Ethical and Technical arguments for using Diesel engines in future transportation – philosophy for children and grownups

D L Băldean[1, 2]**, and V Chindea**[1]

[1] Automotive and Transportation Dep., Technical University of Cluj-N., Cluj, Muncii 103, Ro.

[2] Applied Philosophy Dep., Babeș-Bolyai University, Cluj, Kogălniceanu 1, Ro.

doru.baldean@auto.utcluj.ro, doru.baldean@ubbcluj.ro

Abstract. The use of Diesel engines seems to be destined to end in a decade or so. We wonder if it is the best idea to throw the Diesel engine out of the market. Are there any arguments or defensible positions to use Diesel engines furthermore in the future? Some may argue that Diesel engines are obsolete and overpassed in efficiency by electric cars, but others may argue that compression ignited engines can be used safely and reliably in the future due to their low consumption and high energy efficiency. In the present paper we put together the ethical and technical arguments for using Diesel engines in future transportation to improve fuel efficiency. Based on experimental research and testing the vehicle in combined road traffic we have collected solid data for a comparison of the studied Diesel fuel vehicle versus electric vehicles. The first testing package has been conducted on 150 km in combined road traffic with a medium size Diesel vehicle from city of Cluj-Napoca to city of Gherla (reaching a consumption of 2.2 l/100km which equals to 19.6 kWh), then to city of Dej (reaching a consumption of 2.3 l/100km which equals to 20.45 kWh), through Bistrița and toward the city of Vatra Dornei in the mountains (reaching 2.4 l/100km which equals 21.4 kWh). The second specific test was made on 1600 km from Cluj-Napoca to city of Năvodari and other sites in Constanța county (reaching 2.6 l/100km which equals 23.11 kWh) competing with popular EVs.

1. Introduction

As trained and educated motorist I am convinced that a proper design and a well-developed project for energy use will diminish pollution and health risks, respectively it will provide a basis for controlling CO_2 emissions in cold and warm-up phases [1, 2]. Ethical arguments as a code of conduct and operation give us the theoretical means to reach the proposed objectives: being energy efficient, low pollutant and desire to be competitive in environmental protecting behaviour. Technical support and arguments are the practical methodology used in reaching the former postulated objectives.

Experimental research of chemical emissions is most of the time related to fuel consumption and operating regime of the engine. As higher the weight of the vehicle will be then higher the fuel consumption and emissions will also be. The transient operating cycles leads to higher levels of consumption as it was recorded in each experimental testing [3, 4, 5]. Electronic control of Diesel systems has been proved to be useful in making the engine operation more efficient and improving fuel economy [6, 7, 8]. Digital reports and precise control on fuel consumption and emissions can help the users to choose the proper operation scenario to achieve better outcomes in vehicle operational economy and lower carbon footprint [9, 10]. Through applied research and experiments the optimal operating regime of each powertrain is defined and mapped [11,12]. Important data regarding the operating aspects from the injection process and consumption properly presented to the driver allows him to make better choices in choosing the speed regime and accelerator operation [13, 14]. Automation, software accessibility, level of computer programming and sensor accuracy are just a part of technical contributing factors in the study of fuel efficiency and emissions [15, 16, 17]. Developing automatic fuel delivery and data management systems lead to the strengthening of both ethical and technical aspects of human-machinery-environment mediated relationship [18, 19]. Such aspects are the basis for developing the present research work. Ethical arguments state that the pollution is not good for health and environment, on one hand, and that the vehicles contribute to the pollution level, on the other hand. It is ethically correct to admit that both Diesel vehicles and electric vehicles contribute to pollution level, the first one through emissions and the second one at the energy production level, respectively in the battery and electronic equipment disposal phase. Another economic argument consists in the fact that Diesel engines are efficient in long run and highly competitive in the highway and combined (city + highway) scenarios compared with battery-electric vehicles and hybrid-electric vehicles.

