A Comparison of Consumer Reports' Passenger Vehicle Average MPG Estimates with Those Reported by the EPA and Survey Respondents

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INTRODUCTION

Consumer Reports (CR) has had a longstanding public concern about the national need to require better vehicle fuel economy across the fleet of passenger vehicles. As part of our ongoing product-testing program, CR evaluates approximately 70 new vehicle models each year. We publish the results in Consumer Reports magazine and on our website, at ConsumerReports.org. Our ratings include an evaluation, via road and track tests, of the fuel economy of all the vehicles we rate. CR measures the actual amount of fuel consumed by the vehicle during its controlled road tests by inserting an accurate fuel meter into the vehicle's fuel system. Our testing procedures are designed to replicate real-world driving patterns and are intended to include factors such as the higher levels of urban congestion existing today.

In 2005 we published an in-depth analysis of 303 vehicles from model years 2000 through 2006 tested by CR. That analysis showed that 274 models (90 percent) delivered lower fuel economy using CR's tests than that promised by the Environmental Protection Agency (EPA) sticker. Only 29 models achieved fuel economies as good as or better than EPA estimates. For conventional gas-powered vehicles, the average overall EPA fuel-economy estimates were approximately 2.0 mpg (10.3 percent) higher than the levels obtained by CR, with individual differences ranging from -4.7 mpg to 5.3 mpg. One of the most significant findings of that analysis was that the estimated 2003 model-year fleet average based on the individual fuel-economy estimates used by the National Highway Traffic Safety Administration was more than 30 percent higher than the corresponding estimated fleet average based on the CR estimates. Hence, consumers were using far more fuel than they would expect based on the window-sticker labels required for new vehicles.

In this paper, we seek to update our original analysis using CR-tested vehicles from model years 2009 through 2016. As part of an Energy Foundation-funded research project on fuel economy, we also modified our 2015 Annual Questionnaire to include a question about owner fuel efficiency. The 2015 AQ was conducted in the spring of 2015. In addition, a follow-up survey was sent in the summer to all 2015 AQ automobile respondents and a random subset of subscribers who did not respond to the initial survey. The final dataset consisted of approximately 1 million records and represents the population of CR subscribers. This new information was used to compare CR's measured fuel-economy estimates with owner-reported fuel efficiency.

CONSUMER REPORTS' TESTING PROCEDURES

CR's fuel-economy testing procedures are designed to replicate real-world driving patterns and are intended to reflect factors like the higher levels of urban congestion existing today. Two tests are conducted by CR: city and expressway. To minimize test variability, all vehicles are preconditioned to a minimum of 2,000 miles on the odometer. They are parked overnight in our shop prior to testing. Tire pressures are set to the vehicle manufacturer's recommended pressures, and the fuel tank is filled at the start of each test. All testing is done at an ambient temperature at or above 32° F, with winds not to exceed 15 mph and no precipitation. Air conditioning is turned off. A fuel flow

meter with a readout in the cabin of the vehicle is used to measure fuel consumption. The fuel meter is zeroed at the start of each leg of the test. The ambient temperature is measured at the start and finish of each test.

The CR city fuel-economy tests are performed on a 1-mile course precisely marked out on our test track. It is a stop-and-go city-driving simulation that has three stops and includes 40 seconds of total idle time, and 40 mph is the top speed reached. We use two drivers, and they each do three runs on every test vehicle. Each run is timed and limited to 2 minutes and 40 seconds +/- 3 seconds. The inline fuel meter measures fuel consumption to the nearest cubic centimeter. The resulting city fuel-economy number (in miles per gallon) is obtained by averaging the six runs and rounding to the nearest whole number for publication.

The CR expressway fuel-economy test is run on a specific section of Route 2 in Connecticut. The course is driven at a constant 65 mph and is 5.0 miles long. The test consists of eight runs, two east and two west runs by each of two drivers. The test is performed in both directions to limit the effects of wind and grade differences. Each run is timed and limited to 4 minutes and 38 seconds +/- 3 seconds. The runs are averaged for each driver, and then corrected (SAE) for ambient temperature. The resulting expressway fuel-economy number (in miles per gallon) is obtained by averaging the driver estimates and rounding to the nearest whole number for publication.

