

Total Cost of Ownership: A Gas Versus Diesel Comparison

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Abstract

The U.S. automotive market is evolving to a more fuel-efficient fleet, and alternative powertrains are part of the mix of options that manufacturers and consumers view as part of this evolution. This report reviews the role clean diesel vehicles play in the current vehicle fleet by analyzing the total cost of ownership (TCO) for clean diesel vehicles and comparing their TCO to that of their gas vehicle counterparts. We build our TCO model by developing three- and five-year cost estimates of depreciation by modeling used-vehicle auction data and fuel costs by modeling government data. We combine these estimates with three- and five-year estimates for repairs, fees and taxes, insurance, and maintenance from an outside data source. Our results show that clean diesel vehicles generally provide a return on investment in both the three- and five-year timeframes, though there are differences in the amounts of return among mass market vehicles, medium duty trucks, and luxury vehicles.

Keywords: total cost of ownership, clean diesel vehicle, fuel economy, auction, used vehicles

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Total Cost of Ownership: A Gas Versus Diesel Comparison

Introduction

Alternative powertrains play the key role in the sustainability of the future automotive ecosystem. All countries are planning for futures where the role of oil in their transportation system is dramatically reduced, and alternative powertrains, specifically clean diesels, hybrids, compressed natural gas, and pure electrics, offer the current path to sustainability for the auto industry. All four of these powertrains are currently in the U.S. marketplace, providing an opportunity to measure their value to consumers.

There are a number of ways of measuring the success of these alternative powertrains in the U.S. market. First, the most obvious method is to measure the sales of vehicles with these powertrains. For 2011, sales of vehicles with alternative powertrains for light-duty vehicles were

- 2.7 percent clean diesels
- 2.1 percent hybrids
- 0.08 percent pure electrics (Polk, 2012).
- 0.01 percent compressed natural gas (CNG) (Polk, 2012).

Comparing these alternative powertrains to traditional spark-ignited engines has its limits because of the limited number of alternative powertrain offerings in the U.S. marketplace. For example, our analysis of the number of models available in the U.S. market in 2011 showed that of the 312 models available, only 34 models (11 percent) offered alternative powertrains. So, the potential buyer has a very small number of vehicles with alternative powertrains available to choose from, relative to the total number of models.

Second, for similar or identical pairs of vehicles that offer an alternative powertrain and a spark-ignited powertrain, one can measure the “take rate”¹ of each vehicle based on its powertrain. For example, for clean diesel powertrains, the average take rate compared to that of spark-ignited competitors is shown for 2008 to 2011 in Table 1 (Polk, 2012).

Model Year	Light Duty Vehicles	Medium Duty Pickup Trucks
2008	10%	63%
2009	22%	59%
2010	30%	59%
2011	30%	62%

Table 1: Average Take Rate for Clean Diesel Vehicles Compared to Spark-Ignited Vehicles for 2008 to 2011

¹ The total number of diesel vehicles sold divided by the sum of the total number of gas and diesel vehicles sold.

Third, one can also measure the intentions of buyers who are considering purchasing a new vehicle to see how alternative powertrains fit into their potential purchase. Research on this topic is plentiful, though sometimes proprietary, with market research firms and the auto companies continually measuring consumer preferences for alternative powertrains in surveys and focus groups. Consumer research shows that people are increasingly considering diesels (30 percent) and hybrids (38 percent), but this has not translated directly to sales. (CNW, 2012) This disconnect from consideration to actual sales may be due to the additional cost of the product, the limited availability of models with the new technology, or a limited knowledge about alternative powertrains that creates uncertainty for potential buyers.

Finally, one can measure the value (and by extension, the success) of vehicles with alternative powertrains already in the marketplace by comparing all the costs involved in ownership of a particular vehicle, what is known as the total cost of ownership (TCO). For this paper, we compare the TCO for near identical gasoline and clean diesel versions of the same vehicle by combining our estimate of resale value and our cost estimate for fuel, with costs for insurance, repairs, maintenance, and taxes and fees over a three- and five-year time period.

Others have written about the total cost of ownership related to information technology, supply chain (including purchasing and logistics), energy such as lighting, and manufacturing related to quality. These articles mostly focus on TCO from a business perspective rather than a consumer perspective. One article looks at the total lifecycle cost of hybrid vehicles, which includes manufacturing and ownership (Lipman, 2006). Many vehicle-related TCO articles focus on electric cars (Vliet, 2011), (Hensley, 2009), (Gao, 2008), (Dickerman, 2010), and (Becker, 2010). Other articles look at TCO for hybrid vehicles (Ernst, 2011), plug-in hybrid vehicles (Van Vliet, 2010) and (Michalek, 2011), as well as fuel cell vehicles (Van Vliet, 2010), and (Dusterwald, 2007). TCO is also discussed in terms of energy policy scenarios for future vehicle options (Thiel, 2010) and an optimal vehicle maintenance schedule (Lad, 2008). The only similar analysis to our TCO analysis of gas and diesel vehicles comes in a working paper from Gilmore, 2010.

Total cost of ownership is also a term used by the major automotive consumer websites such as Edmunds.com, Kelley Blue Book (kbb.com), Vincentric.com, National Automobile Dealer Association Guides (nadaguides.com), Driverside.com, Cars.com, Intellichoice.com, and Consumer Reports (consumerreports.org) to help consumers compare the cost of ownership between pairs of vehicles. Even the U.S. Department of Energy (<http://www.afdc.energy.gov/calc/>) has a site where consumers can see the long-term financial effects of vehicle ownership based on one's individual driving habits. Each site uses its own proprietary models for estimating the costs of depreciation, fuel, insurance, repairs, maintenance, and fees and taxes, while also offering estimated costs associated with loans and what is called opportunity costs. For this paper, we do not estimate loan costs because of the wide variety of methods and rates that buyers use to purchase vehicles. We also do not use a version of

opportunity costs because it is not clear how these costs are estimated and consequently the value of these costs in a TCO model.

Method

Despite the current low levels of availability of vehicles with alternative powertrains, there are now enough clean diesel powertrains in the U.S. fleet to measure their value in the resale market. The resale market is interesting because it has a formal auction process where dealers bid on used/pre-owned vehicles to sell in the used-vehicle business. As independent businesses, automotive dealers carefully manage their used/pre-owned inventory to maximize their profits. As such, they generally do not take chances by paying more for a vehicle than they can sell it for in the marketplace.

Using the resale value from the auction of vehicles with alternative powertrains compared to near identical gas versions of these vehicles thus becomes a way of measuring the success of alternative powertrains in the marketplace. This analysis provides a real-world test of whether the current vehicles with alternative powertrains hold their value in the resale market.

