total sales are from formal end-of-year CAFE submissions by automakers, and about 20% of the total sales are based on confidential pre-model year sales projections submitted to the Agency by the automakers, with these latter projections updated based on actual 2007 sales data reported in trade publications. For MY2008, EPA has exclusively used confidential pre-model year sales projections.

Accordingly, values for all model years up to 2006 can be considered final. EPA has a high level of confidence in the data for MY2007, given that 80% of the 2007 data is based on actual CAFE reports. MY2008 projections are much more uncertain, particularly given the changes in the automotive marketplace driven by much higher fuel prices. Over the last several years, the final fuel economy values for a given model year have varied from 0.4 mpg lower to 0.4 mpg higher compared to original estimates for the same model year that were based exclusively on projected sales.

All fuel economy averages in this report are sales-weighted harmonic averages. In prior reports in this series, up to and including the one for MY2000, the only fuel economy values used in this series were the laboratory-based city, highway, and composite (combined city/highway) mpg values — the same ones that are used as the basis for compliance with the fuel economy

* Numbers in brackets denote references listed in the references section of this report.

standards and the gas guzzler tax. Since the laboratory mpg values tend to over predict the mpg achieved in actual use, adjusted mpg values are used for the Government's fuel economy information programs: the *Fuel Economy Guide* and the *Fuel Economy Labels* that are on new vehicles and in EPA's *Green Vehicle Guide.*

Starting with the report issued for MY2001, this series of reports has provided fuel economy trends in adjusted mpg values in addition to the laboratory mpg values. In this way, the fuel economy trends can be shown for both laboratory mpg and mpg values which can be considered to be an estimate of on-road mpg. In the tables, these two mpg values are called "Laboratory MPG" and "Adjusted MPG," and abbreviated "LAB" MPG and "ADJ" MPG.

Where only one mpg value is presented in this report, it is the "adjusted composite" fuel economy value. This value represents a combined city/highway fuel economy value, and is based on equations (see Appendix A) that allow a computation of adjusted city and highway fuel economy values based on laboratory city and highway fuel economy test values.

It is important to note that EPA revised the methodology by which EPA estimates real-world fuel economy values in December 2006. This is the second report in this series to reflect this new real-world fuel economy methodology, and every adjusted (ADJ) fuel economy value in this report for 1986 and later model years is lower than given in pre-2007 reports in this series. Accordingly, adjusted fuel economy values for 1986 and later model years should not be compared with corresponding values from older reports. These new downward adjustments are phased in, linearly, beginning in 1986, and for 2005 and later model years the new adjusted composite values are, on average, about 6% lower than under the methodology previously used by EPA. See Appendix A for more in-depth discussion of this new methodology and how it affects both the adjusted fuel economy values for individual models and the historical fuel economy trends database.

The data presented in this report were tabulated on a model year basis, but many of the figures in this report use three-year moving averages which effectively smooth the trends, and these three-year moving averages are tabulated at their midpoint. For example, the midpoint for model years 2002, 2003, and 2004 is model year 2003 (See Table A-2, Appendix A). Use of the three-year moving averages results in an improvement in distinguishing real trends from what might be relatively small year-to-year variations in the data.

To facilitate comparison with data in older reports in this series, most data tables include laboratory 55/45 fuel economy values as well as the adjusted city, highway, and composite fuel economy values. Presenting both types of mpg values facilitates the use of this report by those who study either type of fuel economy metric.

The fuel economy values reported by the Department of Transportation (DOT) for compliance with the Corporate Average Fuel Economy (CAFE) compliance purposes are higher than the data in this report for four reasons:

(1) the DOT data does not include the EPA real world fuel economy adjustment factors for city and highway mpg,

(2) the DOT data include CAFE credits for those manufacturers that produce dedicated alternative fuel vehicles and CAFE credits up to 1.2 mpg for those manufacturers that produce flexible fuel vehicles,

(3) the DOT data include credits for test procedure adjustments for cars, and

(4) there are some differences in the way vehicles are classified as cars and trucks for this report compared to the way they are classified by DOT.

Accordingly, the fuel economy values in this series of reports are always lower than those reported by DOT. Table A-6, Appendix A, compares CAFE data reported by DOT with EPA adjusted and laboratory fuel economy data.

## Other Variables

All vehicle weight data are based on inertia weight class (nominally curb weight plus 300 pounds). For vehicles with inertia weights up to and including the 3000-pound inertia weight class, these classes have 250-pound increments. For vehicles above the 3000-pound inertia weight class (i.e., vehicles 3500 pounds and above), 500-pound increments are used.

All interior volume data for cars built after model year 1977 are based on the metric used to classify cars for the DOE/EPA *Fuel Economy Guide*. The car interior volume combines the passenger compartment and trunk/cargo space. In the *Fuel Economy Guide*, interior volume is undefined for the two-seater class; for this series of reports, all two-seater cars have been assigned an interior volume value of 50 cubic feet.

The light truck data used in this series of reports includes only vehicles classified as light trucks with gross vehicle weight ratings (GVWR) up to 8500 pounds (lb). Vehicles with GVWR above 8500 lb are not included in the database used for this report. Omitting these vehicles influences the overall averages for all variables studied in this report. The most recent estimates we have made for the impact of these greater than 8500 lb GVWR vehicles was made for model year 2001. In that year, there were roughly 931,000 vehicles above 8500 lb GVWR. A substantial fraction (42 percent) of the MY2001 vehicles above 8500 lb GVWR were powered by diesel engines, and three-fourths of the vehicles over 8500 lb GVWR were pickup trucks. Adding in the trucks above 8500 lb GVWR would have increased the truck market share for that year by three percentage points.

Based on a limited amount of actual laboratory fuel economy data, MY2001 trucks with GVWR greater than 8500 lb GVWR are estimated to have fuel economy values about 14 percent lower than the average of trucks below 8500 lb GVWR. The combined fleet of all vehicles under 8500 lb GVWR and trucks over 8500 lb GVWR is estimated to average a few percent less in fuel economy compared to that for just the vehicles with less than 8500 lb GVWR.

In addition to fuel economy, some tables in this report contain alternate measures of vehicle fuel efficiency as used in reference 17.

"Ton-MPG" is defined as a vehicle’s mpg multiplied by its inertia weight in tons. Ton-MPG is a measure of powertrain/drive-line efficiency. Just as an increase in vehicle mpg at constant weight can be considered an improvement in a vehicle's efficiency, an increase in a vehicle’s weight at constant mpg can also be considered an improvement.

"Cubic-feet-MPG" for cars is defined in this report as the product of a car's mpg and its interior volume, including trunk space. This metric associates a relative measure of a vehicle's ability to transport both passengers and their cargo. An increase in vehicle volume at constant mpg could be considered an improvement just as an increase in mpg at constant volume can be.

"Cubic-feet-ton-MPG" is defined in this report as a combination of the two previous metrics, i.e., a car's mpg multiplied by its weight in tons and also by its interior volume. It ascribes vehicle utility to fuel economy, weight and volume.

This report also includes an estimate of 0-to-60 mph acceleration time, calculated from engine rated horsepower and vehicle inertia weight, from the relationship:

$$t = F\ (HP/WT)^{-f}$$

where the values used for F and f coefficients are .892 and .805 respectively for vehicles with automatic transmissions and .967 and .775 respectively for those with manual transmissions [35]. Other authors [36, 37, and 38] have evaluated the relationships between weight, horsepower, and 0-to-60 acceleration time and have calculated and published slightly different values for the F and f coefficients. Since the equation form and coefficients were developed for vehicles with conventional powertrains with gasoline-fueled engines, we have not used the equation to estimate 0-to-60 time for vehicles with hybrid powertrains or diesel engines. Published values are used for these vehicles instead.

The 0-to-60 estimate used in this report is intended to provide a quantitative time "index" of vehicle performance capability. It is the authors' engineering judgment that, given the differences in test methods for measuring 0-to-60 time and given the fact that the weight is based on inertia weight, use of these other published values for the F and f coefficients would not result in statistically significantly different 0-to-60 averages or trends. The results of a similar calculation of estimated “top speed” are also included in some tables.

Grouping all vehicles into classes and then constructing time trends of parameters of interest, like mpg, can provide interesting and useful results. These results, however, are a strong function of the class definitions. Classes based on other definitions than those used in this report are possible, and results from these other classifications may also be useful.

For cars, vehicle classification as to vehicle type, size class, and manufacturer/origin generally follows fuel economy label, *Fuel Economy Guide*, and fuel economy standards protocols; exceptions are listed in Table A-3, Appendix A. In many of the passenger car tables, large sedans and wagons are aggregated as "Large," midsize sedans and wagons are aggregated as "Midsize," and "Small" includes all other cars. In some of the car tables, an alternative classification system is used, namely: Large Cars, Large Wagons, Midsize Cars, Midsize Wagons, Small Cars, and Small Wagons with the EPA Two-Seater, Mini-Compact, Subcompact, and Compact car classes are combined into the “Small Car” class. In some of the tables and figures in this report, only four vehicle types are used. In these cases, wagons have been merged with cars. This is because the wagon sales fraction for some instances is so small that the information is more conveniently represented by combining the two vehicle types. When they have been combined, the differences between them are not important.

The truck classification scheme used for all model years in this report is slightly different from that used in some previous reports in this series, because pickups, vans, and sports utility vehicles (SUVs) are sometimes each subdivided as "Small," "Midsize," and "Large." These truck size classifications are based primarily on published wheelbase data according to the following criteria:

| | Pickup | Van | SUV |
|---|---|---|---|
| Small | Less than 105" | Less than 109" | Less than 100" |
| Midsize | 105" to 115" | 109" to 124" | 100" to 110" |
| Large | More than 115" | More than 124" | More than 110" |

This classification scheme is similar to that used in many trade and consumer publications. For those vehicle nameplates with a variety of wheelbases, the size classification was determined by considering only the smallest wheelbase produced. The classification of a vehicle for this report is based on the authors' engineering judgment and is not a replacement for definitions used in implementing automotive standards legislation.

Published data is also used for two other vehicle characteristics for which data is not currently being submitted to EPA by the automotive manufacturers: (1) engines with variable valve timing (VVT) that use either cams or electric solenoids to provide variable intake and/ or exhaust valve timing and in some cases valve lift; and (2) engines with cylinder deactivation, which involves allowing the valves of selected cylinders of the engine to remain closed under certain driving conditions.

## III. General Car and Truck Trends

Figure 1 and Table 1 depict time trends in car, light truck, and car-plus-light truck fuel economy. Also shown on Figure 1 is the fraction of the combined fleet that are light trucks and trend lines representing three-year moving averages of the fuel economy and truck sales fraction data. Since 1975, the fuel economy of the combined car and light truck fleet has moved through several phases:

1. a rapid increase from 1975 through the early 1980s,

2. a slow increase until reaching its peak in 1987,

3. a gradual decline until 2004, and

4. an increase beginning in 2005.

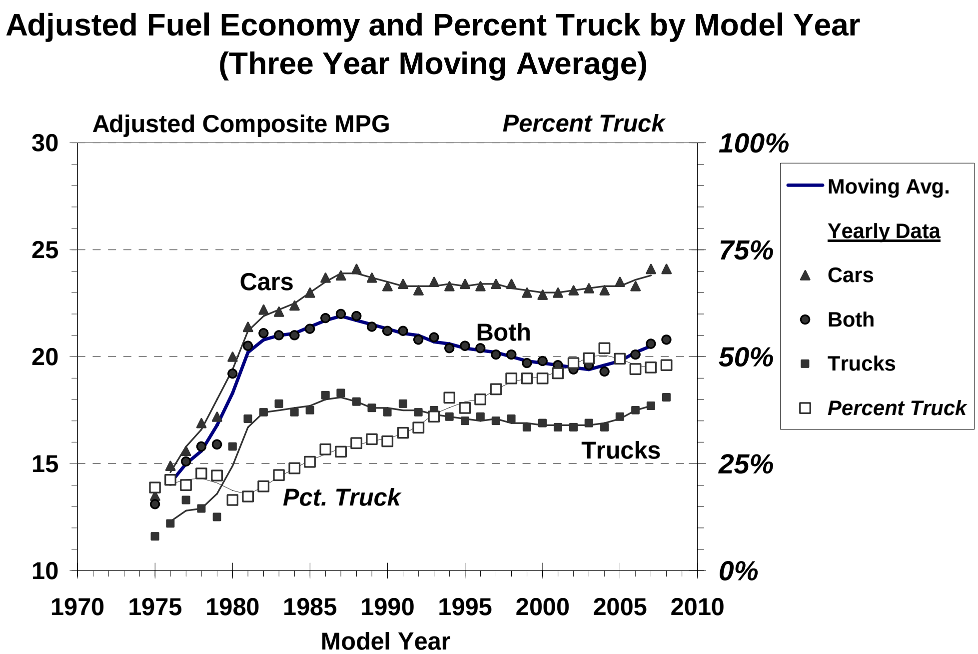



Figure 1

As shown in Table 1, the projected MY2008 fleetwide fuel economy value of 20.8 mpg is the highest value since 1993 and is 1.5 mpg higher than the 2004 value of 19.3 mpg, which was the lowest value since 1980. Average fleetwide fuel economy has now increased for four consecutive years. These increases reverse the longer term trend of declining fuel economy since its peak in 1987. Most of the increase in overall fuel economy since 2004 is due to higher truck fuel economy, as truck fuel economy has increased by 1.4 mpg since 2004, while car fuel economy has increased by 1.0 mpg. The 20.8 mpg adjusted fuel economy value projected for 2008 is 1.2 mpg below the peak in 1987, but this difference is due to the new methodology for calculating adjusted fuel economy values that is phased in over the 1986-2005 timeframe. As shown in Table 1, based on laboratory 55/45 fuel economy values, the projected value of 26.0 mpg is an all-time record, and is 0.1 mpg higher than the previous peak of 25.9 mpg in 1987.

Figure 1 shows that the estimated light truck share of the market, based on the three-year moving average trend, has leveled off at about 50 percent. Figure 2 compares laboratory 55/45 fuel economy for the combined car and truck fleet and the sales fraction for trucks.

MY2008 cars are estimated to average 24.1 mpg, matching the peak also achieved in MY1988 and MY2007. For MY2008, light trucks are estimated to average 18.1 mpg, their highest level since 1987. Fuel economy standards were unchanged for MY1996 through MY2004. In 2003 DOT raised the truck CAFE standards for 2005-2007, and in 2006 DOT raised the truck CAFE standards for 2008-2011. The recent fuel economy improvement for trucks is likely due, in part, to these higher standards. The CAFE standard for cars has not been changed since 1990.

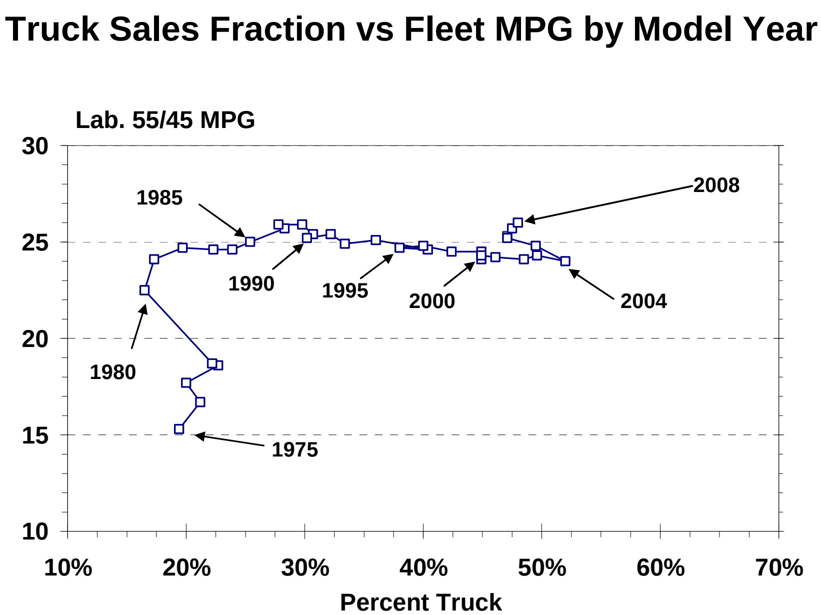



Figure 2

Table 1

**Fuel Economy Characteristics of 1975 to 2008 Light Duty Vehicles**

| MODEL YEAR | SALES (000) | FRAC | <--------- LAB CITY | LAB HWY | FUEL ECONOMY LAB 55/45 | ADJ CITY | ADJ HWY | ---------> ADJ COMP | TON -MPG | CU-FT -MPG | CU-FT-TON-MPG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cars** | | | | | | | | | | | |
| 1975 | 8237 | .806 | 13.7 | 19.5 | 15.8 | 12.3 | 15.2 | 13.5 | 27.6 | | |
| 1976 | 9722 | .788 | 15.2 | 21.3 | 17.5 | 13.7 | 16.6 | 14.9 | 30.2 | | |
| 1977 | 11300 | .800 | 16.0 | 22.3 | 18.3 | 14.4 | 17.4 | 15.6 | 31.0 | 1780 | 3423 |
| 1978 | 11175 | .773 | 17.2 | 24.5 | 19.9 | 15.5 | 19.1 | 16.9 | 30.6 | 1908 | 3345 |
| 1979 | 10794 | .778 | 17.7 | 24.6 | 20.3 | 15.9 | 19.2 | 17.2 | 30.2 | 1922 | 3301 |
| 1980 | 9443 | .835 | 20.3 | 29.0 | 23.5 | 18.3 | 22.6 | 20.0 | 31.2 | 2136 | 3273 |
| 1981 | 8733 | .827 | 21.7 | 31.1 | 25.1 | 19.6 | 24.2 | 21.4 | 33.1 | 2338 | 3547 |
| 1982 | 7819 | .803 | 22.3 | 32.7 | 26.0 | 20.1 | 25.5 | 22.2 | 34.2 | 2419 | 3645 |
| 1983 | 8002 | .777 | 22.1 | 32.7 | 25.9 | 19.9 | 25.5 | 22.1 | 34.7 | 2476 | 3776 |
| 1984 | 10675 | .761 | 22.4 | 33.3 | 26.3 | 20.2 | 26.0 | 22.4 | 35.1 | 2482 | 3776 |
| 1985 | 10791 | .746 | 23.0 | 34.3 | 27.0 | 20.7 | 26.8 | 23.0 | 35.8 | 2553 | 3884 |
| 1986 | 11015 | .717 | 23.7 | 35.5 | 27.9 | 21.2 | 27.6 | 23.7 | 36.2 | 2598 | 3899 |
| 1987 | 10731 | .722 | 23.9 | 35.9 | 28.1 | 21.2 | 27.7 | 23.8 | 36.2 | 2584 | 3872 |
| 1988 | 10736 | .702 | 24.2 | 36.6 | 28.6 | 21.4 | 28.2 | 24.1 | 36.9 | 2631 | 3963 |
| 1989 | 10018 | .693 | 23.8 | 36.3 | 28.1 | 20.9 | 27.9 | 23.7 | 36.8 | 2591 | 3977 |
| 1990 | 8810 | .698 | 23.4 | 36.0 | 27.8 | 20.5 | 27.5 | 23.3 | 37.1 | 2528 | 3984 |
| 1991 | 8524 | .678 | 23.6 | 36.3 | 28.0 | 20.5 | 27.6 | 23.4 | 37.0 | 2540 | 3970 |
| 1992 | 8108 | .666 | 23.1 | 36.3 | 27.6 | 20.0 | 27.5 | 23.1 | 37.4 | 2534 | 4071 |
| 1993 | 8456 | .640 | 23.6 | 36.9 | 28.2 | 20.3 | 27.9 | 23.5 | 37.7 | 2580 | 4098 |
| 1994 | 8415 | .596 | 23.4 | 36.9 | 28.0 | 20.0 | 27.7 | 23.3 | 37.9 | 2554 | 4108 |
| 1995 | 9396 | .620 | 23.6 | 37.6 | 28.3 | 20.0 | 28.1 | 23.4 | 38.3 | 2584 | 4171 |
| 1996 | 7890 | .600 | 23.5 | 37.6 | 28.3 | 19.8 | 28.0 | 23.3 | 38.3 | 2572 | 4186 |
| 1997 | 8335 | .576 | 23.7 | 37.7 | 28.4 | 19.8 | 28.0 | 23.4 | 38.3 | 2565 | 4168 |
| 1998 | 7972 | .551 | 23.7 | 37.9 | 28.5 | 19.7 | 28.0 | 23.4 | 38.7 | 2565 | 4210 |
| 1999 | 8379 | .551 | 23.4 | 37.4 | 28.2 | 19.4 | 27.5 | 23.0 | 38.7 | 2531 | 4237 |
| 2000 | 9128 | .551 | 23.5 | 37.3 | 28.2 | 19.3 | 27.3 | 22.9 | 38.6 | 2534 | 4246 |
| 2001 | 8408 | .539 | 23.7 | 37.6 | 28.4 | 19.4 | 27.3 | 23.0 | 39.1 | 2551 | 4280 |
| 2002 | 8304 | .515 | 24.0 | 37.6 | 28.6 | 19.4 | 27.2 | 23.1 | 39.3 | 2561 | 4311 |
| 2003 | 7951 | .504 | 24.2 | 38.1 | 28.9 | 19.5 | 27.5 | 23.2 | 40.0 | 2582 | 4378 |
| 2004 | 7538 | .480 | 24.1 | 38.2 | 28.9 | 19.3 | 27.4 | 23.1 | 40.3 | 2601 | 4464 |
| 2005 | 8027 | .505 | 24.7 | 38.7 | 29.5 | 19.6 | 27.6 | 23.5 | 41.0 | 2677 | 4590 |
| 2006 | 7993 | .529 | 24.4 | 38.5 | 29.2 | 19.4 | 27.5 | 23.3 | 41.6 | 2655 | 4649 |
| 2007 | 8029 | .525 | 25.4 | 39.7 | 30.3 | 20.1 | 28.3 | 24.1 | 42.8 | 2731 | 4735 |
| 2008 | 8537 | .520 | 25.4 | 39.8 | 30.3 | 20.1 | 28.4 | 24.1 | 43.3 | 2738 | 4789 |

Table 1 (Continued)

**Fuel Economy Characteristics of 1975 to 2008 Light Duty Vehicles**

| MODEL YEAR | SALES (000) | FRAC | <------ FUEL ECONOMY ------> LAB CITY | LAB HWY | LAB 55/45 | ADJ CITY | ADJ HWY | ADJ COMP | TON -MPG |
|---|---|---|---|---|---|---|---|---|---|
| **Trucks** | | | | | | | | | |
| 1975 | 1987 | .194 | 12.1 | 16.2 | 13.7 | 10.9 | 12.7 | 11.6 | 24.2 |
| 1976 | 2612 | .212 | 12.8 | 16.9 | 14.4 | 11.5 | 13.2 | 12.2 | 26.0 |
| 1977 | 2823 | .200 | 14.0 | 18.1 | 15.6 | 12.6 | 14.1 | 13.3 | 28.0 |
| 1978 | 3273 | .227 | 13.8 | 17.5 | 15.2 | 12.4 | 13.7 | 12.9 | 27.5 |
| 1979 | 3088 | .222 | 13.4 | 16.8 | 14.7 | 12.1 | 13.1 | 12.5 | 27.3 |
| 1980 | 1863 | .165 | 16.5 | 21.9 | 18.6 | 14.8 | 17.1 | 15.8 | 30.9 |
| 1981 | 1821 | .173 | 17.8 | 23.9 | 20.1 | 16.0 | 18.6 | 17.1 | 33.0 |
| 1982 | 1914 | .197 | 18.1 | 24.4 | 20.5 | 16.3 | 19.0 | 17.4 | 33.7 |
| 1983 | 2300 | .223 | 18.3 | 25.2 | 20.9 | 16.5 | 19.6 | 17.8 | 34.0 |
| 1984 | 3345 | .239 | 17.9 | 24.8 | 20.5 | 16.1 | 19.3 | 17.4 | 33.5 |
| 1985 | 3669 | .254 | 18.0 | 24.9 | 20.6 | 16.2 | 19.4 | 17.5 | 33.7 |
| 1986 | 4350 | .283 | 18.8 | 25.9 | 21.4 | 16.8 | 20.2 | 18.2 | 34.3 |
| 1987 | 4134 | .278 | 18.8 | 26.5 | 21.6 | 16.8 | 20.5 | 18.3 | 34.2 |
| 1988 | 4559 | .298 | 18.3 | 26.2 | 21.2 | 16.2 | 20.2 | 17.9 | 34.5 |
| 1989 | 4435 | .307 | 18.1 | 25.8 | 20.9 | 15.9 | 19.8 | 17.6 | 34.7 |
| 1990 | 3805 | .302 | 17.8 | 25.9 | 20.7 | 15.6 | 19.8 | 17.4 | 35.1 |
| 1991 | 4049 | .322 | 18.3 | 26.6 | 21.3 | 15.9 | 20.3 | 17.8 | 35.3 |
| 1992 | 4064 | .334 | 17.8 | 26.2 | 20.8 | 15.5 | 19.9 | 17.4 | 35.4 |
| 1993 | 4754 | .360 | 17.9 | 26.5 | 21.0 | 15.5 | 20.1 | 17.5 | 35.7 |
| 1994 | 5710 | .404 | 17.8 | 26.1 | 20.8 | 15.3 | 19.7 | 17.2 | 35.7 |
| 1995 | 5749 | .380 | 17.5 | 25.9 | 20.5 | 15.0 | 19.5 | 17.0 | 35.7 |
| 1996 | 5254 | .400 | 17.7 | 26.5 | 20.8 | 15.1 | 19.9 | 17.2 | 36.6 |
| 1997 | 6124 | .424 | 17.6 | 26.1 | 20.6 | 14.8 | 19.5 | 17.0 | 36.9 |
| 1998 | 6485 | .449 | 17.7 | 26.6 | 20.9 | 14.9 | 19.8 | 17.1 | 36.8 |
| 1999 | 6839 | .449 | 17.4 | 26.0 | 20.5 | 14.6 | 19.2 | 16.7 | 37.0 |
| 2000 | 7447 | .449 | 17.7 | 26.2 | 20.8 | 14.7 | 19.4 | 16.9 | 37.1 |
| 2001 | 7202 | .461 | 17.6 | 26.0 | 20.6 | 14.6 | 19.1 | 16.7 | 37.4 |
| 2002 | 7815 | .485 | 17.6 | 26.0 | 20.6 | 14.4 | 19.1 | 16.7 | 38.0 |
| 2003 | 7824 | .496 | 17.8 | 26.5 | 20.9 | 14.6 | 19.3 | 16.9 | 38.7 |
| 2004 | 8173 | .520 | 17.7 | 26.5 | 20.8 | 14.3 | 19.2 | 16.7 | 39.4 |
| 2005 | 7866 | .495 | 18.2 | 27.4 | 21.4 | 14.6 | 19.8 | 17.2 | 40.2 |
| 2006 | 7111 | .471 | 18.5 | 27.8 | 21.8 | 14.9 | 20.1 | 17.5 | 40.9 |
| 2007 | 7257 | .475 | 18.7 | 28.3 | 22.1 | 15.1 | 20.4 | 17.7 | 42.1 |
| 2008 | 7871 | .480 | 19.1 | 28.9 | 22.5 | 15.3 | 20.9 | 18.1 | 42.9 |

Table 1 (Continued)

**Fuel Economy Characteristics of 1975 to 2008 Light Duty Vehicles**

| MODEL YEAR | SALES (000) | FRAC | <------ FUEL ECONOMY ------> LAB CITY | LAB HWY | LAB 55/45 | ADJ CITY | ADJ HWY | ADJ COMP | TON -MPG |
|---|---|---|---|---|---|---|---|---|---|
| **Both** | | | | | | | | | |
| 1975 | 10224 | 1.000 | 13.4 | 18.7 | 15.3 | 12.0 | 14.6 | 13.1 | 26.9 |
| 1976 | 12334 | 1.000 | 14.6 | 20.2 | 16.7 | 13.2 | 15.7 | 14.2 | 29.3 |
| 1977 | 14123 | 1.000 | 15.6 | 21.3 | 17.7 | 14.0 | 16.6 | 15.1 | 30.4 |
| 1978 | 14448 | 1.000 | 16.3 | 22.5 | 18.6 | 14.7 | 17.5 | 15.8 | 29.9 |
| 1979 | 13882 | 1.000 | 16.5 | 22.3 | 18.7 | 14.9 | 17.4 | 15.9 | 29.5 |
| 1980 | 11306 | 1.000 | 19.6 | 27.5 | 22.5 | 17.6 | 21.5 | 19.2 | 31.2 |
| 1981 | 10554 | 1.000 | 20.9 | 29.5 | 24.1 | 18.8 | 23.0 | 20.5 | 33.1 |
| 1982 | 9732 | 1.000 | 21.3 | 30.7 | 24.7 | 19.2 | 23.9 | 21.1 | 34.1 |
| 1983 | 10302 | 1.000 | 21.2 | 30.6 | 24.6 | 19.0 | 23.9 | 21.0 | 34.5 |
| 1984 | 14020 | 1.000 | 21.2 | 30.8 | 24.6 | 19.1 | 24.0 | 21.0 | 34.7 |
| 1985 | 14460 | 1.000 | 21.5 | 31.3 | 25.0 | 19.3 | 24.4 | 21.3 | 35.3 |
| 1986 | 15365 | 1.000 | 22.1 | 32.2 | 25.7 | 19.8 | 25.0 | 21.8 | 35.7 |
| 1987 | 14865 | 1.000 | 22.2 | 32.6 | 25.9 | 19.8 | 25.3 | 22.0 | 35.7 |
| 1988 | 15295 | 1.000 | 22.1 | 32.7 | 25.9 | 19.6 | 25.2 | 21.9 | 36.2 |
| 1989 | 14453 | 1.000 | 21.7 | 32.3 | 25.4 | 19.1 | 24.8 | 21.4 | 36.2 |
| 1990 | 12615 | 1.000 | 21.4 | 32.2 | 25.2 | 18.7 | 24.6 | 21.2 | 36.5 |
| 1991 | 12573 | 1.000 | 21.6 | 32.5 | 25.4 | 18.8 | 24.7 | 21.2 | 36.5 |
| 1992 | 12172 | 1.000 | 21.0 | 32.1 | 24.9 | 18.2 | 24.4 | 20.8 | 36.8 |
| 1993 | 13211 | 1.000 | 21.2 | 32.4 | 25.1 | 18.2 | 24.4 | 20.9 | 37.0 |
| 1994 | 14125 | 1.000 | 20.8 | 31.6 | 24.6 | 17.8 | 23.8 | 20.4 | 37.0 |
| 1995 | 15145 | 1.000 | 20.8 | 32.1 | 24.7 | 17.7 | 24.1 | 20.5 | 37.3 |
| 1996 | 13144 | 1.000 | 20.8 | 32.2 | 24.8 | 17.6 | 24.0 | 20.4 | 37.6 |
| 1997 | 14459 | 1.000 | 20.6 | 31.8 | 24.5 | 17.4 | 23.6 | 20.1 | 37.7 |
| 1998 | 14458 | 1.000 | 20.6 | 31.9 | 24.5 | 17.2 | 23.6 | 20.1 | 37.9 |
| 1999 | 15218 | 1.000 | 20.3 | 31.2 | 24.1 | 16.9 | 23.0 | 19.7 | 38.0 |
| 2000 | 16574 | 1.000 | 20.5 | 31.4 | 24.3 | 16.9 | 23.0 | 19.8 | 37.9 |
| 2001 | 15610 | 1.000 | 20.5 | 31.1 | 24.2 | 16.8 | 22.8 | 19.6 | 38.3 |
| 2002 | 16119 | 1.000 | 20.4 | 30.9 | 24.1 | 16.6 | 22.5 | 19.4 | 38.7 |
| 2003 | 15775 | 1.000 | 20.6 | 31.3 | 24.3 | 16.7 | 22.7 | 19.6 | 39.4 |
| 2004 | 15711 | 1.000 | 20.2 | 31.0 | 24.0 | 16.3 | 22.4 | 19.3 | 39.9 |
| 2005 | 15893 | 1.000 | 21.0 | 32.1 | 24.8 | 16.8 | 23.1 | 19.9 | 40.6 |
| 2006 | 15105 | 1.000 | 21.2 | 32.6 | 25.2 | 17.0 | 23.4 | 20.1 | 41.2 |
| 2007 | 15287 | 1.000 | 21.7 | 33.3 | 25.7 | 17.3 | 23.9 | 20.6 | 42.4 |
| 2008 | 16407 | 1.000 | 21.9 | 33.7 | 26.0 | 17.5 | 24.2 | 20.8 | 43.1 |

The distribution of fuel economy in any model year is of interest. In Figure 3, highlights of the distribution of car mpg are shown. Since 1975, half of the cars have consistently been within a few mpg of each other. The fuel economy difference between the least efficient and most efficient car increased from about 20 mpg in 1975 to nearly 50 mpg in 1986, but was less than 35 mpg in 1999. With the introduction for sale of the Honda Insight gasoline-electric hybrid vehicle in MY2000, the range once again approached 50 mpg. The increased market share of hybrid cars also accounts for the increase in the fuel economy of the best 1% of cars with the cutpoint for this stratum now over 40 mpg. The ratio of the highest to lowest has increased from about three to one in 1975 to nearly five to one today, because the fuel economy of the least fuel efficient cars has remained roughly constant in comparison to the most fuel efficient cars whose fuel economy has more than doubled.

The overall fuel economy distribution trend for trucks (see Figure 4) is narrower than that for cars, with a peak in the efficiency of the most efficient truck in the early 1980s when small pickup trucks equipped with diesel engines were being sold. As a result, the fuel economy range between the most efficient and least efficient truck peaked at about 25 mpg in 1982. The fuel economy range for trucks then narrowed, but with the introduction of the hybrid Escape SUV in MY2005, it is nearly 20 mpg. Like cars, half of the trucks built each year have always been within a few mpg of each year's average fuel economy value. Appendix C contains additional fuel economy distribution data.

