# Benefits of Electric Hybrid Class 8 Semi Trucks

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Transportation is a keystone part of the US economy. The US Energy Information Administration predicts the transportation sector of the American industry will continue to increase beyond 2040.[1] In this essay, I will be looking at the benefits of choosing an electric hybrid class 8 semi truck over a traditional diesel engine semi truck. A class 8 truck is defined to be a vehicle in which its gross weight exceeds 33,000 pounds. This paper focuses on Coca Cola's class 8 truck dedicated for deliveries throughout different cities.

## 1. Technology behind diesel and hybrid electric semi-trucks

Diesel engine semi-trucks are inefficient compared to its electric hybrid counterpart. In the traditional diesel engine truck, the sole power of the vehicle is its engine. It uses compression technology to light a mixture of fuel and air producing power. This power is used to propel the vehicle forward. However, because these trucks create miniature explosions to create power, heat is lost in the process. As a result, diesel engine trucks fail to harvest this type of heat to create power. Diesel engine trucks also fail to use the energy released during the braking process. When the vehicle uses its brakes to slow down, the truck transfers its kinetic energy into heat energy.[2] This means that the energy that may have been used to move a vehicle forward is completely lost during the braking process.

Electric hybrid semi-trucks have the same technologies as diesel engine trucks, but with added features.[3] In it, the truck contains a much smaller diesel engine that operates along with an electric motor. The truck utilizes an additional module in which it can take the energy from the braking process, and store it inside lithium ion batteries. The energy stored inside the batteries can then be used to power the electric motor. As a result, hybrid electric vehicles benefit even more when the driving style contains more frequent braking. The truck also stores energy inside of its batteries when moving forward through its generators. The generators take the mechanical energy produced from the engine and stores the energy into its batteries, which again, is used to

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[1] http://www.eia.gov/forecasts/ieo/pdf/0484(2013).pdf
[2] Woodford, Chris, "Regenerative brakes", 6 November 2015. http://www.explainthatstuff.com/how-regenerative-brakes-work.html
[3] "Electric Hybrid", ©2016. http://www.eaton.com/Eaton/ProductsServices/HybridPower/index.htm

power the electric motor.[4] While concerns may be present of the possibility that the electric motor can fail, the hybrid can run on its diesel engine by itself. This useful in knowing that it does not hurt to add an electric hybrid system to a truck.

The main benefit from choosing an electric hybrid system versus a diesel power system is that the electric hybrid uses two types of motors. These two motors, diesel and electric, can improve fuel efficiency since the diesel does not work alone to move the truck. It also relieves the stress of a diesel engine since the engine is supported by the electric motor. This is important as it will demonstrate a significant decrease in maintenance cost in a later section.

## 2. Fuel Economy

*Table 1 MPG Rating of diesel and hybrid electric semi trucks*[5]

| Drive Cycle | HEV Fuel Economy (mpg) | Diesel Fuel Economy (mpg) | Percent Increase |
|---|---|---|---|
| 1 | 5.79 | 4.44 | 30.3 % |
| 2 | 7.55 | 6.18 | 22.2 % |

According to a study on Coca Cola hybrid electric vehicles (HEV), the HEV has a significantly improved fuel economy compared to diesel fuel economy as seen in Table 1. Here we have two types of driving cycles. While both are city driving, one style has significantly less stops. The drive style is the main factor in determining the miles per gallon (mpg) rating of the vehicle. Drive cycle 1 is the driving style in a city with many stops. The HEV scored an average mpg of 5.79 while a similar diesel truck running the same cycle scored an mpg of 4.44. The difference in these two values is drastic because truckers will need to drive hundreds of miles, thus the miles per gallon will accumulate quickly. Additionally, there is a 30.3 % increase in fuel economy simply by switching from diesel to HEV. This increased efficiency will be noticeable

[4] "How Does a Generator Create Electricity? How Generators Work" ©2013. http://www.dieselserviceandsupply.com/How_Generators_Work.aspx

