Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2011

Appendix A
Database Details and Calculation Methods

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.

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Harmonically Averaging Fuel Economy Values

Dimensionally, fuel economy is miles divided by gallons. Then, presented with more than one fuel economy value, an approach to averaging the values is to compute the result by determining the total miles traveled and dividing that by the total gallons used.

Example: A motorist's fuel economy log for May shows that 704 miles were accumulated around town in which the fuel economy was 16 mpg, and one 216 mile highway trip was taken on which the fuel economy was 24 mpg. What is the average fuel economy for May?

The total miles are 704 + 216 = 920. The total gallons thus are 704 / 16 = 44 plus 216 / 24 = 9 or a total of 53 gallons. The average mpg is 920 / 53 = 17.4 mpg. Notice that the arithmetic average of the two fuel economy values (16 + 24) / 2 = 20 mpg gives an individual result that is higher than the total miles/total gallons result.

Even if the around-town miles traveled and the highway trip miles traveled were the same (460 miles), the average fuel economy would not be 20; it would be 19.2 mpg. This is because in the total miles/total gallons approach, *fuel consumption* is arithmetically averaged, but *fuel economy* is harmonically averaged, so for the second example (equal trip distances), the calculation would be:

$$Average\ MPG = \frac{2}{\left(\frac{1}{16} + \frac{1}{24}\right)}$$

which is the same as arithmetically averaging the two fuel consumption values.

A specific example of this type of averaging approach is shown in the calculation of the overall average fuel economy using the EPA "city" (MPG_C) and EPA "highway" (MPG_H) fuel economy values.

$$Average\ MPG = \frac{Total\ Miles}{Total\ Gallons}$$

$$= \frac{Total\ Miles}{City\ Gallons + Highway\ Gallons}$$

$$= \frac{Total\ Miles}{\left(\frac{City\ Miles}{City\ MPG} + \frac{Highway\ Miles}{Highway\ MPG}\right)}$$

Now, if city miles are 55 percent of total miles and highway miles are the remaining 45 percent, after dividing by total miles,

$$Average\ MPG = \frac{1}{\left(\frac{0.55}{MPG_C} + \frac{0.45}{MPG_H}\right)}$$

and this average mpg would represent a composite mpg value based on the 55% city/45% highway driving in this example. This 55% city/45% highway weighting is the metric in this report for laboratory composite fuel economy values.

The same approach can be used when the average mpg of a group of vehicles with different mpg values is to be calculated. Suppose a fleet of 100,000 vehicles is made up of two classes, one of 70,000 vehicles whose fuel economy is 10 mpg and the other of 30,000 vehicles whose fuel economy is 14 mpg. Each vehicle in the fleet is assumed to travel the same number of miles (**M**),

$$Total\ Miles = 100{,}000\ \mathbf{M}$$

$$Total\ Gallons = \frac{70{,}000\ \mathbf{M}}{10} + \frac{30{,}000\ \mathbf{M}}{14}$$

and the average fuel economy is:

$$Average\ Fuel\ Economy = \frac{1}{\left(\frac{0.7}{10} + \frac{0.3}{14}\right)} = 10.9\ \text{mpg}$$

where .7 and .3 are the relative shares of each vehicle class in the fleet. Notice that, again, the arithmetic average of the class fuel economy values (10 + 14)/2 = 12 mpg is higher.

In general, some form of a weighted harmonic mean must be used when averaging different fuel economy values in order to maintain mathematical integrity.

While fuel economy values (in miles per gallon) must be harmonically averaged to maintain mathematical integrity, fuel consumption values (in gallons per mile) and carbon dioxide emissions values (in grams per mile) can be arithmetically averaged.

Estimated and Final Production Data

Table A-1 compares average laboratory 55/45 fuel economy for model years 1998 through 2011 at three points in time:

(1) an initial estimate determined early in the model year using projected production;

(2) for some years, a revised estimate determined by using trade publication sales data that were obtained after the end of each model year, but before the final CAFE data were submitted by automakers to the Federal Government; and

(3) final fuel economy values determined from CAFE compliance data provided by the manufacturers to the Federal Government after the end of the model year.

Historically, the final car plus truck laboratory 55/45 fuel economy values have generally varied from 0.4 mpg lower to 0.6 mpg higher compared to the original estimates based exclusively on projected production. But, MY2009 was a very unusual year in this regard. The final car plus truck laboratory 55/45 value for MY2009 was 1.8 mpg higher than the initial estimate for 2009, due to the market turmoil in MY2009. The final car plus truck adjusted fuel economy value for MY2009 was 1.3 mpg higher than the initial estimate. For MY 2010, the final car plus truck laboratory and adjusted values were both 0.1 mpg higher than the initial estimates in last year's report.

Table A-1

Comparison of Laboratory 55/45 MPG

	Model Year	Initial Estimate	Revised Estimate	Final Value
Cars	1998	28.6	28.6	28.5
	1999	28.1	28.2	28.1
	2000	28.1	28.3	28.2
	2001	28.3	28.3	28.4
	2002	28.5	28.5	28.6
	2003	29.0	28.9	28.9
	2004	28.7	28.9	28.9
	2005	28.9	29.2	29.5
	2006	28.8	29.2	29.2
	2007	29.4	30.3	30.3
	2008	30.3		30.5
	2009	30.9		32.1
	2010	32.7		32.3
	2011	32.8		
Trucks	1998	20.6	20.6	20.9
	1999	20.3	20.4	20.5
	2000	20.5	20.5	20.8
	2001	20.3	20.4	20.6
	2002	20.4	20.3	20.6
	2003	20.8	20.9	20.9
	2004	20.9	20.9	20.8
	2005	21.3	21.2	21.4
	2006	21.5	21.9	21.8
	2007	22.1	22.1	22.1
	2008	22.5		22.7
	2009	22.9		23.8
	2010	23.8		23.4
	2011	23.6		
Both	1998	24.4	24.4	24.5
	1999	23.8	24.0	24.1
	2000	24.0	23.9	24.3
	2001	23.9	24.0	24.2
	2002	24.0	23.9	24.1
	2003	24.4	24.2	24.3
	2004	24.4	24.4	24.0
	2005	24.6	24.6	24.8
	2006	24.6	25.3	25.2
	2007	25.3	25.7	25.8
	2008	26.0		26.3
	2009	26.4		28.2
	2010	28.3		28.4
	2011	28.6		

