Overall energy efficiency analysis of different C-class vehicles

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Introduction

Background:

Passenger transportation, in particular light-duty vehicles, accounts for close to 60% of the global transportation energy consumption [1]. Certain vehicle fuel and powertrain combinations are more energy efficient than others.

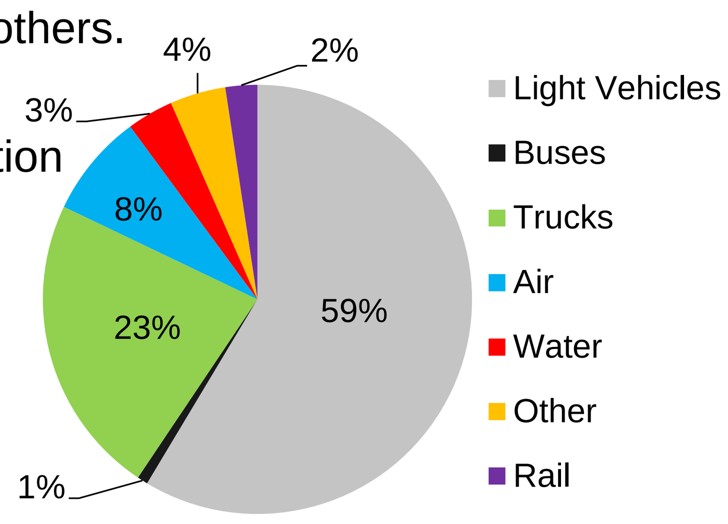

Figure 1: Transportation energy use by mode. (2014) [2]

Purpose:

The purpose of this investigation was to determine the C-class vehicle fuel and powertrain combinations that are in general more energy efficient overall.

This investigation could help consumers to purchase vehicles and transport fuels in the future that are more energy efficient.

Analysis Scope

- A well-to-tank (WTT) efficiency analysis was performed for four different types of transport fuel (electricity, gasoline, diesel and hydrogen gas).
- A tank-to-wheel (TTW) efficiency analysis was performed for four different types of vehicle powertrain (internal combustion (IC), hybrid electric (HE), hydrogen fuel cell (HFC) and battery electric (BE)).
- All of the fuel production stage efficiencies and vehicle losses used in the WTT and TTW analyses were obtained from previous studies.
- The results of these analyses were then used to determine the well-to-wheel (WTW) energy efficiencies of all the possible fuel and powertrain combinations.
- The efficiencies were calculated as follows:

$$\eta_{WTT} = \prod_{i=1}^{n} \eta_i$$

η_i → The efficiency of a life cycle stage as a fraction.

$$\eta_{TTW} = \left(\prod_{i=1}^{n} (1 - l_i) \right)$$

l_i → An energy loss as a fraction.

$$\eta_{WTW} = \eta_{WTT} \times \eta_{TTW}$$

- The results of the investigation were presented in a scientific paper.

For further information on any aspect of this investigation, please email me at:

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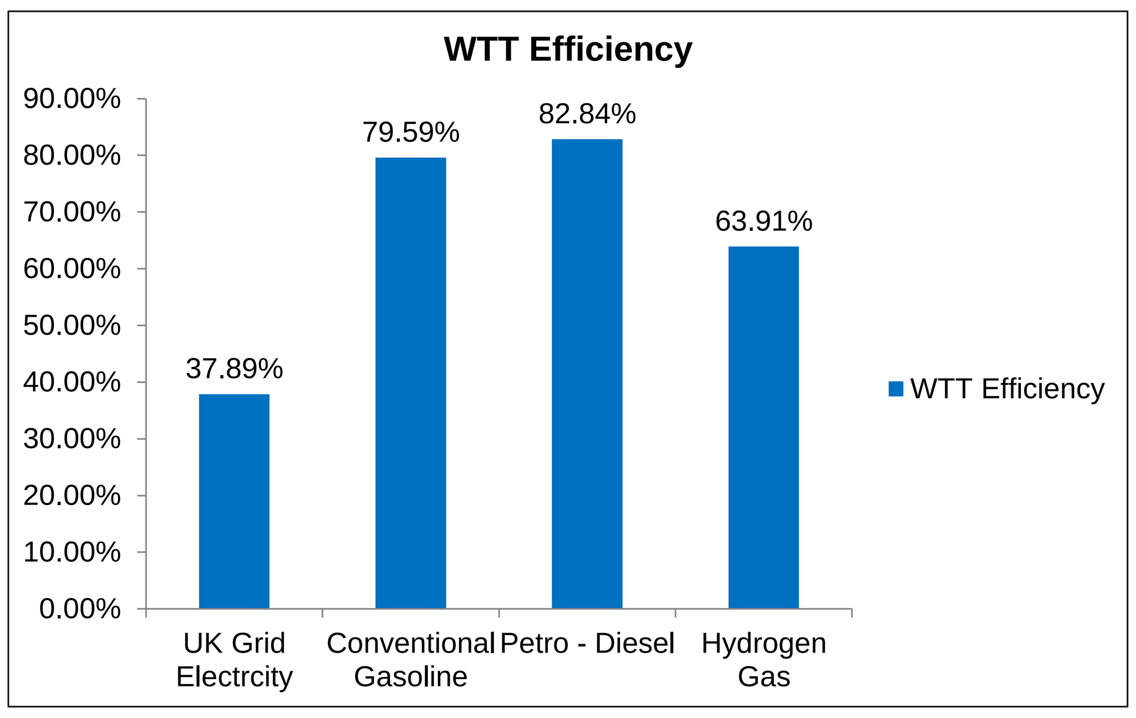
Results