The objective of the study is to outline at least three arguments for using Diesel engines in future transportation, supporting in this way a theory or a philosophy for environmental protection and economic development. The secondary objectives are as the following: selecting a popular and common Diesel vehicle for applied research; developing a methodology for practical study; making the experiment in both conditions (cold operation and nominal temperatures). Starting with experimental research we put here a strong basis for creating an environmental philosophy in which Compression Ignited engines and the brilliant ideas of Rudolf Diesel have a significant role in future transportation. So much so, children of today will be the grownups of tomorrow and both the present and future can benefit from the research and development outcomes of tradition initiated by Rudolf Diesel and his successors. Chris Jones, being the president Australian Electric Vehicle Association, spoke to a journalist from *Drive* indicating the important factors in energy efficiency as: “aerodynamics and weight, but also the width and size of the tyres”. The same key-factors are important for Diesel cars. Jones said that consumption below13kWh/100km is efficient, whereas above 20kWh/100km is not.

In the present paper are shown the results of measurements regarding average consumption, average speeds, ambient and oil temperatures, recorded during the practical testing and experimental research.

2. Applied research

The research methodology in our study is based on the experimental testing applied in urban, highway and combined transient cycles with Diesel engine in comparison to the most efficient electric vehicles. The vehicle equipped with Diesel engine is tested in various working scenarios. First is used at cold and warm-up phase consisting of the first minutes up to half-hour in operation.

Figure 1 presents the important phases of testing methodology in recording data related to operation.

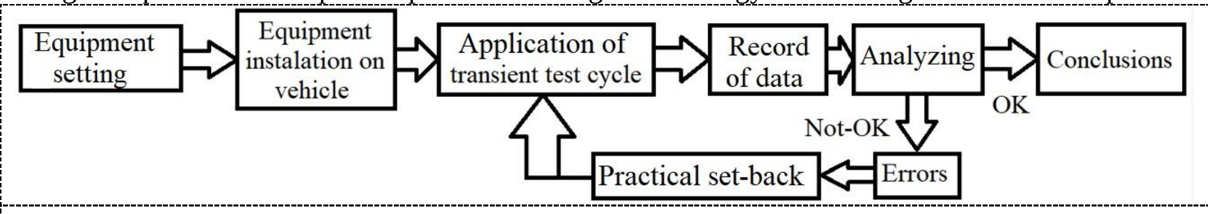

Figure 1. Methodology used as testing support in the present applied research for Diesel car testing

The research method uses a Diesel vehicle with technical specification presented in table 1.

Table 1. Technical specifications of Diesel vehicle under testing

Parameter	Value
Propulsion	Common Rail Diesel 1598 cm^3/ 4 in line cylinders
Fuel system	High pressure injection
Gear box	5+1-gear ratio
Powertrain	Transversal Front drive, 4x2/VW Golf 6

In figures 2 to 7 are presented the recorded values for average vehicle speed, average fuel consumption (expressed both in kWh/100km and l/100km), oil temperature, environment temperature and distance travelled in each test.

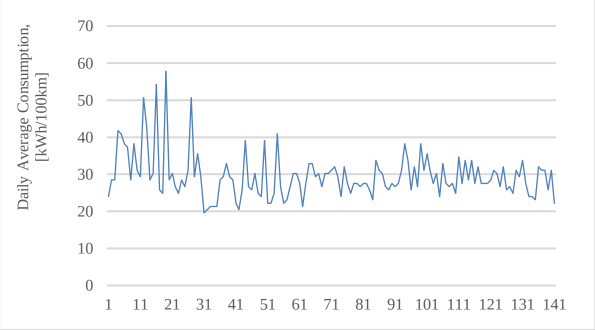

Figure 2. Power consumption during the tests.

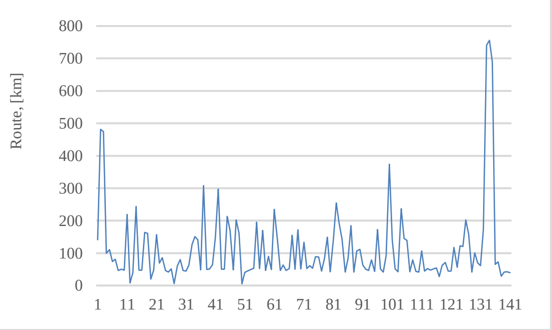

Figure 3. Route in km as testing distance.