Our method to measure the differences between clean diesel and gas versions of the same vehicle is based on gathering information from government sources including

- Federal Highway Administration (FHWA): average numbers of vehicle miles driven
- Energy Information Administration (EIA): historical average annual fuel prices
- Bureau of Labor Statistics (BLS): consumer price index for new and used vehicles
- National Highway Traffic Safety Administration (NHTSA): average annual vehicle miles travelled and vehicle survivability
- Environmental Protection Agency (EPA): average miles per gallon

We also used exclusive data from

- Mannheim auction system: vehicle auction prices and mileage
- Blackbook: original manufacturer's suggested retail price (MSRP)
- Vincentric : insurance, repairs, maintenance, fees, and tax estimates for three and five years

Our TCO model for three and five years of ownership consists of

- Depreciation based on
 - our resale model
 - original MSRP (Blackbook)
- Fuel cost based on our fuel cost model that includes
 - vehicle model year (Mannheim)
 - vehicle miles per gallon (EPA) and (J.D. Power and Associates)

- annual average cost of fuel per gallon (EIA)
- the average number of miles driven and vehicle survivability (NHTSA)
- Repairs (Vincentric)
- Insurance (Vincentric)
- Maintenance (Vincentric)
- Fees and taxes (Vincentric)

Our method for comparing vehicle prices from different timeframes, for example a vehicle purchased in 2002 and sold at auction in 2011 versus a vehicle purchased in 2009 and sold at auction in 2010, is to adjust all prices to 2011 dollars using the Consumer Price Index (CPI) estimates for new and used vehicles provided by the BLS. Thus, a vehicle's original MSRP, its price at auction, the average cost of fuel in any particular year, and its estimates for insurance, repairs, maintenance, and fees and taxes are all adjusted to make them equal to 2011 dollars using the CPI.

Vehicle Comparisons

For this analysis we compared gas and diesel versions of the same or nearly identical vehicles. Table 1 shows the pairs of vehicles examined in our analyses. It shows the comparison vehicles' miles per gallon² and average MSRP.

Two interesting effects that are important for our TCO analysis can be seen in this table.

- First, all the diesel vehicles have better miles per gallon than their gas counterparts. This will affect the fuel costs that are a part of the TCO formula.
- Second, the average difference in MSRP among groups of vehicles differs significantly.
 - The mass market passenger cars, VW Jetta, VW Jetta Sportwagen, and VW Golf have about a \$2,000 to \$3,000 difference between the gas and diesel versions.
 - The medium-duty trucks, Chevrolet Silverado 2500, GMC Sierra 2500, Dodge Ram 2500, and Ford F-250, and the VW Touareg have much larger average differences between the gas and diesel versions.
 - The luxury vehicles, Mercedes E Class, GL Class, M Class, and R Class, have very small differences between the gas and diesel versions. The R Class diesel version is only \$185 more than the gas version, the M Class diesel is only \$669 more than the gas version, and the GL Class diesel version is \$1,983 *less* than the gas version.

These MSRP costs will be part of the depreciation model, which feeds into the TCO formula, so these differences will have significant effects on the results. They also show some of the strategies of the manufacturers, especially in terms of their pricing of diesel vehicles.

² Miles per gallon is measured as a combined city/highway (60%/40%) driving average.

Vehicle	MPG Spark-Ignited Gas Vehicles	MSRP Spark-Ignited Gas Vehicles	MPG Diesel Vehicles	MSRP Diesel Vehicles
Volkswagen Jetta	24	\$ 22,336	33	\$ 24,373
Volkswagen Jetta Sportwagen	24	\$ 22,734	33	\$ 25,822
Volkswagen Golf	23	\$ 18,528	33	\$ 20,505
Chevrolet Silverado 2500	13	\$ 33,639	15	\$ 41,087
GMC Sierra 2500	13	\$ 28,911	15	\$ 43,193
Dodge Ram 2500	13	\$ 34,592	14	\$ 43,163
Ford F250	13	\$ 31,375	16	\$ 40,563
Mercedes-Benz E Class	19	\$ 53,600	26	\$ 54,269
Mercedes-Benz GL Class	15	\$ 60,192	20	\$ 58,209
Mercedes-Benz ML Class	16	\$ 42,557	21	\$ 48,195
Mercedes Benz R Class	16	\$ 47,625	21	\$ 47,805
Volkswagen Touareg	16	\$ 39,263	20	\$ 46,600

Table 1. Vehicle Type, Model Years, MSRP, and MSRP SD for Spark-Ignited and Diesel Engines

Figure 1 looks at the percentage differences (increases) in miles per gallon (MPG) between diesel and gas versions of the comparable vehicles that are part of the study. As expected, diesel versions of a vehicle have significantly higher MPGs than the gas versions, though the Chevrolet Silverado 2500 and the GMC Sierra 2500 have a much smaller difference between their diesel and gas versions, and the Dodge Ram 2500 has an especially small difference between the diesel and gas versions. These small differences in fuel economy will have an effect on the fuel costs that are part of the TCO model.

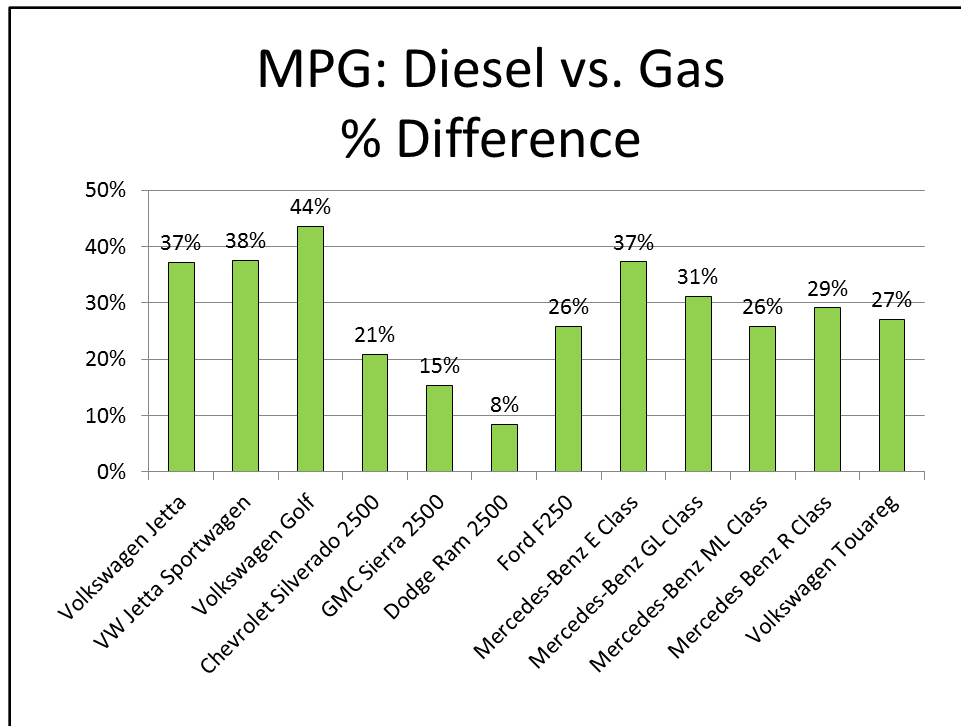


Figure 1: Percentage Differences (Increases) in Miles per Gallon (MPG) Between Comparable Diesel and Gas Vehicle Pairs

Figure 2 shows the percentage differences (increases) in manufacturer suggested resale prices (MSRP) between the diesel and gas versions of the comparable vehicles in the study. As in all of our analyses for this report, MSRP is adjusted to 2011 dollars.

It is very interesting that there are a variety of percentage differences in MSRPs for the vehicles in the study. Historically, manufacturers have always charged more for vehicles with diesel engines than gas engines because diesel engines tend to be more expensive to manufacture. In this sample, the same manufacturer can have quite significant differences between diesel and gas versions of its vehicles, as noted in Table 1.