The CR overall miles-per-gallon estimates are calculated as a weighted harmonic average of the CR city and CR expressway miles-per-gallon estimates:

$$CR_{Overall} = \frac{1}{\frac{1/3}{CR_{City}} + \frac{2/3}{CR_{Expressway}}}.$$

The final value is rounded to the nearest integer.

EPA'S TESTING PROCEDURES

Manufacturers test their vehicles and report their results to the EPA. The EPA reviews the results and confirms a small percentage (approximately 10 to 15 percent) under controlled laboratory conditions using a standardized test procedure specified by federal law. The EPA fuel-economy test is conducted on a dynamometer that simulates driving. The tests are conducted at the National Vehicle and Fuel Emissions Laboratory in Ann Arbor, Mich. In 2008 the EPA changed its method for estimating fuel economy by incorporating the effects of faster speeds and acceleration, air-conditioning use, and colder external temperature. The EPA miles-per-gallon estimates for this analysis were obtained from the sticker on the vehicle tested by CR.

Comparison of MPG Estimates

The following histograms display the individual miles-per-gallon data. Figure 1 shows the distribution of the CR overall miles per gallon for 399 new vehicles tested from model year 2009 to model year 2016. Figure 2 shows the distribution of the corresponding EPA overall miles-per-gallon estimates for those vehicles. Figure 3 shows the median reported miles-per-gallon estimate from the survey respondents for the same set of vehicles.