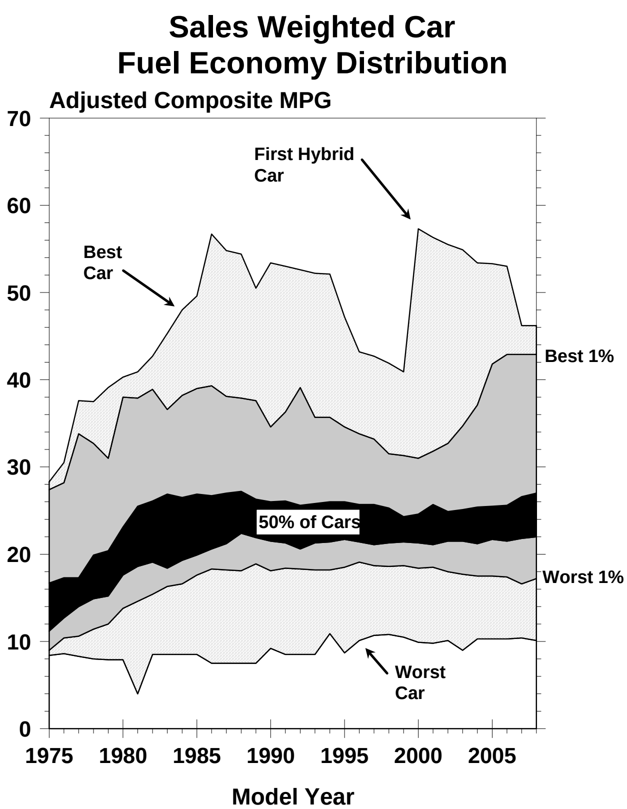



Figure 3

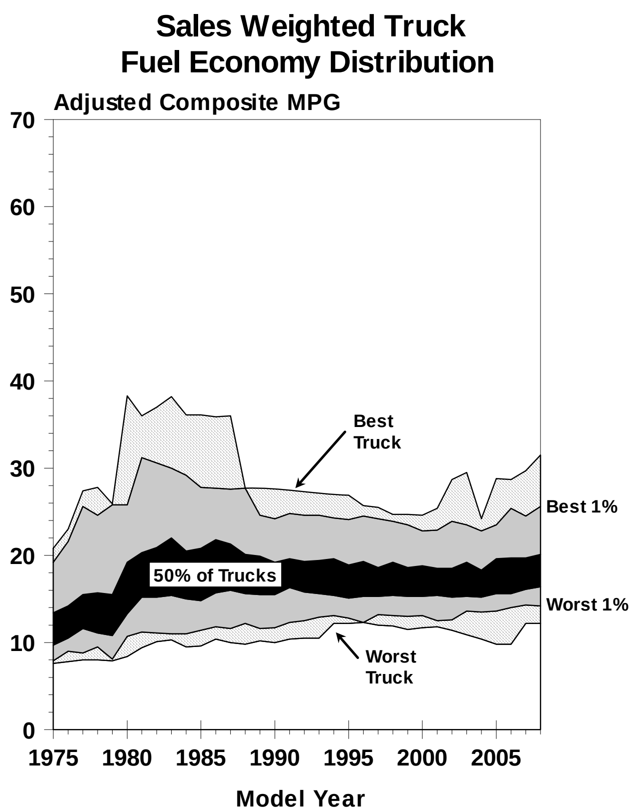



Figure 4

Table 2

**Vehicle Size and Design Characteristics of 1975 to 2008**

**Cars**

| | <-------- Vehicle Characteristics: --------> | | | | | | | | <- Percent By: -> | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **MODEL YEAR** | **FRAC** | **ADJ COMP MPG** | **VOL CU-FT** | **WGHT LB** | **ENG HP** | **HP/ WT** | **0-60 TIME** | **TOP SPD** | **VEHICLE SIZE SMALL** | **MID** | **LARGE** |
| 1975 | .806 | 13.5 | | 4058 | 136 | .0331 | 14.2 | 111 | 55.4 | 23.3 | 21.3 |
| 1976 | .788 | 14.9 | | 4059 | 134 | .0324 | 14.4 | 110 | 55.4 | 25.2 | 19.4 |
| 1977 | .800 | 15.6 | 110 | 3944 | 133 | .0335 | 14.0 | 111 | 51.9 | 24.5 | 23.5 |
| 1978 | .773 | 16.9 | 109 | 3588 | 124 | .0342 | 13.7 | 111 | 44.7 | 34.4 | 21.0 |
| 1979 | .778 | 17.2 | 109 | 3485 | 119 | .0338 | 13.8 | 110 | 43.7 | 34.2 | 22.1 |
| 1980 | .835 | 20.0 | 104 | 3101 | 100 | .0322 | 14.3 | 107 | 54.4 | 34.4 | 11.3 |
| 1981 | .827 | 21.4 | 106 | 3076 | 99 | .0320 | 14.4 | 106 | 51.5 | 36.4 | 12.2 |
| 1982 | .803 | 22.2 | 106 | 3054 | 99 | .0320 | 14.4 | 106 | 56.5 | 31.0 | 12.5 |
| 1983 | .777 | 22.1 | 109 | 3112 | 104 | .0330 | 14.0 | 108 | 53.1 | 31.8 | 15.1 |
| 1984 | .761 | 22.4 | 108 | 3099 | 106 | .0339 | 13.8 | 109 | 57.4 | 29.4 | 13.2 |
| 1985 | .746 | 23.0 | 108 | 3093 | 111 | .0355 | 13.3 | 111 | 55.7 | 28.9 | 15.4 |
| 1986 | .717 | 23.7 | 107 | 3041 | 111 | .0360 | 13.2 | 111 | 59.5 | 27.9 | 12.6 |
| 1987 | .722 | 23.8 | 107 | 3031 | 112 | .0365 | 13.0 | 112 | 63.5 | 24.3 | 12.2 |
| 1988 | .702 | 24.1 | 107 | 3047 | 116 | .0375 | 12.8 | 113 | 64.8 | 22.3 | 12.8 |
| 1989 | .693 | 23.7 | 108 | 3099 | 121 | .0387 | 12.5 | 115 | 58.3 | 28.2 | 13.5 |
| 1990 | .698 | 23.3 | 107 | 3176 | 129 | .0401 | 12.1 | 117 | 58.6 | 28.7 | 12.8 |
| 1991 | .678 | 23.4 | 107 | 3154 | 132 | .0413 | 11.8 | 118 | 61.5 | 26.2 | 12.3 |
| 1992 | .666 | 23.1 | 108 | 3240 | 141 | .0428 | 11.5 | 120 | 56.5 | 27.8 | 15.6 |
| 1993 | .640 | 23.5 | 108 | 3207 | 138 | .0425 | 11.6 | 120 | 57.2 | 29.5 | 13.3 |
| 1994 | .596 | 23.3 | 108 | 3250 | 143 | .0432 | 11.4 | 121 | 58.5 | 26.1 | 15.4 |
| 1995 | .620 | 23.4 | 109 | 3263 | 152 | .0460 | 10.9 | 125 | 57.3 | 28.6 | 14.0 |
| 1996 | .600 | 23.3 | 109 | 3282 | 154 | .0464 | 10.8 | 125 | 54.3 | 32.0 | 13.6 |
| 1997 | .576 | 23.4 | 109 | 3274 | 156 | .0469 | 10.7 | 126 | 55.1 | 30.6 | 14.3 |
| 1998 | .551 | 23.4 | 109 | 3306 | 159 | .0475 | 10.6 | 127 | 49.4 | 39.1 | 11.4 |
| 1999 | .551 | 23.0 | 109 | 3365 | 164 | .0481 | 10.5 | 128 | 47.7 | 39.7 | 12.6 |
| 2000 | .551 | 22.9 | 110 | 3369 | 168 | .0492 | 10.4 | 129 | 47.5 | 34.3 | 18.2 |
| 2001 | .539 | 23.0 | 109 | 3380 | 168 | .0492 | 10.3 | 129 | 50.9 | 32.3 | 16.8 |
| 2002 | .515 | 23.1 | 109 | 3391 | 173 | .0504 | 10.2 | 131 | 48.6 | 36.3 | 15.1 |
| 2003 | .504 | 23.2 | 109 | 3421 | 176 | .0510 | 10.0 | 132 | 50.8 | 33.4 | 15.9 |
| 2004 | .480 | 23.1 | 110 | 3462 | 182 | .0521 | 9.8 | 133 | 47.4 | 35.5 | 17.0 |
| 2005 | .505 | 23.5 | 111 | 3463 | 182 | .0518 | 9.8 | 133 | 44.2 | 38.9 | 16.8 |
| 2006 | .529 | 23.3 | 112 | 3534 | 194 | .0540 | 9.6 | 136 | 46.2 | 32.9 | 20.9 |
| 2007 | .525 | 24.1 | 110 | 3510 | 190 | .0531 | 9.7 | 135 | 44.0 | 40.6 | 15.4 |
| 2008 | .520 | 24.1 | 110 | 3541 | 196 | .0543 | 9.5 | 137 | 43.7 | 36.1 | 20.2 |

Table 2 (Continued)

**Vehicle Size and Design Characteristics of 1975 to 2008**

**Trucks**

| | | <----- Vehicle Characteristics: | | | | -----> | | <- Percent By: -> | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **MODEL YEAR** | **SALES FRAC** | **ADJ COMP MPG** | **WGHT LB** | **ENG HP** | **HP/ WT** | **0-60 TIME** | **TOP SPD** | **VEHICLE TYPE VAN** | **SUV** | **PICKUP** |
| 1975 | .194 | 11.6 | 4072 | 142 | .0349 | 13.6 | 114 | 23.0 | 9.4 | 67.6 |
| 1976 | .212 | 12.2 | 4155 | 141 | .0340 | 13.8 | 113 | 19.2 | 9.3 | 71.4 |
| 1977 | .200 | 13.3 | 4135 | 147 | .0356 | 13.3 | 115 | 18.2 | 10.0 | 71.8 |
| 1978 | .227 | 12.9 | 4151 | 146 | .0351 | 13.4 | 114 | 19.1 | 11.6 | 69.3 |
| 1979 | .222 | 12.5 | 4252 | 138 | .0325 | 14.3 | 111 | 15.6 | 13.0 | 71.5 |
| 1980 | .165 | 15.8 | 3869 | 121 | .0313 | 14.5 | 108 | 13.0 | 9.9 | 77.1 |
| 1981 | .173 | 17.1 | 3806 | 119 | .0311 | 14.6 | 108 | 13.5 | 7.5 | 79.1 |
| 1982 | .197 | 17.4 | 3806 | 120 | .0317 | 14.5 | 109 | 16.2 | 8.5 | 75.3 |
| 1983 | .223 | 17.8 | 3763 | 118 | .0313 | 14.5 | 108 | 16.6 | 12.6 | 70.8 |
| 1984 | .239 | 17.4 | 3782 | 118 | .0310 | 14.7 | 108 | 20.2 | 18.7 | 61.1 |
| 1985 | .254 | 17.5 | 3795 | 124 | .0326 | 14.1 | 110 | 23.3 | 20.0 | 56.6 |
| 1986 | .283 | 18.2 | 3738 | 123 | .0330 | 14.0 | 110 | 24.0 | 17.8 | 58.2 |
| 1987 | .278 | 18.3 | 3713 | 131 | .0351 | 13.3 | 113 | 26.9 | 21.1 | 51.9 |
| 1988 | .298 | 17.9 | 3841 | 141 | .0366 | 12.9 | 115 | 24.8 | 21.2 | 53.9 |
| 1989 | .307 | 17.6 | 3921 | 146 | .0372 | 12.8 | 116 | 28.8 | 20.9 | 50.3 |
| 1990 | .302 | 17.4 | 4005 | 151 | .0377 | 12.6 | 117 | 33.2 | 18.6 | 48.2 |
| 1991 | .322 | 17.8 | 3948 | 150 | .0379 | 12.6 | 117 | 25.5 | 27.0 | 47.4 |
| 1992 | .334 | 17.4 | 4056 | 155 | .0382 | 12.5 | 118 | 30.0 | 24.7 | 45.3 |
| 1993 | .360 | 17.5 | 4073 | 162 | .0398 | 12.1 | 120 | 30.3 | 27.6 | 42.1 |
| 1994 | .404 | 17.2 | 4125 | 166 | .0403 | 12.0 | 121 | 24.8 | 28.4 | 46.7 |
| 1995 | .380 | 17.0 | 4184 | 168 | .0401 | 12.0 | 121 | 28.9 | 31.6 | 39.5 |
| 1996 | .400 | 17.2 | 4225 | 179 | .0423 | 11.5 | 124 | 26.8 | 36.0 | 37.2 |
| 1997 | .424 | 17.0 | 4344 | 187 | .0429 | 11.4 | 126 | 20.7 | 40.0 | 39.3 |
| 1998 | .449 | 17.1 | 4283 | 187 | .0435 | 11.2 | 126 | 23.0 | 39.8 | 37.2 |
| 1999 | .449 | 16.7 | 4412 | 197 | .0446 | 11.0 | 128 | 21.4 | 41.4 | 37.2 |
| 2000 | .449 | 16.9 | 4375 | 197 | .0448 | 11.0 | 128 | 22.7 | 42.2 | 35.1 |
| 2001 | .461 | 16.7 | 4463 | 209 | .0466 | 10.6 | 131 | 17.1 | 47.9 | 35.0 |
| 2002 | .485 | 16.7 | 4546 | 219 | .0482 | 10.4 | 134 | 15.9 | 53.6 | 30.5 |
| 2003 | .496 | 16.9 | 4586 | 221 | .0481 | 10.4 | 134 | 15.7 | 52.6 | 31.6 |
| 2004 | .520 | 16.7 | 4710 | 236 | .0501 | 10.0 | 137 | 11.7 | 57.7 | 30.7 |
| 2005 | .495 | 17.2 | 4668 | 237 | .0505 | 10.0 | 137 | 18.8 | 51.9 | 29.2 |
| 2006 | .471 | 17.5 | 4665 | 235 | .0502 | 10.0 | 137 | 16.4 | 52.8 | 30.8 |
| 2007 | .475 | 17.7 | 4741 | 248 | .0521 | 9.7 | 140 | 12.1 | 58.9 | 29.0 |
| 2008 | .480 | 18.1 | 4742 | 251 | .0526 | 9.7 | 141 | 11.3 | 61.8 | 26.9 |

Table 2 (Continued)

**Vehicle Size and Design Characteristics of 1975 to 2008**

**Cars and Trucks**

**<------ Vehicle Characteristics: ------>**

| MODEL YEAR | SALES FRAC | ADJ COMP MPG | WGHT LB | ENG HP | HP/ WT | 0-60 TIME | TOP SPD |
|---|---|---|---|---|---|---|---|
| 1975 | 1.000 | 13.1 | 4060 | 137 | .0335 | 14.1 | 112 |
| 1976 | 1.000 | 14.2 | 4079 | 135 | .0328 | 14.3 | 111 |
| 1977 | 1.000 | 15.1 | 3982 | 136 | .0339 | 13.8 | 112 |
| 1978 | 1.000 | 15.8 | 3715 | 129 | .0344 | 13.6 | 112 |
| 1979 | 1.000 | 15.9 | 3655 | 124 | .0335 | 13.9 | 110 |
| 1980 | 1.000 | 19.2 | 3228 | 104 | .0320 | 14.3 | 107 |
| 1981 | 1.000 | 20.5 | 3202 | 102 | .0318 | 14.4 | 107 |
| 1982 | 1.000 | 21.1 | 3202 | 103 | .0320 | 14.4 | 107 |
| 1983 | 1.000 | 21.0 | 3257 | 107 | .0327 | 14.1 | 108 |
| 1984 | 1.000 | 21.0 | 3262 | 109 | .0332 | 14.0 | 109 |
| 1985 | 1.000 | 21.3 | 3271 | 114 | .0347 | 13.5 | 110 |
| 1986 | 1.000 | 21.8 | 3238 | 114 | .0351 | 13.4 | 111 |
| 1987 | 1.000 | 22.0 | 3221 | 118 | .0361 | 13.1 | 112 |
| 1988 | 1.000 | 21.9 | 3283 | 123 | .0372 | 12.8 | 114 |
| 1989 | 1.000 | 21.4 | 3351 | 129 | .0382 | 12.5 | 115 |
| 1990 | 1.000 | 21.2 | 3426 | 135 | .0394 | 12.2 | 117 |
| 1991 | 1.000 | 21.2 | 3410 | 138 | .0402 | 12.1 | 118 |
| 1992 | 1.000 | 20.8 | 3512 | 145 | .0413 | 11.8 | 120 |
| 1993 | 1.000 | 20.9 | 3519 | 147 | .0416 | 11.8 | 120 |
| 1994 | 1.000 | 20.4 | 3603 | 152 | .0420 | 11.7 | 121 |
| 1995 | 1.000 | 20.5 | 3613 | 158 | .0438 | 11.3 | 123 |
| 1996 | 1.000 | 20.4 | 3659 | 164 | .0447 | 11.1 | 125 |
| 1997 | 1.000 | 20.1 | 3727 | 169 | .0452 | 11.0 | 126 |
| 1998 | 1.000 | 20.1 | 3744 | 171 | .0457 | 10.9 | 126 |
| 1999 | 1.000 | 19.7 | 3835 | 179 | .0465 | 10.7 | 128 |
| 2000 | 1.000 | 19.8 | 3821 | 181 | .0472 | 10.6 | 129 |
| 2001 | 1.000 | 19.6 | 3879 | 187 | .0480 | 10.5 | 130 |
| 2002 | 1.000 | 19.4 | 3951 | 195 | .0493 | 10.3 | 132 |
| 2003 | 1.000 | 19.6 | 3999 | 199 | .0496 | 10.2 | 133 |
| 2004 | 1.000 | 19.3 | 4111 | 211 | .0511 | 9.9 | 135 |
| 2005 | 1.000 | 19.9 | 4059 | 209 | .0512 | 9.9 | 135 |
| 2006 | 1.000 | 20.1 | 4067 | 213 | .0522 | 9.8 | 137 |
| 2007 | 1.000 | 20.6 | 4094 | 218 | .0526 | 9.7 | 137 |
| 2008 | 1.000 | 20.8 | 4117 | 222 | .0535 | 9.6 | 139 |

## Ton-MPG by Model Year
## (Three Year Moving Average)

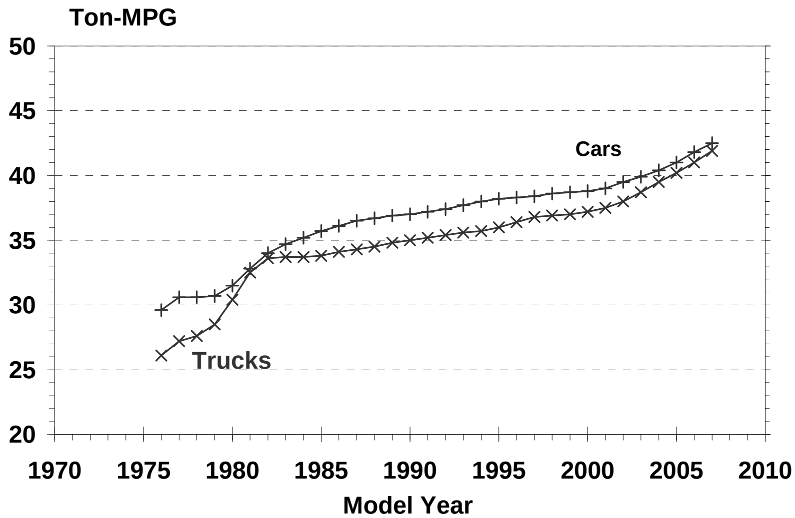



**Figure 5**

As shown in Table 2, the average weight of the overall fleet has remained relatively constant since 2004, with a slight increase in car weight offset by a small decrease in truck market share (as trucks have a higher average weight than cars). Overall average horsepower has continued to increase, but at a slower rate than in the past. The projected 2008 weight has increased by over 900 pounds and the average horsepower level has more than doubled since the early 1980s.

The long term trends for both weight and performance have been steady increases. As shown in Figure 5, since 1975 Ton-MPG for both cars and trucks increased substantially; i.e., over 60% for cars and 80% for trucks. Typically, Ton-MPG for both vehicle types has increased at a rate of about one or two percent a year.

Another dramatic trend over that time frame has been the substantial increase in performance of cars and light trucks as measured by their estimated 0-to-60 time. These trends are shown graphically in Figure 6 (for cars) and Figure 7 (for light trucks) which are plots of fuel economy versus performance, with model years as indicated. Both graphs show the same story: in the late 1970s and early 1980s, responding to the regulatory requirements for mpg improvement, the industry increased mpg and kept performance roughly constant. After the regulatory mpg requirements stabilized, mpg improvements slowed and performance dramatically improved. This trend toward increased performance is as important as the truck market share trend in understanding trends in overall fleet mpg. Figures 8 and 9 are similar to Figures 6 and 7, but show the trends in weight and laboratory fuel economy and show that the era of weight reductions that took place for both cars and trucks between 1975 and the early 1980s has been followed by an era of weight increases until 2005.

## Car 55/45 Laboratory MPG vs 0 to 60 Time by Model Year

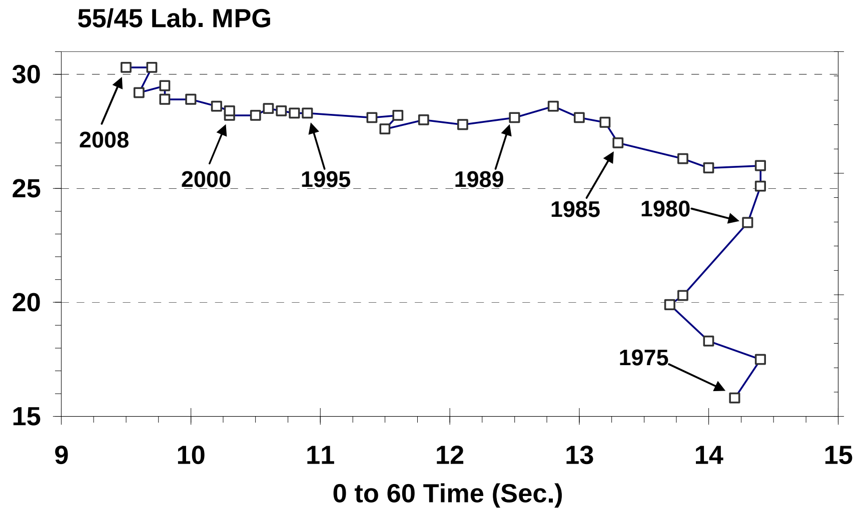



Figure 6

## Truck 55/45 Laboratory MPG vs 0 to 60 Time by Model Year

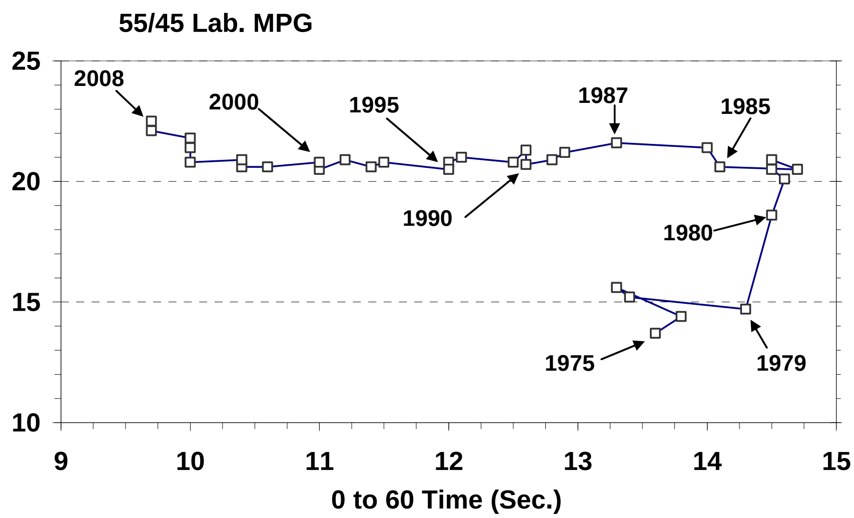



Figure 7

## Car 55/45 Laboratory MPG vs Inertia Weight by Model Year

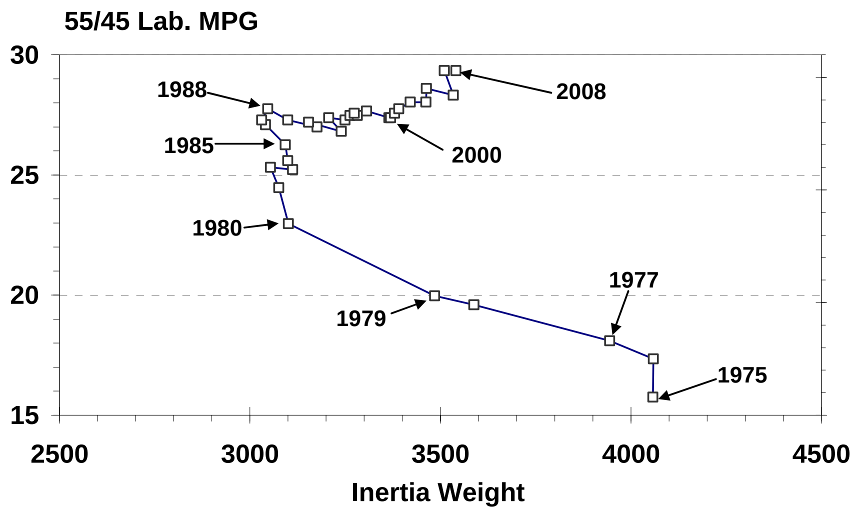



Figure 8

## Truck 55/45 Laboratory MPG vs Inertia Weight by Model Year

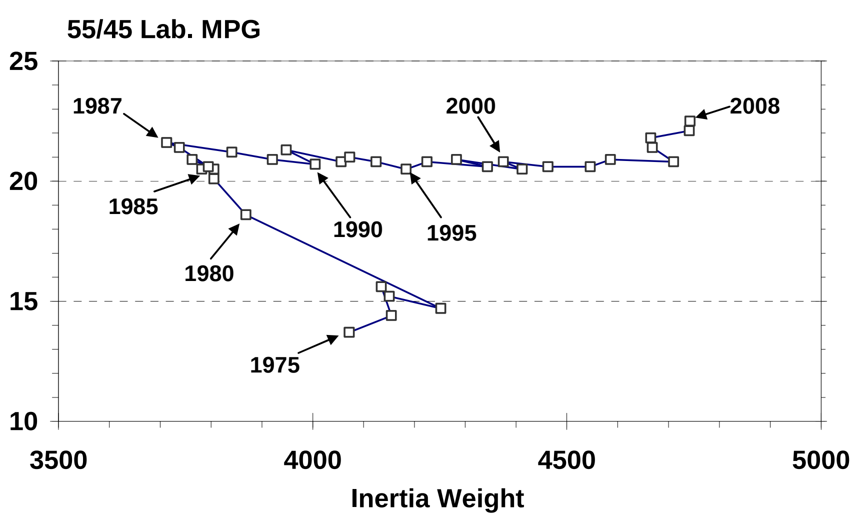



Figure 9

## IV. Trends by Vehicle Type, Size, and Weight

Table 1 showed that for the past several years trucks have accounted for about 50 percent of the light-duty vehicles produced each year. MY2004 was the peak year for trucks with 52 percent market share, and trucks have been between 47 and 50 percent since. Considering the five classes: cars, wagons, sports utility vehicles (SUVs), vans, and pickups, since 1975 the biggest overall increase in market share has been for SUVs, up from less than two percent in 1975 to just under 30 percent this year (see Figure 10 and Table 3). The biggest overall decrease has been for cars, down from over 70 percent of the fleet in 1975 to 52 percent. By comparison the sales fraction for pickup trucks has remained constant at 13-15 percent of the market.

Figures 11 to 15 compare sales fractions by vehicle type and size with the fleet again stratified into five vehicle types: cars (i.e., coupes, sedans, and hatchbacks), station wagons, vans, SUVs, and pickup trucks; and three vehicle sizes: small, midsize, and large. As shown in Figure 11, large cars accounted for about 20 percent of all car sales in the late 1970s, but their share of the car market dropped in the early 1980s to about 12 percent of the market where it remained for about two decades, but has since increased back to about 20 percent. Within the car segment, the market share for small cars peaked in the late 1980s at about 65 percent and is now lower than at anytime since 1975.

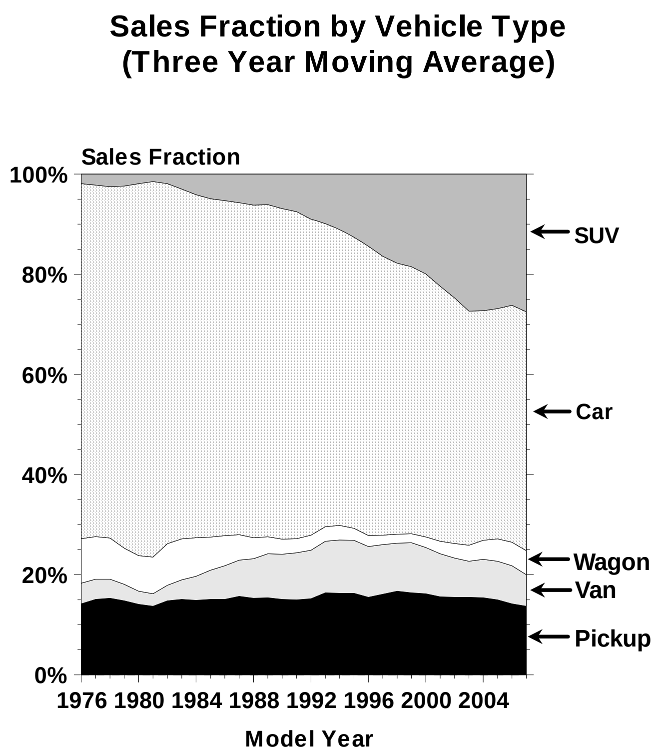



Figure 10

Large wagons accounted for more than 20 percent of the wagon segment of the market in the late 1970s but then lost market share relatively consistently and were not produced at all between 1996 and 2004 when they re-emerged. They now account for about 10 percent of all wagons, but less than one percent of all light vehicles. Similarly (see Figure 13), large vehicles accounted for nearly 40 percent of all vans through the early 1980s compared to less than 10 percent the past five years. Small vans have never had a significant market share, and none have been produced in recent years. Figures 14 and 15 show that the longer term trend of increased market share for both large SUVs and pickups has levelled off in the last few years.

Table 3 compares the sales fractions by vehicle type and size on a different basis, that for the total market. Since 1975, the largest increases in sales fractions have been for midsize and large SUVs. These two classes are expected to account for nearly 25 percent of all light vehicles built this year, compared to combined totals of about 1.3 and 4.5 percent in 1975 and 1988, respectively. Conversely, the largest sales fraction decrease has occurred for small cars which accounted for 40 percent of all light-duty vehicles produced in 1975 and over 43 percent in 1988, but less than 20 percent this year. An overall decrease has occurred for large cars which accounted for about 15 percent of total light-duty sales in 1975 and now account for about 10 percent.

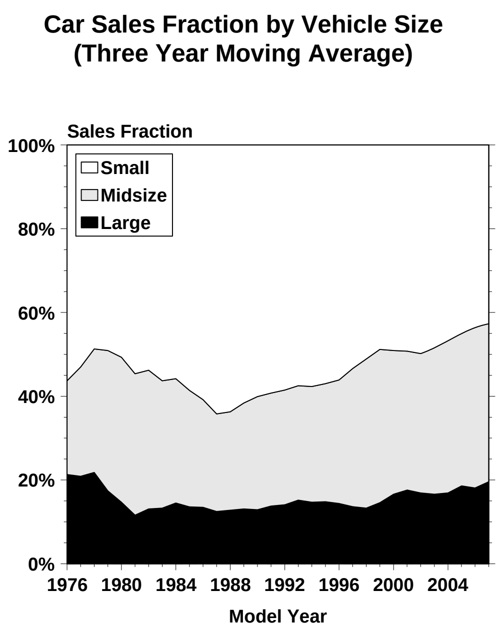


Figure 11

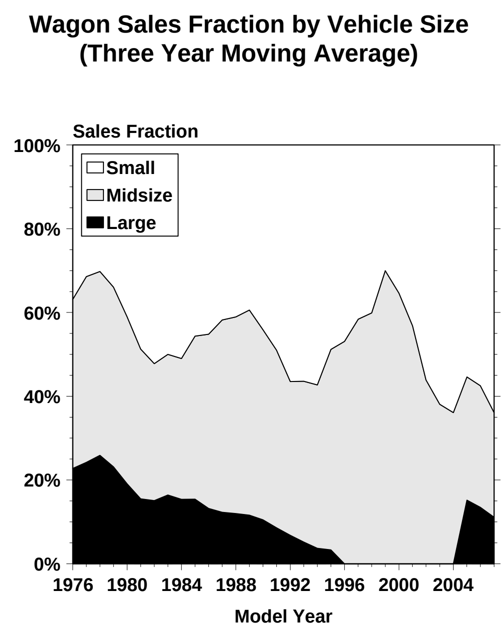


Figure 12

**Van Sales Fraction by Vehicle Size**
**(Three Year Moving Average)**

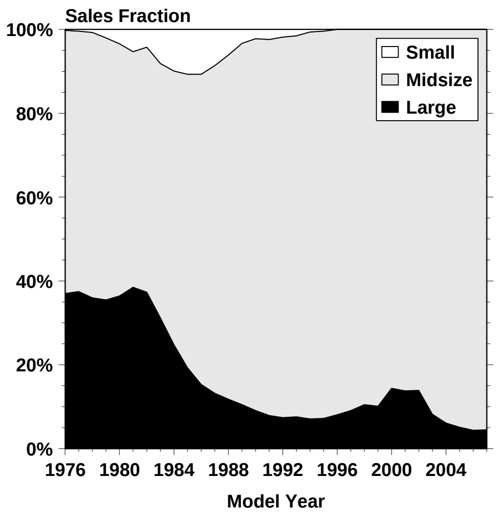



Figure 13

**SUV Sales Fraction by Vehicle Size**
**(Three Year Moving Average)**

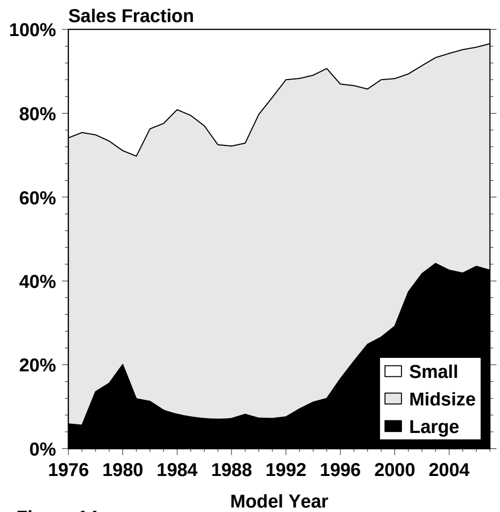



Figure 14

**Pickup Sales Fraction by Vehicle Size**
**(Three Year Moving Average)**

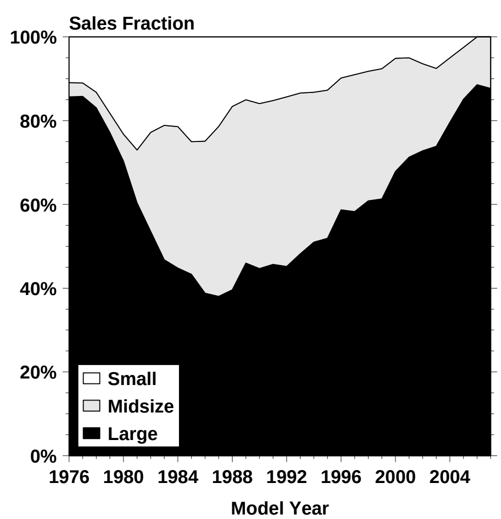



Figure 15

Table 3

**Sales Fractions of MY1975, MY1988 and MY2008**
**Light Duty Vehicles by Vehicle Size and Type**

| Vehicle Type | Size | Sales Fraction 1975 | 1988 | 2008 | Differences in Sales Fraction: From 1975 To 2008 | From 1975 To 1988 | From 1988 To 2008 |
|---|---|---|---|---|---|---|---|
| Car | Small | 40.0% | 43.8% | 19.4% | -20.6% | 3.9% | -24.5% |
| | Midsize | 16.0% | 13.8% | 17.7% | 1.8% | -2.1% | 3.9% |
| | Large | 15.2% | 8.5% | 10.0% | -5.2% | -6.7% | 1.5% |
| | All | 71.1% | 66.2% | 47.1% | -24.0% | -5.0% | -19.1% |
| Wagon | Small | 4.7% | 1.7% | 3.4% | -1.3% | -3.0% | 1.7% |
| | Midsize | 2.8% | 1.9% | 1.1% | -1.8% | -1.0% | -0.8% |
| | Large | 1.9% | 0.5% | 0.5% | -1.5% | -1.4% | 0.0% |
| | All | 9.4% | 4.0% | 4.9% | -4.5% | -5.4% | 0.9% |
| Van | Small | 0.0% | 0.4% | 0.0% | 0.0% | 0.3% | -0.4% |
| | Midsize | 3.0% | 6.2% | 5.3% | 2.3% | 3.2% | -0.9% |
| | Large | 1.5% | 0.9% | 0.2% | -1.3% | -0.6% | -0.7% |
| | All | 4.5% | 7.4% | 5.4% | 1.0% | 2.9% | -2.0% |
| SUV | Small | 0.5% | 1.9% | 0.9% | 0.3% | 1.4% | -1.0% |
| | Midsize | 1.2% | 4.0% | 16.5% | 15.3% | 2.8% | 12.5% |
| | Large | 0.1% | 0.5% | 12.3% | 12.2% | 0.3% | 11.9% |
| | All | 1.8% | 6.3% | 29.6% | 27.8% | 4.5% | 23.3% |
| Pickup | Small | 1.6% | 2.2% | 0.0% | -1.6% | 0.7% | -2.2% |
| | Midsize | 0.5% | 6.9% | 1.6% | 1.0% | 6.3% | -5.3% |
| | Large | 11.0% | 7.0% | 11.3% | 0.3% | -4.1% | 4.4% |
| | All | 13.1% | 16.1% | 12.9% | -0.2% | 2.9% | -3.2% |
| All | Trucks | 19.4% | 29.8% | 48.0% | 28.5% | 10.4% | 18.2% |

Figures 16 through 20 show trends in performance, weight, and adjusted fuel economy for cars, wagons, vans, SUVs, and pickups. For all five vehicle types, there has been a clear long term trend towards increased weight, moderating since 2005 for wagons, vans, and SUVs.