One could argue that the European manufacturers may have an advantage in introducing diesel versions of their vehicles because they already have built large numbers of these vehicles in Europe over many years, providing economies of scale for manufacturing diesel engines. They may also have a global scale effect if they sell the same diesel engines in their vehicles in other parts of the world.

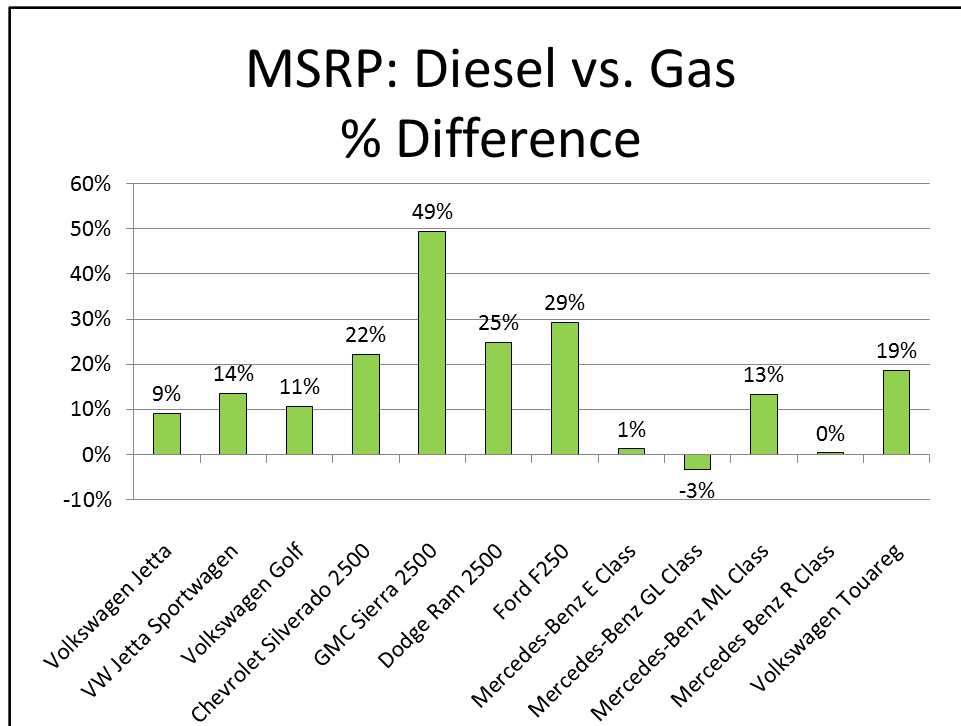


Figure 2: Percentage Differences (Increases) in MSRP between Comparable Diesel and Gas Vehicle Pairs

The Resale Model

In order to measure the resale value of the vehicles in our study and generate three- and five-year estimates for sale prices for both gas and diesel vehicles, we used the data provided by Mannheim auctions, the world's largest distributor of used/pre-owned vehicles to dealers. Our sample of 20,192 auction records comes from auctions that took place in 2010 and 2011.

The main variables in our resale value analysis include the sale price of the vehicle at auction (adjusted to 2011 dollars), the condition of the vehicle, the number of miles driven, and the age of the vehicle. Our preliminary correlation analysis showed very high multi-collinearity among these variables. Because of this high multi-collinearity, we examined each variable separately to see which variable was the best predictor of sale price. Based on this examination, we chose the number of miles driven as our independent variable to explain the variance in sale price.

We used the LOWESS regression program to get the best fit for our distribution. LOWESS differs from the typical regression program in that it creates a smoothed, curved regression line, which sometimes provides a better fit for the distribution. Because the relationship between sale price and the number of miles driven, at times, showed a curved distribution, we used LOWESS to generate both a typical regression line as well as the smoothed, curved regression line. Figure 3 shows this effect for the gas version of the Volkswagen (VW) Jetta. Note how the Smooth Fit provides a better fit for the data, especially for vehicles that are older with higher mileage.

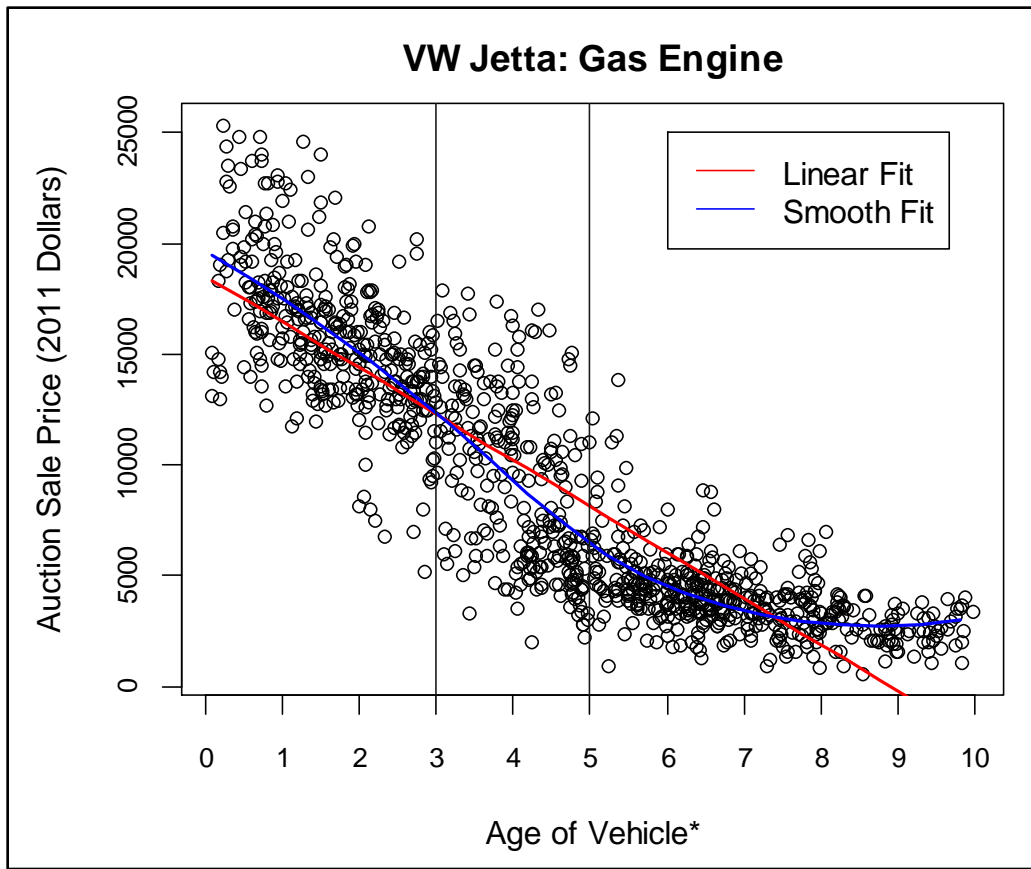


Figure 3: Auction Sale Price by Age of Vehicle for the Gas Version of the VW Jetta

* We define the age of the vehicle by dividing the actual miles at auction by 15,000, the average number of miles driven by consumers age 20 to 54. (FHWA, <http://www.fhwa.dot.gov/ohim/onh00/bar8.htm>)

Figure 3 also visually shows how our auction sale-price estimates for three and five years were generated. The three- and five-year estimates of the auction sale price for these vehicles are noted by the points at which the 3-year and 5-year vertical lines intersect the smoothed regression lines.