Use of 3-Year Moving Averages

Use of the three-year moving averages, which effectively smoothes the trends, results in an improvement in discriminating real trends from what might be relatively small year-to-year variations in the data. For this report, as shown in Table A-2 (laboratory) and Table A-3 (adjusted), these three-year moving averages are tabulated at the midpoint. For example, the midpoint for model years 2007, 2008, and 2009 is MY2008.

Table A-2

Light-Duty Vehicle Laboratory Fuel Economy and Truck Sales Fraction

	Actual Data				Three-Year Moving Average			
	55/45 Fuel Economy			Truck	55/45 Fuel Economy			Truck
Model Year	Car	Truck	Both	Production Fraction	Car	Truck	Both	Production Fraction
1975	15.8	13.7	15.3	19.2%				
1976	17.4	14.4	16.7	20.9%	17.2	14.6	16.6	19.9%
1977	18.3	15.6	17.7	19.7%	18.5	15.1	17.7	21.0%
1978	19.9	15.3	18.6	22.4%	19.5	15.2	18.3	21.4%
1979	20.2	14.7	18.7	22.1%	21.2	16.2	19.9	20.3%
1980	23.5	18.6	22.5	16.4%	23.0	17.8	21.8	18.6%
1981	25.1	20.1	24.1	17.2%	24.9	19.7	23.8	17.7%
1982	26.0	20.5	24.7	19.5%	25.7	20.5	24.5	19.6%
1983	25.9	20.8	24.6	22.0%	26.1	20.6	24.6	21.6%
1984	26.3	20.5	24.6	23.4%	26.4	20.6	24.7	23.4%
1985	26.9	20.6	25.0	24.7%	27.0	20.8	25.1	25.3%
1986	27.8	21.5	25.7	27.9%	27.6	21.2	25.6	26.5%
1987	28.0	21.6	25.9	27.1%	28.1	21.4	25.8	28.0%
1988	28.5	21.2	25.9	29.0%	28.2	21.2	25.8	28.7%
1989	28.1	20.9	25.4	29.9%	28.1	20.9	25.5	29.5%
1990	27.7	20.7	25.2	29.6%	27.9	20.9	25.4	29.9%
1991	27.8	21.2	25.4	30.4%	27.6	20.9	25.2	30.4%
1992	27.4	20.8	24.9	31.3%	27.6	21.0	25.1	31.3%
1993	27.6	21.0	25.1	32.3%	27.6	20.8	24.9	33.9%
1994	27.7	20.7	24.6	38.1%	27.8	20.7	24.8	35.4%
1995	28.0	20.5	24.7	35.9%	27.8	20.7	24.7	36.7%
1996	27.7	20.8	24.8	36.3%	27.9	20.6	24.7	36.9%
1997	27.9	20.5	24.5	38.5%	27.9	20.7	24.6	38.5%
1998	27.9	20.8	24.5	40.7%	27.8	20.5	24.4	40.0%
1999	27.6	20.3	24.1	40.7%	27.7	20.6	24.3	40.6%
2000	27.5	20.7	24.3	40.3%	27.6	20.4	24.2	40.0%
2001	27.6	20.2	24.2	38.8%	27.6	20.4	24.2	40.1%
2002	27.7	20.3	24.1	41.2%	27.8	20.4	24.2	41.1%
2003	28.2	20.6	24.3	43.4%	28.0	20.4	24.1	43.2%
2004	28.1	20.4	24.0	45.0%	28.4	20.7	24.4	43.7%
2005	28.8	21.0	24.8	42.8%	28.5	20.9	24.7	42.6%
2006	28.6	21.3	25.2	40.0%	29.0	21.3	25.3	40.5%
2007	29.5	21.5	25.8	38.8%	29.3	21.6	25.7	39.1%
2008	29.8	22.1	26.3	38.5%	30.2	22.2	26.7	36.0%
2009	31.3	23.0	28.2	30.8%	31.2	22.8	27.6	35.0%
2010	32.3	23.4	28.4	35.7%	32.1	23.3	28.4	34.7%
2011	32.8	23.6	28.6	37.6%				