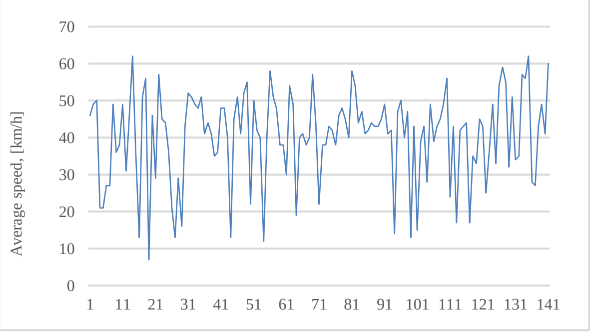

Figure 4. Average speed during vehicle testing.

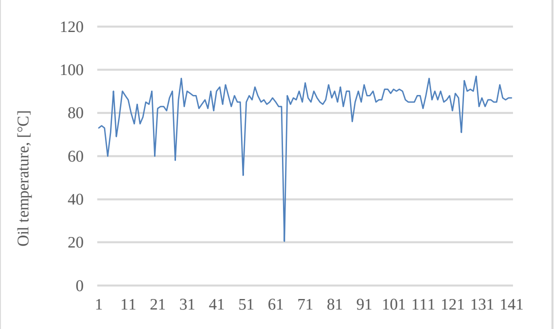

Figure 5. Oil temperature during the tests.

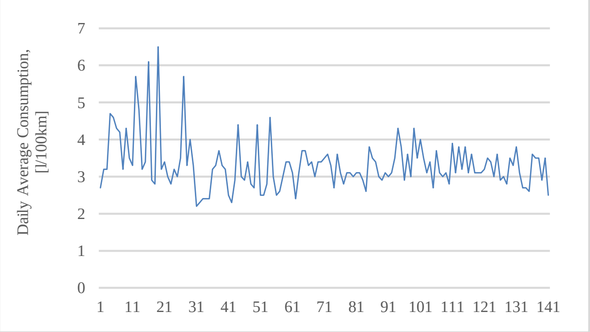

Figure 6. Average fuel consumption during tests.

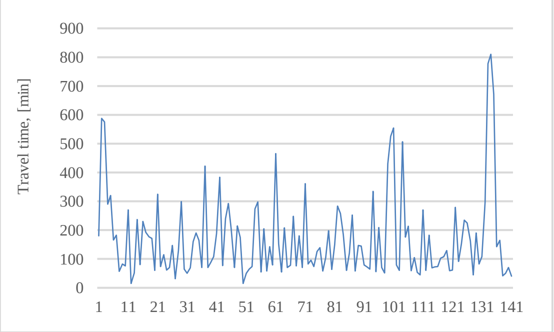

Figure 7. Recorded travelled time during tests.

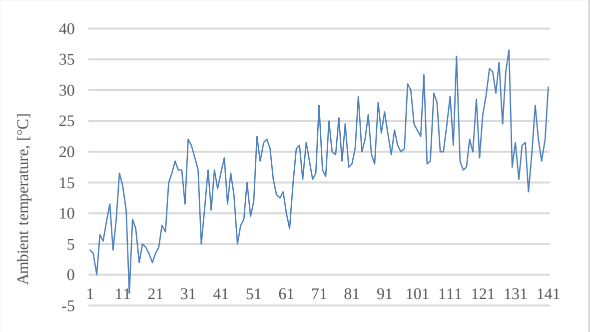

Figure 8. Recorded environment temperature.

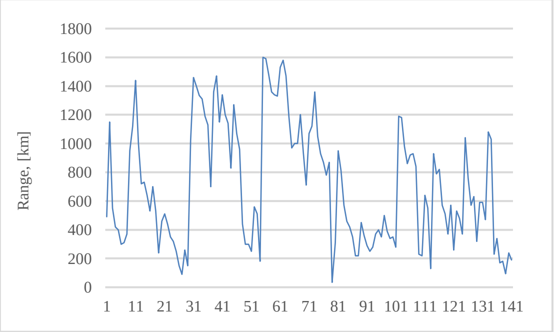

Figure 9. Estimated range as autonomy.

The test number 31 shows that the fuel consumption in combined traffic is 2.2 l/100km of Diesel fuel, a value which is quite remarkable because is situated under the 19.6 kWh/100 km. The mentioned test took place from city of Cluj-Napoca to the city of Gherla, travelling 44 km with average speed of 52 km/h. The Ambiental temperature was 22°C, lubricant and coolant temperature was 90°C. The time needed for the route was 51 minutes. The parameters were recorded using digital equipment and EDC system, which stands for Electronic Diesel Control. The EV for comparison were looked up at *Electric car EPA fuel economy* on Wikipedia. (EV=electric vehicle; EPA=environmental protection agency)

Figure 10 presents the level of energy consumption of a Diesel vehicle compared with 8 electric cars.