Results

Figure 4 graphically displays the differences in three-year resale estimates for each of the vehicle pairs, where diesel vehicles show distinct advantages in resale values compared to their gas counterparts. These resale values control for vehicle miles driven.

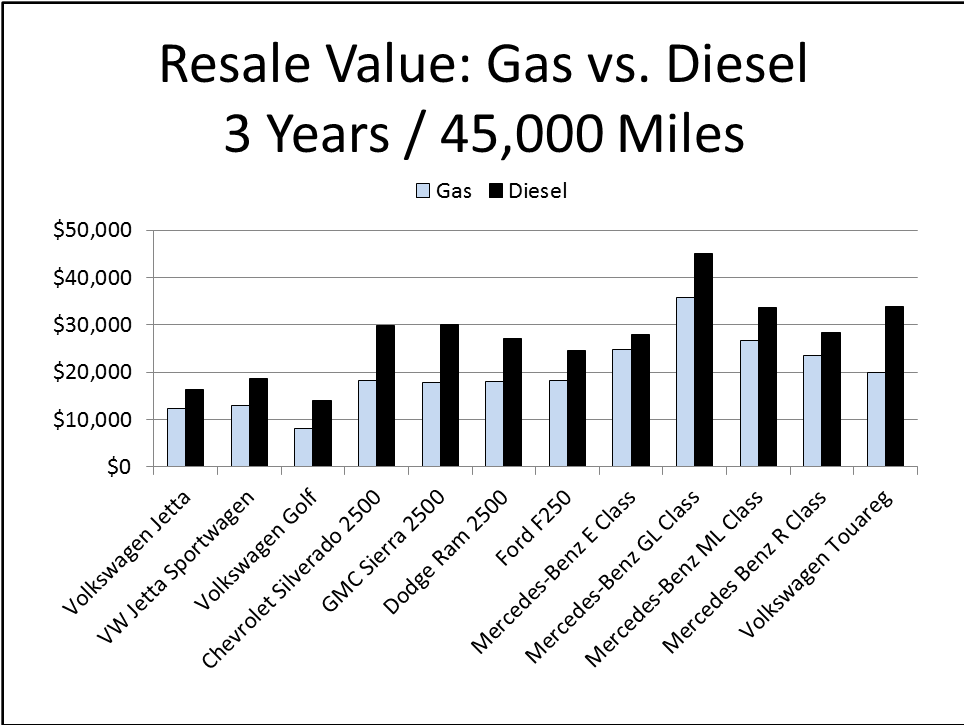


Figure 4: Resale Value of Gas and Diesel Vehicles after Three Years of Ownership

Figure 5 shows the estimated resale values of all the vehicle pairs in the study after five years of ownership. All the diesel vehicles show significantly higher resale values while controlling for vehicle miles driven. The VW Jetta Sportwagen and VW Touareg are not represented in the resale value at five years of ownership figure because there were not enough vehicles in this vehicle mileage/age group to estimate five years of ownership.

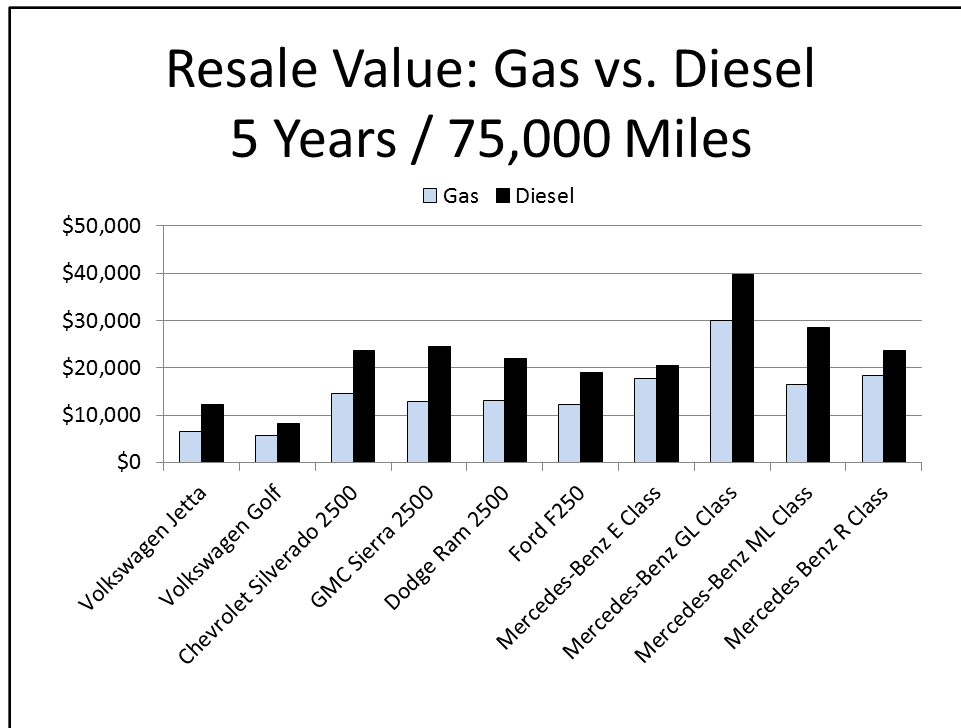


Figure 5: Resale Value Comparisons for Gas and Diesel Vehicles after Five Years of Ownership

Our depreciation model that feeds into our TCO model is based on subtracting the estimated resale value for three and five years (adjusted to 2011 dollars) from the average MSRP (adjusted for 2011 dollars) for comparable diesel and gas vehicles. Figure 6 displays the three-year depreciation for the diesel and gas versions of comparable vehicles in the study, as well as the percentage difference (reduction) between the diesel and gas versions.

Eleven of the twelve diesel vehicles hold their value better than comparable gas vehicles over the three-year timeframe, but there is a wide variance in the percentage of savings. Eight of the ten vehicles show double-digit percentage savings over the three-year period, ranging from 17 percent up to 46 percent. Two diesel vehicles show eight percent savings, while only one gas vehicle, the Ford F-250, holds its value better than its diesel counterpart at 22 percent. The Ford F-250 diesel may be suffering from a reputation problem due to a number of years where the quality of its diesel engine was suspect. This issue would lower the resale value of the F-250 diesel and allow the gas version to better hold its value.

There does not seem to be any pattern to the diesel and gas vehicle depreciation or the percentage of the savings for either type of vehicle other than the fact that the Mercedes-Benz GL Class diesel version tends to hold its value much better than the gas version. As we noted earlier, this is most likely because Mercedes-Benz priced the diesel version lower than the gas version of this vehicle. In particular, the GL diesel version was a smaller engine than the gas version, yet provided higher performance.

