Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2010

Appendix A
Database Details and Calculation Methods

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.

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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 2009 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 in this report is 1.8 mpg higher than the initial estimate for 2009 in last year's report, due to the market turmoil in MY2009. The final adjusted car plus truck fuel economy value for MY2009 is 1.3 mpg higher than the initial estimate in last year’s report.

Table A-1

Comparison of Laboratory 55/45 MPG

	Model Year	Initial Estimates	Revised Estimates	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		
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		
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		

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, 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 Production Fraction	55/45 Fuel Economy			Truck Production Fraction
Year	Cars	Trucks	Both		Cars	Trucks	Both	
1975	15.8	13.7	15.3	0.194				
1976	17.5	14.4	16.7	0.212	17.1	14.5	16.5	0.202
1977	18.3	15.6	17.7	0.200	18.5	15.1	17.6	0.213
1978	19.9	15.2	18.6	0.227	19.4	15.2	18.3	0.216
1979	20.3	14.7	18.7	0.222	21.1	16.0	19.8	0.205
1980	23.5	18.6	22.5	0.165	22.8	17.5	21.5	0.187
1981	25.1	20.1	24.1	0.173	24.8	19.7	23.7	0.178
1982	26.0	20.5	24.7	0.197	25.7	20.5	24.5	0.197
1983	25.9	20.9	24.6	0.223	26.1	20.6	24.6	0.219
1984	26.3	20.5	24.6	0.239	26.4	20.6	24.7	0.239
1985	27.0	20.6	25.0	0.254	27.0	20.8	25.1	0.258
1986	27.9	21.4	25.7	0.283	27.6	21.2	25.5	0.272
1987	28.1	21.6	25.9	0.278	28.2	21.4	25.8	0.286
1988	28.6	21.2	25.9	0.298	28.3	21.2	25.8	0.294
1989	28.1	20.9	25.4	0.307	28.2	20.9	25.5	0.302
1990	27.8	20.7	25.2	0.302	28.0	21.0	25.3	0.310
1991	28.0	21.3	25.4	0.322	27.8	20.9	25.2	0.319
1992	27.6	20.8	24.9	0.334	27.9	21.0	25.1	0.339
1993	28.2	21.0	25.1	0.360	28.0	20.8	24.8	0.366
1994	28.0	20.8	24.6	0.404	28.2	20.7	24.8	0.381
1995	28.3	20.5	24.7	0.380	28.2	20.7	24.7	0.395
1996	28.3	20.8	24.8	0.400	28.3	20.7	24.7	0.401
1997	28.4	20.6	24.5	0.424	28.4	20.8	24.6	0.424
1998	28.5	20.9	24.5	0.449	28.4	20.7	24.4	0.441
1999	28.2	20.5	24.1	0.449	28.3	20.7	24.3	0.449
2000	28.2	20.8	24.3	0.449	28.3	20.6	24.2	0.453
2001	28.4	20.6	24.2	0.461	28.4	20.6	24.2	0.465
2002	28.6	20.6	24.1	0.485	28.7	20.7	24.2	0.481
2003	28.9	20.9	24.3	0.496	28.8	20.8	24.1	0.500
2004	28.9	20.8	24.0	0.520	29.1	21.0	24.4	0.504
2005	29.5	21.4	24.8	0.495	29.2	21.3	24.7	0.495
2006	29.2	21.8	25.2	0.471	29.7	21.7	25.2	0.480
2007	30.3	22.1	25.8	0.471	30.0	22.2	25.7	0.471
2008	30.6	22.7	26.3	0.473	31.0	22.9	26.7	0.447
2009	32.1	23.8	28.2	0.398	31.8	23.4	27.6	0.428
2010	32.7	23.8	28.3	0.411				

Table A-2 (Continued)