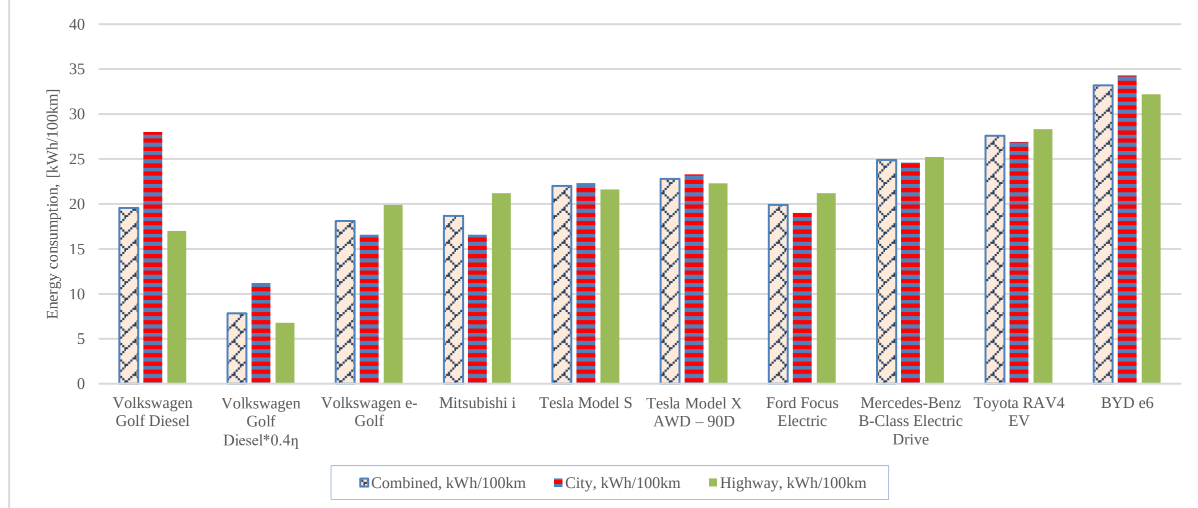

Figure 10. Energy efficiency of tested car in comparison with other vehicles powered by electricity.

Efficiency calculation is made by taking into consideration the energy input and output with the following equation:

$$\eta = E_{out} / E_{in} \times 100, [\%] \quad (1)$$

where η is the engine efficiency, in [%]; E_{ou} – energy output, [kWh] or [MJh]; E_{in} – energy input, in [kWh] or [MJh].

3. Observations and conclusions

Looking up to our Petrom energy supplier the cetane number of delivered standard Diesel fuel is 51, according to EN ISO 5165 proofing method. Density of diesel fuel at 15 °C is 820 kg/m^3 (820 g/litre), having a calorific value of 36.9 MJ/litre. Since the Diesel engine consumed 2.3 litres of fuel, in two hours, to propel the vehicle 100 km, we then have 84.87 MJ generated from burning the total amount of fuel supplied to the injectors. As it is already known 1MJ is equal to 0.2777777778 kW*h thus the engine has produced 23.58 kWh during the distance travelled of 100 km, but only 40% (which means 9,43 kWh) were used for useful energy output to travel the given route and the 60% (14.145 kWh) were converted into heat.

Argument 1: innovation results should be used wisely with conventional existing things because the former might not be exceedingly better than the later ones, as the newest technology in electric vehicles is not evidently outstanding or surpassing the properly operated Diesel engine in road vehicle operation.

Argument 2: the electric vehicles might be quite useful for the long hours of traffic jams in which the gas emissions might be harmful if the internal combustion engine is kept running, but not even in this scenario the electric battery vehicle is not sure to last a long time with the AC and lights turned on.

Conclusion 1: Using responsibly the Diesel engine operated vehicle is proved as reliable solution.

Conclusion 2: Energy efficiency might be improved with technical innovations and digital control.

Conclusion 3: Artificial intelligence can be used as automated driving pilot to improve fuel economy.

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