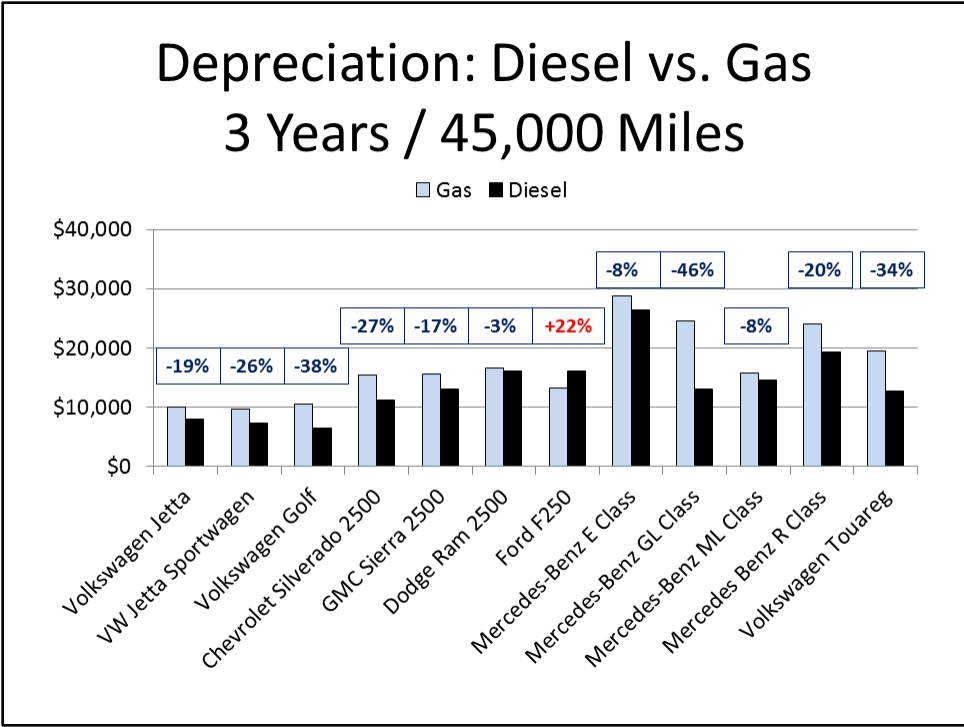


Figure 6: Depreciation Comparisons for Diesel and Gas Vehicles after Three Years of Ownership

Figure 7 displays the five-year depreciation for the diesel and gas versions of comparable vehicles in the study, as well as the percentage difference between the diesel and gas versions. Again, the VW Jetta Sportswagen and VW Touareg are not represented in the depreciation at five years of ownership figure because there were not enough vehicles in this vehicle mileage/age group to estimate five years of ownership.

Nine of the ten diesel vehicles hold their value better than comparable gas vehicles over the five-year timeframe, but there is a wide variance in the percentage of savings. Five of the ten vehicles show double-digit percentage savings over the five-year period, ranging from 10 percent up to 39 percent. Three diesel vehicles show single-digit percentage savings of three, six, and nine percent savings. Only the gas version of the Ford F-250 holds its value better than its diesel counterpart at 13 percent savings.

This analysis displays a point that will occur in the TCO analysis as well: the gap in depreciation between the gas and diesel versions of the same vehicle tends to narrow as a vehicle ages. Sometimes the gap is very narrow as in the Mercedes-Benz R Class where the three-year estimate shows a 20 percent difference in depreciation between the gas and diesel versions, while

the five-year estimate shows an 18 percent difference. This also applies to the Mercedes-Benz E Class (8 percent to 6 percent) and the Dodge Ram 2500 (3 percent to 1 percent). Some differences in percentages are significantly larger, such as the Mercedes-Benz GL Class (46 percent to 36 percent), the GMC Sierra 2500 (17 percent to 10 percent), the Chevrolet Silverado 2500 (27 percent to 9 percent), and the VW Golf (38 percent to 4 percent). Yet there are also some differences in the percentage of depreciation that actually increase from three to five years, such as the Mercedes-Benz M Class (8 percent to 25 percent) and the VW Jetta (19 percent to 24 percent). These differences are most likely the effect of the unique characteristics of a vehicle's engine over time that provide a better or worse reputation for these vehicles in the eyes of buyers. And these differences will affect not only the depreciation but also the TCO for a vehicle.

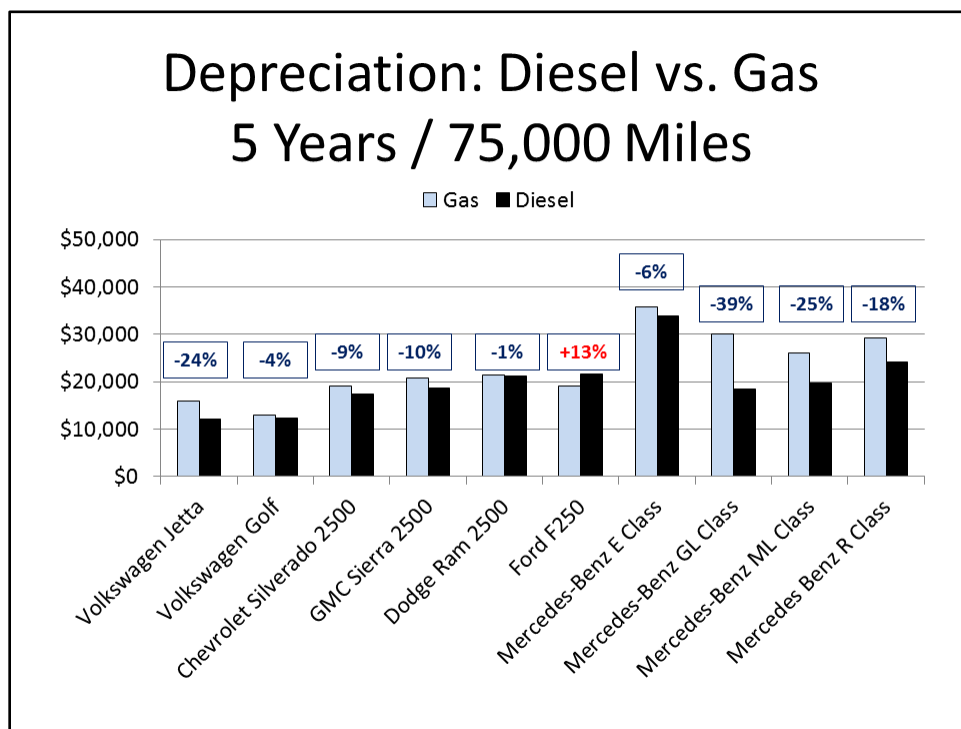


Figure 7: Depreciation Comparisons for Diesel and Gas Vehicles after Five Years of Ownership

Fuel Cost Model

We developed our fuel cost model with three- and five-year estimates using the combination of the model year of the vehicle from Mannheim, average annual gas and diesel fuel prices from the EIA, the number of annual miles driven based on vehicle survival analyses from NHTSA, and vehicle miles per gallon from the EPA. We also adjust fuel prices to 2011 dollars using the CPI.

We begin by taking the average annual fuel price for the model year of a vehicle, multiply that price by the average number of miles driven for the first year of ownership, and divide the result

by the vehicle miles per gallon. We do this same calculation for the following two and four years, sum the three- and five-year calculations and arrive at fuel cost estimates for three and five years for each vehicle in the dataset.

Results

Figure 8 shows the estimated diesel and gas fuel cost comparisons for three years of ownership. As expected, all diesel vehicles show lower fuel costs than all the gas versions of comparable vehicles, with eleven of the twelve vehicles showing double-digit reductions in fuel costs, ranging from 10 to 29 percent.