Light-Duty Vehicle Adjusted Fuel Economy

Cars

Model	Actual Data			Three-Year Moving Average		
Year	CITY	HWY	COMP	CITY	HWY	COMP
1975	12.3	15.2	13.5			
1976	13.7	16.6	14.9	13.4	16.3	14.6
1977	14.4	17.4	15.6	14.5	17.6	15.8
1978	15.5	19.1	16.9	15.3	18.5	16.6
1979	15.9	19.2	17.2	16.5	20.2	18.0
1980	18.3	22.6	20.0	17.8	21.8	19.4
1981	19.6	24.2	21.4	19.3	24.1	21.2
1982	20.1	25.5	22.2	19.8	25.1	21.9
1983	19.9	25.5	22.1	20.1	25.7	22.2
1984	20.2	26.0	22.4	20.3	26.1	22.5
1985	20.7	26.8	23.0	20.7	26.8	23.0
1986	21.2	27.6	23.7	21.0	27.4	23.5
1987	21.2	27.7	23.8	21.3	27.8	23.9
1988	21.4	28.2	24.1	21.2	27.9	23.9
1989	20.9	27.9	23.7	20.9	27.8	23.7
1990	20.5	27.5	23.3	20.6	27.7	23.5
1991	20.5	27.6	23.4	20.3	27.5	23.3
1992	20.0	27.5	23.1	20.2	27.6	23.3
1993	20.3	27.9	23.5	20.1	27.7	23.3
1994	20.0	27.7	23.3	20.1	27.9	23.4
1995	20.0	28.1	23.4	19.9	27.9	23.3
1996	19.8	28.0	23.3	19.9	28.0	23.4
1997	19.8	28.0	23.4	19.8	28.0	23.4
1998	19.7	28.0	23.4	19.6	27.8	23.2
1999	19.4	27.5	23.0	19.5	27.6	23.1
2000	19.3	27.3	22.9	19.3	27.4	23.0
2001	19.4	27.3	23.0	19.4	27.3	23.0
2002	19.4	27.2	23.1	19.4	27.3	23.1
2003	19.5	27.5	23.2	19.4	27.4	23.2
2004	19.3	27.4	23.1	19.4	27.5	23.3
2005	19.6	27.6	23.5	19.4	27.5	23.3
2006	19.4	27.5	23.3	19.7	27.8	23.6
2007	20.1	28.3	24.1	19.9	28.1	23.9
2008	20.3	28.5	24.3	20.6	28.9	24.6
2009	21.3	29.7	25.4	21.1	29.4	25.1
2010	21.7	30.1	25.8			

Table A-2 (Continued)

Light-Duty Vehicle Adjusted Fuel Economy

Trucks

Model	Actual Data			Three-Year Moving Average		
Year	CITY	HWY	COMP	CITY	HWY	COMP
1977	12.6	14.1	13.3	12.2	13.7	12.8
1978	12.4	13.7	12.9	12.4	13.6	12.9
1979	12.1	13.1	12.5	13.0	14.4	13.6
1980	14.8	17.1	15.8	14.1	15.9	14.9
1981	16.0	18.6	17.1	15.7	18.2	16.7
1982	16.3	19.0	17.4	16.3	19.1	17.4
1983	16.5	19.6	17.8	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	20.2	17.9	16.3	20.2	17.9
1989	15.9	19.8	17.6	15.9	19.9	17.6
1990	15.6	19.8	17.4	15.8	20.0	17.6
1991	15.9	20.3	17.8	15.7	20.0	17.5
1992	15.5	19.9	17.4	15.6	20.1	17.5
1993	15.5	20.1	17.5	15.4	19.9	17.3
1994	15.3	19.7	17.2	15.2	19.7	17.2
1995	15.0	19.5	17.0	15.1	19.7	17.1
1996	15.1	19.9	17.2	15.0	19.6	17.0
1997	14.8	19.5	17.0	14.9	19.7	17.1
1998	14.9	19.8	17.1	14.8	19.5	16.9
1999	14.6	19.2	16.7	14.7	19.5	16.9
2000	14.7	19.4	16.9	14.6	19.2	16.8
2001	14.6	19.1	16.7	14.6	19.2	16.8
2002	14.4	19.1	16.7	14.5	19.1	16.8
2003	14.6	19.3	16.9	14.4	19.2	16.8
2004	14.3	19.2	16.7	14.5	19.4	16.9
2005	14.6	19.8	17.2	14.6	19.7	17.1
2006	14.9	20.1	17.5	14.9	20.1	17.5
2007	15.1	20.4	17.7	15.1	20.5	17.8
2008	15.5	21.0	18.2	15.6	21.1	18.3
2009	16.2	21.9	19.0	15.9	21.7	18.8
2010	16.2	22.0	19.1			