Table 4 shows the lowest, average, and highest adjusted mpg performance by vehicle class and size for three selected years. For both 1988 and 2008, the mpg performance is such that the midsize vehicles in all classes, except pickups, have better fuel economy than the corresponding entry for small vehicles in 1975. In Table 5, the percentage changes obtainable from the entries in Table 4 are presented. Average mpg for four classes (midsize cars, large cars, midsize wagons, and midsize SUVs) have improved over 80 percent since 1975. Since 1988, average fuel economy has decreased for small cars, all wagons, small SUVs, and midsize pickups and the largest improvements in average mpg has been over 20 percent for midsize and large SUVs, respectively.

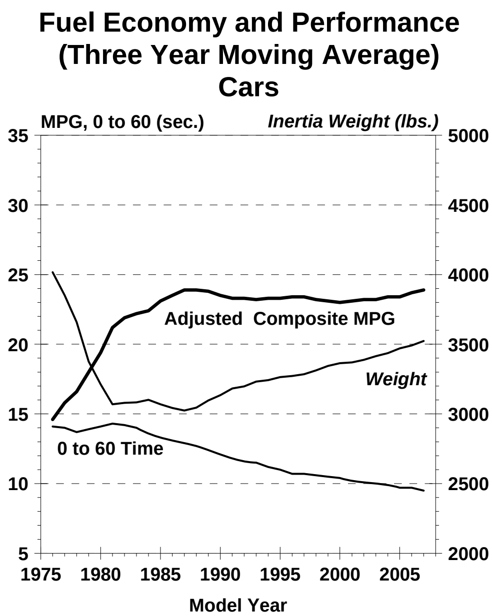



Figure 16

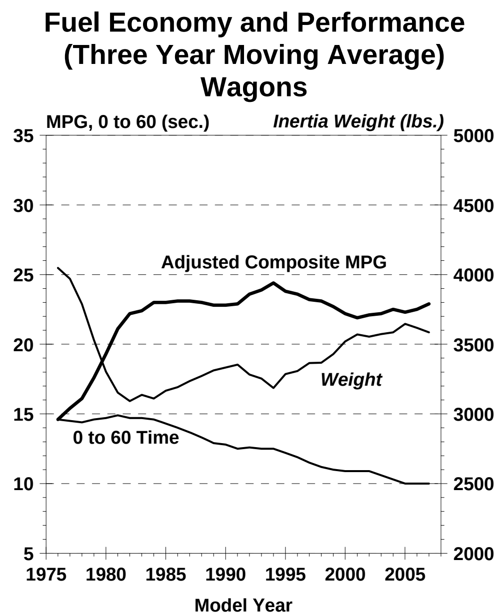



Figure 17

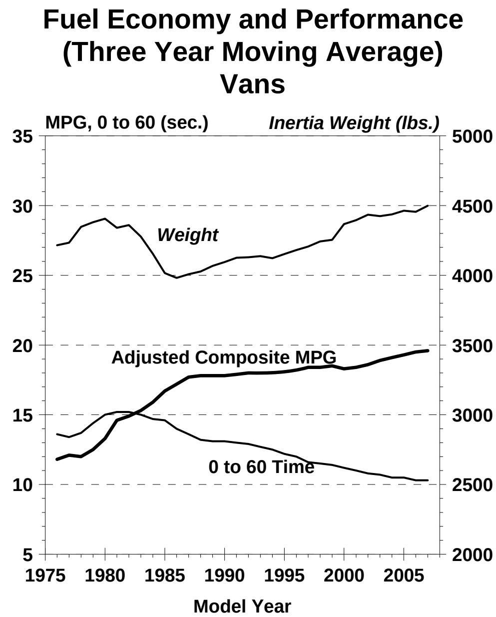



Figure 18

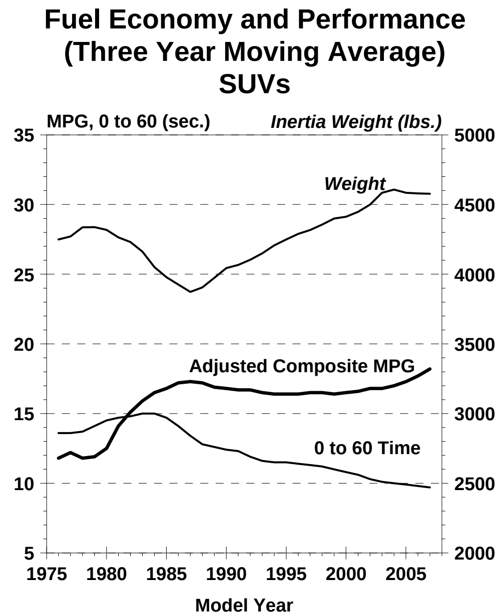



Figure 19

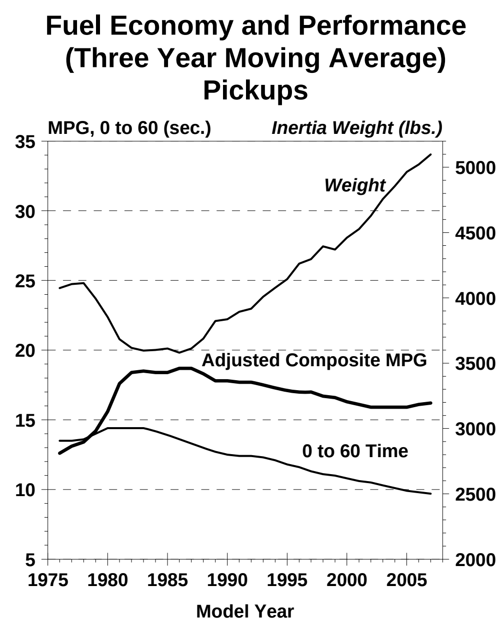



Figure 20

Table 4

**Lowest, Average and Highest Adjusted Fuel Economy by Vehicle Type and Size**

| **Vehicle Type** | **Size** | **1975 Low.** | **1975 Avg.** | **1975 High.** | **1988 Low.** | **1988 Avg.** | **1988 High.** | **2008 Low.** | **2008 Avg.** | **2008 High.** |
|---|---|---|---|---|---|---|---|---|---|---|
| Car | Small | 8.6 | 15.6 | 28.3 | 7.5 | 25.7 | 54.4 | 10.1 | 25.0 | 42.9 |
| | Midsize | 8.6 | 11.6 | 18.4 | 10.5 | 22.6 | 27.7 | 12.0 | 24.9 | 46.2 |
| | Large | 8.4 | 11.2 | 14.6 | 10.0 | 20.6 | 26.0 | 12.1 | 21.6 | 26.1 |
| | All | 8.4 | 13.4 | 28.3 | 7.5 | 24.2 | 54.4 | 10.1 | 24.2 | 46.2 |
| Wagon | Small | 11.8 | 19.1 | 24.1 | 17.1 | 26.3 | 33.2 | 16.2 | 25.2 | 31.3 |
| | Midsize | 8.4 | 11.3 | 25.0 | 17.5 | 22.2 | 27.7 | 14.7 | 21.4 | 24.8 |
| | Large | 8.4 | 10.2 | 12.8 | 19.2 | 19.4 | 19.4 | 17.0 | 17.9 | 21.3 |
| | All | 8.4 | 13.8 | 25.0 | 17.1 | 23.3 | 33.2 | 14.7 | 23.4 | 31.3 |
| Van | Small | 16.2 | 17.5 | 18.5 | 15.5 | 20.6 | 25.0 | | | |
| | Midsize | 8.2 | 11.3 | 18.4 | 11.3 | 18.4 | 23.4 | 14.3 | 19.9 | 23.0 |
| | Large | 8.9 | 10.7 | 14.5 | 9.9 | 14.3 | 16.8 | 14.3 | 16.0 | 17.4 |
| | All | 8.2 | 11.1 | 18.5 | 9.9 | 17.9 | 25.0 | 14.3 | 19.7 | 23.0 |
| SUV | Small | 10.2 | 13.7 | 16.3 | 15.6 | 20.4 | 27.7 | 16.9 | 18.2 | 23.2 |
| | Midsize | 8.2 | 10.2 | 18.4 | 10.2 | 16.5 | 23.6 | 12.7 | 20.0 | 31.5 |
| | Large | 7.9 | 10.3 | 13.7 | 12.2 | 14.0 | 18.8 | 12.2 | 17.2 | 21.5 |
| | All | 7.9 | 11.0 | 18.4 | 10.2 | 17.2 | 27.7 | 12.2 | 18.7 | 31.5 |
| Pickup | Small | 13.0 | 19.2 | 20.8 | 13.3 | 21.0 | 24.6 | | | |
| | Midsize | 17.8 | 17.9 | 18.0 | 15.3 | 21.3 | 25.9 | 15.4 | 19.0 | 23.7 |
| | Large | 7.6 | 11.1 | 18.5 | 9.8 | 15.2 | 21.0 | 13.0 | 16.0 | 21.3 |
| | All | 7.6 | 11.9 | 20.8 | 9.8 | 18.1 | 25.9 | 13.0 | 16.3 | 23.7 |
| All | Cars | 8.4 | 13.5 | 28.3 | 7.5 | 24.1 | 54.4 | 10.1 | 24.1 | 46.2 |
| All | Trucks | 7.6 | 11.6 | 20.8 | 9.8 | 17.9 | 27.7 | 12.2 | 18.1 | 31.5 |
| All | Vehicles | 7.6 | 13.1 | 28.3 | 7.5 | 21.9 | 54.4 | 10.1 | 20.8 | 46.2 |

Table 5

**Percent Change in Lowest, Average and Highest Adjusted Fuel Economy by Vehicle Type and Size**

| Vehicle Type | Size | From 1975 to 2008 Low. | Avg. | High. | From 1975 to 1988 Low. | Avg. | High. | From 1988 to 2008 Low. | Avg. | High. |
|---|---|---|---|---|---|---|---|---|---|---|
| Car | Small | 17% | 60% | 52% | -12% | 65% | 92% | 35% | -2% | -20% |
| | Midsize | 40% | 115% | 151% | 22% | 95% | 51% | 14% | 10% | 67% |
| | Large | 44% | 93% | 79% | 19% | 84% | 78% | 21% | 5% | 0% |
| | All | 20% | 81% | 63% | -10% | 81% | 92% | 35% | 0% | -14% |
| Wagon | Small | 37% | 32% | 30% | 45% | 38% | 38% | -4% | -3% | -5% |
| | Midsize | 75% | 89% | 0% | 108% | 96% | 11% | -15% | -3% | -9% |
| | Large | 102% | 75% | 66% | 129% | 90% | 52% | -10% | -7% | 10% |
| | All | 75% | 70% | 25% | 104% | 69% | 33% | -13% | 0% | -5% |
| Van | Small | | | | -3% | 18% | 35% | | | |
| | Midsize | 74% | 76% | 25% | 38% | 63% | 27% | 27% | 8% | -1% |
| | Large | 61% | 50% | 20% | 11% | 34% | 16% | 44% | 12% | 4% |
| | All | 74% | 77% | 24% | 21% | 61% | 35% | 44% | 10% | -7% |
| SUV | Small | 66% | 33% | 42% | 53% | 49% | 70% | 8% | -10% | -15% |
| | Midsize | 55% | 96% | 71% | 24% | 62% | 28% | 25% | 21% | 33% |
| | Large | 54% | 67% | 57% | 54% | 36% | 37% | 0% | 23% | 14% |
| | All | 54% | 70% | 71% | 29% | 56% | 51% | 20% | 9% | 14% |
| Pickup | Small | | | | 2% | 9% | 18% | | | |
| | Midsize | -12% | 6% | 32% | -13% | 19% | 44% | 1% | -10% | -7% |
| | Large | 71% | 44% | 15% | 29% | 37% | 14% | 33% | 5% | 1% |
| | All | 71% | 37% | 14% | 29% | 52% | 25% | 33% | -9% | -7% |
| All | Cars | 20% | 79% | 63% | -10% | 79% | 92% | 35% | 0% | -14% |
| All | Trucks | 61% | 56% | 51% | 29% | 54% | 33% | 24% | 1% | 14% |
| All | Vehicles | 33% | 59% | 63% | 0% | 67% | 92% | 35% | -4% | -14% |

Cars and light trucks with conventional drivetrains have a fuel consumption and weight relationship which is well known and is shown on Figures 21 and 22. Fuel consumption increases linearly with weight. Because vehicles with different propulsion systems, i.e., diesels and hybrids, occupy a different place on such a fuel consumption and weight plot, the data for hybrid and diesel vehicles are plotted separately and excluded from the regression lines shown on the graphs. At constant weight, MY2008 cars consume about 30 to 40 percent less fuel per mile than their MY1975 counterparts

On this same constant weight basis, this year's cars with diesel engines nominally consume 20-25 percent less fuel than the conventionally powered ones, while this year's hybrid cars are about 30-40 percent better. Similarly, at constant weight this year's conventionally powered trucks achieve about 40 percent better fuel consumption than MY1975 vehicles did.

Figures 23 and 24 show that the relationship between interior volume and fuel consumption is currently not as important as it used to be. The data points on both of these graphs exclude two seaters and represent sales weighted average fuel consumption calculated at increments of 1.0 cu. ft. As was done for Figures 21 and 22, the data points for hybrid and diesel vehicles were plotted separately from that for the conventionally powered vehicles.

Figures 25 and 26 show the improvement that occurred between 1975 and 2007 for fuel consumption as a function of 0-to-60 time for cars and trucks. Figures 27 and 28 compare Ton-MPG data versus 0-to-60 time and show that at constant vehicle performance, there has been substantial improvement in Ton-mpg, particularly for hybrid and diesel vehicles.

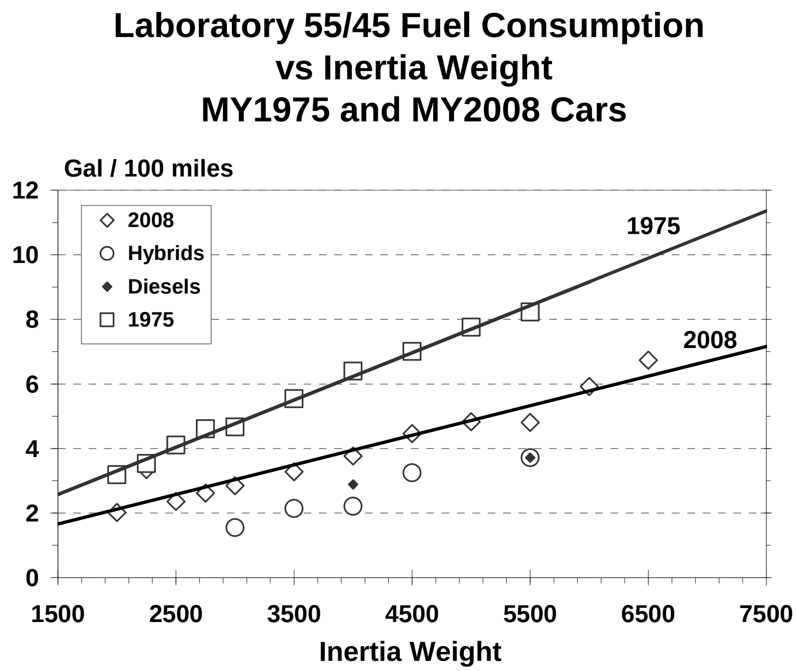



Figure 21

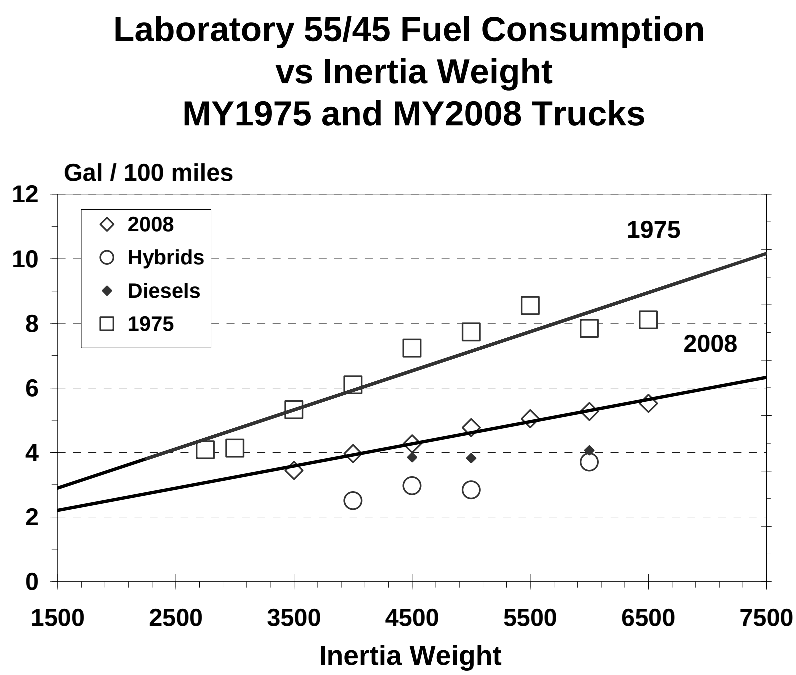



Figure 22

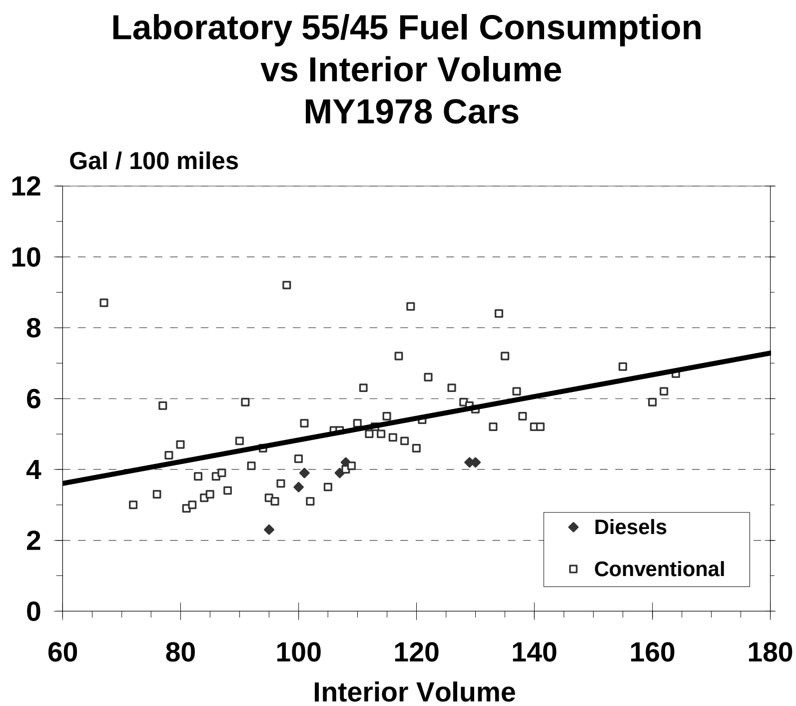



Figure 23

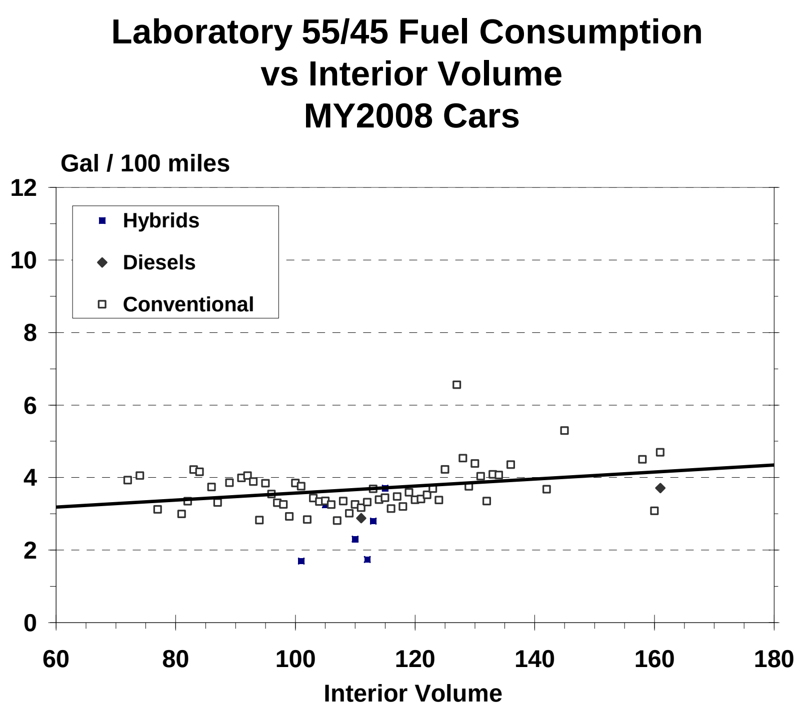



Figure 24

Table 6

**Adjusted Fuel Consumption (Gal./100 miles) by Vehicle Type and Size**

| Vehicle Type | Size | 1975 Low. | 1975 Avg. | 1975 High. | 1988 Low. | 1988 Avg. | 1988 High. | 2008 Low. | 2008 Avg. | 2008 High. |
|---|---|---|---|---|---|---|---|---|---|---|
| Car | Small | 11.6 | 6.4 | 3.5 | 13.3 | 3.9 | 1.8 | 9.9 | 4.0 | 2.3 |
| | Midsize | 11.6 | 8.6 | 5.4 | 9.5 | 4.4 | 3.6 | 8.3 | 4.0 | 2.2 |
| | Large | 11.9 | 8.9 | 6.8 | 10.0 | 4.9 | 3.8 | 8.3 | 4.6 | 3.8 |
| | All | 11.9 | 7.5 | 3.5 | 13.3 | 4.1 | 1.8 | 9.9 | 4.1 | 2.2 |
| Wagon | Small | 8.5 | 5.2 | 4.1 | 5.8 | 3.8 | 3.0 | 6.2 | 4.0 | 3.2 |
| | Midsize | 11.9 | 8.8 | 4.0 | 5.7 | 4.5 | 3.6 | 6.8 | 4.7 | 4.0 |
| | Large | 11.9 | 9.8 | 7.8 | 5.2 | 5.2 | 5.2 | 5.9 | 5.6 | 4.7 |
| | All | 11.9 | 7.2 | 4.0 | 5.8 | 4.3 | 3.0 | 6.8 | 4.3 | 3.2 |
| Van | Small | 6.2 | 5.7 | 5.4 | 6.5 | 4.9 | 4.0 | | | |
| | Midsize | 12.2 | 8.8 | 5.4 | 8.8 | 5.4 | 4.3 | 7.0 | 5.0 | 4.3 |
| | Large | 11.2 | 9.3 | 6.9 | 10.1 | 7.0 | 6.0 | 7.0 | 6.3 | 5.7 |
| | All | 12.2 | 9.0 | 5.4 | 10.1 | 5.6 | 4.0 | 7.0 | 5.1 | 4.3 |
| SUV | Small | 9.8 | 7.3 | 6.1 | 6.4 | 4.9 | 3.6 | 5.9 | 5.5 | 4.3 |
| | Midsize | 12.2 | 9.8 | 5.4 | 9.8 | 6.1 | 4.2 | 7.9 | 5.0 | 3.2 |
| | Large | 12.7 | 9.7 | 7.3 | 8.2 | 7.1 | 5.3 | 8.2 | 5.8 | 4.7 |
| | All | 12.7 | 9.1 | 5.4 | 9.8 | 5.8 | 3.6 | 8.2 | 5.3 | 3.2 |
| Pickup | Small | 7.7 | 5.2 | 4.8 | 7.5 | 4.8 | 4.1 | | | |
| | Midsize | 5.6 | 5.6 | 5.6 | 6.5 | 4.7 | 3.9 | 6.5 | 5.3 | 4.2 |
| | Large | 13.2 | 9.0 | 5.4 | 10.2 | 6.6 | 4.8 | 7.7 | 6.3 | 4.7 |
| | All | 13.2 | 8.4 | 4.8 | 10.2 | 5.5 | 3.9 | 7.7 | 6.1 | 4.2 |
| All | Cars | 11.9 | 7.4 | 3.5 | 13.3 | 4.1 | 1.8 | 9.9 | 4.1 | 2.2 |
| All | Trucks | 13.2 | 8.6 | 4.8 | 10.2 | 5.6 | 3.6 | 8.2 | 5.5 | 3.2 |
| All | Vehicles | 13.2 | 7.6 | 3.5 | 13.3 | 4.6 | 1.8 | 9.9 | 4.8 | 2.2 |

Table 7

**Percent Change* in Adjusted Fuel Consumption by Vehicle Type and Size**

| Vehicle Type | Size | From 1975 to 2008 Low | Avg. | High | From 1975 to 1988 Low | Avg. | High. | From 1988 to 2008 Low | Avg. | High |
|---|---|---|---|---|---|---|---|---|---|---|
| Car | Small | 15% | 38% | 34% | -15% | 39% | 49% | 26% | -3% | -28% |
| | Midsize | 28% | 53% | 59% | 18% | 49% | 33% | 13% | 9% | 39% |
| | Large | 30% | 48% | 44% | 16% | 45% | 44% | 17% | 6% | 0% |
| | All | 17% | 45% | 37% | -12% | 45% | 49% | 26% | 0% | -22% |
| Wagon | Small | 27% | 23% | 22% | 32% | 27% | 27% | -7% | -5% | -7% |
| | Midsize | 43% | 47% | 0% | 52% | 49% | 10% | -19% | -4% | -11% |
| | Large | 50% | 43% | 40% | 56% | 47% | 33% | -13% | -8% | 10% |
| | All | 43% | 40% | 20% | 51% | 40% | 25% | -17% | 0% | -7% |
| Van | Small | -- | -- | -- | -5% | 14% | 26% | -- | -- | -- |
| | Midsize | 43% | 43% | 20% | 28% | 39% | 20% | 20% | 7% | 0% |
| | Large | 38% | 32% | 17% | 10% | 25% | 13% | 31% | 10% | 5% |
| | All | 43% | 43% | 20% | 17% | 38% | 26% | 31% | 9% | -8% |
| SUV | Small | 40% | 25% | 30% | 35% | 33% | 41% | 8% | -12% | -19% |
| | Midsize | 35% | 49% | 41% | 20% | 38% | 22% | 19% | 18% | 24% |
| | Large | 35% | 40% | 36% | 35% | 27% | 27% | 0% | 18% | 11% |
| | All | 35% | 42% | 41% | 23% | 36% | 33% | 16% | 9% | 11% |
| Pickup | Small | -- | -- | -- | 3% | 8% | 15% | -- | -- | -- |
| | Midsize | -16% | 5% | 25% | -16% | 16% | 30% | 0% | -13% | -8% |
| | Large | 42% | 30% | 13% | 23% | 27% | 11% | 25% | 5% | 2% |
| | All | 42% | 27% | 13% | 23% | 35% | 19% | 25% | -11% | -8% |
| All | Cars | 17% | 45% | 37% | -12% | 45% | 49% | 26% | 0% | -22% |
| All | Trucks | 38% | 36% | 33% | 23% | 35% | 25% | 20% | 2% | 11% |
| All | Vehicles | 25% | 37% | 37% | -1% | 39% | 49% | 26% | -4% | -22% |

*Note: A Negative Change indicates that the fuel consumption has increased.

## Laboratory 55/45 Fuel Consumption vs 0 to 60 Time MY1975 and MY2008 Cars

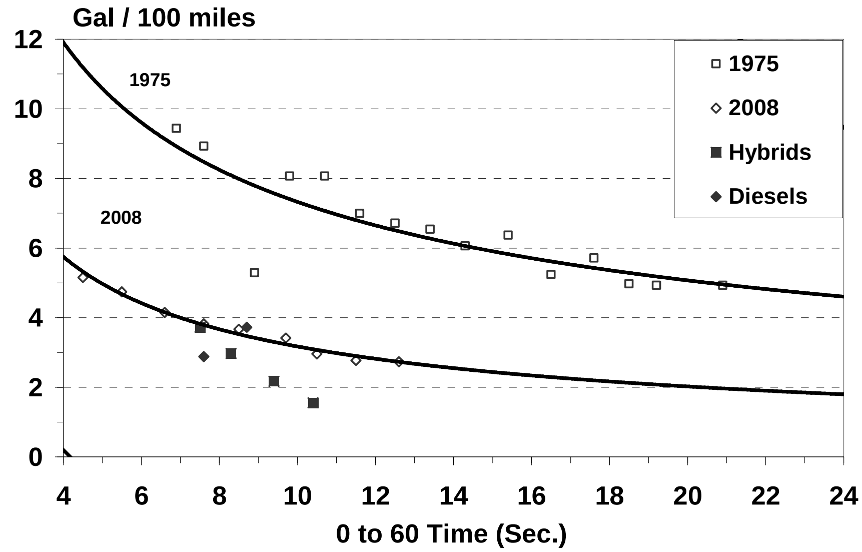



**Figure 25**

## Laboratory 55/45 Fuel Consumption vs 0 to 60 Time MY1975 and MY2008 Trucks

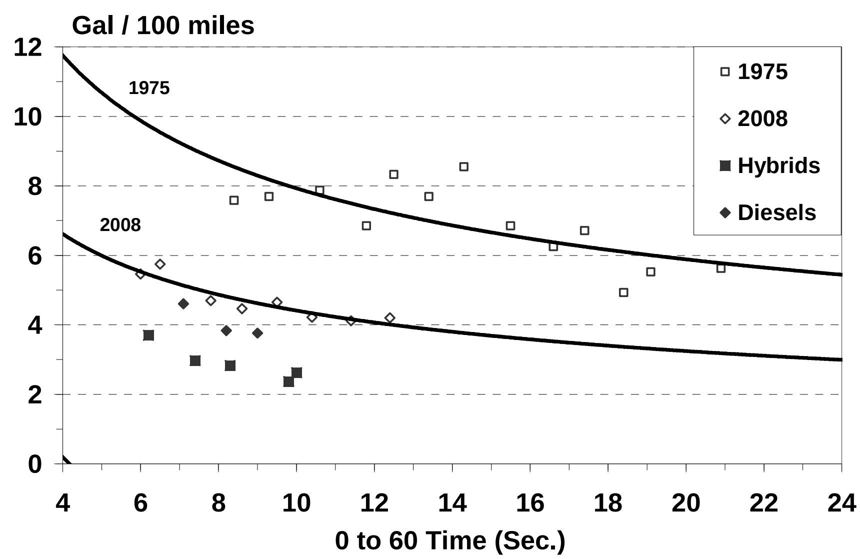



**Figure 26**

## Ton-MPG vs 0 to 60 Time
## MY1975 and MY2008 Cars

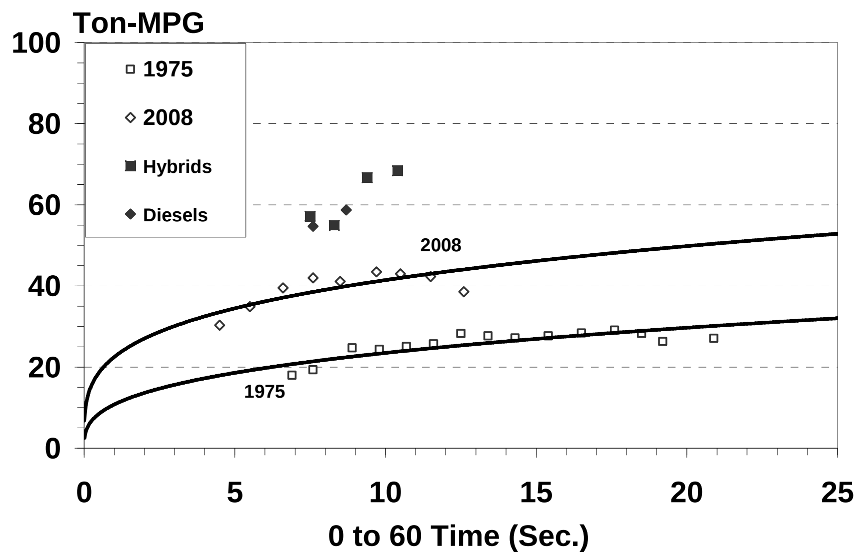



**Figure 27**

## Ton-MPG vs 0 to 60 Time
## MY1975 and MY2008 Trucks

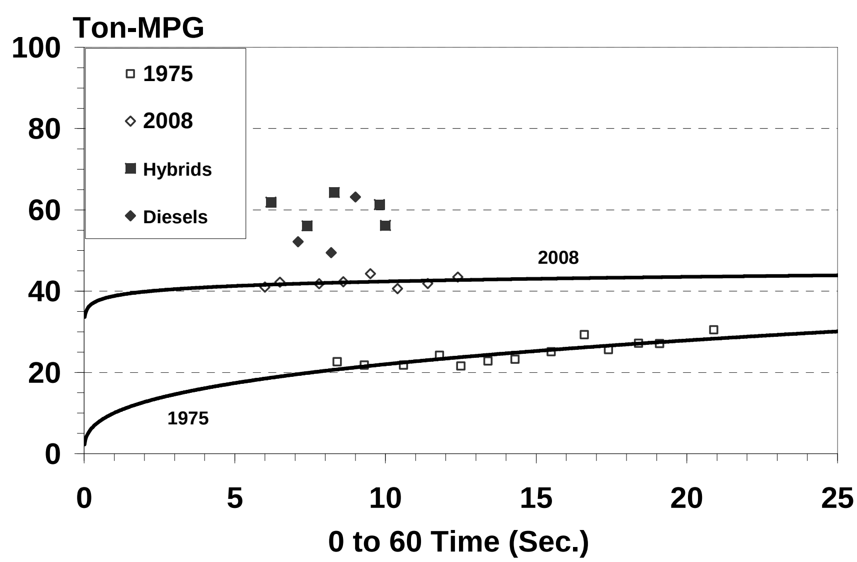



**Figure 28**

Figure 29 and Table 8 show some of the changes in the distribution of inertia weight that have occurred over the years for the light-duty fleet. In 1975, 13 percent of all light-duty vehicles had inertia weights of less than 3000 lb compared to 5 percent in 2007. Since 1988, market share for vehicles with weight of 5000 pounds or more has increased from 3 percent to 21 percent.