Figure 1: Histogram of CR Overall MPG Estimates

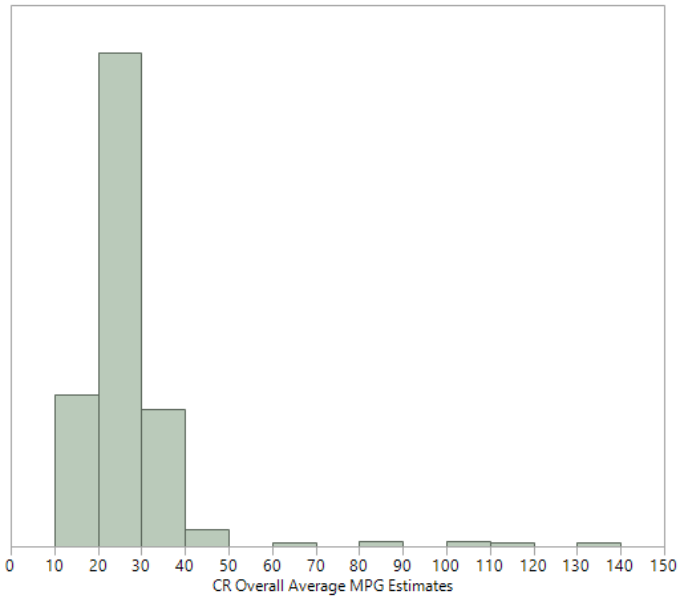


Figure 2: Histogram of EPA Overall MPG Estimates

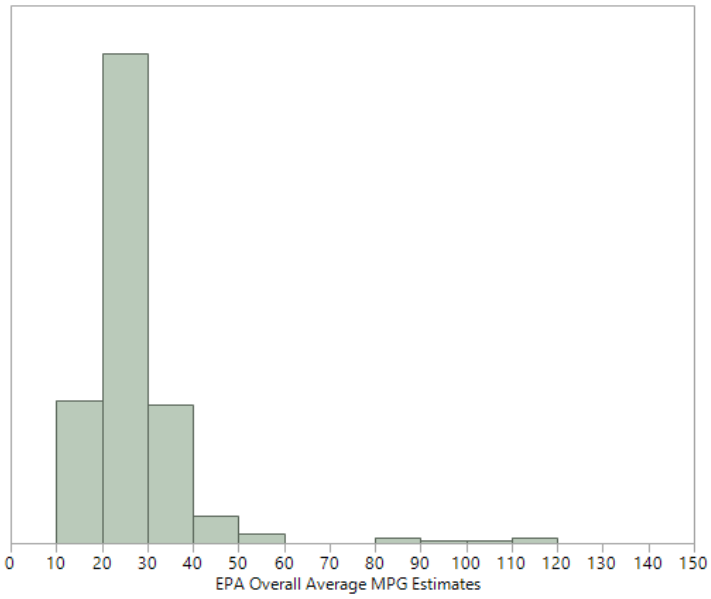
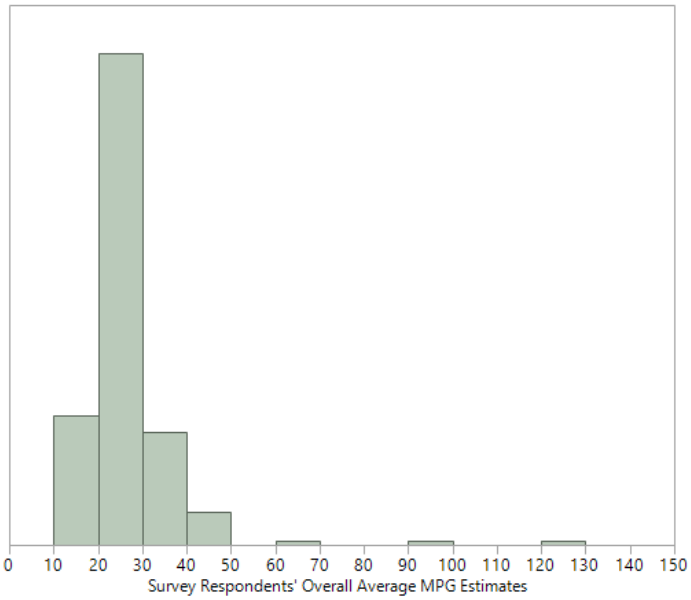


Figure 3: Histogram of Median MPG Estimates From Survey Respondents



Examinations of these histograms show that the distributions of miles-per-gallon estimates from these three methods are similar. The following tables show the average CR, EPA, and survey-reported miles-per-gallon estimates for vehicles tested by CR. Table 1 shows the averages by model year.

Table 1: Overall MPG by Model Year[1]

Model Year	Number of Models[2]	Average CR MPG	Average EPA MPG	Median Survey MPG
2009	25/24	22.4	22.6	23.6
2010	48/43	23.9	24.2	25.0
2011	65/63	24.2	24.7	24.1
2012	73/68	28.6	29.5	27.5
2013	62/58	26.4	27.7	26.5
2014	63/58	26.5	27.5	27.0
2015	46/46	23.5	24.3	24.5
2016[3]	15/5	24.6	25.3	23.6
Total	397/365	25.5	26.3	25.7

Despite the somewhat different sampling by CR of vehicle categories from year to year, Table 1 shows that the average miles-per-gallon differences are relatively consistent over the time period examined.

[1] Tables exclude the 2011 Chevy Volt and 2014 BMW i3 Giga.
[2] Number of models available in the CR/Survey datasets.
[3] Model Year 2016 testing was not complete at the time of this report, resulting in fewer observations.

Table 2 shows the average overall miles-per-gallon estimates by vehicle type. This table shows that the average CR, EPA, and survey miles-per-gallon estimates are similar, especially for cars that make up the bulk of the dataset. That is in contrast to the 2005 study, where we found a larger difference between the CR and EPA overall miles-per-gallon estimates.

Table 2: Average Overal MPG by Vehicle Type (2009 to 2016)

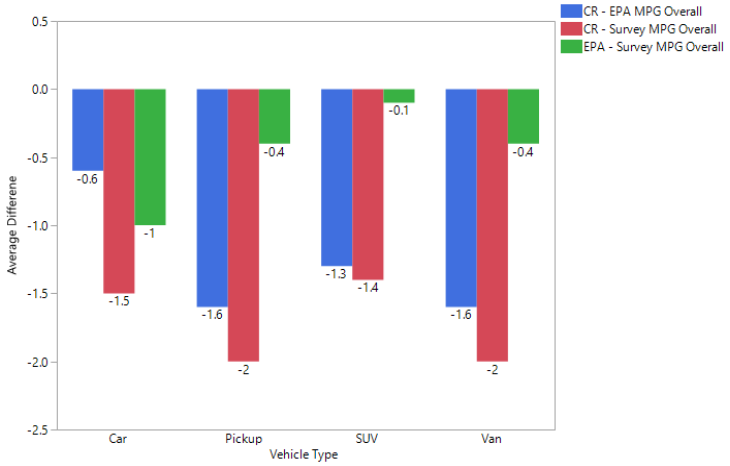
Vehicle Type	Number of Models	Average CR MPG	Average EPA MPG	Average Survey MPG
Car	262/238	28.2	28.7	28.5
Pickup	12/12	15.9	17.5	17.9
SUV	114/107	20.4	21.7	21.6
Van	9/9	19.3	20.9	21.3
All	397/366	25.4	26.2	26.0