The results of the WTT and TTW analyses are displayed below:



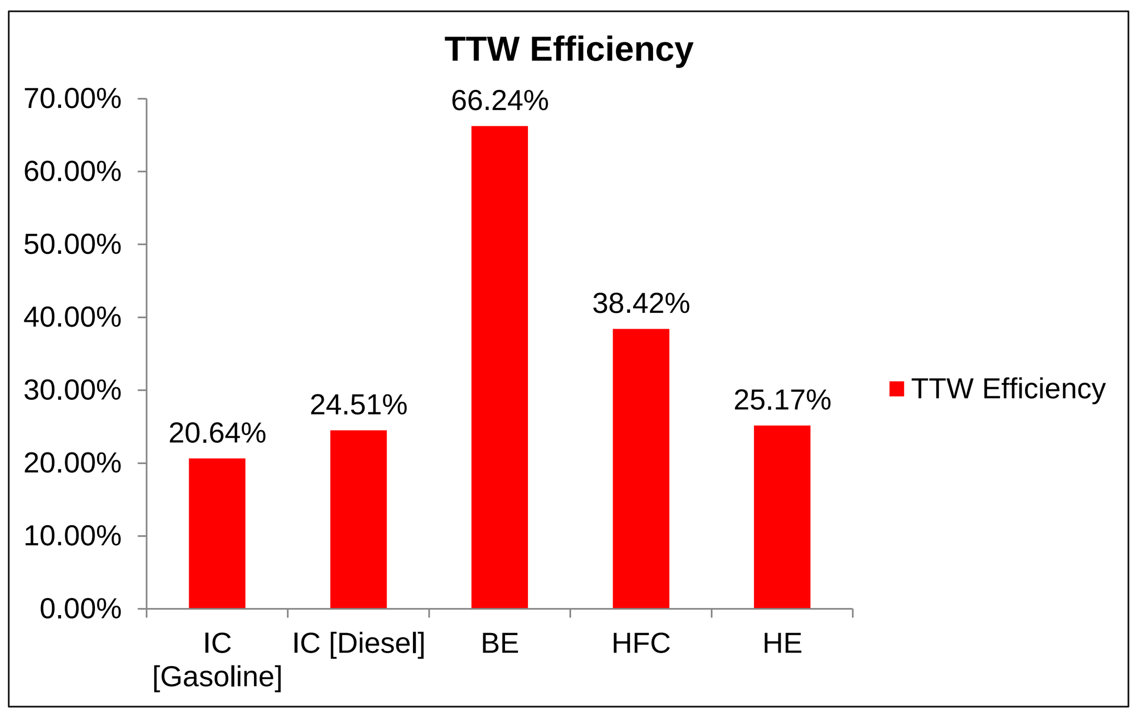


Figure 2: The WTT & TTW efficiencies.