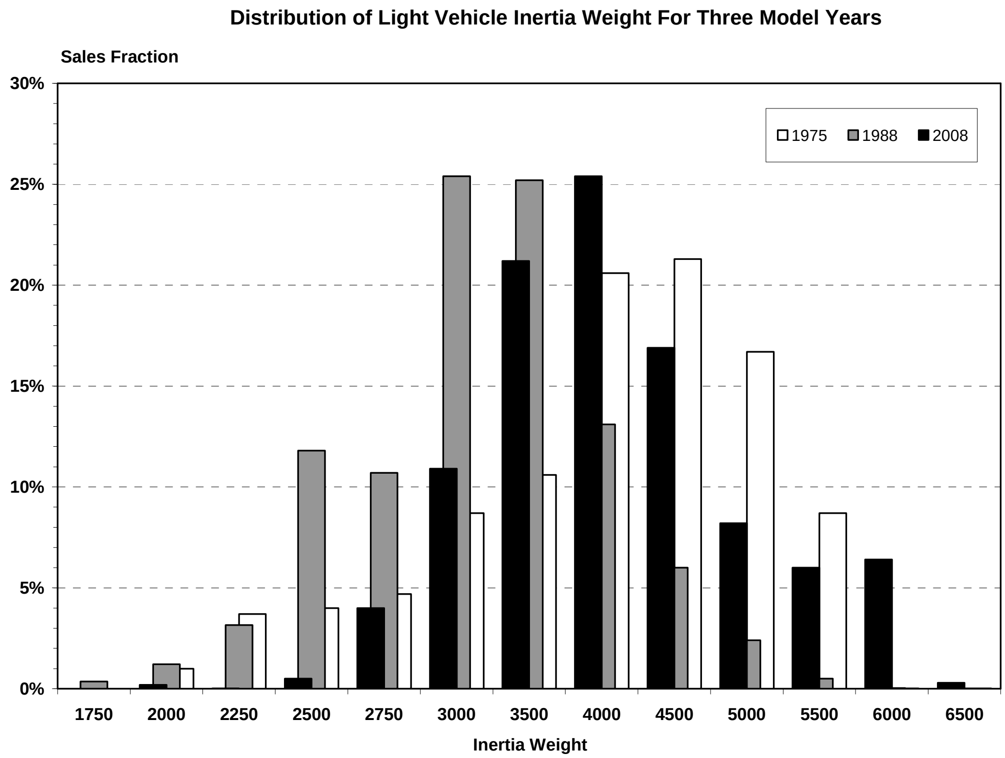



**Figure 29**

Table 8

**Light Vehicle Sales Fraction by Inertia Weight Class for Three Model Years**

| Inertia Weight | <---- 1975 | Model Year 1988 | ----> 2008 |
|---|---|---|---|
| <3000 | 13.4% | 27.2% | 4.7% |
| 3000 | 8.7% | 25.4% | 10.9% |
| 3500 | 10.6% | 25.2% | 21.2% |
| 4000 | 20.6% | 13.2% | 25.4% |
| 4500 | 21.3% | 6.0% | 16.9% |
| 5000 | 16.7% | 2.4% | 8.3% |
| 5500 | 8.7% | .5% | 6.0% |
| >5500 | .0% | .0% | 6.7% |
| Avg Wt. | 4060 | 3283 | 4117 |

Figures 30 through 34 provide an indication of the market share of different weight vehicles within the different classes. Trends within classes are shown which underlie the increasing weight shown by the fleet as a whole. In 1975, about 40 percent of the cars had an inertia weight of 4500 lb or more compared to about 5 percent this year. For MY2008, three weight classes (3000, 3500 and 4000 lbs) account for over 90 percent of all cars. Conversely, the market share of trucks in the inertia weight classes of 4500 lb or more have increased substantially, and these vehicles currently account for over 70 percent of all trucks, compared to about 30 percent in 1975. Figures 32, 33, and 34 provide additional details of the truck data presented in Figure 31 for vans, SUVs, and pickups respectively. Appendixes D, E, and F contain a series of tables describing light-duty vehicles at the vehicle size/type level of stratification in more detail; Appendix G provides similar data by vehicle type and inertia weight class.

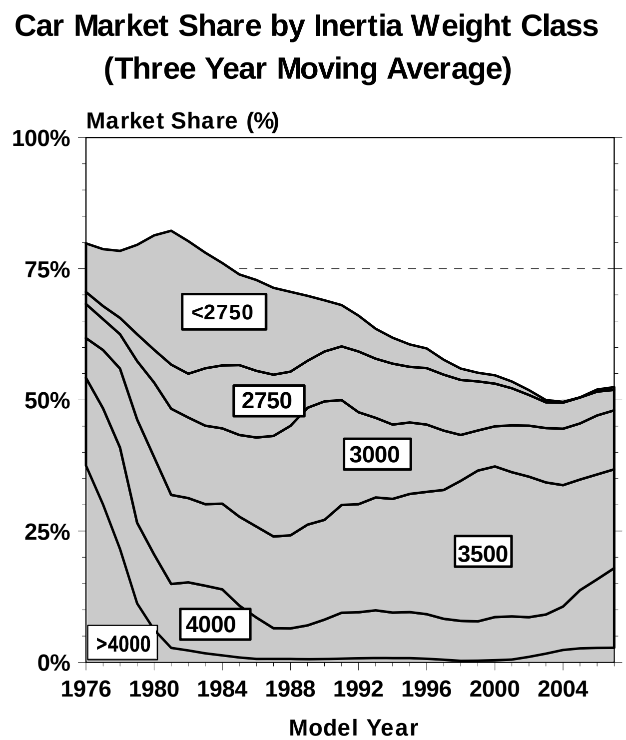


Figure 30

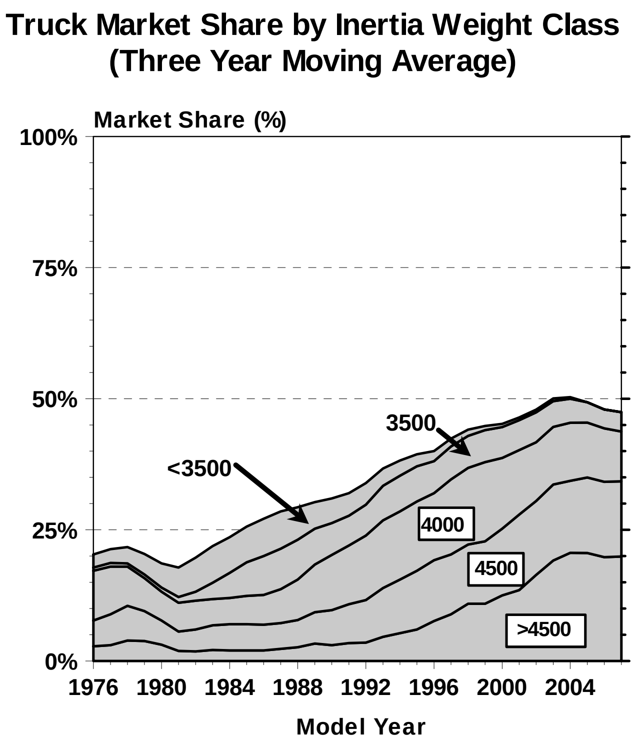


Figure 31

## Van Market Share by Inertia Weight Class (Three Year Moving Average)

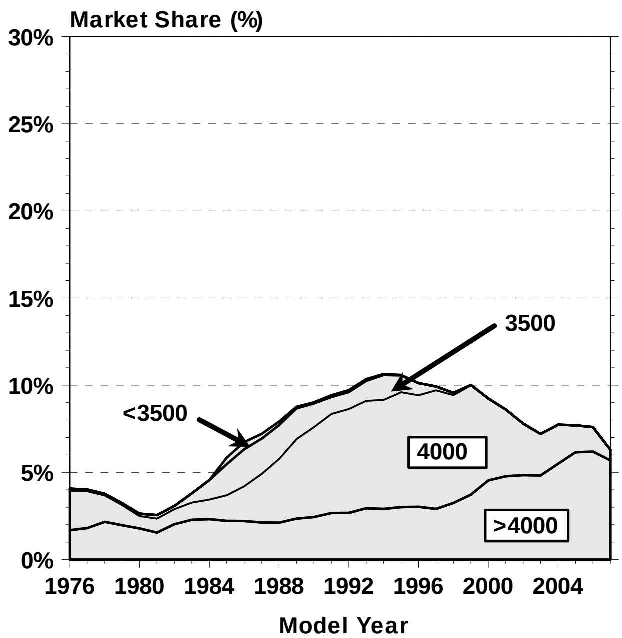



Figure 32

## SUV Market Share by Inertia Weight Class (Three Year Moving Average)

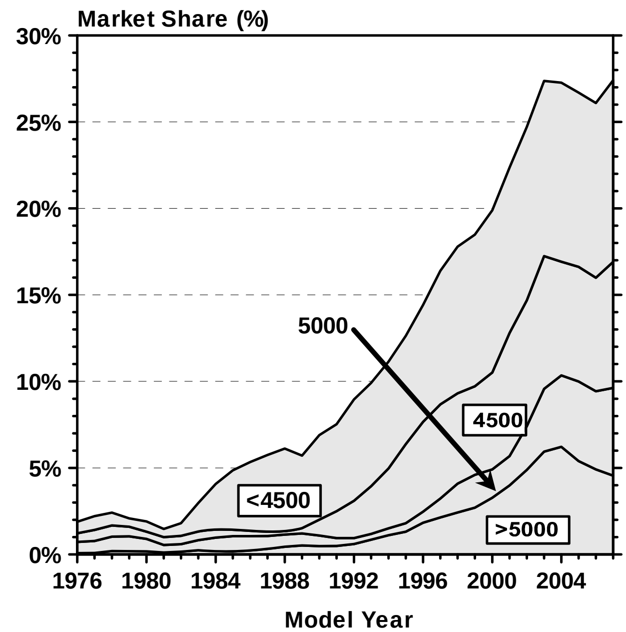



Figure 33

## Pickup Market Share by Inertia Weight Class (Three Year Moving Average)

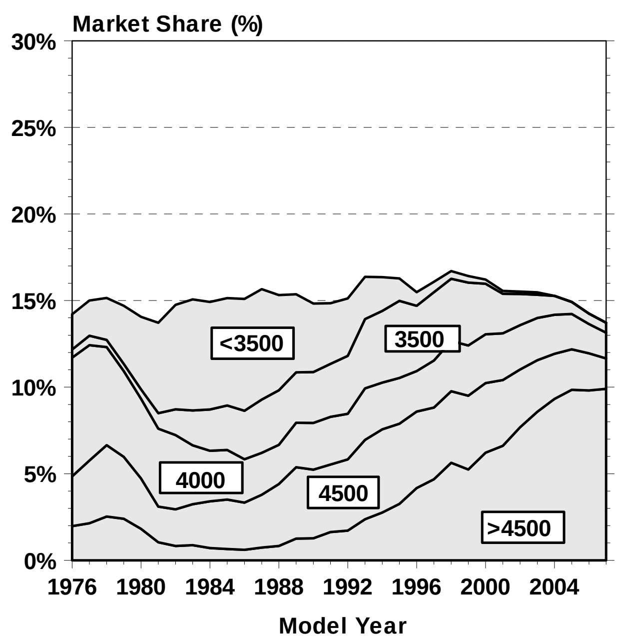



Figure 34

## V. Technology Trends

Table 9 repeats the sales fraction and adjusted composite fuel economy data from Tables 1 and 2 and adds three measures of powertrain information: engine displacement (CID), horsepower (HP), and specific power (HP/CID). This table also includes sales fraction data giving the percent of vehicles that: have front- (FWD) or four-wheel drive (4wd); have manual, lockup, or continuously variable (CVT) transmissions; have port or throttle body fuel injection (TBI) or are Diesels; are equipped with engines that have more than two valves per cylinder; use variable valve timing (VVT); have turbochargers; and use hybrid vehicle technology.

For the overall MY2008 fleet, FWD continues to account for about one-half of the market and 4wd for nearly 30 percent. With transmissions, manuals remain less than 10 percent of the market, while CVTs have grown to 8 percent. Nearly 80 percent of the MY2008 fleet has multi-valve engines, and nearly 60 percent use VVT, both all-time highs. Turbochargers are used on about 2.5 percent of the fleet. Hybrids also represent about 2.5 percent of the fleet, the highest ever, while diesels represent just 0.1 percent of the MY2008 sales. Appendix K contains additional data on fuel metering and number of valves per cylinder.

Table 10 compares technology usage for MY2008 by vehicle type and size. As discussed earlier, wheelbase is used in this report to distinguish whether a truck is small, mid-size, or large, and four EPA car classes (Two-Seater, Minicompact, Compact, and Subcompact) have been combined to form the small car class. For this table, the car classes are separated into cars and station wagons, so that the table stratifies light-duty vehicles into a total of 15 vehicle types and sizes. Note that this table does not contain any data for small vans and small pickups, because none have been produced for several years.

Front-wheel drive (FWD) is used heavily in all of the car classes, in small wagons and in midsize vans. By comparison, none of this year’s pickups or large vans will have front-wheel drive, and it is used less often in SUVs or large vans than in midsize wagons. Conversely, four-wheel drive (4WD) is used heavily in SUVs and pickups. A large portion of the midsize and large wagons also have 4WD, but very little use of it is made in vans and cars.

Manual transmissions are used primarily in small vehicles and midsize pickups. Similarly, usage of engines with more than two valves per cylinder is more prevalent on small and midsize vehicles than on larger ones.

Detailed tabulations of different technology types, including technology usage percentages for other model years, can be found in the Appendixes.

Table 9

**Powertrain Characteristics of 1975 to 2008 Light Duty Vehicles (Percentage Basis)**

Cars

| MODEL YEAR | SALES FRAC | ADJ COMP MPG | ENGINE CID | ENGINE HP | HP/ CID | DRIVETRAIN Front | DRIVETRAIN 4wd | TRANSMISSION Manual | TRANSMISSION Lock | CVT | FUEL GDI | METERING Port | METERING TBI | Dsl | Multi Valve | VVT | Turbo Chrgd | Hybrid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | .806 | 13.5 | 288 | 136 | .515 | 6.5 | | 19.9 | | | | 5.1 | | .2 | | | | |
| 1976 | .788 | 14.9 | 287 | 134 | .502 | 5.8 | | 17.1 | | | | 3.2 | | .3 | | | | |
| 1977 | .800 | 15.6 | 279 | 133 | .516 | 6.8 | | 16.8 | | | | 4.2 | | .5 | | | | |
| 1978 | .773 | 16.9 | 251 | 124 | .538 | 9.6 | | 20.2 | 6.7 | | | 5.1 | | .9 | | | | |
| 1979 | .778 | 17.2 | 238 | 119 | .545 | 11.9 | .3 | 22.3 | 8.0 | | | 4.7 | | 2.1 | | | | |
| 1980 | .835 | 20.0 | 188 | 100 | .583 | 29.7 | .9 | 31.9 | 16.5 | | | 6.2 | .7 | 4.4 | | | | |
| 1981 | .827 | 21.4 | 182 | 99 | .594 | 37.0 | .7 | 30.4 | 33.3 | | | 6.1 | 2.6 | 5.9 | | | | |
| 1982 | .803 | 22.2 | 175 | 99 | .609 | 45.6 | .8 | 29.7 | 51.4 | | | 7.2 | 9.8 | 4.7 | | | | |
| 1983 | .777 | 22.1 | 182 | 104 | .615 | 47.3 | 3.1 | 26.5 | 56.7 | | | 9.5 | 18.9 | 2.1 | | | | |
| 1984 | .761 | 22.4 | 179 | 106 | .637 | 53.7 | 1.0 | 24.1 | 58.3 | | | 15.0 | 24.4 | 1.7 | | | | |
| 1985 | .746 | 23.0 | 177 | 111 | .671 | 61.6 | 2.1 | 22.8 | 58.7 | | | 21.4 | 32.0 | .9 | | | | |
| 1986 | .717 | 23.7 | 167 | 111 | .701 | 71.1 | 1.1 | 24.8 | 58.0 | | | 36.7 | 28.4 | .3 | 4.8 | | | |
| 1987 | .722 | 23.8 | 162 | 112 | .732 | 77.0 | 1.1 | 24.9 | 59.5 | | | 42.5 | 30.5 | .3 | 14.7 | | | |
| 1988 | .702 | 24.1 | 160 | 116 | .759 | 81.7 | .8 | 24.3 | 66.1 | | | 53.7 | 30.0 | | 19.9 | | | |
| 1989 | .693 | 23.7 | 163 | 121 | .783 | 82.5 | 1.0 | 21.0 | 69.3 | .1 | | 62.4 | 27.8 | .0 | 24.4 | | | |
| 1990 | .698 | 23.3 | 163 | 129 | .829 | 84.6 | 1.0 | 19.6 | 72.9 | .0 | | 77.5 | 21.1 | .0 | 33.0 | .6 | | |
| 1991 | .678 | 23.4 | 163 | 132 | .851 | 83.2 | 1.4 | 20.5 | 73.5 | .0 | | 78.0 | 21.8 | .1 | 34.1 | 2.4 | | |
| 1992 | .666 | 23.1 | 170 | 141 | .868 | 80.8 | 1.1 | 17.4 | 76.4 | | | 89.5 | 10.4 | .1 | 35.0 | 4.6 | | |
| 1993 | .640 | 23.5 | 166 | 138 | .865 | 85.1 | 1.2 | 17.8 | 77.0 | | | 91.6 | 8.4 | | 36.7 | 4.8 | | |
| 1994 | .596 | 23.3 | 168 | 143 | .884 | 84.4 | .4 | 16.7 | 79.3 | | | 94.9 | 5.1 | | 41.0 | 8.0 | | |
| 1995 | .620 | 23.4 | 167 | 152 | .945 | 82.0 | 1.2 | 16.3 | 81.9 | | | 98.8 | 1.2 | .1 | 52.2 | 9.8 | | |
| 1996 | .600 | 23.3 | 165 | 154 | .958 | 86.5 | 1.5 | 14.8 | 83.6 | .0 | | 98.8 | 1.1 | .1 | 57.3 | 11.7 | 0.3 | |
| 1997 | .576 | 23.4 | 164 | 156 | .974 | 86.5 | 1.7 | 13.5 | 85.8 | .1 | | 99.1 | .8 | .1 | 58.6 | 11.3 | 0.7 | |
| 1998 | .551 | 23.4 | 164 | 159 | .993 | 87.0 | 2.3 | 12.3 | 87.3 | .1 | | 99.7 | .1 | .2 | 61.4 | 18.4 | 2.4 | |
| 1999 | .551 | 23.0 | 166 | 164 | 1.009 | 87.2 | 2.2 | 10.9 | 88.4 | .0 | | 99.7 | .1 | .2 | 64.6 | 17.1 | 3.3 | |
| 2000 | .551 | 22.9 | 165 | 168 | 1.032 | 84.9 | 2.1 | 11.2 | 87.7 | .0 | | 99.7 | .1 | .2 | 65.1 | 23.4 | 2.3 | .1 |
| 2001 | .539 | 23.0 | 165 | 168 | 1.042 | 84.1 | 3.2 | 11.4 | 87.5 | .2 | | 99.7 | | .3 | 67.2 | 28.3 | 3.6 | .0 |
| 2002 | .515 | 23.1 | 166 | 173 | 1.066 | 84.9 | 3.8 | 11.2 | 88.1 | .4 | | 99.6 | | .4 | 69.9 | 33.9 | 4.2 | .3 |
| 2003 | .504 | 23.2 | 166 | 176 | 1.086 | 81.7 | 3.8 | 11.1 | 87.9 | .9 | | 99.6 | | .4 | 73.5 | 41.2 | 2.1 | .6 |
| 2004 | .480 | 23.1 | 168 | 182 | 1.106 | 80.8 | 5.4 | 10.2 | 88.2 | 1.4 | | 99.7 | | .3 | 77.2 | 44.2 | 4.0 | .9 |
| 2005 | .505 | 23.5 | 166 | 182 | 1.115 | 79.8 | 5.8 | 9.3 | 88.0 | 2.6 | | 99.6 | | .4 | 78.2 | 51.6 | 2.7 | 2.1 |
| 2006 | .529 | 23.3 | 172 | 194 | 1.146 | 75.8 | 5.8 | 9.4 | 88.1 | 2.4 | | 99.4 | | .6 | 80.8 | 60.6 | 3.6 | 1.5 |
| 2007 | .525 | 24.1 | 167 | 190 | 1.150 | 80.4 | 5.6 | 8.7 | 81.6 | 9.7 | | 99.9 | | .1 | 84.6 | 65.5 | 3.9 | 3.4 |
| 2008 | .520 | 24.1 | 168 | 196 | 1.173 | 77.9 | 7.1 | 10.3 | 78.9 | 10.8 | 3.3 | 96.7 | | .0 | 89.2 | 64.1 | 3.8 | 3.7 |

Table 9 (continued)

**Powertrain Characteristics of 1975 to 2008 Light Duty Vehicles (Percentage Basis)**

Trucks

| MODEL YEAR | SALES FRAC | ADJ COMP MPG | ENGINE CID | ENGINE HP | HP/ CID | DRIVETRAIN Front | DRIVETRAIN 4wd | TRANSMISSION Manual | TRANSMISSION Lock | TRANSMISSION CVT | FUEL GDI | METERING Port | METERING TBI | Dsl | Multi Valve | VVT | Turbo Chrgd | Hybrid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | .194 | 11.6 | 311 | 142 | .476 | | 17.1 | 37.0 | | | | | .1 | | | | | |
| 1976 | .212 | 12.2 | 319 | 141 | .458 | | 22.9 | 34.8 | | | | | .1 | | | | | |
| 1977 | .200 | 13.3 | 318 | 147 | .482 | | 23.6 | 32.0 | | | | | .1 | | | | | |
| 1978 | .227 | 12.9 | 314 | 146 | .481 | | 29.0 | 32.4 | | | | | .1 | .8 | | | | |
| 1979 | .222 | 12.5 | 298 | 138 | .486 | | 18.0 | 35.2 | 2.1 | | | | .3 | 1.8 | | | | |
| 1980 | .165 | 15.8 | 248 | 121 | .528 | 1.4 | 25.0 | 53.0 | 24.6 | | | | 1.7 | 3.5 | | | | |
| 1981 | .173 | 17.1 | 247 | 119 | .508 | 1.9 | 20.1 | 51.6 | 31.1 | | | | 1.1 | 5.6 | | | | |
| 1982 | .197 | 17.4 | 243 | 120 | .524 | 1.7 | 20.0 | 45.7 | 33.2 | | | | .7 | 9.3 | | | | |
| 1983 | .223 | 17.8 | 231 | 118 | .543 | 1.4 | 25.8 | 45.9 | 36.1 | | | | .6 | 4.7 | | | | |
| 1984 | .239 | 17.4 | 224 | 118 | .557 | 4.9 | 31.0 | 42.1 | 35.1 | | | 1.9 | .6 | 2.3 | | | | |
| 1985 | .254 | 17.5 | 224 | 124 | .586 | 7.1 | 30.6 | 37.1 | 42.2 | | | 8.7 | 3.5 | 1.1 | | | | |
| 1986 | .283 | 18.2 | 211 | 123 | .621 | 5.9 | 30.3 | 42.7 | 42.0 | | | 21.8 | 18.7 | .7 | | | | |
| 1987 | .278 | 18.3 | 210 | 131 | .654 | 7.4 | 31.5 | 39.9 | 44.8 | | | 33.3 | 33.6 | .3 | | | | |
| 1988 | .298 | 17.9 | 227 | 141 | .650 | 9.0 | 33.3 | 35.5 | 53.1 | | | 43.3 | 44.4 | .2 | | | | |
| 1989 | .307 | 17.6 | 234 | 146 | .653 | 9.9 | 32.0 | 32.7 | 56.8 | | | 45.9 | 47.6 | .2 | | | | |
| 1990 | .302 | 17.4 | 237 | 151 | .668 | 15.5 | 31.3 | 28.1 | 67.4 | | | 55.2 | 40.8 | .2 | | | | |
| 1991 | .322 | 17.8 | 228 | 150 | .681 | 9.7 | 35.3 | 31.0 | 67.4 | | | 55.0 | 43.2 | .1 | | | | |
| 1992 | .334 | 17.4 | 234 | 155 | .685 | 13.6 | 31.4 | 27.3 | 71.5 | | | 65.9 | 32.5 | .1 | | | | |
| 1993 | .360 | 17.5 | 235 | 162 | .710 | 15.1 | 29.4 | 23.3 | 75.7 | | | 73.4 | 25.7 | | | | | |
| 1994 | .404 | 17.2 | 239 | 166 | .717 | 13.1 | 36.9 | 23.5 | 75.1 | | | 77.2 | 22.5 | | 5.6 | | | |
| 1995 | .380 | 17.0 | 244 | 168 | .715 | 17.7 | 40.7 | 20.5 | 78.6 | | | 79.8 | 20.2 | | 8.4 | | | |
| 1996 | .400 | 17.2 | 243 | 179 | .757 | 20.1 | 37.1 | 15.6 | 83.5 | | | 99.9 | | .1 | 12.4 | | | |
| 1997 | .424 | 17.0 | 248 | 187 | .775 | 13.9 | 43.2 | 14.6 | 85.0 | | | 100.0 | | .0 | 13.7 | | | |
| 1998 | .449 | 17.1 | 242 | 187 | .795 | 18.7 | 42.0 | 13.4 | 86.0 | | | 100.0 | | .0 | 15.8 | | | |
| 1999 | .449 | 16.7 | 249 | 197 | .814 | 17.4 | 44.6 | 9.1 | 90.5 | | | 100.0 | | | 17.3 | | | |
| 2000 | .449 | 16.9 | 242 | 197 | .832 | 19.4 | 42.4 | 8.0 | 91.7 | | | 100.0 | | | 19.9 | 4.7 | | |
| 2001 | .461 | 16.7 | 243 | 209 | .882 | 18.5 | 43.8 | 6.3 | 93.4 | | | 100.0 | | | 27.6 | 9.3 | | |
| 2002 | .485 | 16.7 | 244 | 219 | .918 | 18.5 | 47.6 | 4.9 | 94.7 | .0 | | 100.0 | | | 35.6 | 16.2 | | |
| 2003 | .496 | 16.9 | 243 | 221 | .927 | 19.2 | 46.5 | 4.8 | 93.7 | 1.2 | | 100.0 | | | 37.2 | 19.8 | 0.2 | |
| 2004 | .520 | 16.7 | 252 | 236 | .953 | 17.2 | 52.3 | 3.7 | 95.0 | 1.0 | | 100.0 | | | 48.4 | 31.6 | 0.8 | |
| 2005 | .495 | 17.2 | 244 | 237 | .983 | 25.7 | 48.3 | 3.0 | 95.0 | 2.0 | | 99.9 | | .1 | 52.8 | 39.8 | 0.6 | .1 |
| 2006 | .471 | 17.5 | 240 | 235 | .992 | 25.1 | 48.4 | 3.2 | 93.5 | 3.3 | | 99.9 | | .1 | 61.4 | 49.6 | 0.5 | 1.4 |
| 2007 | .475 | 17.7 | 245 | 248 | 1.031 | 24.8 | 48.9 | 2.5 | 94.1 | 3.4 | | 99.9 | | .1 | 56.3 | 47.9 | 1.3 | .9 |
| 2008 | .480 | 18.1 | 240 | 251 | 1.060 | 26.6 | 50.2 | 2.7 | 92.7 | 4.6 | 1.2 | 98.5 | | .2 | 64.5 | 50.8 | 1.0 | 1.2 |

Table 9 (continued)

**Powertrain Characteristics of 1975 to 2008 Light Duty Vehicles (Percentage Basis)**

Cars and Trucks

| MODEL YEAR | SALES FRAC | ADJ COMP MPG | ENGINE CID | ENGINE HP | HP/ CID | DRIVETRAIN Front | DRIVETRAIN 4wd | TRANSMISSION Manual | TRANSMISSION Lock | TRANSMISSION CVT | FUEL GDI | METERING Port | METERING TBI | METERING Dsl | Multi Valve | VVT | Turbo Chrgd | Hybrid |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1975 | 1.000 | 13.1 | 293 | 137 | .507 | 5.3 | 3.3 | 23.2 | | | | 4.1 | | .2 | | | | |
| 1976 | 1.000 | 14.2 | 294 | 135 | .493 | 4.6 | 4.8 | 20.9 | | | | 2.5 | .0 | .2 | | | | |
| 1977 | 1.000 | 15.1 | 287 | 136 | .510 | 5.5 | 4.7 | 19.8 | | | | 3.4 | .0 | .4 | | | | |
| 1978 | 1.000 | 15.8 | 266 | 129 | .525 | 7.4 | 6.6 | 23.0 | 5.2 | | | 3.9 | .0 | .9 | | | | |
| 1979 | 1.000 | 15.9 | 252 | 124 | .532 | 9.2 | 4.3 | 25.1 | 6.7 | | | 3.7 | .1 | 2.0 | | | | |
| 1980 | 1.000 | 19.2 | 198 | 104 | .574 | 25.0 | 4.9 | 35.4 | 17.8 | | | 5.2 | .8 | 4.3 | | | | |
| 1981 | 1.000 | 20.5 | 193 | 102 | .580 | 31.0 | 4.0 | 34.1 | 33.0 | | | 5.1 | 2.4 | 5.9 | | | | |
| 1982 | 1.000 | 21.1 | 188 | 103 | .593 | 37.0 | 4.6 | 32.8 | 47.8 | | | 5.8 | 8.0 | 5.6 | | | | |
| 1983 | 1.000 | 21.0 | 193 | 107 | .599 | 37.0 | 8.1 | 30.8 | 52.1 | | | 7.3 | 14.8 | 2.7 | | | | |
| 1984 | 1.000 | 21.0 | 190 | 109 | .618 | 42.1 | 8.2 | 28.4 | 52.8 | | | 11.9 | 18.7 | 1.8 | | | | |
| 1985 | 1.000 | 21.3 | 189 | 114 | .650 | 47.8 | 9.3 | 26.5 | 54.5 | | | 18.2 | 24.8 | .9 | | | | |
| 1986 | 1.000 | 21.8 | 180 | 114 | .678 | 52.6 | 9.3 | 29.8 | 53.5 | | | 32.5 | 25.7 | .4 | | | | |
| 1987 | 1.000 | 22.0 | 175 | 118 | .710 | 57.7 | 9.6 | 29.1 | 55.4 | | | 39.9 | 31.4 | .3 | | | | |
| 1988 | 1.000 | 21.9 | 180 | 123 | .726 | 60.0 | 10.5 | 27.6 | 62.2 | | | 50.6 | 34.3 | .1 | | | | |
| 1989 | 1.000 | 21.4 | 185 | 129 | .743 | 60.2 | 10.5 | 24.6 | 65.5 | .1 | | 57.3 | 33.9 | .1 | | | | |
| 1990 | 1.000 | 21.2 | 185 | 135 | .781 | 63.8 | 10.1 | 22.2 | 71.2 | .0 | | 70.8 | 27.0 | .1 | | | | |
| 1991 | 1.000 | 21.2 | 184 | 138 | .796 | 59.6 | 12.3 | 23.9 | 71.6 | .0 | | 70.6 | 28.7 | .1 | | | | |
| 1992 | 1.000 | 20.8 | 191 | 145 | .807 | 58.4 | 11.2 | 20.7 | 74.8 | | | 81.6 | 17.8 | .1 | | | | |
| 1993 | 1.000 | 20.9 | 191 | 147 | .809 | 59.9 | 11.3 | 19.8 | 76.5 | | | 85.0 | 14.6 | | | | | |
| 1994 | 1.000 | 20.4 | 197 | 152 | .816 | 55.6 | 15.2 | 19.5 | 77.6 | | | 87.7 | 12.1 | | 26.7 | | | |
| 1995 | 1.000 | 20.5 | 196 | 158 | .857 | 57.6 | 16.2 | 17.9 | 80.7 | | | 91.6 | 8.4 | .0 | 35.6 | | | |
| 1996 | 1.000 | 20.4 | 197 | 164 | .878 | 60.0 | 15.7 | 15.1 | 83.5 | | | 99.3 | .7 | .1 | 39.3 | | 0.2 | |
| 1997 | 1.000 | 20.1 | 199 | 169 | .890 | 55.8 | 19.3 | 14.0 | 85.5 | .0 | | 99.5 | .5 | .1 | 39.6 | | 0.4 | |
| 1998 | 1.000 | 20.1 | 199 | 171 | .904 | 56.4 | 20.1 | 12.8 | 86.7 | .0 | | 99.8 | .1 | .1 | 40.9 | | 1.4 | |
| 1999 | 1.000 | 19.7 | 203 | 179 | .921 | 55.8 | 21.3 | 10.1 | 89.4 | .0 | | 99.9 | .1 | .1 | 43.4 | | 1.8 | |
| 2000 | 1.000 | 19.8 | 200 | 181 | .942 | 55.5 | 20.2 | 9.7 | 89.5 | .0 | | 99.8 | .0 | .1 | 44.8 | 15.0 | 1.3 | |
| 2001 | 1.000 | 19.6 | 201 | 187 | .968 | 53.8 | 21.9 | 9.0 | 90.2 | .1 | | 99.9 | | .1 | 49.0 | 19.6 | 2.0 | |
| 2002 | 1.000 | 19.4 | 203 | 195 | .994 | 52.7 | 25.0 | 8.1 | 91.3 | .2 | | 99.8 | | .2 | 53.3 | 25.3 | 2.2 | |
| 2003 | 1.000 | 19.6 | 204 | 199 | 1.007 | 50.7 | 25.0 | 8.0 | 90.8 | 1.1 | | 99.8 | | .2 | 55.5 | 30.6 | 1.2 | |
| 2004 | 1.000 | 19.3 | 212 | 211 | 1.026 | 47.7 | 29.8 | 6.8 | 91.8 | 1.2 | | 99.9 | | .1 | 62.3 | 37.6 | 2.3 | .5 |
| 2005 | 1.000 | 19.9 | 205 | 209 | 1.049 | 53.0 | 26.8 | 6.2 | 91.4 | 2.3 | | 99.7 | | .3 | 65.6 | 45.8 | 1.7 | 1.1 |
| 2006 | 1.000 | 20.1 | 204 | 213 | 1.073 | 51.9 | 25.8 | 6.5 | 90.6 | 2.8 | | 99.6 | | .4 | 71.7 | 55.4 | 2.1 | 1.5 |
| 2007 | 1.000 | 20.6 | 204 | 218 | 1.094 | 54.0 | 26.1 | 5.8 | 87.5 | 6.7 | | 99.9 | | .1 | 71.2 | 57.2 | 2.6 | 2.2 |
| 2008 | 1.000 | 20.8 | 203 | 222 | 1.119 | 53.3 | 27.8 | 6.7 | 85.5 | 7.8 | 2.3 | 97.6 | | .1 | 77.4 | 57.7 | 2.5 | 2.5 |

Table 10

**MY2008 Technology Usage by Vehicle Type and Size**
**(Percent of Vehicle Type/Size Strata)**

| Vehicle Type | Size | Front Wheel Drive | Four Wheel Drive | Manual Trans% | Multi-Valve | Variable Valve |
|---|---|---|---|---|---|---|
| Car | Small | 74% | 6% | 19% | 93 | 64% |
| | Midsize | 86% | 6% | 4% | 92 | 73% |
| | Large | 72% | 4% | 1% | 72 | 57% |
| | All | 78% | 6% | 10% | 88% | 66% |
| Wagon | Small | 90% | 10% | 23% | 100 | 58% |
| | Midsize | 33% | 52% | 6% | 100 | 23% |
| | Large | 54% | 42% | | 86 | 1% |
| | All | 74% | 22% | 17% | 99% | 45% |
| Van | Small | 0% | 0% | 0% | 0 | 0% |
| | Midsize | 96% | 3% | | 76 | 45% |
| | Large | | 20% | | 0 | |
| | All | 93% | 4% | | 74% | 44% |
| SUV | Small | | 89% | 28% | 23 | 2% |
| | Midsize | 32% | 59% | 2% | 85 | 63% |
| | Large | 20% | 58% | 0% | 61 | 53% |
| | All | 26% | 59% | 2% | 73% | 57% |
| Pickup | Small | 0% | 0% | 0% | 0 | 0% |
| | Midsize | | 28% | 26% | 70 | 53% |
| | Large | | 52% | 2% | 37 | 53% |
| | All | | 49% | 5% | 41% | 40% |

Figures 35 through 39 show trends in drive use for the five vehicle classes. Cars used to be nearly all rear-wheel drive; from 1988 to 2004 they were over 80 percent front-wheel drive with a small four-wheel (4WD) drive fraction. In recent years, there has been an increase in the use of rear wheel drive from less than 12 percent in 1998 to 16 percent this year, and a slight increase in the use of four wheel drive in cars with use of this technology increasing from about 2 percent in the late 1990s to 6 percent this year. Only a small percentage of wagons still have rear-wheel drive, but in recent years they have made substantial use of 4WD.

