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Comparative study on the fuel consumption of road vehicles equipped with thermal engines

Gheorghe NEAMȚU[1]
[1] "Lucian Blaga" University of Sibiu, 10 Victoriei Street, Sibiu, Romania

E-mail: geluneamtu@yahoo.com

Abstract. The scientific paper presents a concrete research carried out by the author in order to implement some concepts, in wich technical aspects (theoretical and practical) are presented regarding the specific normed fuel consumption of thermal engines with spark ignition and compression ignition from road vehicles. In this way, those interested can learn about the amount of gasoline or diesel fuel determed on the basis of the second order active type experiment, wich is consumed by vehicle per 100 km traveled in real terms, taken in comparison with an average consumption of fuel approved by the manufacturer of each car using the WLTP method. In parallel with this research, experiments were carried out on cars and on the average fuel consumption under the conditions of the requirements of the World Health Organization to reduce the speed of traffic of road vehicles in the urban environment from 50 km/h to 30 km/h with the purpose of reducing the number of traffic accidents and the noise emitted by road vehicles. For the research, a sample of cars from the national car park was used as measurable entity, wich includes all the vehicles belonging to the owners (individuals) and legal entities (road transport organizations), at the national level. Finally, the conclusions in the adressed field are presented.
Keywords: *spark ignition engine, compression ignition engine, motor vehicle, fuel consumption. Active type experiment, traffic speed.*

1. Introduction

By definition, fuel consumption [1], [2] calculated in liters, represents the maximum allowed amount of gasoline, diesel, liquefied petroleum gas (LPG) or biofuel wich can be consumed by a vehicle propelled by a thermal engine over well established distance (usually 1,000 m), on a specific travel route, in wich specific operating conditions, road category and environmental conditions are taken into account. The fuel consumption of a motor vehicle is conditioned by the technical characteristics, equipment and and the environment in wich it is used. It can change depending: the actual state of operation, the number and weight of passengers or goods transported, the driving style of the car, the ambient temperature, the type or size of the tires, the aerodynamic coefficient of the vehicle (C_x) [3], [4, pp. 235-239], [5, p. 130], the category or state of the road on wich it is driven, the category or state of road traffic, the comfort and state of fatigue of the driver, etc. The requirements for the type approval of road vehicles have gradually become more restrictive, through the incorporation and subsequent revision of the Euro pollution norms.

The aspects pursued in this research consist in the investigation of fuel consumption in cars with spark ignition and compression ignition engines:

- in the context of World Health Organization to reduce the speed of traffic in the urban environment from 50 km/h to 30 km/h [6], [7], [8];

➢ practically obtained in the urban and extraurban environment, by comparison with the consumption approved by the manufacturer using the Worldwide Harmonized Light-Duty Vehicles Test Procedure (WLTP) method [9].

Experimental data [10, p. 254] on the average fuel consumption were obtained using the second order active type experiment and are compared with the experimental results on the standard fuel consumption, obtained by the manufacturer of each passenger car using the WLTP method. According to the Experimental Research Plan [10, p. 254], [11, p. 1], [12] in the framework of the second order active type experiment, research was carried out on the fuel consumption of a hybrid car engine, with 6 passenger cars with gasoline thermal engines and 3 passenger cars with diesel thermal engines. The experimental research was carried out for each type of vehicle, by traveling predetermined routes, in the city with a relatively constant speed of 30 km/h, respectively 50 km/h, and on the higway with a constant speed of 130 km/h. They were carried out at different time intervals, respecting the same external temperature and traffic conditions. The physical wear of each vehicle used for experimentation is defined by the number of kilometers traveled, and the moral wear and tear is defined by the age in years. The exception was the Ford Focus ZX 4 USA car, wich has traveled 81,525 km, although it has appreciable moral wear. For this car, the average of the actual kilometers traveled per year of age is 5,435 km. The average actual kilometers traveled, reported for each year of age for the other cars with spark ignition engines used in the experiments are as follows: Toyota RAV 4 – 2.5 hibrid car, Euro 6 – 8,566 km; Volkswagen Jetta 1.4 car, Euro 4 – 9,327 km; Dacia Solenza 1.4 MPI car, Euro 3 – 9,509 km; Dacia Logan 1.4 MPI car – 10,264 km; Volkswagen Jetta 1.4 TSI car, Euro 6 – 11,317 km; Volkswagen Golf 1.6 Liters car, Euro 4 – 14,909 km. The average of the actual kilometers traveled per year of age for the compression ignition engine cars used in the experiments is as follows: Renault Symbol 1.5 dCI car, Euro 3 – 13,817 km; Volkswagen Jetta 2.0 TDI car, Euro 4 – 15,926 km; Renault Captur 1.5 dCI car, Euro 5 – 17,480 km. The previous aspects are specified because the physical wear and tear of a motor vehicle can result in a high lecel of standard fuel consumption (a motor vehicle whose engine mechanism or fuel system is in an advanced condition of physical wear usually produces an increased level of fuel and chemical noxes).