CR received 184,820 responses associated with the models evaluated in this analysis. Table 3 and Figure 4 show the average differences between the miles-per-gallon estimates by vehicle type. Overall, the difference between the CR and EPA estimates is 0.8 mpg (3.1 percent); the difference between the CR and average self-reported estimates is 1.5 mpg.

Table 3: Average Difference by Vehicle Type

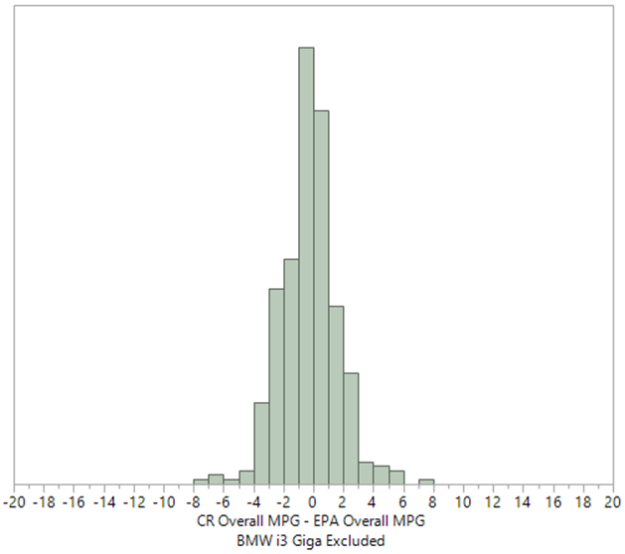
Vehicle Type	# Models	Average CR - EPA MPG	Average CR - Survey MPG	Average EPA - Survey MPG
Car	262/238	-0.6	-1.5	-1.0
Pickup	12/12	-1.6	-2.0	-0.4
SUV	114/107	-1.3	-1.4	-0.1
Van	9/9	-1.6	-2.0	-0.4
All	397/366	-0.8	-1.5	-0.7

Figure 4: Bar Chart of Average Differences by Vehicle Type



Figures 5 through 7 display the individual vehicle differences between the overall CR, EPA, and survey miles-per-gallon estimates. Note that Figure 5 excludes the BMW i3 Giga and Figures 6 and 7 exclude the Giga and Chevy Volt. Both of these vehicles are very different from conventional gas powered vehicles and were excluded from our analysis.

Figure 5: Histogram of Differences Between CR and EPA Overall MPG Estimates



Of the 397 vehicles tested by CR, 191 models were within 1 mpg and 286 models were within 2 mpg of the EPA estimates. That's 48 percent and 72 percent of the models, respectively.