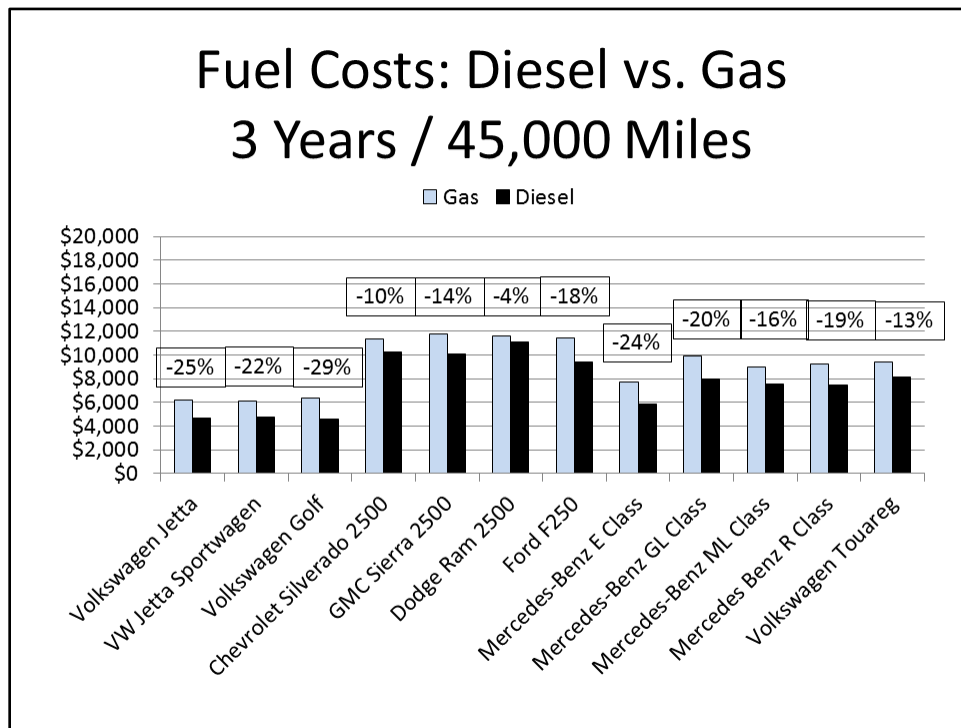


Figure 8: Fuel Cost Comparisons for Diesel and Gas Vehicles after Three Years of Ownership

Figure 9 displays the estimated diesel and gas fuel cost comparisons for five years of ownership. As in the other analyses, the VW Jetta Sportwagen and VW Touareg are not represented in the fuel costs at five years of ownership figure because there were not enough vehicles in this vehicle mileage/age group to estimate five years of ownership.

Similar to the three-year comparisons, five-year estimated fuel costs for diesel vehicles are less than those of comparable gas versions. What is significant is that the percentage difference in terms of the reduction from gas to diesel costs actually decreases for some diesel-gas

comparisons over the five-year ownership period. The main reason for this is the sensitivity of our fuel cost model to the price of fuel. As diesel prices began to increase around the 2005 timeframe, the savings from diesel began to decrease accordingly.

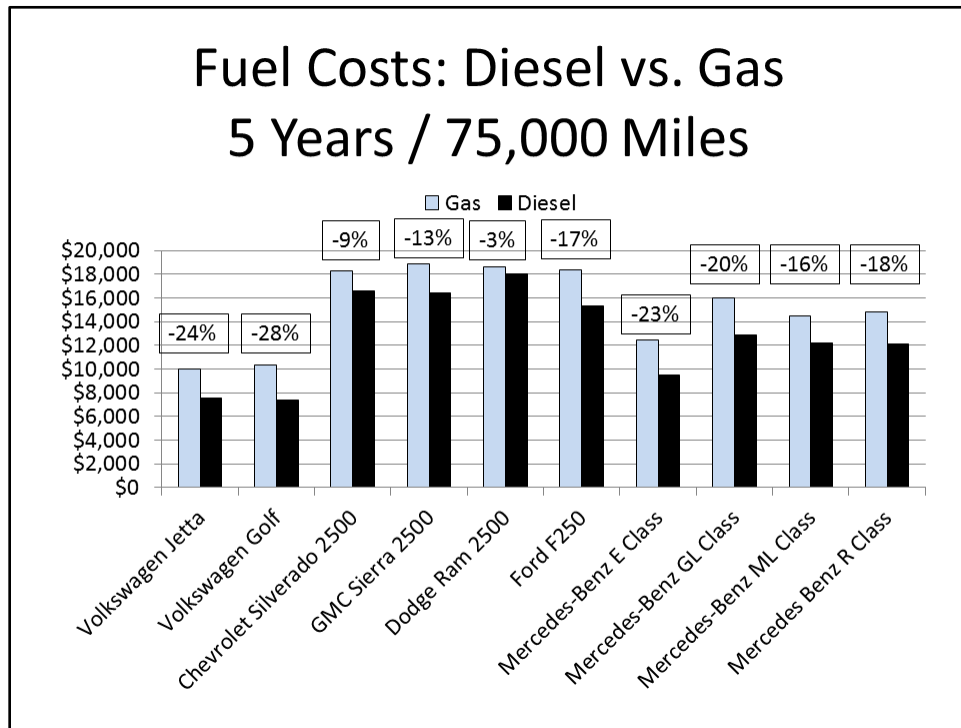


Figure 9: Fuel Costs for Gas and Diesel Vehicles Over 5 Years

Total Cost of Ownership Model

Comparing the total cost of ownership of gas and diesel versions of the same model is challenging. By developing our own resale model based on the actual prices paid at auction (Mannheim auction data) and by developing our own fuel cost model based on actual fuel prices (EIA, FHWA, and EPA data) for our sample of 20,192 vehicles sold at auction in 2010 and 2011, we have the two major pieces of the total cost of ownership model in place. By combining our models based on 2011 dollars with Vincentric’s three- and five-year estimates for repairs, maintenance, insurance, and fees and taxes for the same types of vehicles, also in 2011 dollars, we have developed good estimates for the total cost of ownership of gas and diesel versions of the same vehicles over both three- and five-year ownership periods.

Our basic equation is:

$$\text{Depreciation (Original MSRP-Resale Value)} + \text{Fuel Costs} + \text{Repairs} + \text{Insurance} + \text{Maintenance}$$

Results

Figures 10 and 11 show the dollar amounts that each of the parts of TCO represents in the three-year timeframe. They also show the amount saved or lost by driving a diesel rather than a gas version of the same vehicle.

In the three-year timeframe, diesel vehicles in the mass market passenger car segment are estimated to save the owner significant money, with the VW Jetta owner saving \$3,128, the VW Jetta Sportwagen owner saving \$3,389, and the VW Golf owner saving an estimated \$5,013.

Diesel vehicles in the medium-size pickup segment have a mixed picture of TCO in the three-year timeframe. The Chevrolet Silverado 2500 saves the owner an estimated \$3,673 more than the owner of the gas-powered version of the vehicle, and the GMC Sierra 2500 owner saves \$2,720, while the Dodge Ram 2500 diesel owner saves only \$67 more than the owner of the gas-powered version. The Ford F-250 diesel owner pays an estimated \$1,395 more than the owner of the gas-powered version.