Table A-3

Light-Duty Vehicle Adjusted Fuel Economy

Cars

Model Year	Actual Data			Three-Year Moving Average		
	City	Highway	Composite	City	Highway	Composite
1975	12.3	15.2	13.5			
1976	13.7	16.6	14.9	13.5	16.4	14.6
1977	14.4	17.3	15.6	14.5	17.7	15.8
1978	15.5	19.1	16.9	15.3	18.5	16.6
1979	15.9	19.2	17.2	16.6	20.3	18.1
1980	18.3	22.6	20.0	17.9	22.0	19.6
1981	19.6	24.2	21.4	19.3	24.1	21.2
1982	20.1	25.5	22.2	19.9	25.1	21.9
1983	19.9	25.5	22.1	20.1	25.6	22.2
1984	20.2	25.9	22.4	20.2	26.0	22.5
1985	20.6	26.7	23.0	20.7	26.7	23.0
1986	21.2	27.6	23.7	21.0	27.3	23.5
1987	21.2	27.7	23.8	21.2	27.8	23.8
1988	21.4	28.1	24.1	21.1	27.8	23.8
1989	20.8	27.8	23.6	20.9	27.8	23.7
1990	20.4	27.4	23.3	20.5	27.5	23.4
1991	20.4	27.4	23.3	20.2	27.3	23.1
1992	19.8	27.2	22.9	20.0	27.3	23.0
1993	19.9	27.2	23.0	19.8	27.3	23.0
1994	19.8	27.4	23.0	19.8	27.5	23.1
1995	19.8	27.8	23.2	19.7	27.5	23.0
1996	19.5	27.3	22.9	19.6	27.5	23.0
1997	19.5	27.3	22.9	19.5	27.3	22.9
1998	19.4	27.3	22.9	19.3	27.1	22.8
1999	19.1	26.8	22.6	19.1	26.9	22.6
2000	18.9	26.5	22.4	19.0	26.6	22.4
2001	18.9	26.4	22.4	18.9	26.4	22.4
2002	18.9	26.2	22.3	18.9	26.4	22.5
2003	19.0	26.7	22.7	18.9	26.5	22.5
2004	18.8	26.6	22.5	19.0	26.7	22.7
2005	19.2	26.9	22.9	19.0	26.8	22.8
2006	19.1	26.8	22.8	19.3	27.1	23.1
2007	19.7	27.5	23.5	19.5	27.4	23.3
2008	19.9	27.8	23.7	20.1	28.1	24.0
2009	20.9	28.9	24.8	20.7	28.8	24.7
2010	21.5	29.7	25.5	21.4	29.7	25.4
2011	21.7	30.4	25.9			

Table A-3

Light-Duty Vehicle Adjusted Fuel Economy

Trucks

Model Year	Actual Data			Three-Year Moving Average		
	City	Highway	Composite	City	Highway	Composite
1975	10.9	12.7	11.6			
1976	11.6	13.2	12.3	11.7	13.3	12.4
1977	12.7	14.2	13.3	12.2	13.7	12.8
1978	12.4	13.7	13.0	12.4	13.7	12.9
1979	12.1	13.1	12.5	13.1	14.6	13.8
1980	14.8	17.1	15.8	14.3	16.3	15.1
1981	16.0	18.6	17.1	15.7	18.3	16.8
1982	16.3	19.0	17.4	16.3	19.1	17.4
1983	16.5	19.6	17.7	16.3	19.3	17.5
1984	16.1	19.3	17.4	16.3	19.4	17.6
1985	16.2	19.4	17.5	16.4	19.6	17.7
1986	16.8	20.2	18.2	16.6	20.0	18.0
1987	16.8	20.5	18.3	16.6	20.3	18.1
1988	16.2	20.1	17.9	16.3	20.1	17.9
1989	15.9	19.8	17.6	15.9	19.9	17.6
1990	15.6	19.8	17.4	15.8	19.9	17.6
1991	15.9	20.3	17.8	15.7	20.0	17.5
1992	15.4	19.9	17.4	15.6	20.1	17.5
1993	15.5	20.1	17.5	15.4	19.9	17.3
1994	15.2	19.6	17.2	15.2	19.7	17.2
1995	15.0	19.5	17.0	15.1	19.6	17.1
1996	15.0	19.8	17.2	14.9	19.6	17.0
1997	14.8	19.4	16.9	14.9	19.7	17.1
1998	14.8	19.7	17.1	14.7	19.4	16.9
1999	14.5	19.1	16.6	14.7	19.4	16.9
2000	14.7	19.3	16.9	14.5	19.1	16.6
2001	14.3	18.8	16.4	14.4	19.0	16.6
2002	14.2	18.8	16.4	14.3	18.9	16.5
2003	14.4	19.0	16.6	14.2	18.9	16.5
2004	14.1	18.9	16.4	14.3	19.1	16.7
2005	14.4	19.4	16.9	14.4	19.3	16.8
2006	14.6	19.7	17.1	14.6	19.7	17.1
2007	14.7	19.9	17.3	14.8	20.0	17.4
2008	15.0	20.5	17.7	15.1	20.6	17.8
2009	15.7	21.3	18.4	15.5	21.1	18.3
2010	15.9	21.6	18.7	15.9	21.6	18.7
2011	16.0	22.0	18.9			

Table A-3

Light-Duty Vehicle Adjusted Fuel Economy

Cars and Trucks

Model Year	Actual Data			Three-Year Moving Average		
	City	Highway	Composite	City	Highway	Composite
1975	12.0	14.6	13.1			
1976	13.2	15.7	14.2	13.1	15.7	14.1
1977	14.0	16.6	15.1	14.0	16.6	15.0
1978	14.7	17.5	15.8	14.5	17.2	15.6
1979	14.9	17.4	15.9	15.7	18.8	17.0
1980	17.6	21.5	19.2	17.1	20.6	18.5
1981	18.8	23.1	20.5	18.6	22.8	20.3
1982	19.2	23.9	21.1	19.0	23.6	20.9
1983	19.0	23.9	21.0	19.1	23.9	21.0
1984	19.1	24.0	21.0	19.1	24.1	21.1
1985	19.3	24.4	21.3	19.4	24.5	21.4
1986	19.8	25.0	21.8	19.6	24.9	21.7
1987	19.8	25.3	22.0	19.7	25.2	21.9
1988	19.6	25.2	21.9	19.5	25.1	21.8
1989	19.1	24.8	21.4	19.1	24.9	21.5
1990	18.7	24.6	21.2	18.9	24.7	21.3
1991	18.8	24.7	21.3	18.6	24.6	21.1
1992	18.2	24.4	20.8	18.4	24.5	21.0
1993	18.2	24.4	20.9	18.1	24.2	20.7
1994	17.8	23.8	20.4	17.9	24.1	20.6
1995	17.7	24.1	20.5	17.7	24.0	20.4
1996	17.6	24.0	20.4	17.6	23.9	20.4
1997	17.4	23.6	20.2	17.4	23.8	20.2
1998	17.2	23.6	20.1	17.2	23.4	20.0
1999	16.9	23.1	19.7	17.0	23.2	19.9
2000	16.9	23.1	19.8	16.9	23.0	19.7
2001	16.8	22.8	19.6	16.8	22.8	19.6
2002	16.6	22.5	19.5	16.7	22.7	19.6
2003	16.7	22.7	19.6	16.6	22.6	19.5
2004	16.3	22.4	19.3	16.6	22.8	19.6
2005	16.8	23.1	19.9	16.7	23.0	19.8
2006	17.0	23.4	20.1	17.1	23.5	20.2
2007	17.4	24.0	20.6	17.4	23.9	20.6
2008	17.7	24.4	21.0	18.0	24.8	21.3
2009	18.9	26.0	22.4	18.6	25.5	22.0
2010	19.1	26.2	22.6	19.1	26.3	22.6
2011	19.2	26.6	22.8			