Figure 6: Histogram of Differences Between CR and Survey MPG Estimates

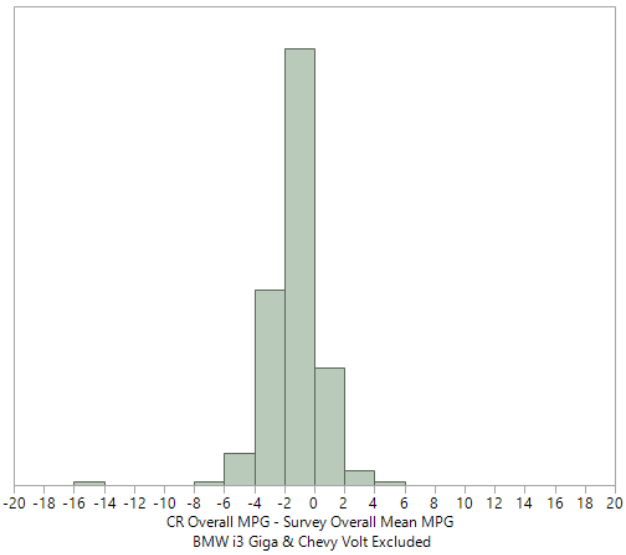


Figure 7: Histogram of Differences Between Survey and EPA MPG Estimates

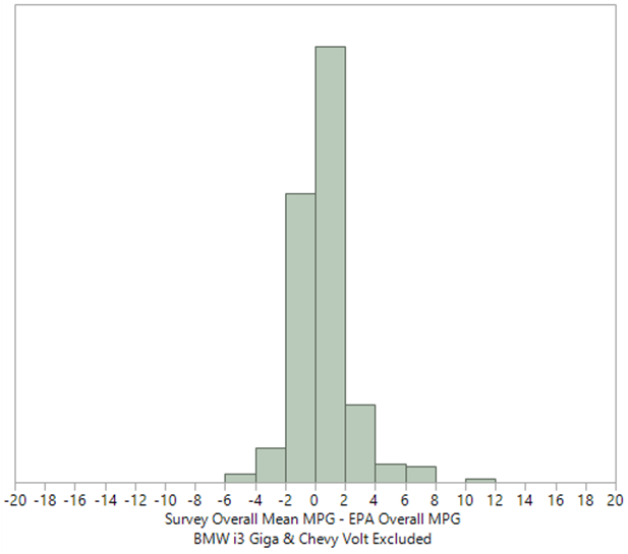
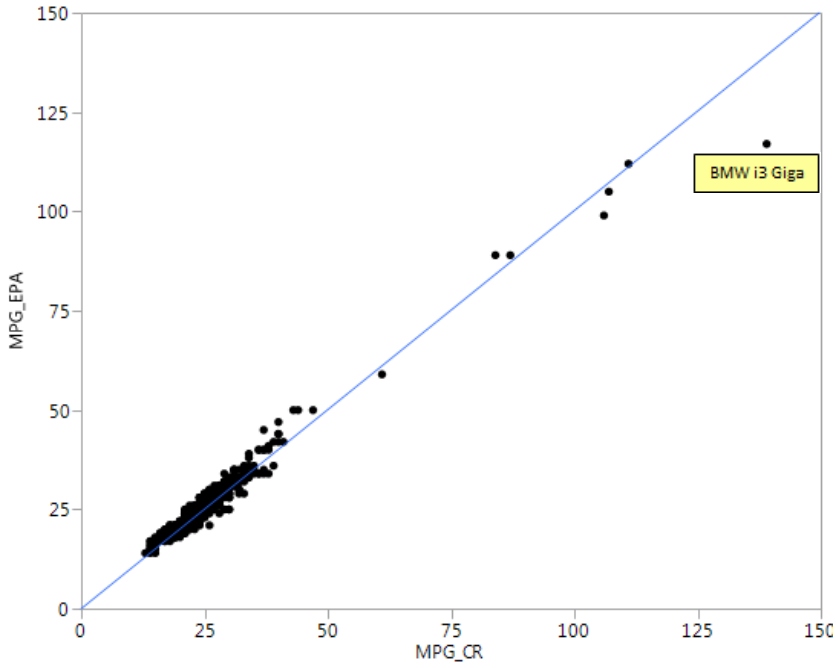


Figure 8 is a scatterplot of the CR vs. EPA miles-per-gallon estimates with a 45-degree reference line to facilitate comparison of these estimates.

Figure 8: Scatterplot of CR vs. EPA MPG Estimates



With the exception of the 2014 BMW i3 Giga, the points generally track the 45-degree line, indicating that the CR and EPA overall miles-per-gallon estimates are similar. Once again, that is in contrast to our 2003 analysis where we found that the EPA estimates were 2.0 mpg higher, on average, than the CR estimates.

For our analysis of survey reported estimates, the median reported miles-per-gallon values were used for comparison with the corresponding CR and EPA overall miles-per-gallon estimates. However, the individually reported survey miles-per-gallon estimates varied significantly. Figure 9 shows the distribution of reported miles-per-gallon[4] values for four representative vehicles: an Acura MDX SUV, a Ford F-150 pickup truck, a Mazda 3 car, and a Toyota Prius 4-Door Hatchback hybrid car.