In the luxury segment, all the diesel versions of the Mercedes-Benz E Class (\$4,175), Mercedes-Benz GL Class (\$13,514), Mercedes-Benz M Class (\$3,063), Mercedes-Benz R Class (\$5,951) and VW Touareg (\$7,819) save owners money in the three-year timeframe.

The general trend is positive for diesel versions of the same gas-powered vehicles, but a number of factors can affect the actual amount of money saved.

- Depreciation plays a large role in a vehicle's TCO analysis, and things that affect it such as a poor reputation in the marketplace can decrease its price when it comes to market for resale.
- Manufacturers also sometimes charge higher prices for very new vehicles in order to recoup their R&D expenses. This higher price may not hold up in the resale market, thus making the TCO higher for a vehicle with new technology.
- Manufacturers can also support particular technologies by making them less expensive than their competitors. Luxury manufacturers may have more room to influence prices because they generally have a larger profit margin on their vehicles than do mass market manufacturers.
- Finally, fuel costs are the second largest contributor to TCO, and higher diesel prices can also have a negative effect on TCO if the gap between the price of gasoline and diesel fuel is wide.

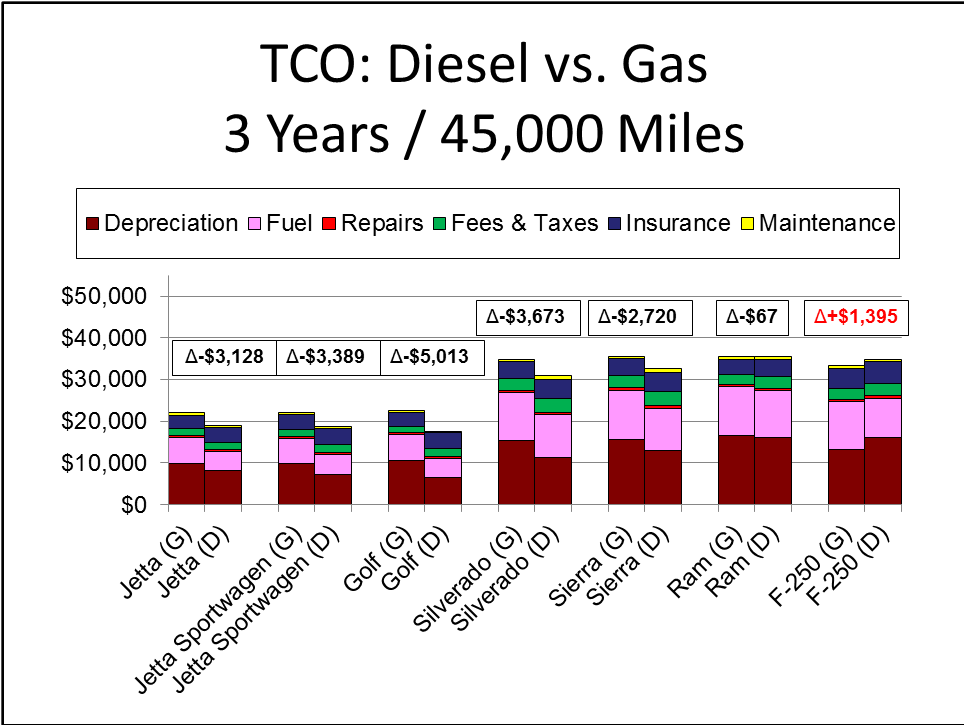


Figure 10: The Total Cost of Ownership for Selected Gas and Diesel Vehicles Over a 3 Year Timeframe

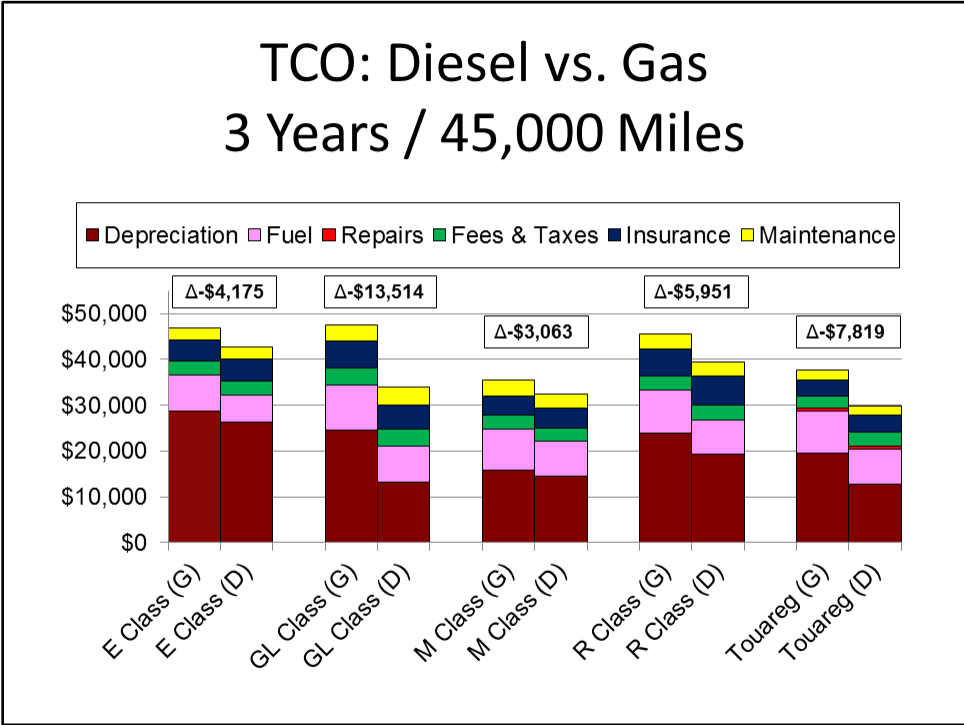


Figure 11: The Total Cost of Ownership for Selected Gas and Diesel Vehicles Over a 3 Year Timeframe

Figures 12 and 13 report the effects of TCO over a five-year timeframe. As in the other analyses, the VW Jetta Sportwagen and VW Touareg are not represented in the TCO analysis at five years of ownership figure because there were not enough vehicles in this vehicle mileage/age group to estimate five years of ownership.

All the diesel versions of the vehicles in our study continue to hold their value as measured by the TCO except for Dodge Ram 2500 where the estimated TCO moves from near breakeven (\$67) in three years to a five-year cost of \$578 for the diesel version of the vehicle over the gas version.

As in our other analyses, there are some positive effects of diesel ownership that accumulate over time, as the vehicle continues to provide better fuel economy than the gas-powered version of the same vehicle. This can be seen in the VW Jetta where the estimates for TCO for three-year ownership (\$3,128) increase for five-year ownership (\$5,475). The luxury models also show increases in the amount of money saved by the diesel version over the gas version of the same model.

- The Mercedes-Benz E Class diesel saves the owner an estimated \$4,406 over a five-year timeframe compared to \$4,175 over a three-year timeframe.
- The Mercedes-Benz GL Class saves \$15,619 over five years compared to \$13,514 over three years.
- The Mercedes-Benz M Class saves \$9,185 over five years compared to \$3,063 over three years.
- The Mercedes-Benz R Class saves \$6,940 over five years compared to \$5,951 over three years.

The high levels of savings from luxury vehicles may be an artifact of pricing flexibility that luxury makers have with their vehicles, but further research is needed to fully understand this issue.