Methodology for Adjusted Fuel Economy Values for Model Years 1986-2011

On December 27, 2006, EPA published regulations that changed the methodology for calculating the city and highway fuel economy label estimates for new passenger cars and light trucks (71 Federal Register 77872). This revised methodology provides fuel economy estimates to consumers that better reflect real world fuel economy. The methodology incorporates test data that directly account for several important factors that affect fuel economy in the real world, such as high speeds, aggressive accelerations and decelerations, the use of air conditioning, and operation in cold temperatures, and indirectly account for a number of other factors that are not reflected in EPA laboratory test data such as changing fuel composition, road conditions, etc.

These vehicle fuel economy label changes were implemented beginning with the 2008 model year. For model years 2008-2010, manufacturers had two options for calculating city and highway fuel economy labels: 1) use vehicle-specific "5-cycle" (Federal Test Procedure for urban stop-and-go driving, Highway Fuel Economy Test for rural driving, US06 test for high speeds and aggressive driving, SCO3 test for air conditioning operation, and cold FTP test for cold temperature operation) fuel economy test data in "composite" equations that calculate vehicle-specific city and highway fuel economy values using weighting factors for data from each of the 5 EPA test cycles, or 2) use an industry-average "mpg-based" method to derive 5-cycle values, which yields mpg-based adjustments based on a regression of recent 5-cycle fuel economy data for the industry as a whole, and applied to "2-cycle" fuel economy test results. Starting with the 2011 models, manufacturers are required to perform an evaluation using 5-cycle tests conducted for vehicle emissions certification that determines whether the models represented by the certification vehicle are eligible to use the less resource-intensive mpg-based method for determining adjusted fuel economy values. The evaluation consists of a comparison of 5-cycle and mpg-based 2-cycle fuel economy values to determine whether the mpg-based method achieves results comparable to the 5-cycle method. If the evaluation finds that the 5-cycle method yields significantly lower estimates than the derived 5-cycle method, then the manufacturer is required to use the 5-cycle method for all models represented by the emission certification vehicle. Of course, a manufacturer may use the full 5-cycle method for any vehicles for which it is not required if they believe it produces better fuel economy results. Although this required evaluation has resulted in more models using the 5-cycle method, they are still in the minority. In the 2010 model year, before this evaluation was required, about seven percent of models used the more complex and labor-intensive method, but two years later, in the 2012 model year, this fraction has doubled to about 14 percent. For more details on the derivation of these options, the specific equations that allow an automaker to calculate new label values using either the vehicle-specific 5-cycle test data or the industry-average mpg-based derive 5-cycle approach, and the impact of these changes on average fuel economy label values, see the Preamble to the new regulations (71 Federal Register 77881-77893).

Beginning with the 2007 Trends report, EPA has made significant changes in how adjusted (ADJ) fuel economy values for model years 1986 through 2011 are calculated to reflect the revised EPA fuel economy label methodology. These changes affect every table and figure in this report that involve adjusted fuel economy data. Accordingly, adjusted fuel economy values for 1986 and later model years should not be compared with the corresponding values from pre-2007 reports in this series. Specifically, the adjusted fuel economy values for 1986-2011 in this report differ from those in pre-2007 reports as explained below.

- For model years 2005-2011, EPA calculates adjusted fuel economy values for most of the individual models in the fuel economy trends database using the following city and highway "mpg-based" equations from the EPA fuel economy labeling rulemaking:

$$New\ \text{ADJ CITY} = \frac{1}{0.003259 + \frac{1.1805}{\text{LAB CITY}}}$$

$$New\ \text{ADJ HWY} = \frac{1}{0.001376 + \frac{1.3466}{\text{LAB HWY}}}$$

The above equations are not used if a manufacturer chooses the option of providing vehicle-specific 5-cycle test data for an individual model. In that case, the adjusted fuel economy values are calculated using equations with weighting factors for the data from the 5-cycle tests. For MY2011, manufacturers chose this option for a small number of individual models.

Calculating fleetwide adjusted city and highway fuel economy values for a given model year requires a harmonic, production-weighted average of all of the adjusted city and highway fuel economy values for individual models.

The above equations yield a greater downward adjustment for higher fuel economy vehicles than for lower fuel economy vehicles. For example, compared to the older fuel economy label methodology, a 15 mpg city value will be reduced by an additional 10%, while a 50 mpg city value will be reduced by an additional 18%. Likewise, a 20 mpg highway value will be reduced by an additional 7%, while a 50 mpg highway value will be reduced by an additional 11%. EPA projected an overall average fleetwide adjustment of 11% lower for city fuel economy and 8% lower for highway fuel economy, beyond that in the older label adjustment methodology that has been used in pre-2007 reports in this series. These factors can be used to convert older adjusted fuel economy values to the newer adjusted fuel economy values for the current fleet as a whole, but would not be appropriate factors to use for individual models or for a future fleet with different mpg characteristics.