Figure 9: Histograms of Survey Reported MPG - Selected Vehicles

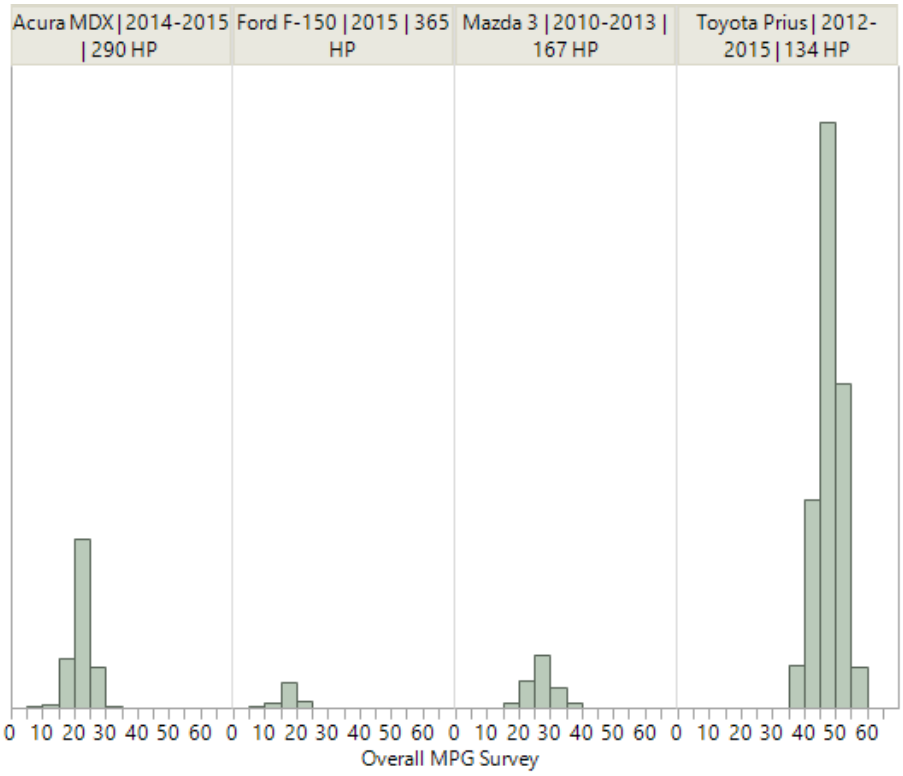


Table 4 shows the average overall miles-per-gallon differences by engine type. Again, the average overall CR and EPA estimates are similar, with the EPA estimates slightly higher on average.

Table 4: Average Overall MPG by Engine Type (2009 to 2016)

Engine Type	Number of Models	Average CR MPG	Average EPA MPG	Average Survey MPG
Diesel	17/15	31.2	30.5	36.1
Electric[5]	4/0	97.3	98.8	
Gas	348/327	23.4	24.1	24.4
Hybrid	28/24	36.2	39.4	40.8
All	397/366	25.4	26.2	26.0

[4] Unusual values, outliers, reported by survey respondents were removed from the data.
[5] Except for the BMW i3 Giga, survey respondents did not provide miles-per-gallon estimates for electric vehicles.