The trend towards increased use of front wheel drive for vans is very similar to that for cars, except it started a few years later and appears to be continuing. Over 90 percent of vans currently use front-wheel drive, compared to essentially none before 1984. SUVs are mostly 4WD; but a trend toward front-wheel drive SUVs started in MY2000. Pickups remain the bastion of rear-wheel drive with the increasing amount of 4WD the only other drive option. Except for a brief period in the early 1980s, front-wheel drive has not been used in pickups.

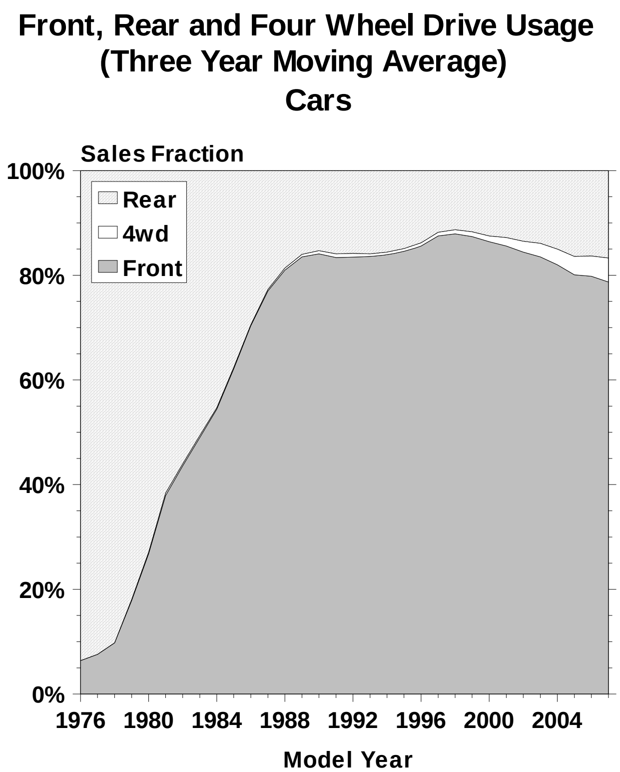



Figure 35

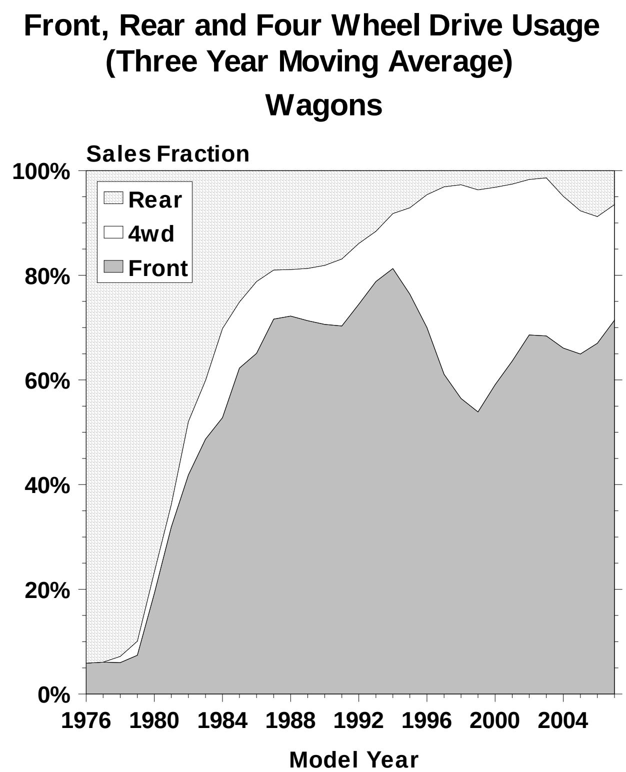



Figure 36

**Front, Rear and Four Wheel Drive Usage (Three Year Moving Average)**

**Vans**

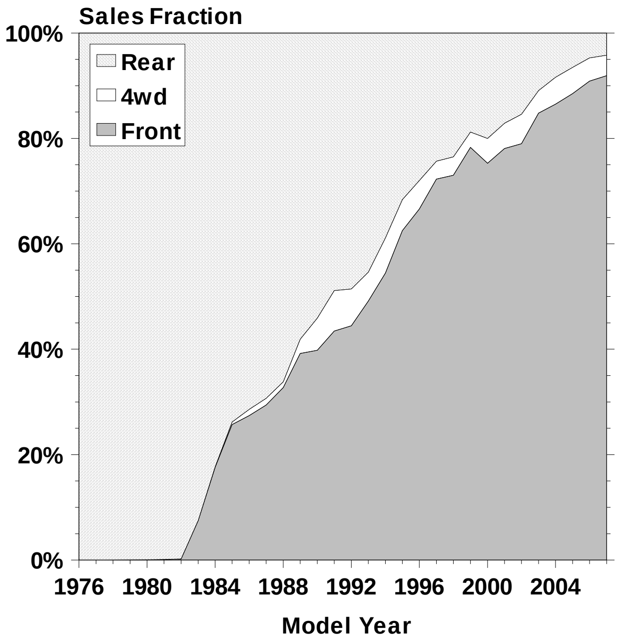



Figure 37

**Front, Rear and Four Wheel Drive Usage (Three Year Moving Average)**

**SUVs**

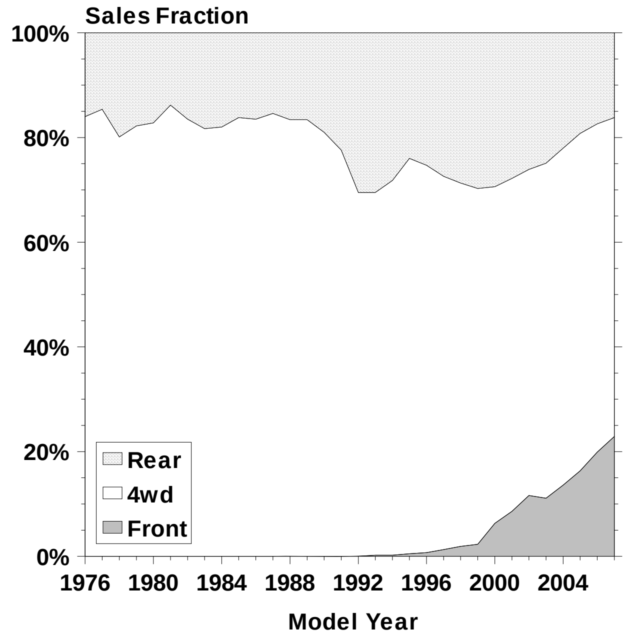



Figure 38

**Front, Rear and Four Wheel Drive Usage (Three Year Moving Average)**

**Pickups**

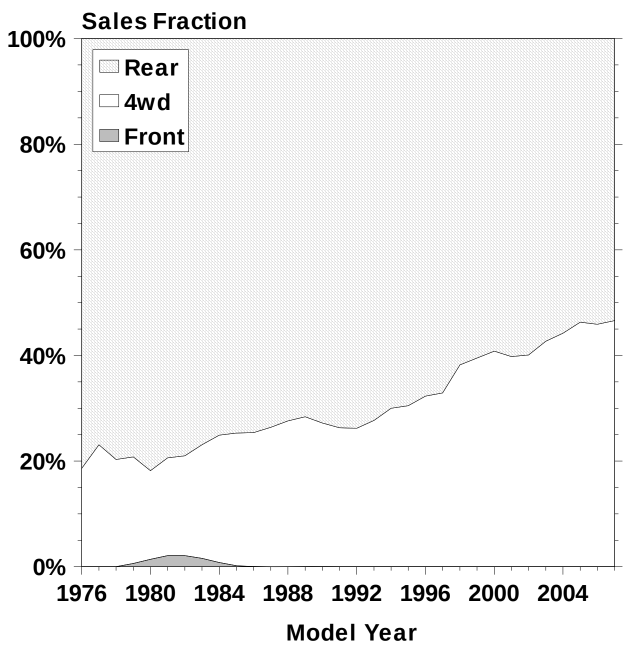



Figure 39

The increasing trend in Ton-MPG shown in Table 1 can be attributed to better vehicle design, including more efficient engines, better transmission designs, and better matching of the engine and transmission. Powertrains are matched to the load better when the engine operates closer to its best efficiency point more of the time. For many conventional engines, this point is approximately 2000 RPM and 2/3 of the maximum torque at that speed. One way to make the engine operate more closely to its best efficiency point is to increase the number of gears in the transmission and, for automatic transmissions, employing a lockup torque converter. Three important changes in transmission design have occurred in recent years:

1) the use of additional gears for both automatic and manual transmissions,

2) for the automatics, conversion to lockup (L3, L4, L5, L6 and now L7) torque converter transmissions, and

3) the use of continuously variable transmissions (CVTs).

Table 11 compares Ton-MPG by transmission and vehicle type for 1988, the peak year for passenger car fuel economy, and this year. In 1988, every transmission type shown in the table achieved less than 40 Ton-MPG. This year, nearly every transmission type achieves at least 40 Ton-MPG. Figures 40 to 43 indicate that the L4 transmission is losing its position as the predominant transmission type for all vehicle classes. Use of the L4 transmission for cars peaked at about 80 percent in 1999 and is now down to about 40 percent. Similarly, its use peaked at over 90 percent in 1996 for SUVs and has dropped below the 40 percent level. Over half of this year's pickups will still have L4 transmissions, as will about 50 percent of the vans. Where manual transmissions are used, the 5-speed (M5) transmission now predominates.

Transmissions alter the ratio of engine speed to drive wheel speed. In conventional transmissions, this speed ratio is limited to a fixed number of discrete values, but for a CVT, the ratio is continuous. These transmissions differ from conventional automatic transmissions and manual transmissions in that CVTs do not have a fixed number of gears with the advantage that the engine speed/drive wheel speed ratio can be altered to enhance vehicle performance or fuel economy in ways not available with conventional transmissions.

More data stratified by transmission type can be found in Appendix I.

## Transmission Sales Fraction (Three Year Moving Average) Cars

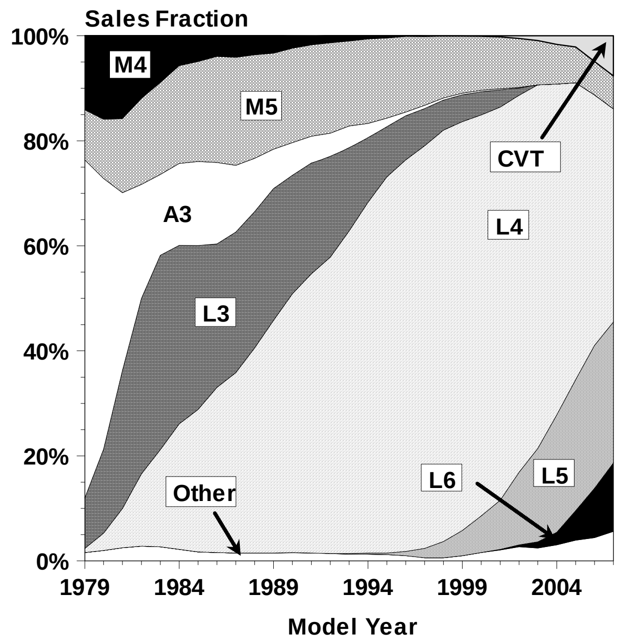



Figure 40

## Transmission Sales Fraction (Three Year Moving Average) Vans

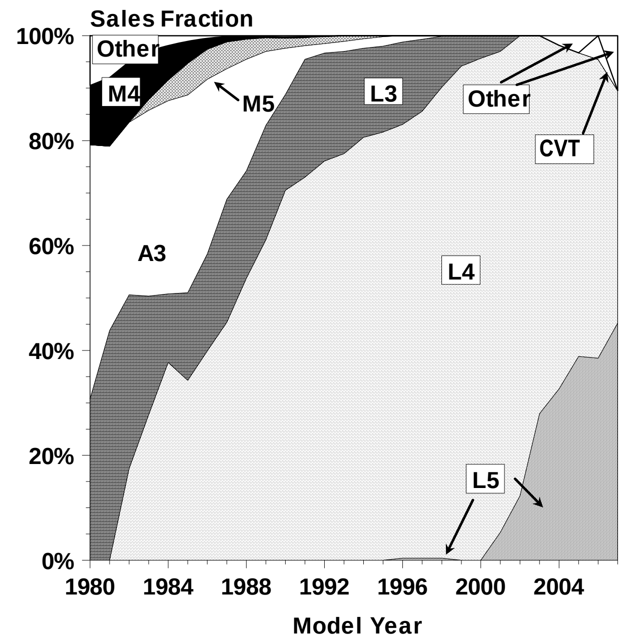



Figure 41

## Transmission Sales Fraction (Three Year Moving Average) SUVs

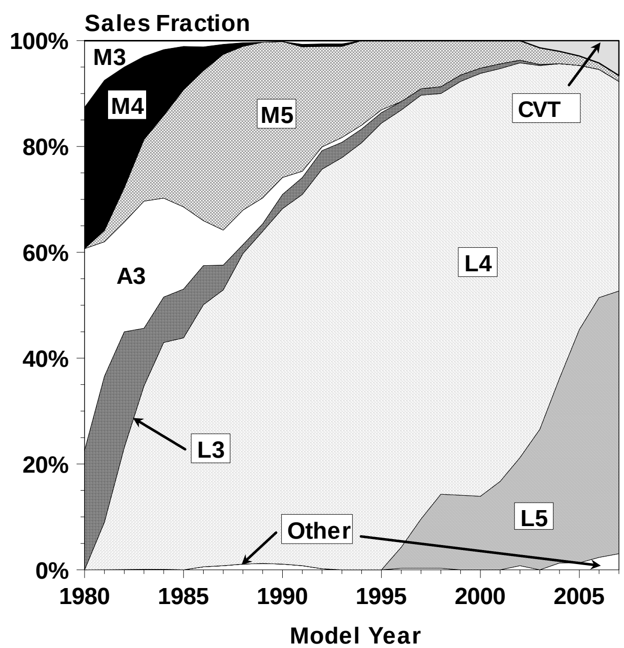



Figure 42

## Transmission Sales Fraction (Three Year Moving Average) Pickups

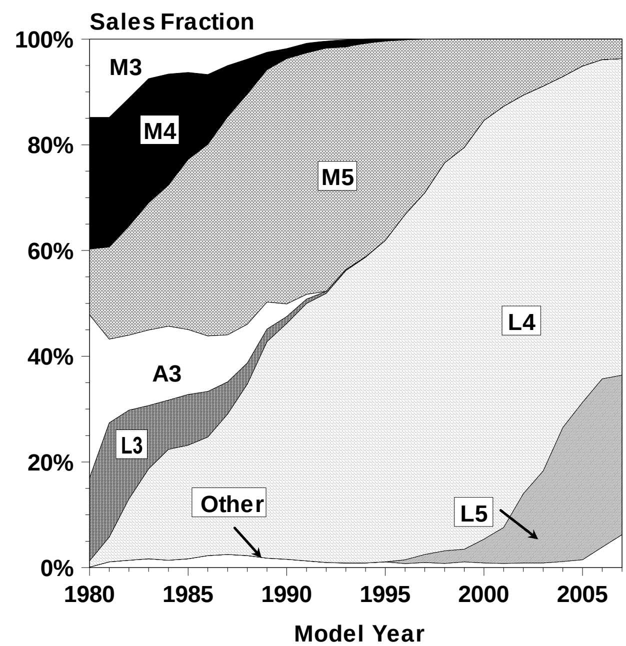



Figure 43

Table 11

**Ton-MPG by Transmission and Vehicle Type**

**(Conventionally Powered Vehicles)**

| | Car | | Van | | SUV | | Pickup | |
|---|---|---|---|---|---|---|---|---|
| **Trans** | **1988** | **2008** | **1988** | **2008** | **1988** | **2008** | **1988** | **2008** |
| M4 | 37.0 | -- | 33.6 | -- | 38.0 | -- | 32.4 | -- |
| M5 | 37.7 | 40.9 | 37.7 | -- | 33.1 | 41.9 | 35.3 | 39.6 |
| M6 | -- | 39.2 | -- | -- | -- | 36.4 | -- | 38.5 |
| CVT | -- | 44.3 | -- | -- | -- | 42.5 | -- | -- |
| L3 | 36.1 | -- | 37.1 | -- | 33.5 | -- | 31.4 | -- |
| L4 | 37.9 | 41.7 | 36.6 | 44.7 | 33.8 | 42.0 | 33.8 | 43.5 |
| L5 | -- | 43.4 | -- | 45.5 | -- | 41.7 | -- | 40.2 |
| L6 | -- | 42.8 | -- | 44.8 | -- | 44.2 | -- | 44.4 |

Table 12 and Figures 44 through 47 compare horsepower (HP), displacement (CID), and specific power or horsepower per cubic inch (HP/CID) for cars, vans, SUVs, and pickups. For all four vehicle types, significant CID reductions occurred in the late 1970s and early 1980s. Engine displacement has been flat for cars and vans since the mid-1980s and has been flat for SUVs since the mid-1990s, but has been increasing for two decades for pickups. Average horsepower has increased substantially for all of these vehicle types since 1981 with the highest increase occurring for pickups whose HP is now more than double what it was then (i.e., 283 versus 115 HP). Light-duty vehicle engines, thus, have also improved in specific power with the highest specific power being for engines used in passenger cars.

Table 12

**MY2008 Engine Characteristics by Vehicle Type**

| **Vehicle Type** | **HP** | **CID** | **HP/ CID** | **Multi-Valve** | **Variable Valve** | **Cylinder Deactivation** |
|---|---|---|---|---|---|---|
| Car | 196 | 168 | 1.17 | 89% | 64% | 3% |
| Van | 224 | 220 | 1.02 | 74% | 44% | 12% |
| SUV | 242 | 222 | 1.11 | 73% | 57% | 9% |
| Pickup | 283 | 291 | 0.97 | 41% | 40% | 22% |
| All | 222 | 203 | 1.12 | 77% | 58% | 7% |

**Car Horsepower, CID and Horsepower per CID (Three Year Moving Average)**

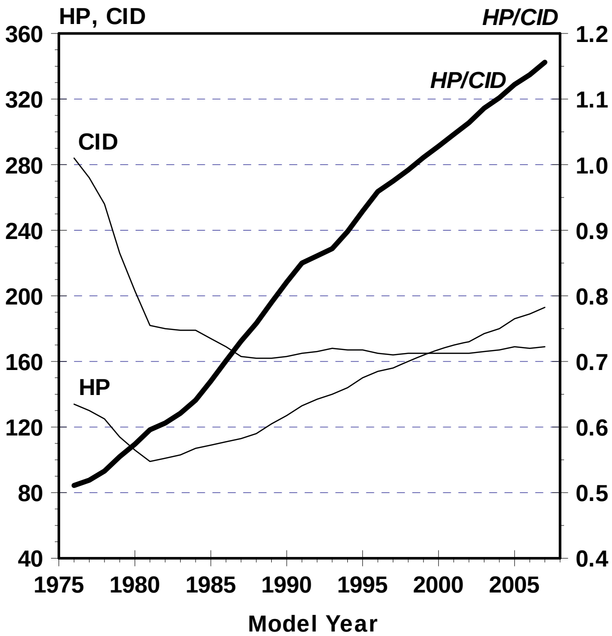



Figure 44

**Van Horsepower, CID and Horsepower per CID (Three Year Moving Average)**

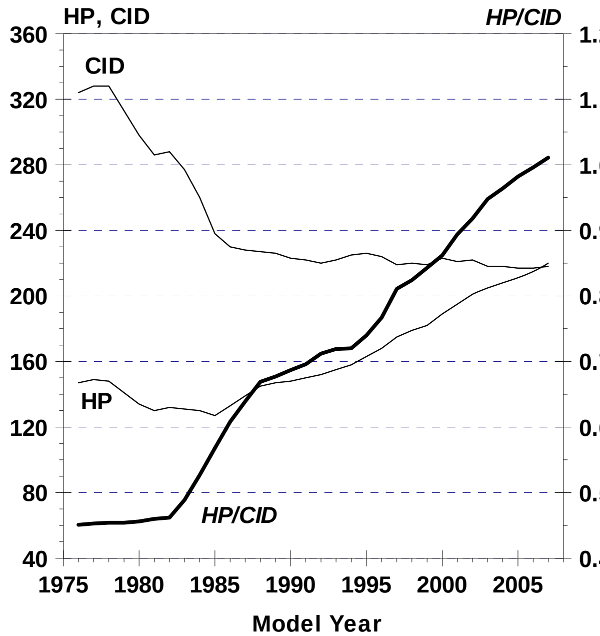



Figure 45

**SUV Horsepower, CID and Horsepower per CID (Three Year Moving Average)**

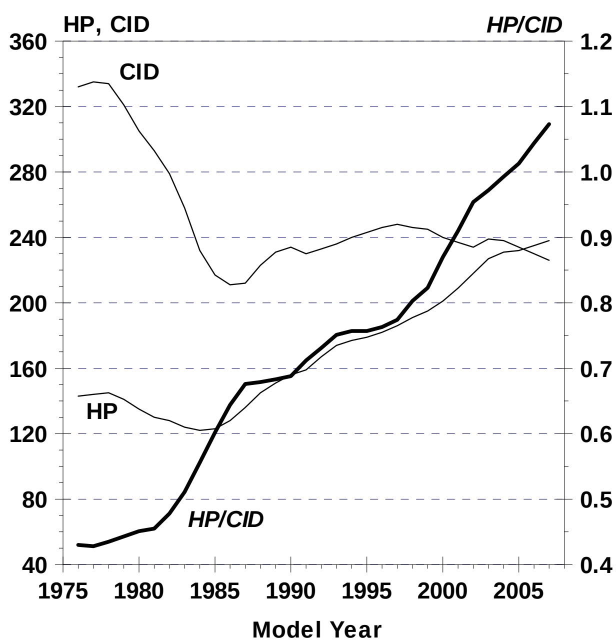



Figure 46

**Pickup Horsepower, CID and Horsepower per CID (Three Year Moving Average)**

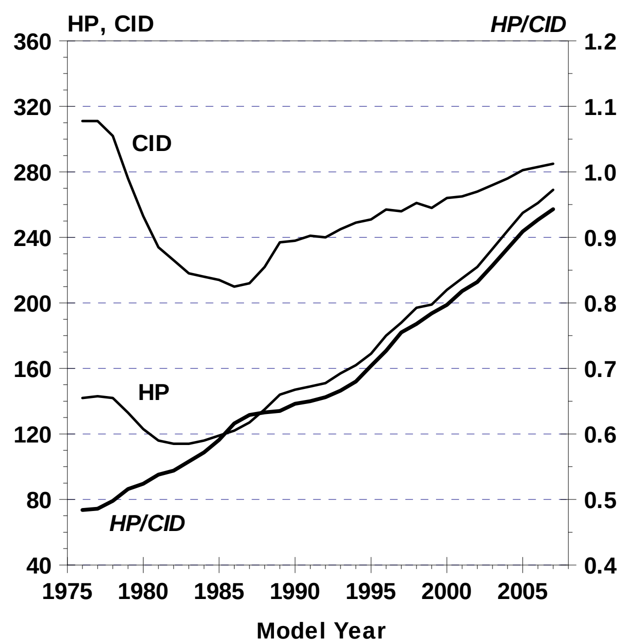



Figure 47

Table 13 compares CID, HP, and HP/CID by vehicle type and number of cylinders for model years 1988 and 2008. Table 13 shows that the increase in horsepower shown for the fleet in Table 9 extends to all vehicle type and cylinder number strata. These increases in horsepower range from 50 to 90%. Because displacement has remained relatively constant, it can be seen that the primary reason for the horsepower increase is increased specific power ─ up between 42 and 92% from 1988 to 2008.

At the number-of-cylinders level of stratification, model year 2008 cars generally achieve higher specific power than vans, SUVs or pickups. One reason for the lower specific power of some truck engines is that these vehicles may be used to carry heavy loads or pull trailers and thus need more "torque rise," (i.e., an increase in torque as engine speed falls from the peak power point) to achieve acceptable drivability. Engines equipped with four valves per cylinder typically have inherently lower torque rise than two valve engines with lower specific power.

Table 13

**Changes in Horsepower and Specific Power by Vehicle Type and Number of Cylinders**

| Vehicle Type | Cyl. | HP 1988 | HP 2008 | Percent Change | CID 1988 | CID 2008 | Percent Change | HP/CID 1988 | HP/CID 2008 | Percent Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Cars | 4 | 95 | 151 | 59% | 118 | 127 | 8% | 0.805 | 1.183 | 47% |
| | 6 | 142 | 243 | 71% | 193 | 207 | 7% | 0.744 | 1.180 | 59% |
| | 8 | 164 | 314 | 91% | 301 | 301 | 0% | 0.544 | 1.046 | 92% |
| Vans | 6 | 149 | 221 | 48% | 213 | 217 | 2% | 0.722 | 1.023 | 42% |
| | 8 | 168 | 301 | 79% | 322 | 325 | 1% | 0.520 | 0.926 | 78% |
| SUVs | 4 | 94 | 170 | 81% | 122 | 143 | 17% | 0.773 | 1.192 | 54% |
| | 6 | 147 | 238 | 62% | 211 | 216 | 2% | 0.706 | 1.110 | 57% |
| | 8 | 183 | 326 | 78% | 338 | 320 | -5% | 0.541 | 1.019 | 88% |
| Pickups | 4 | 97 | 164 | 69% | 142 | 161 | 13% | 0.685 | 1.019 | 49% |
| | 6 | 142 | 216 | 52% | 229 | 236 | 3% | 0.644 | 0.919 | 43% |
| | 8 | 180 | 317 | 76% | 329 | 321 | -2% | 0.544 | 0.982 | 81% |

Table 14

**Improvement in Horsepower and Specific Power by Vehicle Type and Inertia Weight**

| Inertia Weight | HP 1988 | HP 2008 | Percent Change | CID 1988 | CID 2008 | Percent Change | HP/CID 1988 | HP/CID 2008 | Percent Change |
|---|---|---|---|---|---|---|---|---|---|
| **Cars** | | | | | | | | | |
| 2000 | 59 | 70 | 19% | 77 | 61 | -21% | 0.770 | 1.148 | 49% |
| 2250 | 73 | 220 | 201% | 90 | 110 | 22% | 0.808 | 2.002 | 148% |
| 2500 | 78 | 106 | 36% | 100 | 91 | -9% | 0.785 | 1.165 | 48% |
| 2750 | 97 | 121 | 25% | 123 | 106 | -14% | 0.804 | 1.145 | 42% |
| 3000 | 114 | 136 | 19% | 145 | 118 | -19% | 0.797 | 1.155 | 45% |
| 3500 | 151 | 185 | 23% | 212 | 157 | -26% | 0.732 | 1.191 | 63% |
| 4000 | 160 | 250 | 56% | 289 | 213 | -26% | 0.569 | 1.187 | 109% |
| 4500 | 144 | 296 | 106% | 305 | 281 | -8% | 0.474 | 1.061 | 124% |
| 5000 | 207 | 332 | 60% | 408 | 289 | -29% | 0.509 | 1.129 | 122% |
| 5500 | 205 | 305 | 49% | 412 | 239 | -42% | 0.498 | 1.272 | 156% |
| 6000 | 205 | 465 | 127% | 412 | 331 | -20% | 0.498 | 1.366 | 175% |
| **Vans** | | | | | | | | | |
| 4000 | 149 | 269 | 81% | 214 | 211 | -1% | 0.717 | 1.275 | 78% |
| 4500 | 169 | 220 | 30% | 320 | 215 | -33% | 0.528 | 1.027 | 95% |
| 5000 | 156 | 236 | 51% | 312 | 247 | -21% | 0.500 | 0.961 | 92% |
| 5500 | 195 | 301 | 54% | 346 | 325 | -6% | 0.562 | 0.926 | 65% |
| 6000 | 126 | 301 | 139% | 379 | 325 | -14% | 0.332 | 0.926 | 179% |
| **SUVs** | | | | | | | | | |
| 3500 | 147 | 168 | 14% | 210 | 148 | -30% | 0.712 | 1.138 | 60% |
| 4000 | 135 | 203 | 50% | 190 | 181 | -5% | 0.723 | 1.141 | 58% |
| 4500 | 147 | 247 | 68% | 311 | 222 | -29% | 0.494 | 1.118 | 126% |
| 5000 | 181 | 259 | 43% | 330 | 245 | -26% | 0.545 | 1.071 | 97% |
| 5500 | 200 | 334 | 67% | 350 | 299 | -15% | 0.572 | 1.138 | 99% |
| 6000 | 162 | 334 | 106% | 368 | 325 | -12% | 0.445 | 1.028 | 131% |
| **Pickups** | | | | | | | | | |
| 3500 | 129 | 156 | 21% | 183 | 159 | -13% | 0.719 | 0.986 | 37% |
| 4000 | 154 | 195 | 27% | 282 | 211 | -25% | 0.555 | 0.927 | 67% |
| 4500 | 174 | 227 | 30% | 322 | 232 | -28% | 0.539 | 0.987 | 83% |
| 5000 | 193 | 233 | 21% | 342 | 274 | -20% | 0.565 | 0.850 | 51% |
| 5500 | 178 | 315 | 77% | 363 | 320 | -12% | 0.495 | 0.980 | 98% |
| 6000 | 140 | 347 | 148% | 379 | 336 | -11% | 0.369 | 1.033 | 180% |

Table 14 shows similar data to that in Table 13, but the stratification is based on inertia weight. This table clearly shows that, for every case for which a comparison can be made between 1988 and 2008, there were increases in HP, substantial increases in specific power ranging from 40 to 180%, and with just minor exceptions, substantial decreases in CID.

**HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) Cars**

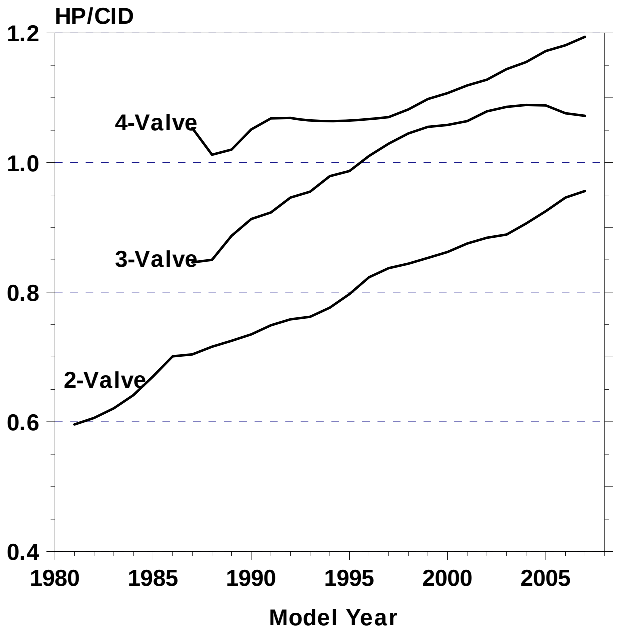



Figure 48

**HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) Vans**

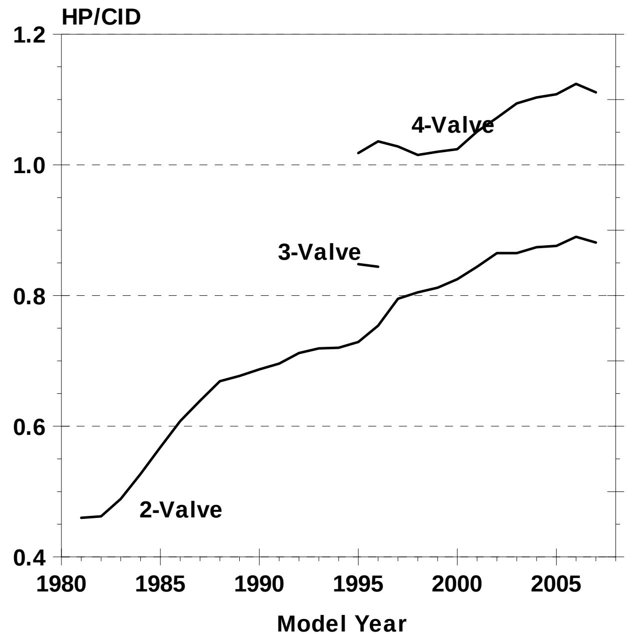



Figure 49

**HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) SUVs**

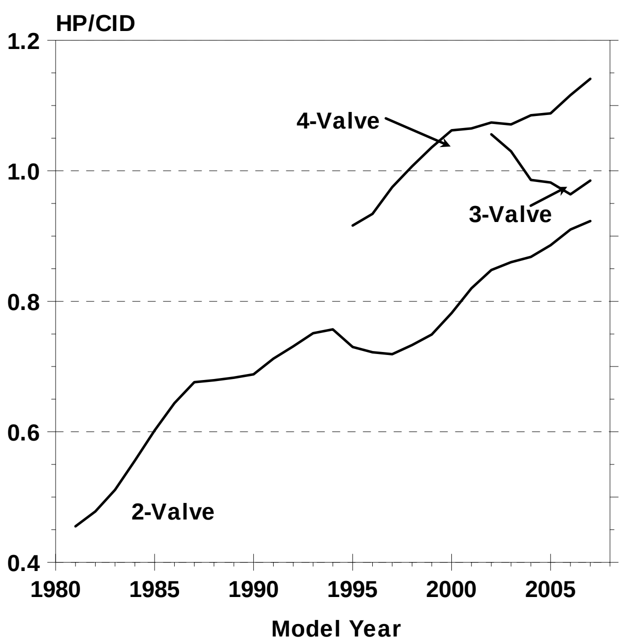



Figure 50

**HP/CID by Number of Valves Per Cylinder (Three Year Moving Average) Pickups**

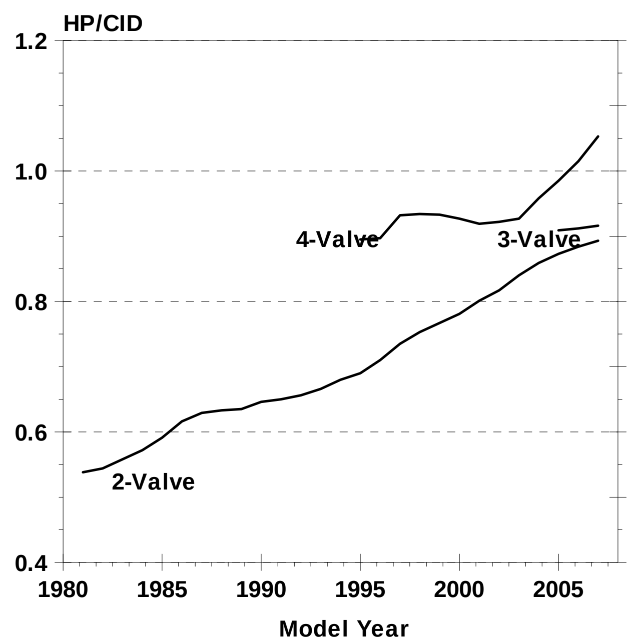



Figure 51

**Number of Valves per Cylinder (Three Year Moving Average) Cars**

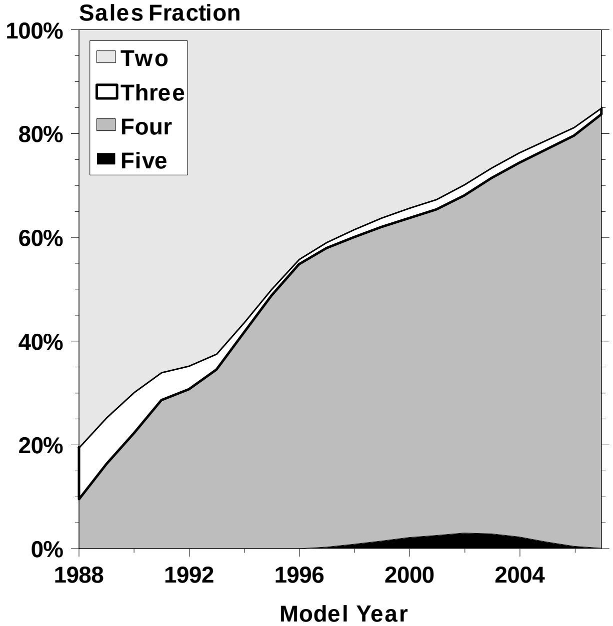



Figure 52

**Number of Valves per Cylinder (Three Year Moving Average) Vans**

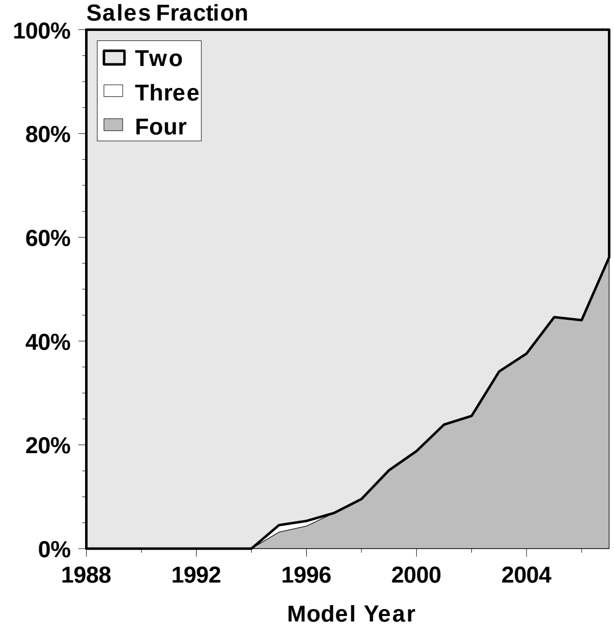



Figure 53

**Number of Valves per Cylinder (Three Year Moving Average) SUVs**

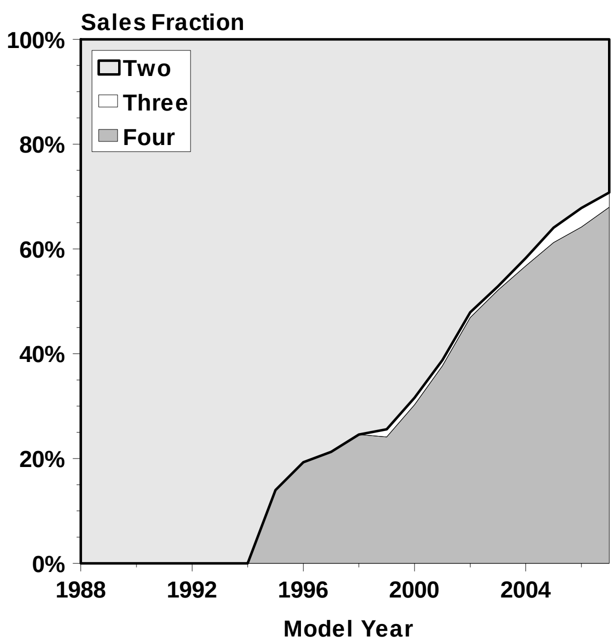



Figure 54

**Number of Valves per Cylinder (Three Year Moving Average) Pickups**

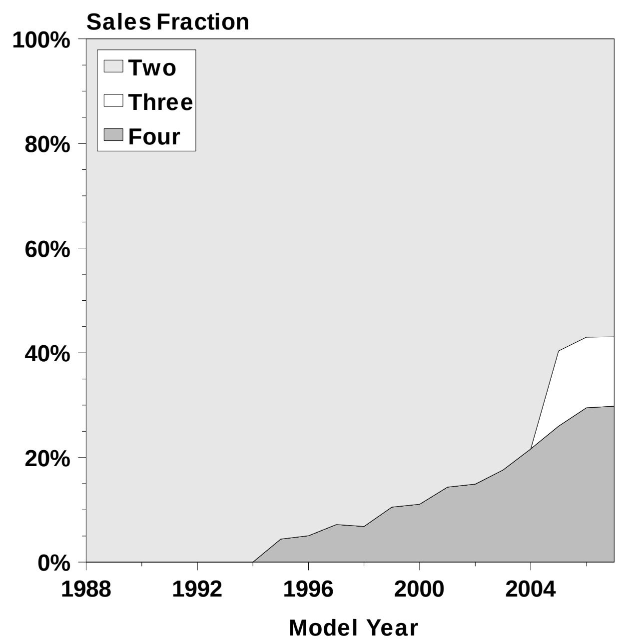



Figure 55

Figures 48 through 51 show that increases in HP per CID apply to all of the engines, except for a couple of case for engines with three valves. Engines with more valves per cylinder deliver higher values of HP per CID. Engines with *only* two valves per cylinder deliver substantially more horsepower per CID then they used to, typically a 50-80 percent increase for the time period shown. The increases in HP and HP-per-CID are due to changes in engine technologies. Figures 52 through 55 show that usage of multi-valve engines is increasing for all vehicle types and as shown in Table 12 for MY2008, is now nearly 90 percent for cars, over 70 percent for SUVs and vans, and about 40 percent for pickups.

Figures 56 and 57 and Table 15 show how the car and truck fleet have evolved from one that consisted almost entirely of carbureted engines to one which is now almost entirely port fuel injected, with a clear trend towards increased use of variable valve timing. In 1975, about 95 percent of all cars had carburetors as did almost all of the trucks, by 1988 use of carburetors had dropped below the 20 percent level for all vehicle types. For MY2008, over 60 percent of cars have multi-valve, port fuel injected engines with variable valve timing, as do about half of SUVs, vans, and pickups.

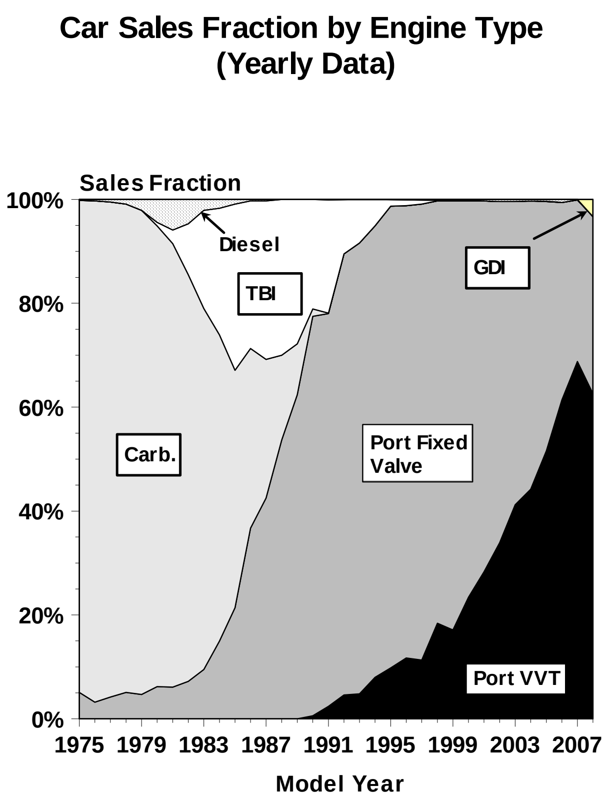



Figure 56

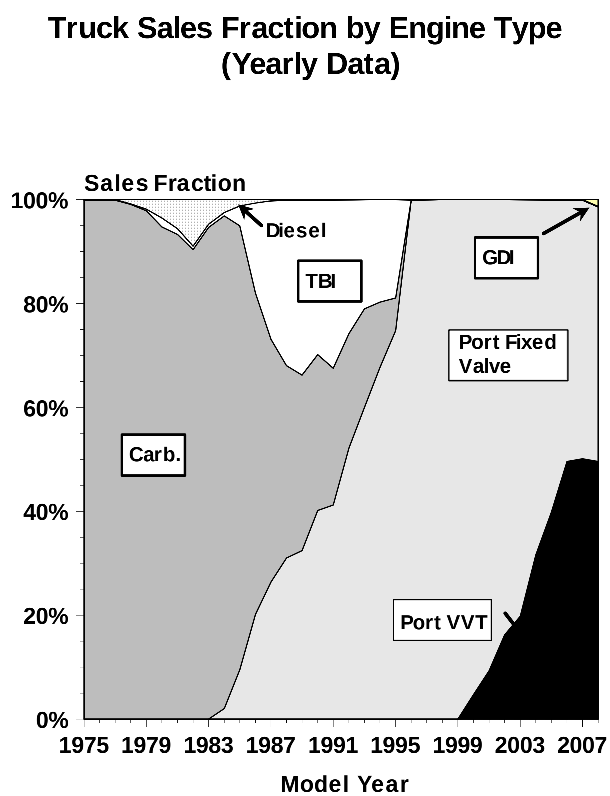



Figure 57

Table 15

**Sales Fraction of MY1988 and MY2008 Light Vehicles by Engine Type and Valve Timing**

| Engine Type | Cars | | Vans | | SUVs | | Pickups | | All | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1988** | **2008** | **1988** | **2008** | **1988** | **2008** | **1988** | **2008** | **1988** | **2008** |
| Carb | 16% | --- | <1% | --- | 16% | --- | 16% | --- | 15% | --- |
| TBI | 30% | --- | 43% | --- | 37% | --- | 48% | --- | 34% | --- |
| Port Fixed | 54% | 34% | 57% | 56% | 47% | 42% | 36% | 60% | 51% | 41% |
| Port Variable | --- | 59% | --- | 44% | --- | 54% | --- | 40% | --- | 54% |
| GDI Fixed | --- | 2% | --- | --- | --- | <1% | --- | --- | --- | 1% |
| GDI Variable | --- | 1% | --- | --- | --- | 2% | --- | --- | --- | 1% |
| Diesel | <1% | <1% | <1% | --- | <1% | <1% | <1% | --- | <1% | <1% |
| Hybrids | --- | 4% | --- | --- | --- | 2% | --- | --- | --- | 3% |

For over a decade and an half, automotive manufacturers have been using engines which use either cams or electric solenoids to provide variable intake and/ or exhaust valve timing and in some cases valve lift. Conventional engines use camshafts which are permanently synchronized with the engine's crankshaft so that they operate the valves at a specific fixed point in each combustion cycle regardless of the speed and load at which the engine is operated. The ability to control valve timing allows the design of an engine combustion chamber with a higher compression level than in engines equipped with fixed valve timing engines which in turn provides greater engine efficiency, more power and improved combustion efficiency. Variable valve timing (VVT) also allows the valves to be operated at different points in the combustion cycle, to provide performance that is precisely tailored to the engine's specific speed and load at any given instant with the valve timing set to allow the best overall performance across the engine's normal operating range. This results in improved engine efficiency under low-load conditions, such as at idle or highway cruising, and increased power at times of high demand. In addition, variable valve timing can result in reduced pumping losses, from the work required to pull air in and push exhaust out of the cylinder.

Because automobile manufacturers are not currently required to provide EPA with data on the type of valve timing their engines have, the data base used to generate EPA's fuel economy trend report was augmented to indicate whether a vehicle had fixed or variable valve timing. The data augmentation was based on data from trade publications and data published by automotive manufacturers. In addition, no differentiation between engines which used cams or solenoids to control the valve timing was made, nor was valve lift considered. For cars, the augmented data covers model years 1989 to 2008, while for trucks the augmentation covered model years 1999 to 2008.

Table 16

**Comparison of MY1988 and MY2008 Cars**
**by Engine Fuel Metering, Number of Valves and Valve Timing**

| Fuel Metering | Number of Valves | Valve Timing | Horsepower | | CID | | HP/CID | | Ton MPG | | 0 to 60 Time | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1988 | 2008 | 1988 | 2008 | 1988 | 2008 | 1988 | 2008 | 1988 | 2008 |
| Carb | | Fixed | 88 | --- | 131 | --- | .75 | --- | 37.2 | --- | 14.3 | --- |
| TBI | 2 | Fixed | 97 | --- | 141 | --- | .71 | --- | 36.9 | --- | 13.7 | --- |
| Port | 2 | Fixed | 136 | 240 | 193 | 267 | .74 | .90 | 36.6 | 40.1 | 11.9 | 8.9 |
| Port | 4 | Fixed | 137 | 195 | 131 | 168 | 1.05 | 1.17 | 37.9 | 41.0 | 11.1 | 9.6 |
| Port | 4 | Variable | --- | 192 | --- | 156 | --- | 1.22 | --- | 43.2 | --- | 9.5 |
| GDI | 4 | Fixed | --- | 185 | --- | 139 | --- | 1.36 | --- | 43.0 | --- | 9.6 |
| GDI | 4 | Variable | --- | 269 | --- | 179 | --- | 1.56 | --- | 42.9 | --- | 7.8 |

**Percent Change over 1988 Port Two Valve, Fixed Valve Timing**

| Fuel Metering | Number of Valves | Valve Timing | Horsepower 1988 | Horsepower 2008 | CID 1988 | CID 2008 | HP/CID 1988 | HP/CID 2008 | Ton MPG 1988 | Ton MPG 2008 | 0 to 60 1988 | 0 to 60 2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carb | | Fixed | -35% | --- | -32% | --- | 1% | --- | 2% | --- | 20% | --- |
| TBI | 2 | Fixed | -29% | --- | -27% | --- | -4% | --- | 1% | --- | 15% | --- |
| Port | 2 | Fixed | 0% | 76% | 0% | 38% | 0% | 22% | 0% | 10% | 0% | -25% |
| Port | 4 | Fixed | 1% | 43% | -32% | -13% | 42% | 58% | 4% | 12% | -7% | -19% |
| Port | 4 | Variable | -- | 41% | --- | -19% | --- | 65% | --- | 18% | --- | -20% |
| GDI | 4 | Fixed | --- | 36% | --- | -28% | --- | 84% | --- | 17% | --- | -19% |
| GDI | 4 | Variable | --- | 98% | --- | -7% | --- | 111% | --- | 17% | --- | -34% |

Table 16 compares horsepower, engine size (CID), specific power (HP/CID), Ton- mpg, and estimated 0-to-60 acceleration time for five selected MY1988 and 2008 engine types.

Because 1988 was the peak year for car fuel economy, and because the two valve, fixed valve timing, port injected engine accounted for about half of the car engines built that year, it was selected as a baseline engine with its average characteristics compared to those for the MY2008 two- and four-valve, fixed valve timing and four-valve VVT engines. As shown in Figure 58, all three of these MY2008 engine types had substantially higher horsepower than the baseline MY1988 engine, but the MY2008 four valve engines fixed and VVT engines are considerably smaller and have substantially higher specific power. Not all of these improvements in engine design for these engine types that occurred between 1988 and 2008 were used to improve fuel economy as indicated by the nominal 20 percent decrease in 0-to-60 time each achieved. As mentioned earlier, in this report vehicle performance for conventionally powered vehicles is determined by an estimate of 0-to-60 acceleration time calculated from the ratio of vehicle power to weight. Obtaining increased power to weight in a time when weight is trending upwards implies that horsepower is increasing. Increased horsepower can be obtained by increasing the engine's displacement, the engine's specific power (HP/CID), or both. Increasing specific power has been the primary driver for increases in performance for the past two decades.

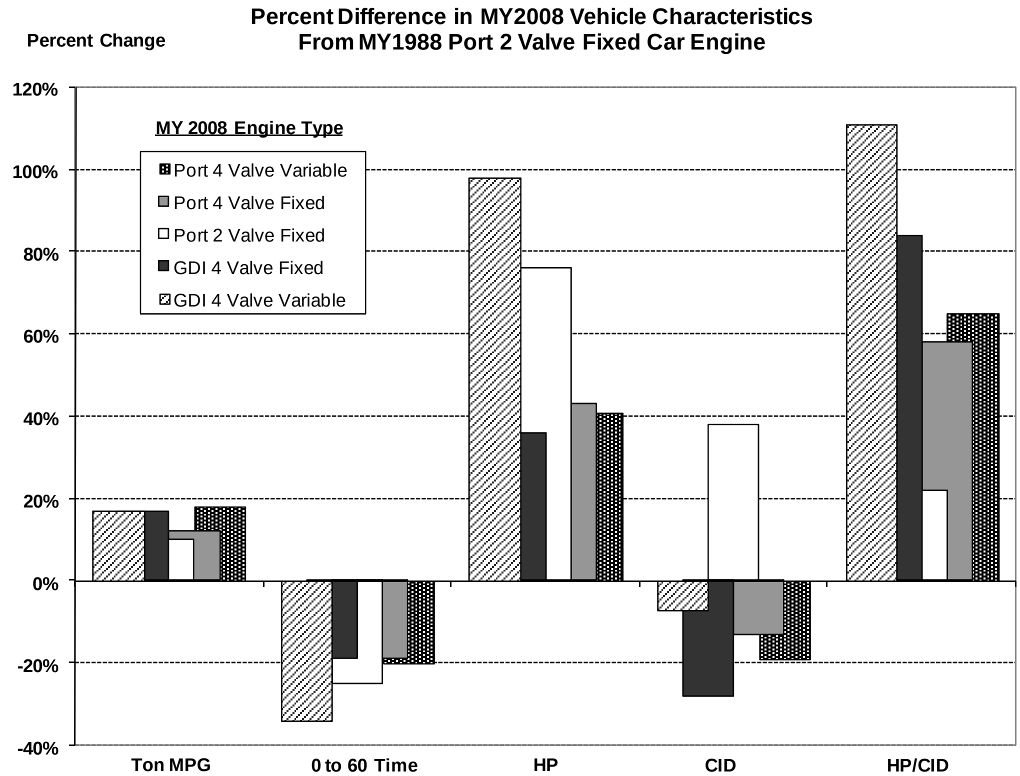



Figure 58

For the current model year fleet, specific power has been studied at an even more detailed level of stratification with both car and truck engines being classified according to: (1) the number of valves per cylinder, (2) the manufacturer's fuel recommendation, (3) the presence or absence of an intake boost device such as a turbocharger or supercharger and (4) whether or not the engine had fixed or variable valve timing (see Tables 17 and 18). Higher HP/CID is associated with: (a) more valves per cylinder, (b) higher octane fuel, (c) intake boost and (4) use of variable valve timing. The technical approaches result in specific power ranges for cars and trucks from about .9 to about 1.8. The relative sales fractions in Tables 17 and 18 are just for each technical option in the table and exclude hybrids.

Tables 17 and 18 show the incremental effect, on a sales weighted basis, of adding each technical option, but not all of the technical options are sales significant. The effect of the use of higher octane fuel cannot be discounted, because roughly 21 percent of the current car fleet is comprised of vehicles which use engines for which high octane fuel is recommended. By comparison, about 12 percent of this year's light trucks require premium fuel.

Engine technology which delivers improved specific power thus can be used in many ways ranging from reduced displacement and improved fuel economy at constant (or worse) performance, to increased performance and the same fuel economy at constant displacement.

Table 17

**HP/CID and Sales Fraction by Fuel and Engine Technology**

**Model Year 2008 Cars**

**Number of Valves per Cylinder**

| Fuel/Boost/Valves | Two | | Three | | Four | | Five | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | HP/CID | Sales Fract. | HP/CID | Sales Fract. | HP/CID | Sales Fract. | HP/CID | Sales Fract. | Sales Fract. |
| Regular/No Boost/FIX | .86 | .044 | ---- | ---- | 1.13 | .253 | ---- | ---- | .297 |
| Regular/No Boost/VVT | 1.03 | .052 | 1.07 | .006 | 1.15 | .427 | ---- | ---- | .485 |
| Regular/Boost /FIX | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | .000 |
| Regular/Boost /VVT | ---- | ---- | ---- | ---- | 1.83 | .004 | ---- | ---- | .004 |
| Premium/No Boost/FIX | 1.08 | .010 | 1.00 | .002 | 1.23 | .030 | 1.35 | ---- | .041 |
| Premium/No Boost/VVT | .99 | .002 | 1.37 | ---- | 1.34 | .138 | ---- | ---- | .139 |
| Premium/Boost /FIX | ---- | ---- | 1.04 | .001 | 1.66 | .021 | ---- | ---- | .022 |
| Premium/Boost /VVT | ---- | ---- | 1.28 | ---- | 1.67 | .011 | ---- | ---- | .011 |
| Diesel/No Boost | ---- | ---- | ---- | ---- | 1.16 | ---- | ---- | ---- | .000 |
| Diesel/Boost | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | .000 |
| Total | | .108 | | .009 | | .882 | | ---- | 1.000 |

Table 18

**HP/CID and Sales Fraction by Fuel and Engine Technology**

**Model Year 2008 Trucks**

**Number of Valves per Cylinder**

| Fuel/Boost/Valves | Two | | Three | | Four | | Five | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | HP/CID | Sales Fract. | HP/CID | Sales Fract. | HP/CID | Sales Fract. | HP/CID | Sales Fract. | Sales Fract. |
| Regular/No Boost/FIX | .91 | .323 | 1.04 | .005 | 1.06 | .147 | ---- | ---- | .476 |
| Regular/No Boost/VVT | .95 | .021 | .91 | .037 | 1.17 | .346 | ---- | ---- | .405 |
| Regular/Boost /FIX | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | .000 |
| Regular/Boost /VVT | ---- | ---- | ---- | ---- | 1.53 | .001 | ---- | ---- | .001 |
| Premium/No Boost/FIX | 1.08 | .003 | 1.12 | ---- | 1.19 | .010 | ---- | ---- | .013 |
| Premium/No Boost/VVT | 1.05 | .007 | ---- | ---- | 1.26 | .095 | ---- | ---- | .102 |
| Premium/Boost /FIX | ---- | ---- | 1.37 | .001 | ---- | ---- | ---- | ---- | .001 |
| Premium/Boost /VVT | ---- | ---- | 1.35 | ---- | 1.71 | ---- | ---- | ---- | .000 |
| Diesel/No Boost | ---- | ---- | ---- | ---- | 1.18 | .002 | ---- | ---- | .002 |
| Diesel/Boost | 1.03 | ---- | ---- | ---- | 1.18 | .001 | ---- | ---- | .001 |
| Total | | .355 | | .043 | | .602 | | ---- | 1.000 |

A recent engine development has been the reintroduction of cylinder deactivation, an automotive technology that was used by General Motors in some MY1981 V-8 engines that could be operated in 8- , 6- and 4-cylinder modes. This approach, which has also been called by a number of names including 'variable displacement', 'displacement on demand', 'active fuel management' and 'multiple displacement', involves allowing the valves of selected cylinders of the engine to remain closed and interrupting the fuel supply to these cylinders when engine power demands are below a predetermined threshold, as typically happens under less demanding driving conditions, such as steady state operation. Under light load conditions, the engine can thus provide better fuel mileage than would otherwise be achieved. Although frictional and thermodynamic energy losses still occur in the cylinders that are not being used, these losses are more than offset by the increased load and reduced specific fuel consumption of the remaining cylinders. Typically half of the usual number of cylinders are deactivated. Challenges to the engine designer for this type of engine include mode transitions, idle quality, and noise and vibration. For MY2008, as shown previously in Table 12, it is estimated that about three percent of cars and about 12 percent of trucks are equipped with cylinder deactivation.

Table 19

**Comparison of MY2008 Cars with Engines with Cylinder Deactivation**

| Car Class | Model Name | Drive | Trans | Inertia Weight | Engine CID | Engine HP | Lab. 55/45 | Cyl. Deact. | Pct. Change HP | Pct. Change MPG |
|---|---|---|---|---|---|---|---|---|---|---|
| Midsize | Lacrosse-Allure | Front | L4 | 4000 | 325 | 290 | 24.7 | Yes | 21% | -4% |
| Car | Grand Prix | | | | 218 | 240 | 25.8 | No | | |
| Large | 300 AWD | 4wd | L5 | 4500 | 348 | 340 | 23.1 | Yes | 34% | 1% |
| Car | 300 AWD | | | | 215 | 253 | 22.8 | No | | |
| Midsize | Magnum AWD | 4wd | L5 | 4500 | 348 | 340 | 23.1 | Yes | 34% | 1% |
| Wagon | Magnum AWD | | | | 215 | 253 | 22.8 | No | | |

Table 20

**Comparison of MY2008 Trucks with Engines with Cylinder Deactivation**

| Truck Class | Model Name | Drive | Trans | Inertia Weight | Engine CID | Engine HP | Lab. 55/45 | Cyl. Deact. | Pct. Change HP | Pct. Change MPG |
|---|---|---|---|---|---|---|---|---|---|---|
| Midsize | Odyssey | Front | L5 | 4500 | 212 | 241 | 25.8 | Yes | -1% | 8% |
| Van | Odyssey | | | | 212 | 244 | 23.9 | No | | |
| Midsize | Grand Cherokee | Rear | L5 | 5000 | 348 | 345 | 19.5 | Yes | 50% | -2% |
| SUV | Grand Cherokee | | | | 287 | 230 | 19.8 | No | | |
| Large | Envoy | 4wd | L4 | 5000 | 325 | 280 | 20.0 | Yes | 2% | -3% |
| SUV | Envoy | | | | 254 | 275 | 20.6 | No | | |
| Large | Ram 1500 | Rear | L5 | 5000 | 348 | 345 | 19.5 | Yes | 50% | -2% |
| Pickup | Ram 1500 | | | | 287 | 230 | 19.8 | No | | |
| | Ram 1500 | 4wd | L5 | 5500 | 348 | 345 | 18.8 | Yes | 17% | -1% |
| | Ram 1500 | | | | 287 | 295 | 18.9 | No | | |

Table 19 compares examples of individual MY2008 car models with cylinder deactivation with their same-model counterparts with optional smaller engines that do not incorporate cylinder deactivation. For every case in the table, the version of the model equipped with cylinder deactivation has horsepower ratings that are significantly higher and about the same fuel economy. Most of the truck examples in Table 20 show a similar trend. The Honda Odyssey shows similar horsepower and an 8 percent fuel economy increase.

The data in Tables 19 and 20 indicate cylinder deactivation can be used to increase fuel economy at constant horsepower, or to maintain equivalent fuel economy at higher horsepower levels.

## Car Technology Penetration
## Years After First Significant Use

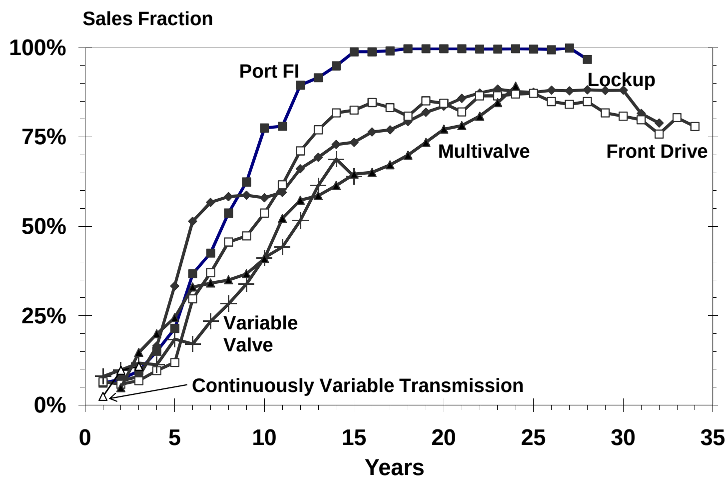



Figure 59

Figure 59 compares penetration rates for six passenger car technologies, namely port fuel injection (Port FI), front-wheel drive (FWD), multi-valve engines (i.e., engines with more than two valves per cylinder), lockup transmissions, engines with variable valve timing, and CVTs. The sales fraction for VVT car engines has increased in a similar fashion to the others shown in the figure. This indicates that, in the past, it has taken a decade for a technology to prove itself and attain a sales fraction of 40 to 50 percent and as long as another five or ten years to reach maximum market penetration.

**Car Technology Penetration**
**Years After First Significant Use**

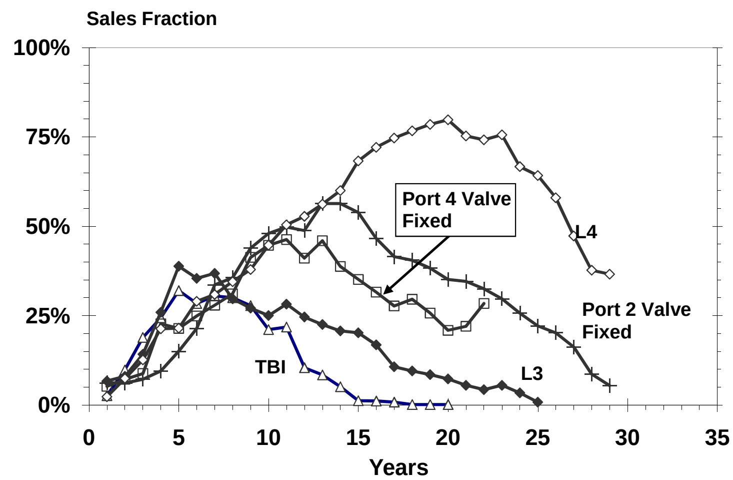



Figure 60

A similar comparison of five technologies whose sales fraction peaked out is shown in Figure 60. This figure shows that, in the past, it has taken a number of years for technologies such as throttle body fuel injection (TBI), lockup 3-speed (L3) and 4-speed (L4) transmissions to reach their maximum sales fraction, and, even then, use of these technologies has often continued for a decade or longer. For the limited number of historical cases studied, the time a given technology has taken to attain and then pass a market share of about 40 to 50 percent appears to be one indicator of whether it later attains a stabilized high level of market penetration. L4 transmissions and both two- and four-valve, port injected, fixed valve timing car engines (Port 2V- and 4V-Fixed) now can be classified with technologies such as TBI engines and L3 transmissions which have reached their peak sales fractions and, thus, are likely to disappear from the new vehicle fleet.