For the other vehicles in our study, estimated TCO savings for diesel versions of the same vehicle in five years are less than the savings in three years.

- The VW Golf saves owners an estimated \$1,506 over a five-year period and \$5,013 in a three-year period.
- Chevrolet Silverado 2500 owners save \$1,278 over a five-year period and \$3,673 in three years.
- GMC Sierra 2500 owners save \$2,613 over a five-year period and \$2,720 in three years.

Most of these differences can be explained by the increase in the percentage that depreciation represents in the TCO, but to better understand these differences, more research is needed. Finally, the Ford F-250 diesel at five years continues to have a TCO that is higher than the gas version (\$763) but less than the three-year TCO estimate (\$1,395).

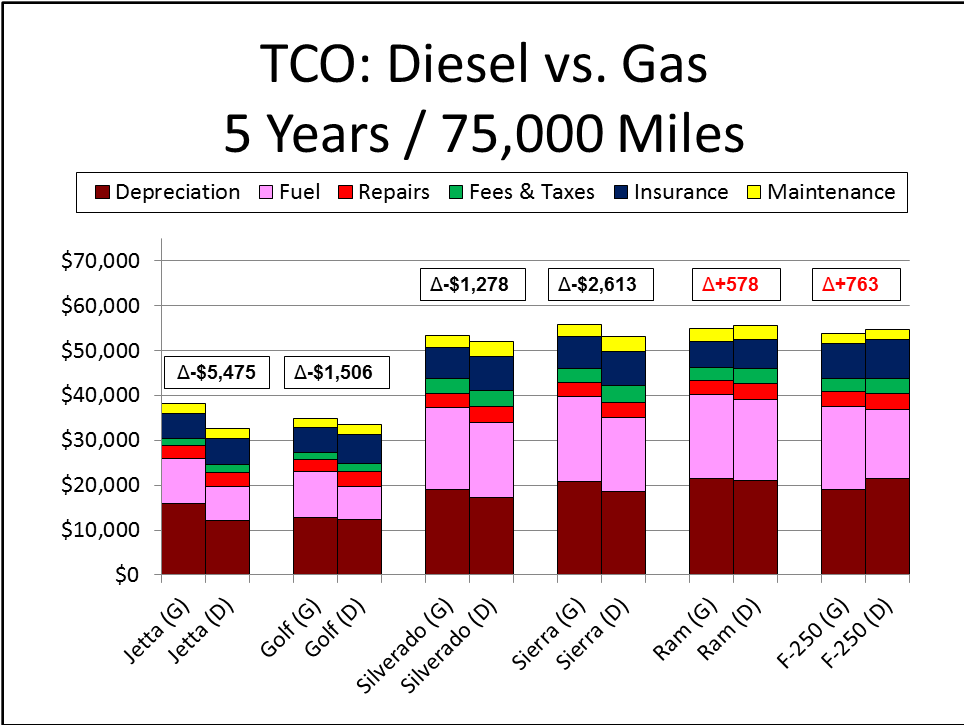


Figure 12: The Total Cost of Ownership for Selected Gas and Diesel Vehicles over a 5 Year Timeframe

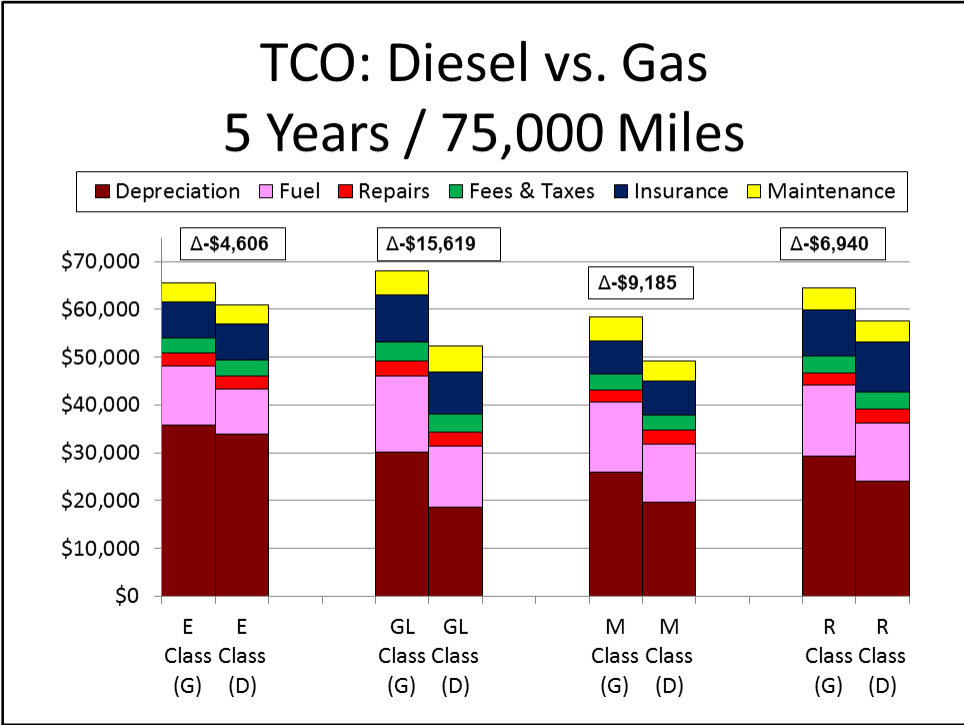


Figure 13: The Total Cost of Ownership for Selected Gas and Diesel Vehicles over a 5 Year Timeframe

Discussion and Conclusions

Overall, the results of our analyses show that diesel vehicles provide owners with a TCO that is less than that of the gas versions of the same vehicles. The estimates of savings for three and five years of ownership vary from a low of \$67 in three years to a high of \$15,619 in five years, but most of the savings are in the \$2,000 to \$6,000 range, which also include the extra cost that is usually added to the diesel version of a vehicle. Though there are some exceptions to these positive results for some of the diesel versions of vehicles from a TCO perspective, the overall direction of the results supports the idea that diesel vehicles compete well within the U.S. market. In particular, the idea that one can get a return on one's initial higher investment in a diesel vehicle within three years is a very positive sign, considering that new vehicle buyers tend to keep their new vehicles for an average of three to five years.

Some continuing challenges for diesels in the U.S. include the potential increase in the cost of diesel fuel compared to gasoline, and the resulting need for diesels to proportionally improve their fuel economy to maintain a TCO advantage. This is particularly important because both gasoline and diesel powered vehicles must improve their fuel economy as required by Corporate Average Fuel Economy (CAFE) regulations for 2016 and 2025.

As the market for diesels increases as more diesel powered vehicles are introduced into the market (diesel variants of the Chevrolet Cruze, Jeep Grand Cherokee, Ram 1500, and Ram ProMaster have recently been announced and will be the first American-branded, light-duty diesel vehicles), the premium that diesels carry in the marketplace today may decrease through the sheer number of competing models. But the increased number of diesel models in the fleet may also bring down the price of diesel-powered vehicles, providing consumers with both price and fuel savings. Diesel-powered vehicles are providing significant value to their owners through their TCO advantage over their gas-powered counterparts, and they will play an increasingly important role for manufacturers and consumers as fuel economy regulations becoming increasingly strict.

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