Table A-2 (Continued)

Light-Duty Vehicle Adjusted Fuel Economy

Cars and Trucks

Model	Actual Data			Three-Year Moving Average		
Year	CITY	HWY	COMP	CITY	HWY	COMP
1977	14.0	16.6	15.1	13.9	16.6	15.0
1978	14.7	17.5	15.8	14.5	17.2	15.6
1979	14.9	17.4	15.9	15.6	18.6	16.8
1980	17.6	21.5	19.2	16.9	20.3	18.3
1981	18.8	23.0	20.5	18.5	22.8	20.2
1982	19.2	23.9	21.1	19.0	23.6	20.8
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	21.7
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	21.2	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	20.3
1997	17.4	23.6	20.1	17.4	23.7	20.2
1998	17.2	23.6	20.1	17.1	23.4	20.0
1999	16.9	23.0	19.7	17.0	23.2	19.8
2000	16.9	23.0	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	19.4	16.7	22.7	19.5
2003	16.7	22.7	19.6	16.6	22.6	19.4
2004	16.3	22.4	19.3	16.6	22.7	19.6
2005	16.8	23.1	19.9	16.7	23.0	19.8
2006	17.0	23.4	20.1	17.0	23.5	20.2
2007	17.3	23.9	20.6	17.3	23.9	20.6
2008	17.7	24.4	21.0	18.0	24.8	21.3
2009	18.9	26.0	22.4	18.5	25.5	22.0
2010	19.0	26.1	22.5			

Vehicle Classification Exceptions

The truck size classification scheme used in this report is based primarily on published wheelbase data. For cars, vehicle classification as to vehicle type, size class, and manufacturer generally follows fuel economy label, *Fuel Economy Guide*, and fuel economy standards protocols; exceptions are listed in Table A-3. 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.

Table A-3

Manufacturer	Make/Vehicles	Classified As:
Chrysler:	Colt 4WD Wagon*	Small Wagon
Chrysler:	Colt Vista*	Small Van
Chrysler:	Pacifica*	Large Wagon
Chrysler:	PT Cruiser	Small Wagon
Chrysler:	PT Cruiser Convertible*	Subcompact
Chrysler:	Summit Wagon*	Small Van
Chrysler:	Dodge Ram Charger*	Large Sedan
Chrysler:	Dodge Magnum*	Midsize Wagon
Chrysler:	Eagle 4WD Wagon*	Car
Ford:	Ford Pinto Van*	Car
Ford:	Volvo V70 XC	Midsize Wagon
GM:	HHR	Small Wagon
GM:	Isuzu Oasis*	Midsize Van
GM:	Pontiac Vibe	Small Wagon
Nissan:	Infiniti EX35	Midsize SUV
Toyota:	Lexus RX300*	Midsize SUV
Toyota:	Matrix	Small Wagon
VW:	Audi Allroad*	Midsize Wagon
Other:	Subaru Outback AWD Wagon	Midsize Wagon
Other:	Subaru Forester	Small SUV
Other:	Subaru Baja*	Small Pickup
Other:	Suzuki X-90*	Small SUV
Other:	Mitsubishi Expo*	Small Van
Other:	Mitsubishi Space Wagon*	Small Van
Other:	Mercedes R-Series	Large Wagon

* Not manufactured for MY 2010.

Methodology for Adjusted Fuel Economy Values for Model Years 1986-2010

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 have 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, which yields mpg-based adjustments based on a regression of recent 5-cycle fuel economy data for the industry as a whole. Beginning in 2011, manufacturers must use the 5-cycle method. 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 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 2010 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 1986-2010 in this report differ from those in pre-2007 reports as explained below.