This report seldom uses separate city and highway fuel economy values, but typically uses the composite city/highway fuel economy value. Pre-2007 reports used a 55% city/45% highway weighting for adjusted composite fuel economy values, the same weighting used for laboratory composite values and for the CAFE compliance program. The analysis of real world driving activity underlying the newer fuel economy label methodology assumed a "speed cutpoint" of 45 miles per hour to differentiate between city and highway driving (71 Federal Register 77904). Based on this speed cutpoint, the correct weighting for correlating the new city and highway fuel economy values with real world driving, on a miles driven basis, is 43% city/57% highway. Accordingly, the 43% city/57% highway weighting is now used for all adjusted composite city/highway fuel economy values in this report beginning with the 2005 model year (note that the historic 55% city/45% highway weighting is still used for both CAFE compliance and fuel economy labels).

The appropriate fleetwide factors to convert laboratory or older adjusted fuel economy values to the newer adjusted fuel economy values are dependent on the city fuel economy-to-highway fuel economy ratios in the fleet. On average, for the current fleet, combining the 11% lower adjustment for city fuel economy, the 8% lower adjustment for highway fuel economy, and the shift to the 43% city/57% highway weighting, the newer adjustment for city/highway composite fuel economy values is 6% lower than that used in the older label adjustment methodology. This 6% lower value is the average impact for a fleet with the mpg and city fuel economy-to-highway fuel economy characteristics of the current fleet, and would not be the appropriate value for individual models, partial fleet segments, or for future fleets with different mpg and city fuel economy-to-highway fuel economy distributions.

- For model years 1986 through 2004, EPA calculates adjusted fuel economy values based on the assumption that the impacts of the factors that have led to lower real world fuel economy have occurred in a gradual (i.e., linear) manner over the 20 years from 1986 through 2005. On April 6, 1984, EPA published regulations that established the older fuel economy label adjustment factors of 0.9 for city fuel economy and 0.78 for highway fuel economy that took effect for model year 1985 vehicles (49 Federal Register 13832). EPA believes that these adjustment factors were appropriate through the 1985 model year. EPA has not attempted to perform a year-by-year analysis to determine the extent to which the many relevant factors (including highway speed limits, more aggressive driving, vehicle horsepower-to-weight ratio, suburbanization, congestion, use of air conditioning, gasoline composition, et al) that have affected real world fuel economy since 1985 have changed over time. Rather, EPA has made the simplifying, but we think reasonable, assumption that the collective impact of these changes has been a linearly increasing impact over the 20 years from 1986 through 2005. Using the equations shown above for individual models, EPA has assumed 1/20 of the fully phased-in downward adjustment for city and highway values would be reflected in the 1986 data, 2/20 of this adjustment would be reflected in the 1987 data, etc., up to 19/20 of this adjustment in 2004 and the full adjustment in 2005 and later years. Likewise, EPA has assumed the 55/45 city/highway weighting changes to a 43/57 city/highway weighting in a linear fashion over the 1986 to 2005 time period as well. As discussed above, the average fleetwide composite city/highway fuel economy values for 2005-2011 are 6% lower than the composite city/highway fuel economy value calculated with the older adjustment factors.

To generate precise adjusted city, highway, or composite fuel economy values for individual models or for future fleetwide averages with different mpg or city fuel economy-to-highway fuel economy ratios than the current fleet, it is essential to use the above equations to calculate adjusted city and highway fuel economy values for individual models, then use the 43% city/57% highway weighting to generate an adjusted composite fuel economy value for individual models, and then calculate the harmonically production-weighted average of the individual models to yield the average composite fuel economy for the fleet as a whole. Alternatively, for a first-order estimate of generic fleetwide factors that one could use to convert values from the historic fuel economy trends database to the newer adjusted fuel economy levels, see the factors in Table A-4, which are based on the mpg and city fuel economy-to-highway fuel economy characteristics of the current fleet. For example, the industry-wide adjusted composite city/highway fuel economy value for model year 1986 in this year's report, which will be reported as ADJ COMP, is about .997 (1.0 minus 0.003, where 0.003 equals 0.3%, and the latter is equal to 6% divided by 20) times the adjusted composite city/highway fuel economy value, or ADJ 55/45, from pre-2007 reports in this series. Likewise, the same industry-wide ADJ COMP value for 1986 can be approximated by multiplying the laboratory composite 55/45 value for 1986 by 0.851. The industry-wide

ADJ COMP fuel economy values for model years 2005-2011 in this year's report are all equal to 0.80 times the laboratory composite 55/45 values.

It is important to note that the above discussion, as well as all the data in this report, is focused on new model year vehicle fleets, i.e., the data for a MY2000 vehicle is most directly relevant for that vehicle operated on the road in calendar year 2000. Because most (though not all) of the real world factors reflected in this methodology are relatively independent of vehicle design, the best approximation of the adjusted fuel economy of a used MY2000 vehicle in calendar year 2011 would be to use the 2011 factors in Table A-4.

Table A-5 provides a comparison of adjusted composite fuel economy values, for cars and trucks combined, using both the older fuel economy label methodology that has been used in pre-2007 reports in this series as well as the newer fuel economy label methodology described above and used in 2007 and later reports.

No changes have been made in the way EPA calculates adjusted fuel economy values for 1975-1985. For these model years, EPA still uses the 0.9 city/0.78 highway fuel economy adjustments established in 1984, along with the 55% city/45% highway weighting factor. EPA believes that this methodology was appropriate for the late 1970s and early 1980s and is not making any changes to adjusted fuel economy values for 1975 through 1985.