WTW efficiencies were calculated for six fuel - powertrain combinations. The results are displayed below:

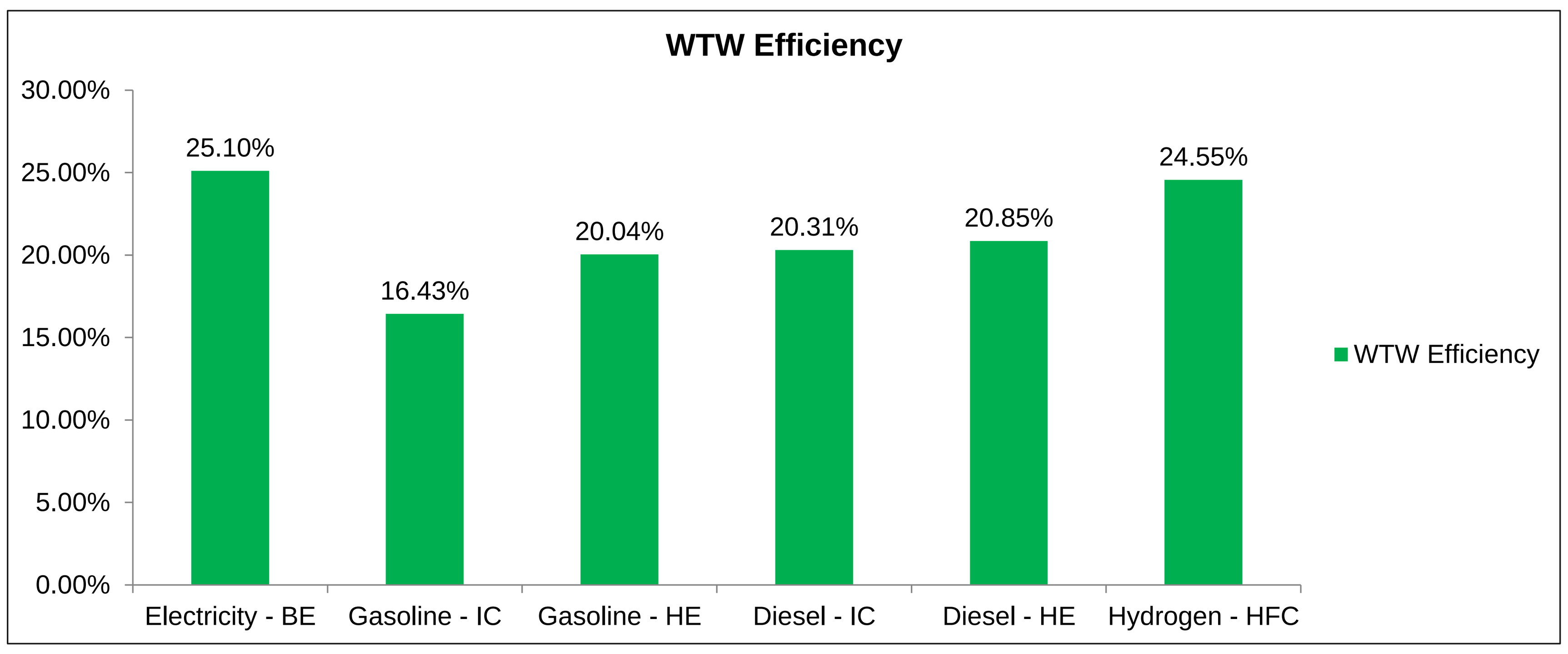


Figure 3: The WTW efficiencies.

Conclusions

The electricity - BE combination was found to have the highest WTW efficiency. This is due to the BE powertrain having a very high TTW efficiency. The hydrogen - HFC combination was found to have the second highest WTW efficiency.

Interestingly, the WTW efficiency of the diesel - IC combination was found to be 0.27% higher than that of the gasoline - HE combination. This is primarily due to the large energy losses that occur in an HE vehicle's DC generator. The study by Wald (2004) [3] showed a similar result.

Summary

The production cycles of gasoline and diesel were found to be the most energy efficient.

The alternative fuel vehicle powertrains (BE & HFC) were found to be the most energy efficient. The IC powertrains were found to be the most inefficient.

The electricity - BE combination was found to be the most energy efficient overall. The hydrogen - HFC combination was found to be the second most energy efficient overall.

Future Work

This investigation could be extended to include several other transport fuels such as biodiesel and ethanol so that a wider comparison can take place.

References

[1] Centre for Climate & Energy Solutions, 2014. *US Emissions.* [Online] Available at: http://www.c2es.org/energy/use/transportation [Accessed November 2016].

[2] Oak Ridge National Laboratory, 2014. *Transportation Energy Data Book (Table 2.8).* Available at: http://cta.ornl.gov/data/chapter2.shtml [Accessed March 2017].

[3] Wald, Scientific American, 2004

(Top Left Image - www.pixabay.com)