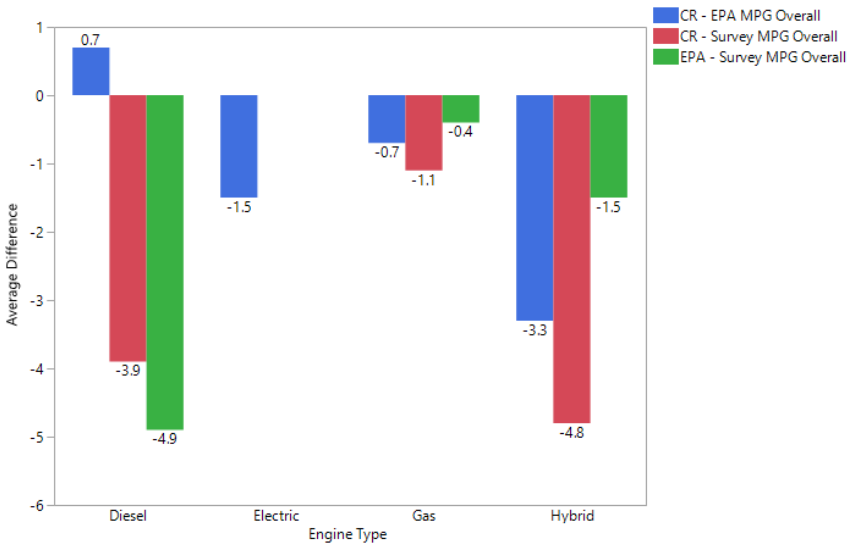
Table 5 displays the average overall differences by engine type. For conventional gas-powered vehicles the average fuel-economy estimates listed on the EPA stickers are approximately 0.7 mpg (3.0 percent) higher than the levels obtained by CR, with individual differences ranging from -5 mpg to 5 mpg. For hybrid-powered vehicles the average fuel-economy estimates listed on the EPA stickers are approximately 3.3 mpg (9.1 percent) higher than the levels obtained by CR. For diesel-powered vehicles the CR miles-per-gallon estimates are 0.7 mpg higher than the EPA estimates. Hybrids had the largest difference: 4.8 mpg (13 percent) higher than the CR estimates.

Table 5: Average Overall Difference by Vehicle Type (2009 to 2016)

Fuel Engine Type	Number of Models	Average CR - EPA MPG	Average CR - Survey MPG	Average EPA - Survey MPG
Diesel	17/15	0.7	-3.9	-4.9
Electric[6]	4/0	-1.5		
Gas	348/327	-0.7	-1.1	-0.4
Hybrid	28/24	-3.3	-4.8	-1.5
All	397/366	-0.8	-1.5	-0.7

Figure 10 graphically displays the data in Table 5 as a side by side bar chart. The positive difference for diesel engines represents a higher EPA estimate than CR's test result.

Figure 10: Bar Chart of Average Differences by Engine Type



[6] Except for the BMW i3 Giga, survey respondents did not provide miles-per-gallon estimates for electric vehicles.

CONCLUSIONS

In our 2005 analysis, we observed that the CR and EPA fuel-economy estimates were substantially and statistically different from one another on average. The average EPA estimate for all vehicles was 2.0 mpg (10.3 percent) higher than the CR estimates. In 2008 the EPA changed its testing procedures to include the effects of faster speeds and acceleration, air-conditioning use, and colder external temperature. Based on our current findings there is no longer a substantial difference between the CR and EPA estimates. In this study, the difference between the CR and EPA was 0.8 mpg (3.1 percent).

Of the 397 vehicles tested by CR, 191 models were within 1 mpg and 286 models were within 2 mpg—48 percent and 72 percent, respectively. Two-hundred-twenty-eight models (57 percent) delivered lower fuel economy using CR's tests than that promised by the EPA sticker, and 169 models achieved fuel economies as good as or better than EPA estimates.

Three-hundred-forty-eight of the vehicles were powered by conventional gas engines, 17 by diesel engines, 28 by hybrid systems, and four by electric power. For conventional gas-powered vehicles, the average overall fuel-economy estimates listed on the EPA stickers were approximately 0.7 mpg (3.0 percent) higher than the levels obtained by CR. For hybrid-powered vehicles the EPA miles-per-gallon estimates were 3.3 mpg (9.1 percent) higher than CR. For diesel-powered vehicles, the EPA miles-per-gallon estimates were 0.7 mpg lower than the CR estimates. For electric-powered vehicles, the EPA estimates were 1.5 mpg (1.5 percent) higher than the CR estimates.

The current study also evaluated miles-per-gallon based on subscriber feedback. For overall mpg, the CR, EPA, and survey estimates were similar.The difference between survey respondents' self-reported miles per gallon and CR test results was 1.5 mpg. However, the survey respondents reported slightly higher miles-per-gallon for diesel and hybrid vehicles. Excluding the BMW i3 Giga, there were no survey owner-reported miles-per-gallon estimates for electric-powered vehicles.