No changes have been made in the laboratory (LAB) fuel economy values in this report. The laboratory city value remains the fuel economy value over the EPA Federal Test Procedure, the laboratory highway value remains the fuel economy value over the EPA Highway Fuel Economy Test, and the laboratory 55/45 is a weighted value of these two tests, with a 55% weighting of the Federal Test Procedure and a 45% weighting of the Highway Fuel Economy Test. The laboratory 55/45 values are used for CAFE compliance, in conjunction with alternative fuel vehicle credits and test procedure adjustments. Because the underlying methodology for generating and reporting the laboratory fuel economy values have not changed since this series began in the mid-1970s, these values provide an excellent basis with which to compare 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.

Finally, this same methodology for including real world factors in the adjusted fuel economy values is also reflected in the adjusted carbon dioxide (CO2) emissions data as well. As discussed in Section IV, EPA back-calculated all CO2 emissions values in this report from corresponding fuel economy values in the historical Trends database. Accordingly, the adjusted CO2 emissions values explicitly account for the above methodology for 1986 and later model years.

Table A-4

Approximate Factors for Converting Industry-Wide Fuel Economy Values from Previous Reports to the New Fuel Economy Values in this 2011 Report

	Factors to convert older ADJ to new ADJ			Factors to convert LAB to new ADJ		
	CITY	HWY	55/45	CITY	HWY	55/45
1975-1985	1.000	1.000	1.000	0.900	0.780	0.854
1986	0.995	0.996	0.997	0.895	0.777	0.851
1987	0.989	0.992	0.994	0.890	0.774	0.849
1998	0.984	0.988	0.991	0.885	0.771	0.846
1989	0.978	0.984	0.988	0.880	0.768	0.843
1990	0.973	0.980	0.985	0.875	0.765	0.841
1991	0.967	0.976	0.982	0.870	0.762	0.838
1992	0.962	0.972	0.979	0.865	0.759	0.835
1993	0.956	0.968	0.976	0.860	0.756	0.832
1994	0.951	0.964	0.973	0.855	0.753	0.830
1995	0.945	0.960	0.970	0.850	0.750	0.827
1996	0.940	0.956	0.967	0.845	0.747	0.824
1997	0.934	0.952	0.964	0.840	0.744	0.822
1998	0.929	0.948	0.961	0.835	0.741	0.819
1999	0.923	0.944	0.958	0.830	0.738	0.816
2000	0.918	0.940	0.955	0.825	0.735	0.814
2001	0.912	0.936	0.952	0.820	0.732	0.811
2002	0.907	0.932	0.949	0.815	0.729	0.808
2003	0.901	0.928	0.946	0.810	0.726	0.805
2004	0.896	0.924	0.943	0.805	0.723	0.803
2005 - 2011	0.890	0.920	0.940	0.800	0.720	0.800

Important Notes for Table A-4:

1. Multiplying the factors above times the appropriate values from pre-2007 reports approximates the newer adjusted (ADJ) fuel economy values in this 2011 report. Also, these factors can be used "in reverse" to convert new adjusted fuel economy values in this report to corresponding old adjusted fuel economy values or to corresponding laboratory fuel economy values, e.g., dividing an adjusted, combined city/highway MY 2011 fuel economy value in this report by .940 would yield a corresponding adjusted fuel economy value based on the methodology used in pre-2007 reports.

2. These factors are first-order approximations relevant only for industry-wide fuel economy values for the 1986 through 2011 timeframe.

3. Precise estimates for individual models require the use of the mpg-based equations for ADJ CITY and ADJ HWY provided above as well as a linear phase-in, over the 1986 to 2005 time period, for both the mpg-based equations and the change from a 55/45 city/highway weighting to a 43/57 city/highway weighting.

4. These approximations would yield the largest error for individual models or fleets with high mpg and/or high city fuel economy-to-highway fuel economy ratios.

Table A-5

Comparison of "Old" and "New" Adjusted Composite Fuel Economy Values, for Cars and Trucks Combined, for 2003-2011

Cars and Trucks Combined

Model Year	"Old" Adjusted Composite	"New" Adjusted Composite
2003	20.8	19.6
2004	20.5	19.3
2005	21.2	19.9
2006	21.5	20.1
2007	22.0	20.6
2008	22.4	21.0
2009	24.1	22.4
2010	24.3	22.6
2011	24.5	22.8

Important Notes for Table A-5:

1. "Old" adjusted composite fuel economy values are based on the EPA fuel economy label methodology used in previous reports in this series, i.e., 10% downward city adjustment, 22% downward highway adjustment, and a 55% city/45% highway weighting factor.

2. "New" adjusted composite fuel economy values are based on the new EPA fuel economy label methodology, applicable to MY2011 vehicles and used for the first time in the 2007 report and described in the previous section.

3. The "new" adjusted composite fuel economy values for cars and trucks combined are approximately 6% lower than the "old" adjusted composite fuel economy values for cars and trucks combined. For cars only, the "new" adjusted composite fuel economy values would be more than 6% lower than the "old" values, while for trucks only, the "new" adjusted composite fuel economy values would be less than 6% lower than the "old" values.

Comparison of EPA and NHTSA Data, 1975-2011

Table A-6 compares CAFE performance data reported by the National Highway Traffic Safety Administration ("Summary of Fuel Economy Performance" report dated October 28, 2011 and available at www.nhtsa.gov) with the adjusted and unadjusted (laboratory) composite fuel economy data in this report. The NHTSA values in Table A-6 are generally higher than the EPA laboratory values due to differences in alternative fuel credits, test procedure adjustment factors for cars, and, for years prior to MY 2011, some minor differences in vehicle classification. In recent years for which both Agencies report final data, the NHTSA values are typically 0.6-1.0 mpg higher than the EPA values. For MY2011, the preliminary NHTSA value is 1.0 mpg higher than the preliminary EPA value. These preliminary projections are based on different data sets. The EPA value is based on automaker submissions in the spring and summer of 2010 to support vehicle fuel economy labels. The NHTSA value is based on automaker estimates provided in pre-model year CAFE reports later in 2010. Final MY2011 results will be reported in next year's report.