Table 21 compares inertia weight, the fuel economy ratings, the ratio of highway to city fuel economy, and ton-mpg of the MY2008 hybrid and diesel vehicles with those for the average conventionally powered MY2008 car and truck. Nearly all of the hybrid and diesel vehicles in the table have a lower highway/city ratio than the average conventional car or truck.

Table 21

**Characteristics of MY 2008 Hybrid and Diesel Vehicles**

| | IWT | CID | Trans | Lab 55/45 MPG | <----- Adjusted City MPG | HWY MPG | -----> COMP MPG | HWY/ City Ratio | Ton-MPG |
|---|---|---|---|---|---|---|---|---|---|
| **Hybrid Cars** | | | | | | | | | |
| Prius | 3000 | 91 | CVT | 65.8 | 47.7 | 45.1 | 46.2 | .95 | 69.3 |
| Altima | 3500 | 152 | CVT | 46.7 | 35.1 | 33.0 | 33.9 | .94 | 59.3 |
| GS 450H | 4500 | 211 | L6 | 30.8 | 21.9 | 25.3 | 23.8 | 1.15 | 53.5 |
| Civic | 3000 | 82 | CVT | 58.8 | 40.2 | 45.3 | 42.9 | 1.13 | 64.4 |
| Camry | 4000 | 144 | CVT | 45.9 | 33.4 | 34.1 | 33.8 | 1.02 | 67.6 |
| Malibu | 4000 | 145 | L4 | 35.7 | 23.9 | 31.9 | 27.9 | 1.33 | 55.8 |
| Aura | 4000 | 145 | L4 | 35.7 | 23.9 | 31.9 | 27.9 | 1.33 | 55.8 |
| LS 600HL | 5500 | 303 | L8 | 26.9 | 19.6 | 21.8 | 20.8 | 1.11 | 57.2 |
| **Hybrid Trucks** | | | | | | | | | |
| Vue | 4000 | 145 | L4 | 36.7 | 24.8 | 32.2 | 28.5 | 1.30 | 57.0 |
| RX 400H 4WD | 4500 | 202 | CVT | 33.4 | 25.8 | 24.2 | 24.8 | .94 | 55.9 |
| RX 400H 2WD | 4500 | 202 | CVT | 34.1 | 27.0 | 23.8 | 25.1 | .88 | 56.5 |
| Highlander 4WD | 5000 | 202 | CVT | 35.2 | 27.3 | 25.1 | 26.0 | .92 | 65.0 |
| Mariner FWD | 4000 | 140 | CVT | 43.7 | 34.3 | 29.6 | 31.5 | .86 | 63.0 |
| Mariner 4WD | 4000 | 140 | CVT | 38.2 | 29.4 | 27.2 | 28.1 | .92 | 56.2 |
| Escape FWD | 4000 | 140 | CVT | 43.7 | 34.3 | 29.6 | 31.5 | .86 | 63.0 |
| Escape 4WD | 4000 | 140 | CVT | 38.2 | 29.4 | 27.2 | 28.1 | .92 | 56.2 |
| Tribute 2WD | 4000 | 140 | CVT | 43.7 | 34.3 | 29.6 | 31.5 | .86 | 63.0 |
| Tribute 4WD | 4000 | 140 | CVT | 38.2 | 29.4 | 27.2 | 28.1 | .92 | 56.2 |
| K1500 Tahoe 4WD | 6000 | 364 | CVT | 26.3 | 19.7 | 20.4 | 20.1 | 1.03 | 60.4 |
| K1500 Yukon 4WD | 6000 | 364 | CVT | 26.3 | 19.7 | 20.4 | 20.1 | 1.03 | 60.4 |
| C1500 Tahoe 2WD | 6000 | 364 | CVT | 28.2 | 21.1 | 21.7 | 21.5 | 1.03 | 64.4 |
| C1500 Yukon 2WD | 6000 | 364 | CVT | 28.2 | 21.1 | 21.7 | 21.5 | 1.03 | 64.4 |
| **Diesel Cars** | | | | | | | | | |
| R320 CDI 4MATIC | 5500 | 182 | L7 | 26.9 | 18.4 | 24.3 | 21.3 | 1.32 | 58.7 |
| E320 BLUETEC | 4000 | 182 | L7 | 34.7 | 22.8 | 32.2 | 27.3 | 1.41 | 54.7 |
| **Diesel Trucks** | | | | | | | | | |
| Touareg | 6000 | 300 | L6 | 21.7 | 14.8 | 20.0 | 17.4 | 1.35 | 52.2 |
| GL320 CDI 4MATIC | 6000 | 182 | L7 | 26.6 | 18.2 | 23.9 | 21.1 | 1.32 | 63.2 |
| ML320 CDI 4MATIC | 5000 | 182 | L7 | 26.9 | 18.5 | 24.0 | 21.3 | 1.30 | 53.1 |
| Grand Cherokee 4WD | 5000 | 183 | L5 | 25.3 | 17.6 | 22.2 | 20.0 | 1.26 | 50.0 |
| Grand Cherokee 2WD | 4500 | 183 | L5 | 26.0 | 17.9 | 23.0 | 20.5 | 1.28 | 46.2 |
| Average Car | 3541 | 168 | -- | 30.3 | 20.1 | 28.3 | 24.1 | 1.41 | 43.3 |
| Average Truck | 4742 | 240 | -- | 22.5 | 15.3 | 20.9 | 18.1 | 1.37 | 42.9 |

In addition, there are several cases in the table for which the highway to city ratio is less than 1.0, and these represent cases where a vehicle achieves higher fuel economy in city than in highway driving. This year's diesel cars achieve ton-mpg values that are roughly the same as some of the hybrid cars. For MY2008, the Toyota Prius achieves 69 Ton-mpg, 60 percent higher than that of the average car.

Most of the vehicles in Table 21 have conventionally powered counterparts. Tables 22 and 23 compare the adjusted composite fuel economy and an estimate of annual fuel usage (assuming 15,000 miles per year) for these vehicles with their conventionally powered (baseline) counterparts. The comparisons in both tables are limited to a basis of model name, drive, inertia weight, transmission, and engine size (CID), and for simplicity there is only one listing for "twin" vehicles such as the Escape/ Mariner and the Highlander/RX400 H. Differences in the performance attributes of these vehicles complicate making the forward analysis of the fuel economy improvement potential due to hybridization and dieselization. In particular, hybrid vehicles are often reported to have faster 0-to-60 acceleration times than their conventional counterparts, while vehicles equipped with diesel engines have higher low-end

Table 22

**Comparison of MY2008 Hybrid Vehicles With Their Conventional Counterparts**

| | <----- Hybrid Version ------> | | | | | <---- Baseline Version ---> | | | | | <Improvement> | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model Name** | **Inertia Weight** | **CID** | **Trans** | **ADJ COMP MPG** | **Gal Per Year*** | **Inertia Weight** | **CID** | **Trans** | **ADJ COMP MPG** | **Gal Per Year*** | **ADJ COMP MPG** | **Gal Per Year*** |
| Altima | 3500 | 152 | CVT | 33.9 | 443 | 3500 | 152 | CVT | 27.5 | 556 | 23% | 103 |
| Civic | 3000 | 82 | CVT | 42.9 | 349 | 3000 | 110 | L5 | 30.6 | 491 | 40% | 141 |
| | | | | | | 3000 | 110 | M5 | 30.1 | 497 | 42 | 147 |
| Camry | 4000 | 144 | CVT | 33.8 | 444 | 3500 | 144 | L5 | 26.1 | 574 | 29% | 130 |
| | | | | | | 3500 | 144 | M5 | 25.8 | 582 | 31% | 138 |
| Malibu | 4000 | 145 | L4 | 27.9 | 538 | 3500 | 145 | L4 | 25.7 | 584 | 9% | 46 |
| GS 450H** | 4500 | 211 | L6 | 23.8 | 631 | 4000 | 211 | L6 | 22.9 | 656 | 4% | 25 |
| LS 600HL** | 5500 | 303 | L8 | 20.8 | 721 | 4500 | 281 | L8 | 20.1 | 748 | 4% | 27 |
| Vue | 4000 | 145 | L4 | 28.5 | 526 | 4000 | 145 | L4 | 22.5 | 666 | 27% | 140 |
| Escape FWD | 4000 | 140 | CVT | 31.5 | 477 | 3500 | 140 | L4 | 23.0 | 653 | 37% | 177 |
| | | | | | | 3500 | 140 | M5 | 24.9 | 601 | 26% | 125 |
| Escape 4WD | 4000 | 140 | CVT | 28.1 | 534 | 3500 | 140 | L4 | 21.3 | 703 | 32% | 169 |
| Highlander 4WD | 5000 | 202 | CVT | 26.0 | 577 | 4500 | 211 | L5 | 19.7 | 760 | 32% | 183 |
| RX 400 2WD** | 4500 | 202 | CVT | 25.1 | 598 | 4000 | 211 | L5 | 20.4 | 737 | 23% | 139 |
| RX 400 4WD** | 4500 | 202 | CVT | 24.8 | 604 | 4500 | 211 | L5 | 19.6 | 766 | 27% | 162 |
| C1500 Tahoe 2WD | 6000 | 364 | CVT | 21.5 | 699 | 6000 | 325 | L4 | 17.2 | 873 | 25% | 174 |
| | | | | | | 6000 | 380 | L6 | 15.2 | 985 | 41% | 286 |
| K1500 Tahoe 4WD | 6000 | 364 | CVT | 20.1 | 745 | 6000 | 325 | L4 | 16.4 | 914 | 23% | 168 |

*Note: Gallons per year calculation is based on all vehicles being driven 15,000 miles.

**Note: Baseline version used for the GS 450H comparison is the GS350. Baseline vehicle used for the LS 600HL comparison is the LS 460L. Baseline vehicle used for the RX 400H 2WD comparison is the RX 350 2WD. Baseline vehicle used for the RX 400H 4WD comparison is the RX 350 4WD.

torque, but slower 0-to-60 times. In addition, some hybrid vehicles use technologies such as cylinder deactivation and CVT transmissions that are not offered in their counterparts. Given the difficulty in choosing the "right" baseline vehicle, Table 21 includes a comparison for the CVT-equipped Escape Hybrid with baseline data for both manual and automatic transmission versions of this vehicle.

Fuel economy improvements and fuel savings per year for the hybrid vehicles in Table 22 vary considerably from about five percent for the larger, luxury hybrid vehicles to around 40 percent for several others. Similarly, fuel economy improvements for diesels range from 16 to 37 percent, and these vehicles also offer relatively high fuel savings. Eight years after the introduction for sale in the U.S. of the first hybrid vehicle, the MY2000 Honda Insight, hybrid vehicles now account for 2.5 percent of the combined car/truck fleet. In addition, the sales fraction for diesels remains below a quarter of one percent, more than an order of magnitude smaller than their 5.9 percent sales fraction in 1981.

Table 23

**Comparison of MY2008 Diesel Vehicles With Their Conventional Counterparts**

| | <----- Diesel Version ------> | | | | | <---- Baseline Version ---> | | | | | <Improvement> | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Model Name** | **Inertia Weight** | **CID** | **Trans** | **ADJ COMP MPG** | **Gal Per Year*** | **Inertia Weight** | **CID** | **Trans** | **ADJ COMP MPG** | **Gal Per Year*** | **ADJ COMP MPG** | **Gal Per Year*** |
| E320 BLUETEC** | 4000 | 182 | L7 | 27.3 | 549 | 4000 | 213 | L7 | 20.2 | 743 | 35% | 195 |
| R320 CDI 4MATIC** | 5500 | 182 | L7 | 21.3 | 703 | 5500 | 213 | L7 | 17.0 | 881 | 25% | 178 |
| ML320 CDI 4MATIC** | 5000 | 182 | L7 | 21.3 | 706 | 5000 | 213 | L7 | 17.2 | 873 | 24% | 167 |
| GL320 CDI 4MATIC** | 6000 | 182 | L7 | 21.1 | 712 | 6000 | 285 | L7 | 15.3 | 978 | 37% | 265 |
| Touareg | 6000 | 300 | L6 | 17.4 | 862 | 5500 | 254 | L6 | 14.8 | 1010 | 17% | 148 |
| Grand Cherokee 4WD | 5000 | 183 | L5 | 20.0 | 750 | 4500 | 226 | L5 | 17.1 | 876 | 17% | 126 |
| Grand Cherokee 2WD | 4500 | 183 | L5 | 20.5 | 731 | 4500 | 226 | L5 | 17.7 | 847 | 16% | 116 |

*Note:

Gallons per year calculation is based on all vehicles being driven 15,000 miles.

**Note:

Baseline version used for the R320 CDI 4MATIC comparison is the R350 4MATIC. Baseline version used for the GL320 CDI 4MATIC comparison is the GL450 4MATIC. Baseline version used for the E320 BLUETEC comparison is the E350. Baseline version used for the ML320 CDI 4MATIC comparison is the ML350 4MATIC.

## VI. Marketing Groups

In its century of evolution, the automotive industry existed first as small, individual companies that relatively quickly went out of business or grew into larger corporations. Prior to the 1970s, the historic term “manufacturer” usually meant an automobile company that manufactured and sold vehicles in its own country and perhaps exported vehicles to a few other countries. Over the years, the nature of the automotive industry has changed substantially, and it has evolved into one in which global consolidations and alliances among heretofore independent manufacturers have become the norm, rather than the exception.

Early reports in this series examined fuel economy and technology trends for the "Domestic" and "Import" vehicle categories which are part of the corporate average fuel economy program. Over time, this classification approach evolved into a market segment approach in which cars were apportioned to a "Domestic," "European," and "Asian" category, with trucks classified as "Domestic" or "Imported." As the automotive industry has become more transnational in nature, this type of vehicle classification has become less useful. In the most recent reports in this series, trends by groups of manufacturers have been used to reflect the transnational and transregional nature of the automobile industry.

There are 35 individual manufacturers in the 2008 fuel economy trends database. To reflect the transition to an industry in which there are only a small number of independent companies, these 35 individual manufacturers have been divided into nine major marketing group segments, and a tenth catch-all group ("Others") that contains smaller manufacturers not assigned to one of the nine major marketing groups.

These nine major marketing groups are:

1) The General Motors Group includes GM, Daewoo, Saab, and Isuzu;

2) The Ford Motor Group includes Ford, Mazda, Volvo, Rover, and Jaguar;

3) The Chrysler Group includes only Chrysler;

4) The Toyota Group includes only Toyota;

5) The Honda Group includes only Honda;

6) The Nissan Group includes only Nissan;

7) The Hyundai-Kia (HK) Group includes Hyundai and Kia;

8) The VW Group includes Volkswagen, Audi, Porsche, Bentley, and Lamborghini; and

9) The BMW group includes only BMW.

Taken together, the nine major marketing groups comprise over 95 percent of the MY2008 new vehicle market in the U.S. It is expected that these marketing groups will continue to evolve and perhaps expand, or possibly contract as further changes in the automotive industry occur. The most important changes in the marketing group definitions for this report are that Chrysler is now its own marketing group (with Daimler, the previous owner of Chrysler, now included in the Others category) and BMW is also included as its own marketing group.

Tables 24 and 25 list the 35 individual manufacturers that are included in EPA’s 2008 fuel economy database, and the marketing group to which they are assigned for this report. Table 24 shows the projected

MY2008 laboratory 55/45 fuel economy values for cars only, trucks only, and cars and trucks combined, along with the truck market share, for each of the 35 individual manufacturers. Table 25 shows the same information, but with projected MY2008 adjusted composite fuel economy values instead.

Tables 26 and 27 provide fuel economy data for the nine marketing groups, with the former providing laboratory 55/45 fuel economy data, and the latter including adjusted composite fuel economy data. The bottom two rows in each table give the overall average MY2008 fuel economy value, as well as the truck market share, for each marketing group. It can be seen that the Honda and Toyota marketing groups have the highest MY2008 fuel economy values, followed by Hyundai-Kia. Chrysler and Ford have the lowest MY2008 fuel economy values. Tables 26 and 27 also show the average marketing group fuel economies by vehicle type and size. For example, Table 26 shows that Honda has the highest projected MY2008 laboratory 55/45 fuel economy value for the small car class. Different marketing groups are leaders in other vehicle classes as defined by this report.

Figures 61 through 69 compare for model years 1975 to 2008: percent truck, laboratory 55/45 fuel economy for cars, trucks, and both cars and trucks for the GM, Ford, Chrysler, Toyota, Honda, Nissan, Hyundai-Kia, VW, and BMW marketing groups, respectively. For all of these marketing groups, with the exception of BMW, combined car and truck fuel economy is lower now than it was in 1988. More information stratified by marketing group can be found in the Appendixes L through O.

It is important to note when a marketing group definition is changed to reflect a change in the industry's financial arrangements, EPA makes the same adjustment in marketing group composition in the historical database, that is used for Figures 61 through 69 and in Appendixes L through O, as well. This maintains a consistent marketing group definition over time, which allows a better identification of long-term trends. On the other hand, this also means that the database does not necessarily reflect actual financial arrangements in the past. For example, the 2008 database no longer accounts for the fact that Chrysler was combined with Daimler for several years.

Table 24

**Model Year 2008 Laboratory 55/45 Fuel Economy by Manufacturer**

| Manufacturer | Marketing Group | <-- FUEL ECONOMY --> Cars | Trucks | Both | Percent Truck |
|---|---|---|---|---|---|
| General Motors | General Motors | 28.5 | 21.6 | 24.2 | 55% |
| Toyota | Toyota | 35.5 | 23.7 | 29.7 | 40% |
| Chrysler | Chrysler | 26.5 | 22.5 | 23.6 | 68% |
| Ford | Ford | 26.8 | 21.7 | 23.3 | 64% |
| Honda | Honda | 33.8 | 25.1 | 29.6 | 41% |
| Nissan | Nissan | 32.0 | 21.5 | 26.6 | 42% |
| Hyundai | Hyundai-Kia | 30.9 | 25.2 | 28.5 | 37% |
| Kia | Hyundai-Kia | 32.2 | 23.9 | 28.2 | 41% |
| BMW | BMW | 27.3 | 23.0 | 26.4 | 19% |
| Daimler AG | Other | 25.6 | 20.4 | 24.3 | 22% |
| Mazda | Ford | 31.1 | 23.7 | 27.9 | 37% |
| Volkswagen | Volkswagen | 29.6 | 20.1 | 28.5 | 8% |
| Mitsubishi | Other | 29.2 | 25.9 | 28.1 | 30% |
| Subaru | Other | 28.5 | 26.3 | 27.8 | 28% |
| Volvo | Ford | 25.9 | 20.5 | 24.3 | 25% |
| Audi | Volkswagen | 27.3 | 20.1 | 25.3 | 22% |
| GM Daewoo | General Motors | 33.3 | | 33.3 | 0% |
| Rover | Ford | | 20.2 | 20.2 | 100% |
| Suzuki | Other | 32.6 | 24.5 | 29.0 | 38% |
| Porsche | Volkswagen | 26.1 | 19.5 | 21.8 | 60% |
| Saab | General Motors | 26.2 | 19.5 | 25.8 | 5% |
| Jaguar | Ford | 24.5 | | 24.5 | 0% |
| Isuzu | General Motors | | 23.1 | 23.1 | 100% |
| Bentley | Volkswagen | | 15.8 | 15.8 | 0% |
| Maserati | Other | 18.3 | | 18.3 | 0% |
| Saleen | Other | 17.8 | 16.7 | 16.6 | 83% |
| Shelby | Ford | 22.2 | | 22.2 | 0% |
| Lotus | Other | 29.9 | | 29.9 | 0% |
| Rousch | Ford | 21.2 | 16.0 | 20.3 | 14% |
| Ferrari | Other | 16.4 | | 16.4 | 0% |
| Aston Martin | Other | 18.5 | | 18.5 | 0% |
| Foose | Ford | | 16.0 | 16.0 | 100% |
| Lamborghini | Volkswagen | 14.8 | | 14.8 | 0% |
| Phantom | BMW | 17.3 | | 17.3 | 0% |
| Alpina Burkard | Other | 20.8 | | 20.8 | 0% |
| Fleet | | 30.3 | 22.5 | 26.0 | 48% |

Table 25

**Model Year 2008 Adjusted Composite Fuel Economy by Manufacturer**

| Manufacturer | Marketing Group | <-- FUEL ECONOMY --> Cars | Trucks | Both | Percent Truck |
|---|---|---|---|---|---|
| General Motors | General Motors | 22.9 | 17.4 | 19.5 | 55% |
| Toyota | Toyota | 27.7 | 18.8 | 23.4 | 40% |
| Chrysler | Chrysler | 21.2 | 18.0 | 18.9 | 68% |
| Ford | Ford | 21.5 | 17.5 | 18.7 | 64% |
| Honda | Honda | 26.8 | 20.1 | 23.6 | 41% |
| Nissan | Nissan | 25.2 | 17.3 | 21.2 | 42% |
| Hyundai | Hyundai-Kia | 24.6 | 20.2 | 22.7 | 37% |
| Kia | Hyundai-Kia | 25.5 | 19.1 | 22.5 | 41% |
| BMW | BMW | 22.0 | 18.5 | 21.2 | 19% |
| Daimler AG | Other | 20.6 | 16.4 | 19.5 | 22% |
| Mazda | Ford | 24.5 | 19.0 | 22.1 | 37% |
| Volkswagen | Volkswagen | 23.6 | 16.2 | 22.8 | 8% |
| Mitsubishi | Other | 23.2 | 20.6 | 22.3 | 30% |
| Subaru | Other | 22.6 | 20.8 | 22.0 | 28% |
| Volvo | Ford | 20.9 | 16.6 | 19.6 | 25% |
| Audi | Volkswagen | 21.8 | 26.2 | 20.3 | 22% |
| GM Daewoo | General Motors | 26.4 | | 26.4 | 0% |
| Rover | Ford | | 16.5 | 16.5 | 100% |
| Suzuki | Other | 25.6 | 19.5 | 22.8 | 38% |
| Porsche | Volkswagen | 21.0 | 15.9 | 17.7 | 60% |
| Saab | General Motors | 21.2 | 15.8 | 20.8 | 5% |
| Jaguar | Ford | 19.8 | | 19.8 | 0% |
| Isuzu | General Motors | | 18.5 | 18.5 | 100% |
| Bentley | Volkswagen | 13.2 | | 13.2 | 0% |
| Maserati | Other | 15.0 | | 15.0 | 0% |
| Saleen | Other | 14.6 | 13.3 | 13.5 | 83% |
| Shelby | Ford | 18.1 | | 18.1 | 0% |
| Lotus | Other | 23.5 | | 23.5 | 0% |
| Rousch | Ford | 17.2 | 13.0 | 16.5 | 14% |
| Ferrari | Other | 13.4 | | 13.4 | 0% |
| Aston Martin | Other | 15.2 | | 15.2 | 0% |
| Foose | Ford | | 13.0 | 13.0 | 100% |
| Lamborghini | Volkswagen | 12.3 | | 12.3 | 0% |
| Phantom | BMW | 14.2 | | 14.2 | 0% |
| Alpina Burkard | Other | 17.1 | | 17.1 | 0% |
| Fleet | | 24.1 | 18.1 | 20.8 | 48% |

Table 26

## Model Year 2008 Laboratory 55/45 Fuel Economy by Marketing Group

| VEHICLE TYPE/SIZE | GM | Toyota | Ford | Chrysler | Honda | Nissan | HK | VW | BMW | All |
|---|---|---|---|---|---|---|---|---|---|---|
| **Cars** | | | | | | | | | | |
| Small | 30.6 | 36.3 | 29.6 | 26.7 | 37.4 | 28.7 | 34.8 | 28.5 | 28.3 | 31.6 |
| Midsize | 27.9 | 35.9 | 27.9 | 29.3 | 26.5 | 33.2 | 33.9 | 26.9 | 25.3 | 31.5 |
| Large | 26.0 | 29.4 | 23.8 | 25.1 | 31.3 | 23.1 | 28.5 | 23.7 | 23.1 | 26.8 |
| All | 28.2 | 35.6 | 27.4 | 27.1 | 33.4 | 32.0 | 31.7 | 28.2 | 27.3 | 30.4 |
| **Wagons** | | | | | | | | | | |
| Small | 33.3 | 33.5 | 28.4 | 27.5 | 39.9 | | | 29.9 | 26.6 | 32.1 |
| Midsize | 26.2 | | 24.8 | 24.4 | | | 27.7 | 28.5 | 24.6 | 26.8 |
| Large | | | | 22.2 | | | | | | 22.0 |
| All | 33.2 | 33.5 | 25.0 | 25.2 | 39.9 | | 27.7 | 29.5 | 25.8 | 29.6 |
| **All Cars** | | | | | | | | | | |
| Small | 31.2 | 35.8 | 29.6 | 27.2 | 37.7 | 28.7 | 34.8 | 28.6 | 28.3 | 31.7 |
| Midsize | 27.9 | 35.9 | 27.6 | 28.6 | 26.5 | 33.2 | 33.0 | 27.1 | 25.3 | 31.2 |
| Large | 26.0 | 29.4 | 23.8 | 24.3 | 31.3 | 23.1 | 28.5 | 23.7 | 23.1 | 26.5 |
| All | 28.7 | 35.5 | 27.3 | 26.5 | 33.8 | 32.0 | 31.5 | 28.3 | 27.2 | 30.3 |
| **Vans** | | | | | | | | | | |
| Small | | | | | | | | | | |
| Midsize | 21.9 | 26.0 | 24.1 | 24.6 | 25.3 | 24.5 | 23.8 | | | 24.7 |
| Large | 20.0 | | | | | | | | | 20.0 |
| All | 20.9 | 26.0 | 24.1 | 24.6 | 25.3 | 24.5 | 23.8 | | | 24.5 |
| **SUVs** | | | | | | | | | | |
| Small | | | | 21.6 | | | | | | 22.9 |
| Midsize | 25.4 | 25.4 | 26.1 | 23.7 | 25.7 | 27.0 | 25.0 | | | 25.2 |
| Large | 21.8 | 19.1 | 21.1 | 19.4 | | 19.6 | 23.2 | 19.8 | 23.0 | 21.2 |
| All | 22.0 | 24.7 | 23.4 | 22.9 | 25.7 | 22.5 | 24.8 | 19.8 | 23.0 | 23.3 |
| **Pickups** | | | | | | | | | | |
| Small | | | | | | | | | | |
| Midsize | 24.5 | 24.2 | 23.3 | | | | | | | 24.0 |
| Large | 20.8 | 19.3 | 19.1 | 19.4 | 21.4 | 18.6 | | | | 19.8 |
| All | 21.0 | 20.8 | 19.7 | 19.4 | 21.4 | 18.6 | | | | 20.2 |
| **Trucks** | | | | | | | | | | |
| Small | | | | 21.6 | | | | | | 22.9 |
| Midsize | 24.4 | 25.4 | 25.4 | 24.0 | 25.6 | 26.0 | 24.7 | | | 25.0 |
| Large | 21.3 | 19.2 | 19.9 | 19.4 | 21.4 | 19.1 | 23.2 | 19.8 | 23.0 | 20.5 |
| All | 21.6 | 23.7 | 21.8 | 22.5 | 25.1 | 21.5 | 24.6 | 19.8 | 23.0 | 22.5 |
| **Fleet** | | | | | | | | | | |
| **All** | **24.3** | **29.7** | **23.7** | **23.6** | **29.6** | **26.6** | **28.4** | **26.2** | **26.3** | **26.0** |
| Truck % | 54% | 40% | 59% | 68% | 41% | 42% | 39% | 19% | 19% | 48% |

Table 27

**Model Year 2008 Adjusted Composite Fuel Economy by Marketing Group**

| **VEHICLE TYPE/SIZE** | **GM** | **Toyota** | **Ford** | **Chrysler** | **Honda** | **Nissan** | **HK** | **VW** | **BMW** | **All** |
|---|---|---|---|---|---|---|---|---|---|---|
| Cars | | | | | | | | | | |
| Small | 24.3 | 28.3 | 23.5 | 21.5 | 29.3 | 22.8 | 27.3 | 22.8 | 22.8 | 25.0 |
| Midsize | 22.5 | 28.0 | 22.4 | 23.3 | 21.3 | 26.0 | 26.7 | 21.6 | 20.5 | 24.9 |
| Large | 21.1 | 23.5 | 19.4 | 20.2 | 25.0 | 18.6 | 22.9 | 19.1 | 18.8 | 21.6 |
| All | 22.7 | 27.8 | 22.0 | 21.6 | 26.5 | 25.2 | 25.2 | 22.6 | 22.0 | 24.2 |
| Wagons | | | | | | | | | | |
| Small | 26.1 | 26.1 | 22.8 | 21.7 | 30.6 | | | 23.8 | 21.4 | 25.2 |
| Midsize | 21.3 | | 19.9 | 19.7 | | | 22.1 | 22.8 | 19.9 | 21.4 |
| Large | | | | 18.2 | | | | | | 17.9 |
| All | 26.1 | 26.1 | 20.1 | 20.2 | 30.6 | | 22.1 | 23.5 | 20.8 | 23.4 |
| All Cars | | | | | | | | | | |
| Small | 24.7 | 27.9 | 23.5 | 21.6 | 29.5 | 22.8 | 27.3 | 22.9 | 22.7 | 25.1 |
| Midsize | 22.5 | 28.0 | 22.1 | 22.7 | 21.3 | 26.0 | 26.1 | 21.8 | 20.5 | 24.7 |
| Large | 21.1 | 23.5 | 19.4 | 19.7 | 25.0 | 18.6 | 22.9 | 19.1 | 18.8 | 21.4 |
| All | 23.0 | 27.7 | 21.9 | 21.2 | 26.8 | 25.2 | 25.0 | 22.6 | 21.9 | 24.1 |
| Vans | | | | | | | | | | |
| Small | | | | | | | | | | |
| Midsize | 17.7 | 20.7 | 19.4 | 19.8 | 20.5 | 19.7 | 19.2 | | | 19.9 |
| Large | 16.0 | | | | | | | | | 16.0 |
| All | 16.8 | 20.7 | 19.4 | 19.8 | 20.5 | 19.7 | 19.2 | | | 19.7 |
| SUVs | | | | | | | | | | |
| Small | | | | 17.2 | | | | | | 18.2 |
| Midsize | 20.4 | 20.1 | 20.7 | 18.8 | 20.4 | 21.3 | 19.9 | | | 20.0 |
| Large | 17.6 | 15.4 | 17.1 | 15.7 | | 16.0 | 18.8 | 16.1 | 18.5 | 17.2 |
| All | 17.8 | 19.5 | 18.8 | 18.2 | 20.4 | 18.1 | 19.8 | 16.1 | 18.5 | 18.7 |
| Pickups | | | | | | | | | | |
| Small | | | | | | | | | | |
| Midsize | 19.6 | 19.1 | 18.6 | | | | | | | 19.0 |
| Large | 16.7 | 15.5 | 15.4 | 15.7 | 17.2 | 15.1 | | | | 16.0 |
| All | 16.9 | 16.7 | 15.8 | 15.7 | 17.2 | 15.1 | | | | 16.3 |
| Trucks | | | | | | | | | | |
| Small | | | | 17.2 | | | | | | 18.2 |
| Midsize | 19.6 | 20.1 | 20.2 | 19.2 | 20.4 | 20.7 | 19.8 | | | 19.9 |
| Large | 17.2 | 15.5 | 16.1 | 15.7 | 17.2 | 15.5 | 18.8 | 16.1 | 18.5 | 16.6 |
| All | 17.4 | 18.8 | 17.5 | 18.0 | 20.1 | 17.3 | 19.7 | 16.1 | 18.5 | 18.1 |
| Fleet | | | | | | | | | | |
| **All** | **19.6** | **23.4** | **19.0** | **18.9** | **23.6** | **21.2** | **22.6** | **21.0** | **21.2** | **20.8** |
| Truck % | 54% | 40% | 59% | 68% | 41% | 42% | 39% | 19% | 19% | 48% |