- For model years 2005-2010, 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 MY2010, 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 2005-2010 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 2005-2010 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 2010 would be to use the 2010 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 2010 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	0.890	0.920	0.940	0.800	0.720	0.800
2006	0.890	0.920	0.940	0.800	0.720	0.800
2007	0.890	0.920	0.940	0.800	0.720	0.800
2008	0.890	0.920	0.940	0.800	0.720	0.800
2009	0.890	0.920	0.940	0.800	0.720	0.800
2010	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 2010 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 MY2010 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 2010 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 2003-2010

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	24.0	22.4
2010	24.2	22.5

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 MY2010 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, 1975-2010

Table A-6 compares CAFE performance data reported by the National Highway Traffic Safety Administration ("Summary of Fuel Economy Performance" report dated April 20, 2010 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 vehicle classification. In recent years for which both Agencies report final data, the NHTSA values are typically 0.6-0.8 mpg higher than the EPA values. For MY2010, the preliminary NHTSA value is 0.9 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 2009 to support vehicle fuel economy labels. The NHTSA value is based on automaker estimates provided in pre-model year CAFE reports later in 2009. Final MY2010 results will be reported in next year's 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		21.2	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	19.4	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	31.6	1.1	18.2	22.7	23.6	0.9	21.0	26.3	27.1	0.8
2009	25.4	32.1	32.6	0.5	19.0	23.8	24.6	0.8	22.4	28.2	28.8	0.6
2010	25.8	32.7	33.8	1.1	19.1	23.8	24.9	1.1	22.5	28.3	29.2	0.9

Comparison of EPA and NHTSA Data for MY2008 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 MY2008 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 (MY2008 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 approximately add up for most manufacturers, in some cases they do not add up precisely. The primary explanation for this is that there are slight differences in car and truck classifications between EPA and NHTSA, which can affect the individual car and truck comparisons, though not the combined car and truck values. In the most notable example, NHTSA classifies the Subaru Forester as a car and the Subaru Outback as a truck, while EPA takes the reverse position. Changing the classification of these two vehicles actually does not affect Subaru's car values, however it does lead to nearly a 1 mpg discrepancy between the truck EPA LAB and NHTSA CAFE values. In addition, rounding differences can lead to slight discrepancies in Table A-7.

The manufacturer column in Table A-7 differs from the manufacturer columns elsewhere in this report in two ways in order to be consistent with the way NHTSA reports CAFE data for MY2008. The differences in Table A-7 are that GM includes Saab, and Ford includes Mazda (Table 28 gives different EPA laboratory fuel economy values for Ford excluding Mazda, while the inclusion of Saab does not change the GM values).

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 MY2008, four manufacturers earned FFV credits for cars and four 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 April 20, 2010 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 MY2008 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 / Saab	28.6	1.1	0.2	29.7	21.6	1.2	0.0	23.2	24.4	1.2	0.1	25.7
Toyota	36.0	0.0	0.3	36.4	23.9	0.0	0.0	23.9	29.0	0.0	0.1	29.0
Ford / Mazda	28.6	0.9	0.3	30.3	22.4	1.2	0.0	23.6	24.7	1.1	0.1	26.0
Honda	34.3	0.0	0.4	34.6	25.5	0.0	0.0	25.5	30.1	0.0	0.2	30.3
Chrysler	27.8	0.9	0.2	29.3	22.4	1.2	0.0	23.6	24.2	1.1	0.1	25.1
Nissan	32.2	0.0	0.3	32.2	22.0	1.2	0.0	23.1	27.6	0.7	0.1	28.3
Hyundai	33.8	0.0	0.4	34.2	25.6	0.0	0.0	25.6	30.9	0.0	0.2	31.1
Volkswagen	28.9	0.0	0.2	29.1	20.2	0.0	0.0	20.2	27.9	0.0	0.2	28.1
BMW	27.2	0.0	0.2	27.4	22.9	0.0	0.0	22.9	26.3	0.0	0.2	26.5
Kia	33.3	0.0	0.3	33.6	24.2	0.0	0.0	24.2	28.8	0.0	0.1	28.9
Daimler	25.3	1.2	0.2	26.9	20.8	0.0	0.0	20.8	24.0	0.8	0.1	24.9
Subaru	28.7	0.0	0.2	28.9	26.4	0.0	0.0	27.3	28.1	0.0	0.1	28.2
Mitsubishi	29.8	0.0	0.2	30.0	24.2	0.0	0.0	24.7	28.1	0.0	0.2	28.5

* Final MY2008 CAFE values are based on manufacturer reports to EPA and NHTSA summarized in "Summary of Fuel Economy Performance" dated April 20, 2010 and available at www.nhtsa.gov