The EPA car and truck fuel economy values shown in Table A-6 for years prior to MY 2011 differ from the values found elsewhere in this report. For the 2011 report, EPA reclassified most small, 2 wheel drive SUVs from trucks to cars for the entire MY 1975-2011 database. This reflects a regulatory change made by NHTSA for CAFE standards beginning in MY 2011 and which will apply for the joint EPA/NHTSA greenhouse gas emissions and CAFE standards that have been finalized for MY 2012-2016 and proposed for MY 2017-2025. These changes were not in effect for years prior to MY 2011, and accordingly NHTSA's CAFE fuel economy values prior to MY 2011 are based on the previous car and truck definitions. To enable a comparison to these values the car and truck values in table A-6 were calculated using the previous car and truck definitions, which is not consistent with the rest of this report. While the individual car and truck numbers in Table A-6 are unique, the car and truck definitions do not affect the overall manufacturer fuel economy values, which are consistent with the rest of this report.

Table A-6

EPA Adjusted, Laboratory, and NHTSA CAFE Fuel Economy Values by Model Year

	Cars				Trucks				Both Cars and Trucks			
Model Year	EPA Adj.	EPA Unadj.	NHTSA (CAFE)	Diff.	EPA Adj.	EPA Unadj.	NHTSA (CAFE)	Diff.	EPA Adj.	EPA Unadj.	NHTSA (CAFE)	Diff.
1975	13.5	15.8	n/a		11.6	13.7	n/a		13.1	15.3	n/a	
1976	14.9	17.5	n/a		12.2	14.4	n/a		14.2	16.7	n/a	
1977	15.6	18.3	n/a		13.3	15.6	n/a		15.1	17.7	n/a	
1978	16.9	19.9	19.9	0.0	12.9	15.2	n/a		15.8	18.6	19.9	1.3
1979	17.2	20.3	20.3	0.0	12.5	14.7	18.2	3.5	15.9	18.7	20.1	1.4
1980	20.0	23.5	24.3	0.8	15.8	18.6	18.5	-0.1	19.2	22.5	23.1	0.6
1981	21.4	25.1	25.9	0.8	17.1	20.1	20.1		20.5	24.1	24.6	0.5
1982	22.2	26.0	26.6	0.6	17.4	20.5	20.5		21.1	24.7	25.1	0.4
1983	22.1	25.9	26.4	0.5	17.8	20.9	20.7	-0.2	21.0	24.6	24.8	0.2
1984	22.4	26.3	26.9	0.6	17.4	20.5	20.6	0.1	21.0	24.6	25.0	0.4
1985	23.0	27.0	27.6	0.6	17.5	20.6	20.7	0.1	21.3	25.0	25.4	0.4
1986	23.7	27.9	28.2	0.3	18.2	21.4	21.5	0.1	21.8	25.7	25.9	0.2
1987	23.8	28.1	28.5	0.4	18.3	21.6	21.7	0.1	22.0	25.9	26.2	0.3
1988	24.1	28.6	28.8	0.2	17.9	21.2	21.3	0.1	21.9	25.9	26.0	0.1
1989	23.7	28.1	28.4	0.3	17.6	20.9	21.0	0.1	21.4	25.4	25.6	0.2
1990	23.3	27.8	28.0	0.2	17.4	20.7	20.8	0.1	21.2	25.2	25.4	0.2
1991	23.4	28.0	28.4	0.4	17.8	21.3	21.3		21.3	25.4	25.6	0.2
1992	23.1	27.6	27.9	0.3	17.4	20.8	20.8		20.8	24.9	25.1	0.2
1993	23.5	28.2	28.4	0.2	17.5	21.0	21.0		20.9	25.1	25.2	0.1
1994	23.3	28.0	28.3	0.3	17.2	20.8	20.8		20.4	24.6	24.7	0.1
1995	23.4	28.3	28.6	0.3	17.0	20.5	20.5		20.5	24.7	24.9	0.2
1996	23.3	28.3	28.5	0.2	17.2	20.8	20.8		20.4	24.8	24.9	0.1
1997	23.4	28.4	28.7	0.3	17.0	20.6	20.6		20.1	24.5	24.6	0.1
1998	23.4	28.5	28.8	0.3	17.1	20.9	21.0	0.1	20.1	24.5	24.7	0.2
1999	23.0	28.2	28.3	0.1	16.7	20.5	20.9	0.4	19.7	24.1	24.5	0.4
2000	22.9	28.2	28.5	0.3	16.9	20.8	21.3	0.5	19.8	24.3	24.8	0.5
2001	23.0	28.4	28.8	0.4	16.7	20.6	20.9	0.3	19.6	24.2	24.5	0.3
2002	23.1	28.6	29.0	0.4	16.7	20.6	21.4	0.8	19.5	24.1	24.7	0.6
2003	23.2	28.9	29.5	0.6	16.9	20.9	21.8	0.9	19.6	24.3	25.1	0.8
2004	23.1	28.9	29.5	0.6	16.7	20.8	21.5	0.7	19.3	24.0	24.6	0.6
2005	23.5	29.5	30.3	0.8	17.2	21.4	22.1	0.7	19.9	24.8	25.4	0.6
2006	23.3	29.2	30.1	0.9	17.5	21.8	22.5	0.7	20.1	25.2	25.8	0.6
2007	24.1	30.3	31.2	0.9	17.7	22.1	23.1	1.0	20.6	25.8	26.6	0.8
2008	24.3	30.5	31.5	1.0	18.2	22.7	23.6	0.9	21.0	26.3	27.1	0.8
2009	25.4	32.1	32.9	0.8	19.0	23.8	24.8	1.0	22.4	28.2	29.0	0.8
2010	25.8	32.7	33.9	1.2	19.1	23.8	25.2	1.4	22.6	28.4	29.3	0.9
2011	25.9	32.8	33.8	1.0	18.9	23.6	24.5	0.9	22.8	28.6	29.6	1.0

Comparison of EPA and NHTSA Data for MY2010 by Manufacturer

The primary differences between EPA unadjusted laboratory fuel economy data and NHTSA CAFE values are flexible fuel vehicle (FFV) credits that are available to manufacturers that produce vehicles capable of operation on an alternative fuel (generally a blend of 85 percent ethanol and 15 percent gasoline), and test procedure adjustment (TPA) credits that apply to manufacturers of passenger cars.