**GM Marketing Group**
**Fuel Economy by Model Year**
**(Three Year Moving Average)**

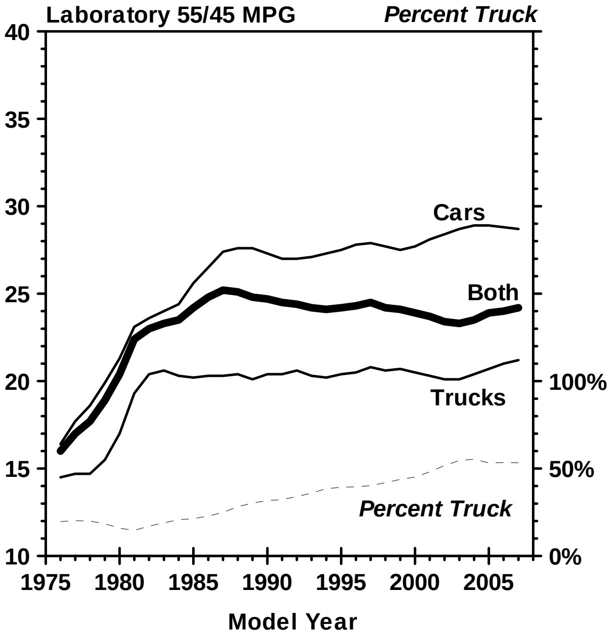



Figure 61

**Ford Marketing Group**
**Fuel Economy by Model Year**
**(Three Year Moving Average)**

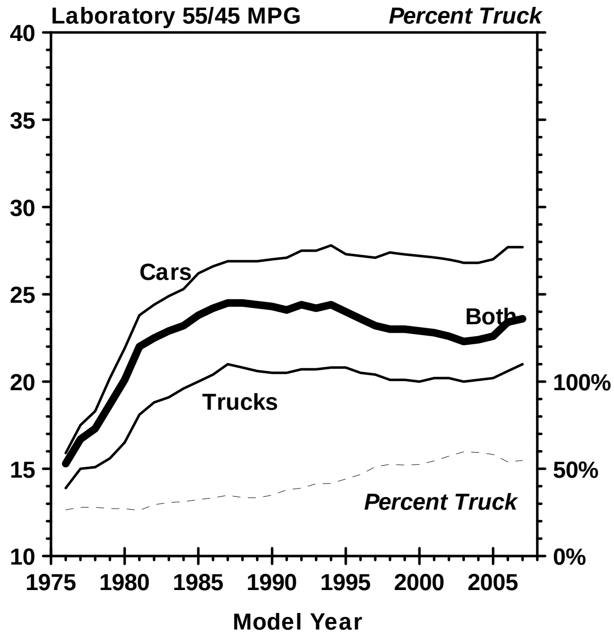



Figure 62

**Chrysler Marketing Group**
**Fuel Economy by Model Year**
**(Three Year Moving Average)**

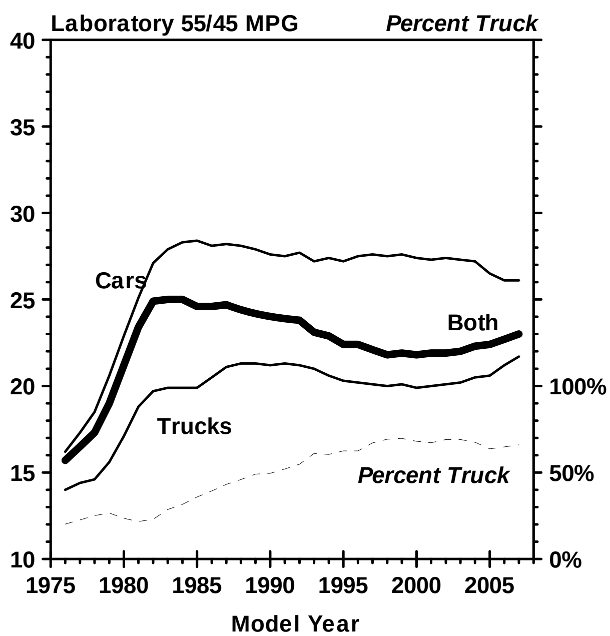



Figure 63

**Toyota Marketing Group**
**Fuel Economy by Model Year**
**(Three Year Moving Average)**

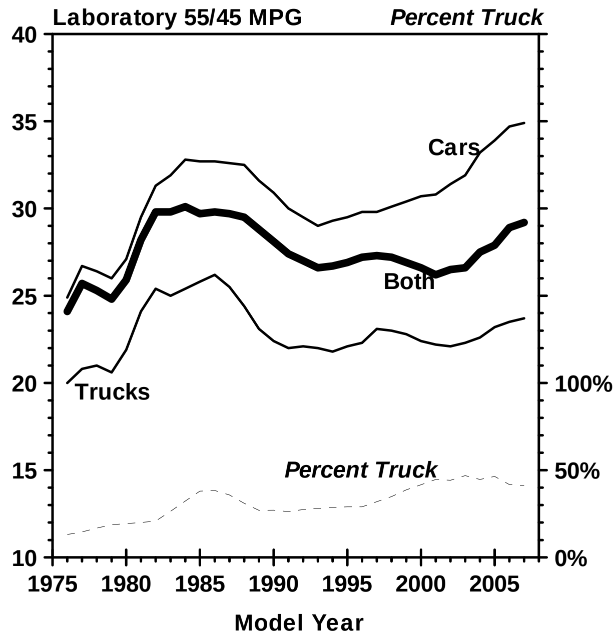



Figure 64

**Honda Marketing Group**
**Fuel Economy by Model Year**
**(Three Year Moving Average)**

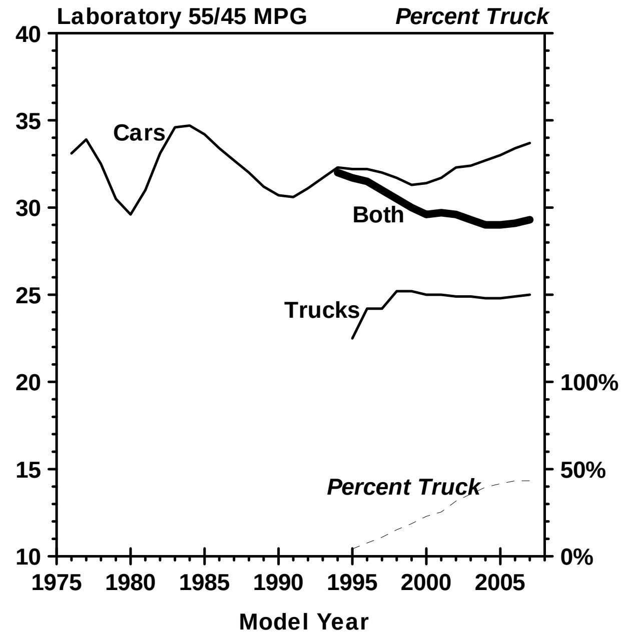



Figure 65

**Nissan Marketing Group**
**Fuel Economy by Model Year**
**(Three Year Moving Average)**

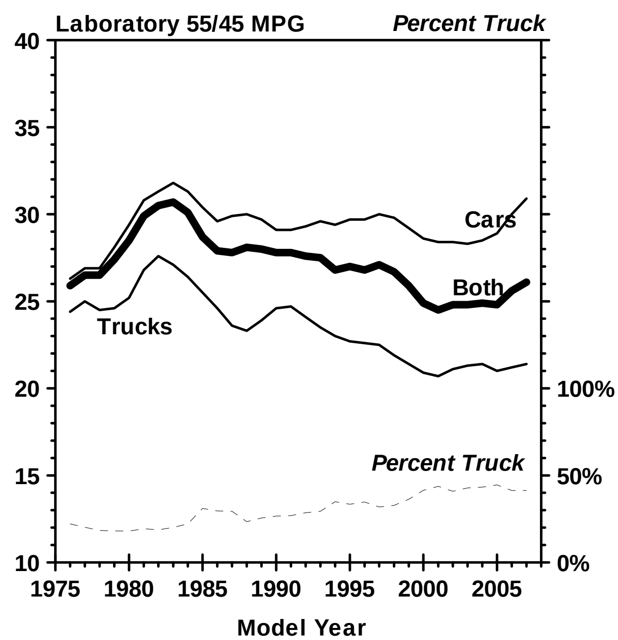



Figure 66

## Hyundai-Kia Marketing Group Fuel Economy by Model Year (Three Year Moving Average)

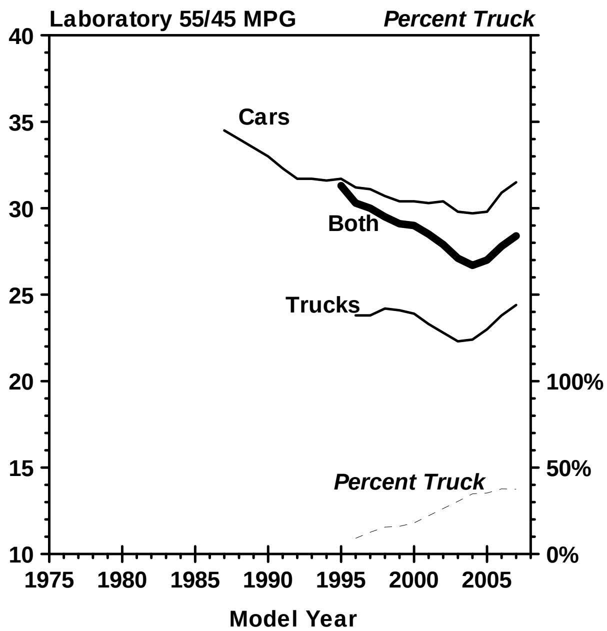



Figure 67

## VW Marketing Group Fuel Economy by Model Year (Three Year Moving Average)

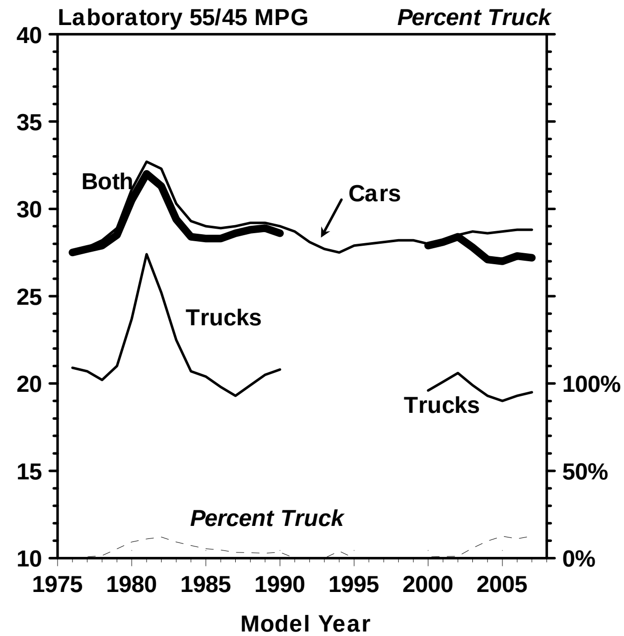



Figure 68

## BMW Marketing Group Fuel Economy by Model Year (Three Year Moving Average)

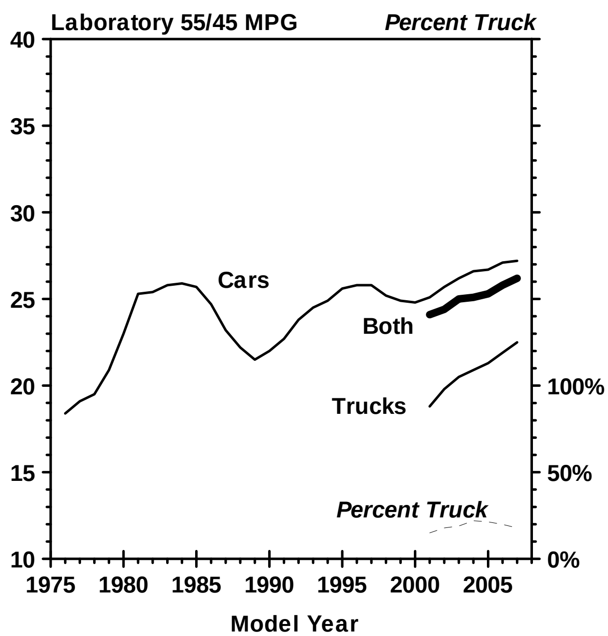



Figure 69

## VII. Characteristics of Fleets Comprised of Existing Fuel-Efficient Vehicles

This section is limited to a discussion of hypothetical fleets of vehicles comprised of existing fuel-efficient vehicles and the fuel economy and other characteristics of those fleets. While it includes a discussion of some of the technical and engineering factors that affect fleet fuel economy, it does not attempt to evaluate either the benefits or the costs of achieving various fuel economy levels. In addition, the analysis presented here also does not attempt to evaluate the marketability or the public acceptance of any of the hypothetical fleets that result from the scenarios studied and discussed below.

There are several different ways to look at the potential for improved fuel economy from the light-duty vehicle fleet. Many of these approaches utilize projections of more fuel efficient technologies that are not currently being used in the fleet today. As an example, a fleet made up of a large fraction of fuel cell vehicles could be considered. Such projections can be associated with a good deal of uncertainty, since uncertainty in the projections of market share compound with uncertainties about the fuel economy performance of yet uncommercialized technology. These uncertainties can be thought of as a combination of technical risk, i.e., can the technology be developed and mass produced?, and market risk, i.e., will people buy vehicles with the improved fuel economy?

One general approach used in this report is to consider only the fuel economy performance of those technologies which exist in today's fleet. This eliminates uncertainty about the feasibility and production readiness of the technology, but does not address market risk. Therefore, the analysis can be thought of as the fuel economy potential now in the fleet, with no new technologies added, if the higher mpg choices available were to be selected by a much higher percentage of consumers.

As was shown in Figures 3 and 4, there is a wide distribution of fuel economy. Because of the interest in the high end of this spectrum, this portion of the database was examined in more detail using three "best in class" (BIC) analysis techniques. This type of technique is not new, and in fact was one of the methods used to investigate future fleet fuel economy capability when the original fuel economy standards were set.

In any group or class of vehicles there will be a distribution of fuel economy performance, and the "best in class" method relies on that fact. The analysis involves dividing the fleet of vehicles into classes, selecting a set of representative high mpg "role model" vehicles from each class, and then calculating the average characteristics of the resultant fleet using the same relative sales proportions as in the baseline fleet.

One potential problem with a BIC analysis is that the high mpg cars used in the analysis may be unusual in some way ─ so unusual that the hypothetical BIC fleet may be deficient in some other attributes considered desirable by vehicle buyers. Because the BIC analysis is also sensitive to the selection of the best vehicles, three different procedures were used to select the role models.

Two of these selection procedures use the EPA car size classes (which for cars are the same as those used for the EPA/DOE *Fuel Economy Guide*) and the truck type/size classes described previously in this report. The third best-in-class role model selection procedure is based on using the vehicle inertia weight classes used for EPA's vehicle testing and certification programs.

The advantage of using and analyzing data from the best-in-size class methods is that if the sales proportions of each class are held constant, the sales distribution of the resultant fleet by *vehicle type and size* does not change. This means that the size of the average vehicle does not change a lot, but there can be some fluctuation in interior volume for cars because of the distribution of interior volume within a car class. Similarly, another advantage of using the inertia weight classes to determine the role models is, if the sales proportions in each inertia weight class are held constant, the sales distribution of the resultant fleet by *weight* does not change, and in this case, the average weight remains the same.

One way of performing a best-in-class analysis is to use as role models the four nameplates with the highest fuel economy in each size class. (See Tables Q-1 and Q-2 in Appendix Q.) Under this procedure, all vehicles in a class with the same nameplate are included as role models regardless of vehicle configuration. Each role model nameplate from each class was assigned the same sales weighting factor, but the original sales weighting distribution for different vehicle configurations within a given nameplate (e.g., transmission type, engine size, and/or drive type) was retained. The resulting values were used to recalculate the fleet average values using the same relative proportions in each of the size classes that constitute the fleet. In cases where two identical vehicles differ by only one characteristic but have slightly different nameplates (such as the two-wheel drive Chevrolet C1500 and the four-wheel drive Chevrolet K1500 pickups), both are considered to be different nameplates. Conversely, in the cases where there are technically identical vehicles with different nameplates (e.g., the Buick LeSabre and Pontiac Bonneville sedans), only one representative vehicle nameplate was considered in the BIC analysis.

The second best-in-class role model selection procedure involves selecting as role models the best dozen vehicles in each size class with each vehicle configuration (some of which may have the same nameplate) considered separately. Tables Q-3 and Q-4 in Appendix Q give listings of the representative vehicles used in this method. As with the previous procedure, in cases where technically identical vehicle configurations have different nameplates, only one representative vehicle was considered. Under this best-in-class method, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to re-calculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

The third best-in-class procedure involves selecting as role models the best dozen vehicles in each weight class. As with the previous method, each vehicle configuration was considered separately. (See Tables Q-5 and Q-6 in Appendix Q for a listing of the vehicles used in this analysis.) It should be noted that some of the weight classes have less than a dozen representative vehicles. In addition, as in the previous two best-in-class methods, where technically identical vehicle configurations with different nameplates exist, only one representative vehicle was included. As with the two best-in-size class methods, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to recalculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

Tables 28 to 30 compare, for cars, trucks, and both cars and trucks, respectively, the results of the best-in-class analysis with actual average data for model year 2008. As discussed earlier, for the size class scenarios, the percentage of vehicles that are small, midsize, or large are the same as for the baseline fleet, and in the weight class scenarios, the average weight of the BIC data sets is the same as the actual one.

In general, the vehicles used for the BIC analysis have less powerful engines, have slower 0-to-60 acceleration times, and are more likely to be equipped with front wheel drive, VVT, CVTs, and hybrid powertrains than the entire fleet as a whole.

Depending on the BIC scenario chosen, MY2008 cars could have achieved from 15 to 27 percent better fuel economy than they did. Similarly, for trucks the potential fuel economy improvement ranges from 12 to 27 percent better fuel economy, and the combined car and truck fleet could have been 13 to 27 percent better.

The best-in-class analyses can be thought of as the mpg potential now in the fleet with no new technologies added if the higher mpg choices available were selected. As such, the best-in-class analyses provide a useful reference point reflecting the variation in fuel economy levels that results in large part from consumer preferences as opposed to technological availability.

Table 28

**Best in Class Results 2008 Cars**

| Vehicle Characteristic | Selection Basis | Actual Data | Size Class | Size Class | Weight Class |
|---|---|---|---|---|---|
| | **Selection Criteria** | **All Cars** | **Best 4 Nameplates** | **Best 12 Vehicles** | **Best 12 Vehicles** |
| Fuel Economy | Lab. 55/45 | 30.3 | 38.4 | 35.8 | 34.7 |
| | Adjusted City | 20.1 | 26.0 | 24.0 | 23.2 |
| | Adjusted Highway | 28.4 | 33.0 | 31.9 | 31.1 |
| | Adjusted Composite | 24.1 | 29.6 | 27.9 | 27.1 |
| Vehicle Size | Weight (lb.) | 3541 | 3266 | 3224 | 3541 |
| | Volume (Cu. Ft) | 110 | 110 | 110 | 107 |
| Engine | CID | 168 | 129 | 130 | 136 |
| | HP | 196 | 150 | 153 | 173 |
| | HP/CID | 1.17 | 1.16 | 1.17 | 1.28 |
| | HP/WT | .054 | .045 | .047 | .048 |
| | Percent Multivalve | 89% | 95% | 95% | 98% |
| | Percent Variable Valve | 64% | 79% | 69% | 76% |
| | Percent Diesel | <0.1% | 0.2% | 0.1% | 2.7% |
| Performance | 0-60 Time (Sec.) | 9.5 | 10.2 | 10.3 | 10.0 |
| | Top Speed | 137 | 124 | 125 | 129 |
| | Ton-MPG | 43.3 | 49.8 | 45.6 | 48.5 |
| | Cu. Ft. Mpg | 2738 | 3361 | 3123 | 2951 |
| | Cu. Ft. Ton-MPG | 4789 | 5490 | 5031 | 5169 |
| Drive | Front | 78% | 97% | 95% | 84% |
| | Rear | 15% | 2% | 5% | 7% |
| | 4WD | 7% | 1% | 1% | 9% |
| Transmission | Manual | 10% | 11% | 36% | 37% |
| | Lockup | 79% | 55% | 49% | 39% |
| | CVT | 11% | 33% | 16% | 24% |
| Hybrid Vehicle | | 3.7% | 30.2% | 12.9% | 12.0% |

Table 29

**Best in Class Results 2008 Trucks**

| **Vehicle Characteristic** | **Selection Basis** | **Actual Data** | **Size Class** | **Size Class** | **Weight Class** |
|---|---|---|---|---|---|
| | **Selection Criteria** | **All Trucks** | **Best 4 Nameplates** | **Best 12 Vehicles** | **Best 12 Vehicles** |
| Fuel Economy | Lab. 55/45 | 22.5 | 28.6 | 27.2 | 25.3 |
| | Adjusted City | 15.3 | 20.2 | 18.9 | 17.4 |
| | Adjusted Highway | 20.9 | 24.1 | 23.9 | 22.6 |
| | Adjusted Composite | 18.1 | 22.2 | 21.4 | 20.0 |
| Vehicle Size | Weight (lb.) | 4741 | 4605 | 4282 | 4741 |
| Engine | CID | 240 | 205 | 198 | 219 |
| | HP | 251 | 206 | 209 | 237 |
| | HP/CID | 1.06 | 1.02 | 1.07 | 1.10 |
| | HP/WT | .053 | .044 | .049 | .050 |
| | Percent Multivalve | 65% | 72% | 76% | 76% |
| | Percent Variable Valve | 51% | 43% | 60% | 59% |
| | Percent Diesel | 0.2% | 12.8% | 4.3% | 7.5% |
| Performance | 0-60 Time (Sec.) | 9.7 | 9.2 | 9.5 | 9.6 |
| | Top Speed | 141 | 129 | 133 | 137 |
| | Ton-MPG | 42.9 | 52.4 | 46.6 | 47.8 |
| Drive | Front | 27% | 28% | 42% | 30% |
| | Rear | 23% | 33% | 27% | 25% |
| | 4WD | 50% | 39% | 31% | 45% |
| Transmission | Manual | 3% | 11% | 27% | 8% |
| | Lockup | 93% | 50% | 49% | 75% |
| | CVT | 5% | 39% | 24% | 18% |
| Hybrid Vehicle | | 1.2% | 47.2% | 21.4% | 13.2% |

Table 30

**Best in Class Results 2008 Light Duty Vehicles**

| **Vehicle Characteristic** | **Selection Basis** | **Actual Data** | **Size Class** | **Size Class** | **Weight Class** |
|---|---|---|---|---|---|
| | **Selection Criteria** | **All Vehicles** | **Best 4 Nameplates** | **Best 12 Vehicles** | **Best 12 Vehicles** |
| Fuel Economy | Lab. 55/45 | 26.0 | 33.0 | 31.1 | 29.4 |
| | Adjusted City | 17.5 | 22.8 | 21.2 | 20.0 |
| | Adjusted Highway | 24.2 | 28.1 | 27.5 | 26.4 |
| | Adjusted Composite | 20.8 | 25.5 | 24.4 | 23.2 |
| Vehicle Size | Weight (lb.) | 4117 | 3909 | 3732 | 4117 |
| Engine | CID | 203 | 166 | 163 | 176 |
| | HP | 222 | 177 | 180 | 204 |
| | HP/CID | 1.12 | 1.09 | 1.12 | 1.19 |
| | HP/WT | .054 | .045 | .048 | .049 |
| | Percent Multivalve | 77% | 84% | 86% | 88% |
| | Percent Variable Valve | 58% | 62% | 65% | 68% |
| | Percent Diesel | 0.1% | 6.3% | 2.1% | 5.0% |
| Performance | 0-60 Time (Sec.) | 9.6 | 9.7 | 9.9 | 9.8 |
| | Top Speed | 139 | 126 | 129 | 133 |
| | Ton-MPG | 43.1 | 51.1 | 46.1 | 48.2 |
| Drive | Front | 53% | 64% | 69% | 58% |
| | Rear | 19% | 17% | 15% | 16% |
| | 4WD | 28% | 19% | 16% | 26% |
| Transmission | Manual | 7% | 11% | 32% | 23% |
| | Lockup | 86% | 53% | 49% | 56% |
| | CVT | 8% | 36% | 20% | 21% |
| Hybrid Vehicle | | 2.5% | 38.3% | 17.0% | 12.6% |

Another general approach for determining potential fuel economy improvement is to study the effects on fuel economy caused by the changes that have occurred in the distributions of vehicle weight and size. This technique involves preserving the average characteristics of vehicles within each size or weight strata in today's fleet, but re-mixing the sales distributions to match those of a baseline year and then calculating the fleet wide averages for those characteristics using the re-mixed sales data. The sales distribution of the resultant fleet by *vehicle type and size,* thus is forced to be the same as that for the base year. As with the best in car size class technique, there can be some fluctuation in average interior volume for cars because of the distribution of interior volume within a car class. Similarly, if the sales proportions in each inertia weight class are held the same as the base year's, the sales distribution of the resultant fleet by *weight* remains the same as that for the base year change, and the recalculated average weight is the same as the base year's.

It is important to note that, for Tables 31 and 32 below, both hybrid and diesel vehicles were excluded so that only vehicles with conventional powertrains were considered. Accordingly, the data in the rows for actual 2008, 1981, and 1988 typically differ slightly from data reported elsewhere in this report.

Table 31 compares weight, interior volume, engine CID and HP, estimated 0-to-60 time and laboratory fuel economy for conventionally powered MY2008 cars as calculated from the actual 2008 sales distribution and then recalculated using the size and weight distributions from MY1981 and MY1988. The base years of 1981 and 1988 were chosen because 1981 was the year with the lowest average weight and horsepower levels, and 1988 was the year with the highest LAB fuel economy. This table includes the actual 1981 and 1988 fleet

Table 31

**Characteristics of MY 2008 Cars**

| | Inertia Weight | Interior Volume | Engine CID | Engine HP | 0 to 60 Time | Lab 55/45 MPG |
|---|---|---|---|---|---|---|
| **Calculated From:** | | | | | | |
| 2008 Actual Distribution | 3549 | 110 | 171 | 199 | 9.5 | 29.8 |
| 1981 Weight Distribution | 3043 | 98 | 136 | 171 | 9.6 | 32.9 |
| 1988 Weight Distribution | 3047 | 102 | 130 | 156 | 10.2 | 34.2 |
| 1981 Size Distribution | 3498 | 108 | 165 | 195 | 9.5 | 30.2 |
| 1988 Size Distribution | 3447 | 107 | 161 | 189 | 9.6 | 30.5 |
| Reference: 1981 Actual | 3043 | 106 | 178 | 99 | 14.1 | 24.9 |
| Reference: 1988 Actual | 3047 | 107 | 160 | 116 | 12.8 | 28.6 |
| **Percent Change:** | | | | | | |
| 2008 Actual Distribution | 0% | 0% | 0% | 0% | 0% | 0% |
| 1981 Weight Distribution | -14% | -11% | -20% | -14% | 1% | 10% |
| 1988 Weight Distribution | -14% | -7% | -24% | -22% | 7% | 15% |
| 1981 Size Distribution | -1% | -2% | -4% | -2% | 0% | 1% |
| 1988 Size Distribution | -3% | -3% | -6% | -5% | 1% | 2% |
| Reference: 1981 Actual | -14% | -4% | 4% | -50% | 48% | -16% |
| Reference: 1988 Actual | -14% | -3% | -6% | -42% | 35% | -4% |

averages as a point of reference. In both of the weight distribution cases, the fuel economy of the re-mixed MY2008 fleet would have been higher than actually is: 10 percent if the 1981 weight distribution is used, 15 percent if the 1988 weight distribution is used. For both re-mixed weight cases, interior volume and horsepower are substantially lower. Using the MY1981 and MY1988 size mix distributions result in a much smaller change of only a 1 to 2 percent increase in car fuel economy. In addition, both of these remixed car class scenarios results in an average weight and horsepower for the hypothetical remixed fleets that is very close to the actual MY2008 data.

Table 32 shows similar data for trucks, and as with the car class cases using either the 1981 or the 1988 sales distribution by weight class, results in higher recalculated fuel economy than using the corresponding size class sales distribution. Figures 70 to 73 compare actual fuel economy for all model years from 1975 to 2007 with what it would have been had the distributions of weight or size been the same as 1981 or 1988. For both cars and trucks, using either the 1981 or 1988 weight class distribution, results in significantly high fuel economy improvements than the similar size class cases.

Table 32

**Characteristics of MY 2008 Trucks**

| | **Inertia Weight** | **Engine CID** | **Engine HP** | **0 to 60 Time** | **Lab 55/45 MPG** |
|---|---|---|---|---|---|
| **Calculated From:** | | | | | |
| 2008 Actual Distribution | 4743 | 241 | 252 | 9.7 | 22.4 |
| 1981 Weight Distribution | 3841 | 173 | 198 | 9.9 | 27.6 |
| 1988 Weight Distribution | 3838 | 174 | 191 | 10.2 | 27.5 |
| 1981 Size Distribution | 4523 | 246 | 250 | 9.8 | 22.4 |
| 1988 Size Distribution | 4362 | 225 | 225 | 10.1 | 23.2 |
| Reference: 1981 Actual | 3841 | 252 | 121 | 14.4 | 19.7 |
| Reference: 1988 Actual | 3838 | 227 | 141 | 12.9 | 21.2 |
| **Percent Change:** | | | | | |
| 2008 Actual Distribution | 0% | 0% | 0% | 0% | 0% |
| 1981 Weight Distribution | -19% | -28% | -21% | 2% | 23% |
| 1988 Weight Distribution | -19% | -28% | -24% | 5% | 23% |
| 1981 Size Distribution | -5% | 2% | -1% | 1% | 0% |
| 1988 Size Distribution | -8% | -7% | -11% | 4% | 4% |
| Reference: 1981 Actual | -19% | 5% | -52% | 48% | -12% |
| Reference: 1988 Actual | -19% | -6% | -44% | 33% | -5% |

## Effect of Weight and Size On Car Fuel Economy

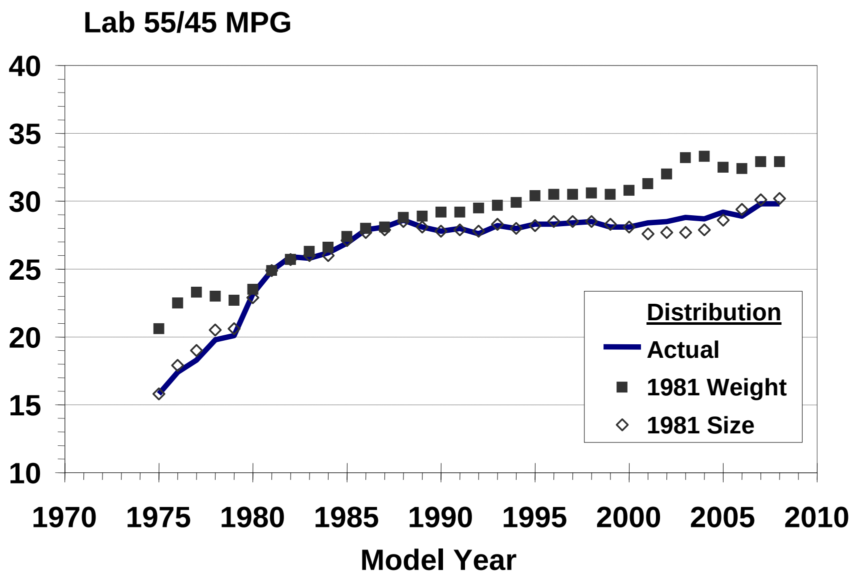



Figure 70

## Effect of Weight and Size On Truck Fuel Economy

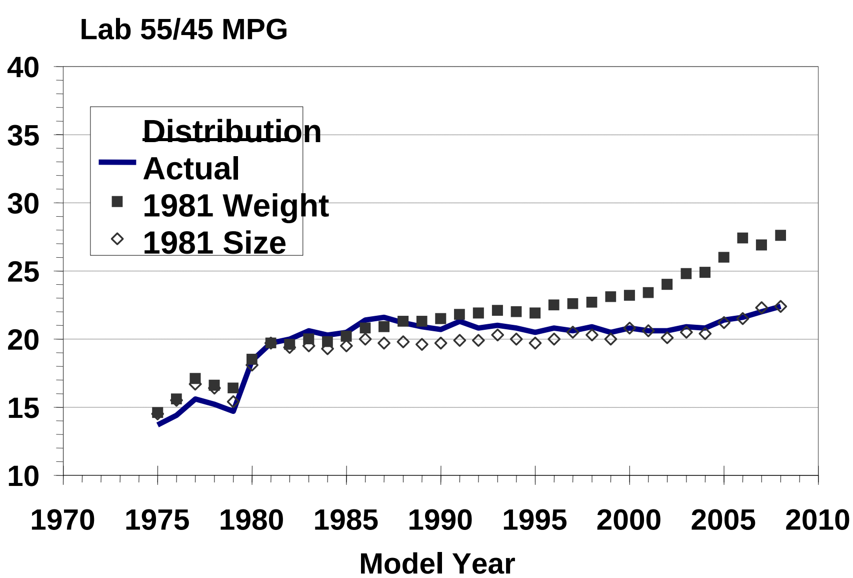



Figure 71

## Effect of Weight and Size On Car Fuel Economy

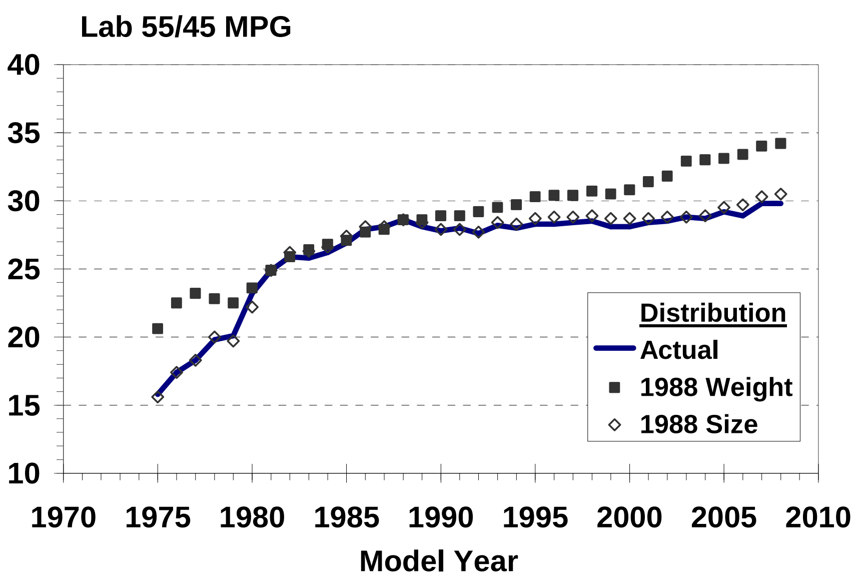



Figure 72

## Effect of Weight and Size On Truck Fuel Economy

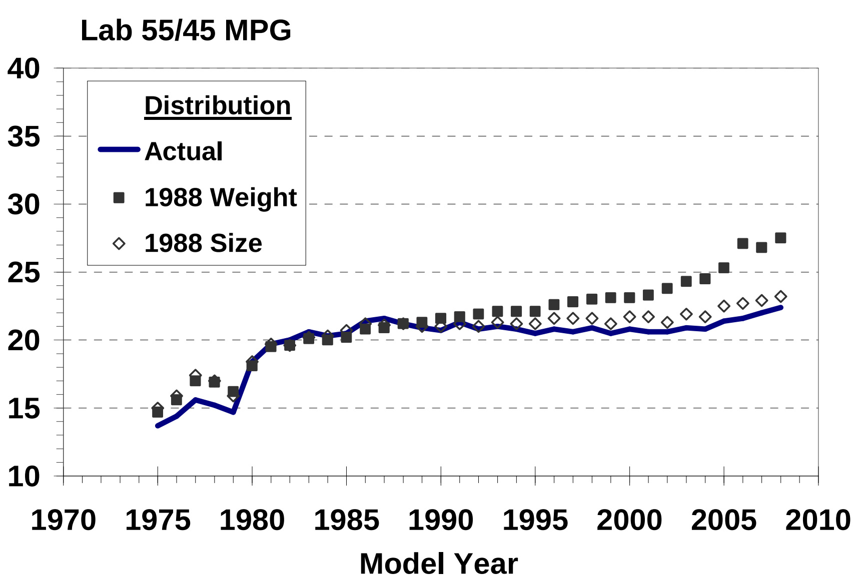



Figure 73

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