[5] Walkowicz, Lammert, and Curran "Coca-Cola Refreshments Class 8 Diesel Electric Hybrid Tractor Evaluation" http://www.nrel.gov/docs/fy12osti/53502.pdf
Note: The Coca-Cola study is a technical report conducted by EIA members on Coca-Cola's electric hybrid semi truck during its normal driving routine. It is an extensive study and has tons of information and quantitative facts based off of their own electric hybrid and diesel engine fleet. Although the data is from 2012, I have chosen this study because technology of hybrids will only improve as time moves on.

when calculating the cost of fuel per year in both trucks. Drive cycle 2 is similar to 1, but with fewer stops in the city due to traffic. The HEV scored a 7.55 mpg rating and the diesel truck scored a 6.18 mpg rating. This resembles a 22.2 % increase in fuel efficiency which can be beneficial over time.

The hybrid electric vehicle can save much more money when used over the diesel fuel trucks. The price per gallon of diesel is approximately $1.989.[6] Using this value and the data in Table 1, the price per mile can be calculated for both types of trucks on the first driving cycle. This is done by dividing the price per gallon by the amount of miles driven per gallon yielding the cost per mile of each truck.

$$\text{HEV: } 1.989\ \frac{dollars}{gallon} * \frac{1}{5.79}\frac{gallon}{miles} = 0.344\ \frac{dollars}{mile}$$

$$\text{Diesel: } 1.989\ \frac{dollars}{gallon} * \frac{1}{4.44}\frac{gallon}{miles} = 0.448\ \frac{dollars}{mile}$$

As seen in the calculation, the price per mile of the HEV is significantly cheaper than the price per mile of the diesel truck. To put this in a better perspective, truckers drive about 66,000 miles per year. Utilizing this number, I can calculate the total price of the fuel HEV and diesel trucks will use per year.

$$\text{HEV: } 66{,}000\ \frac{miles}{year} * 0.344\frac{dollars}{mile} = 22{,}704\ dollars$$

$$\text{Diesel: } 66{,}000\ \frac{miles}{year} * 0.448\frac{dollars}{mile} = 29{,}568\ dollars$$

The HEV saves nearly $7,000 if used over the diesel truck. This is important to large scale corporations, such as Coca Cola because a fleet of HEV will save the company a great deal of money per truck.

Hybrid electric trucks perform even better in driving conditions involving more frequent braking and acceleration because of its technology used to conserve energy, which is mentioned in the previous section. Using the data for the second driving condition from Table 1, the price

[6] https://www.eia.gov/petroleum/gasdiesel/

per mile can be calculated as well as the price of fuel spent per year.

$$\text{HEV: } 1.989\ \frac{dollars}{gallon} * \frac{1}{7.55}\frac{gallon}{miles} = 0.263\frac{dollars}{mile}$$

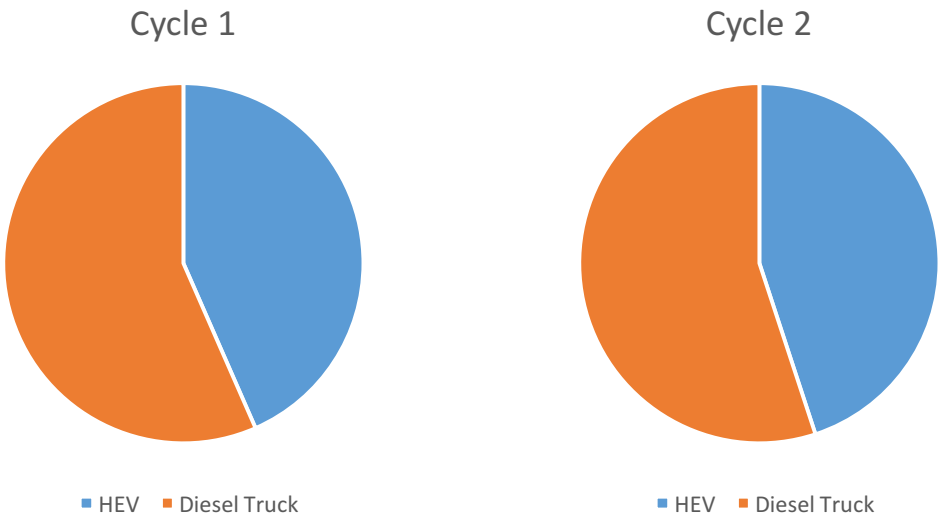
$$\text{Diesel: } 1.989\ \frac{dollars}{gallon} * \frac{1}{6.18}\frac{gallon}{miles} = 0.322\ \frac{dollars}{mile}$$