Table A-7 shows a detailed MY2010 comparison, for the thirteen highest-volume manufacturers, of the EPA laboratory fuel economy values from this report and final NHTSA CAFE values based on the year end fuel economy report data provided to EPA and NHTSA by automakers (MY2010 is the last year for which NHTSA has published final CAFE values). This table shows how EPA laboratory values, FFV credits, and TPA credits "add up" to CAFE values.

It is important to emphasize that while the values in Table A-7 add up for most manufacturers, in some cases rounding differences can lead to slight discrepancies. In order to be consistent with NHTSA CAFE reports for MY 2010, Saab is included in the GM data for Table A-7, but is not included with GM anywhere else in the report.

The EPA car and truck fuel economy numbers shown in Table A-7 differ from the values found elsewhere in this report. For the 2011 report, EPA reclassified most small, 2 wheel drive SUVs from trucks to cars for the entire MY 1975-2011 database. This reflects a regulatory change made by NHTSA for CAFE standards beginning in MY 2011 and which will apply for the joint EPA/NHTSA greenhouse gas emissions and CAFE standards that have been finalized for MY 2012-2016 and proposed for MY 2017-2025. These changes were not in effect for MY 2010, and accordingly NHTSA's CAFE fuel economy numbers for MY 2010 are based on the previous car and truck definitions. To enable a comparison to these values the EPA car and truck values in table A-7 were calculated using the previous car and truck definitions, which is not consistent with the rest of this report. While the individual car and truck numbers in Table A-7 are unique, the car and truck definitions do not affect the overall manufacturer fuel economy values, which are consistent with the rest of this report (see Table 29).

The FFV credit values in Table A-7 for the truck column were obtained directly from EPA's fuel economy compliance program (trucks are not eligible for TPA credits). The FFV and TPA credits for the car columns were generated by weighting the values for domestic cars and import cars by the NHTSA sales for each car category (see cite below). The FFV and TPA credit values for the combined car and truck columns were generated using the car and truck sales from the NHTSA report. For MY2010, four manufacturers earned FFV credits for cars and six manufacturers did so for trucks. All thirteen manufacturers were eligible for the TPA credits for cars.

All of the NHTSA CAFE values in Table A-7 were taken or generated from the October 28, 2011 NHTSA report "Summary of Fuel Economy Performance" available at www.nhtsa.gov. The car values were generated from the NHTSA fuel economy and production data for the separate domestic car and import car CAFE categories. The truck values were taken directly from the NHTSA report. The combined car and truck values were generated from the NHTSA fuel economy and production data for the separate domestic car, import car, and light truck CAFE categories. While there are no CAFE standards for combined cars and trucks, this column is shown for illustrative purposes.

Table A-7

Comparison of MY2010 EPA Laboratory and Final NHTSA CAFE Values by Manufacturer

Manufacturer	Passenger Car				Light Truck				Both Cars and Trucks			
	EPA LAB	FFV Credit	TPA Credit	NHTSA CAFE	EPA LAB	FFV Credit	TPA Credit	NHTSA CAFE	EPA LAB	FFV Credit	TPA Credit	NHTSA CAFE
General Motors (includes Saab)	29.6	1.2	0.3	31.0	24.3	1.2	0.0	25.5	26.5	1.2	0.1	27.7
Toyota	39.4	0.0	0.4	39.8	25.4	0.7	0.0	26.1	32.4	0.4	0.2	33.0
Ford	31.1	1.2	0.3	32.6	22.9	1.2	0.0	24.1	25.6	1.2	0.1	26.9
Honda	35.6	0.0	0.4	36.0	26.8	0.0	0.0	26.8	31.5	0.0	0.2	31.7
Chrysler	27.8	0.2	0.2	28.3	23.1	1.2	0.0	24.3	24.4	1.0	0.0	25.4
Nissan	33.6	0.0	0.4	34.0	23.8	1.1	0.0	24.9	29.4	0.6	0.2	30.1
Hyundai	35.9	0.0	0.4	36.3	30.0	0.0	0.0	30.0	34.4	0.0	0.3	34.7
Volkswagen	33.1	0.0	0.2	33.3	25.2	0.0	0.0	25.2	31.7	0.0	0.2	31.8
BMW	28.5	0.0	0.3	28.8	23.6	0.0	0.0	23.5	27.6	0.0	0.2	27.8
Kia	36.1	0.0	0.5	36.6	25.7	0.0	0.0	25.7	34.5	0.0	0.4	34.9
Daimler	24.7	1.2	0.2	26.1	21.4	0.0	0.0	21.4	23.6	0.7	0.1	24.4
Subaru	30.2	0.0	0.2	30.4	29.6	0.0	0.0	29.6	29.8	0.0	0.1	29.8
Mazda	33.4	0.0	0.4	33.8	26.6	0.1	0.0	26.7	30.9	0.0	0.2	31.2

* Final MY2010 CAFE values are based on manufacturer reports to EPA and NHTSA summarized in "Summary of Fuel Economy Performance" dated October 28, 2011 and available at www.nhtsa.gov