$$\text{HEV: } 66{,}000\ \frac{miles}{year} * 0.263\frac{dollars}{mile} = 17{,}358\ dollars$$

$$\text{Diesel: } 66{,}000\ \frac{miles}{year} * 0.322\frac{dollars}{mile} = 21{,}252\ dollars$$

Figure 1 includes two charts of the calculation for the cost per year of the HEV and diesel trucks. On the left is the data for driving cycle 1, which is city with many stops, and on the right is the data for cycle 2, which is the city driving with few stops. Looking at the two charts, it is clear that the cost of running an HEV is much cheaper than running a diesel engine truck.

*Figure 1: Compiled charts of cost per year for the two drive cycles*




### 3. Comparison of diesel and electric hybrid emissions

In Table 2, the emissions result of the two driving cycles are shown. In driving cycle 1, the HEV scored significantly higher on its nitrogen oxide ($NO_x$) emissions, but its carbon monoxide (CO) and carbon dioxide ($CO_2$) emissions were much lower than the diesel truck. In driving cycle 2,

there is a similar trend of the HEV releasing fewer emissions than the diesel truck. The HEV released little amounts of CO and also $CO_2$, but the nitrogen oxide levels were still fairly high.

*Table 2 Emissions Results of HEV and Diesel Engine Truck*[7]

| Drive Cycle | Vehicle | $NO_x$ (g/mile) | CO (g/mile) | $CO_2$ (g/mile) |
|---|---|---|---|---|
| 1 | HEV | 9.94 | 1.64 | 1.77 |
| | Diesel | 7.70 | 1.70 | 2.31 |
| 2 | HEV | 7.53 | 0.35 | 1.36 |
| | Diesel | 7.16 | 0.93 | 1.66 |

The emissions data of the two types of vehicles are very promising. The hybrid electric vehicle had a much less emissions per mile with the exception of its nitrogen oxide levels. From the data, it is clear that HEV may be a more environmentally friendly type of truck.

## 4. Operating Costs of HEV and Diesel Trucks

Maintaining a vehicle is very important in order to ensure that the truck runs for its maximum lifetime. In Table 3, the cost of operating the two types of power systems are noted. The diesel engine costs around $ 0.97 and the hybrid electric costs $ 0.74. This is a 24 % percent difference in the price which is very high in consideration that truckers put thousands of miles on their vehicles per year.

*Table 3 Cost of Operating HEV and Diesel Trucks*[5]

| Vehicle Type | Cost per mile |
|---|---|
| Diesel | 0.97 |
| Hybrid Electric | 0.74 |
| Hybrid % Difference | 24% |

[7] Walkowicz, Lammert, and Curran "Coca-Cola Refreshments Class 8 Diesel Electric Hybrid Tractor Evaluation" http://www.nrel.gov/docs/fy12osti/53502.pdf

The hybrid electric vehicle has a lower cost per mile maintenance. This is not surprising because as noted previously, the HEV has an additional motor to relieve the stress of the diesel engine. The diesel engine inside the HEV contains many different parts that work together, thus it is more prone to breaking. In the HEV, an additional motor is present relieving the stress the diesel engine must face. This causes there to be a lower cost per mile of maintaining the vehicle.

## 5. Final remarks between diesel and hybrid electric trucks

The benefits of the hybrid electric truck outweigh the diesel truck in many different ways. First, the hybrid has a better cost per mile rating at $ 0.344 and $ 0.263 which are both significantly cheaper than the diesel cost per mile. Secondly, the HEV releases fewer emissions compared to the diesel engine truck. In particularly, it releases less carbon monoxide and carbon dioxide. Third, the maintenance cost of the hybrid is much cheaper than the diesel truck. The hybrid seems to be the better choice in choosing a class 8 truck for primarily city driving usage. [1691]

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