2. Theoretical considerations

Driving cycle *Worldwide Harmonized Light-Duty Vehicles Test Procedure* (WLTP) is a test method newly introduced by the EU to bring fuel consumption for light vehicles (cars, minibuses, vans) with spark ignition engines and compression ignition engines to the same level for all manufacturers worldwide. It replaced previous determination method, *New European Driving Cycle* (NEDC) to September 01. 2017, with the role of providing real information on the fuel consumption of cars, using much more characteristics features that reproduce fuel consumption values identical to those of the use of vehicles in daily use [9], [13].

The testing cosist of longer test distances and durations, less stopping and stationary time, higer average travel speeds and the use of on board facilities and equipment during trials. The changes made during the tests demonstrated a higer actual fuel consumption. The simulations carried out when driving in the city and in the extra urban are no longer mixed. The vehicle is tested in 4 phases (figure 1), at different speed ranges [9], [13]. According to the data shown in figures 1 and 2, to include the different configurations of the previous cycle (NEDC), the theoretical conditions required by the new cycle (WLTP) are changed to more dynamic actions during driving, based an statistical data evaluated by average configurations of users so that accelerations are stronger and average speed and maximum sped are higer. The main objective of the standard is to provide a compliant means for all determinations of polluant emissions and fuel or energy consumption for several types of engines (gasoline, diesel and LPG). The tests should result in the same values for all car manufacurers in the world.

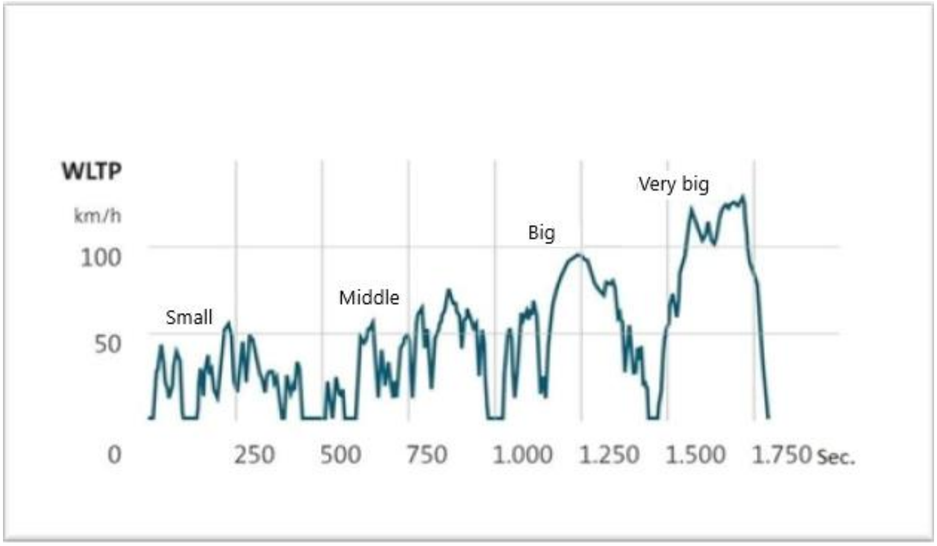

Figure 1. The framework conditions underlyng the measurements carried out by the WLTP method, for the actual fuel consumption and CO_2 emissions of cars [13].

The technical aspects and conditions imposed by the method of approval of the average fuel consumption and polluant emissions for motor vehicles on the route, by the RDE-WLTP method, are as fallows [9], [13]:

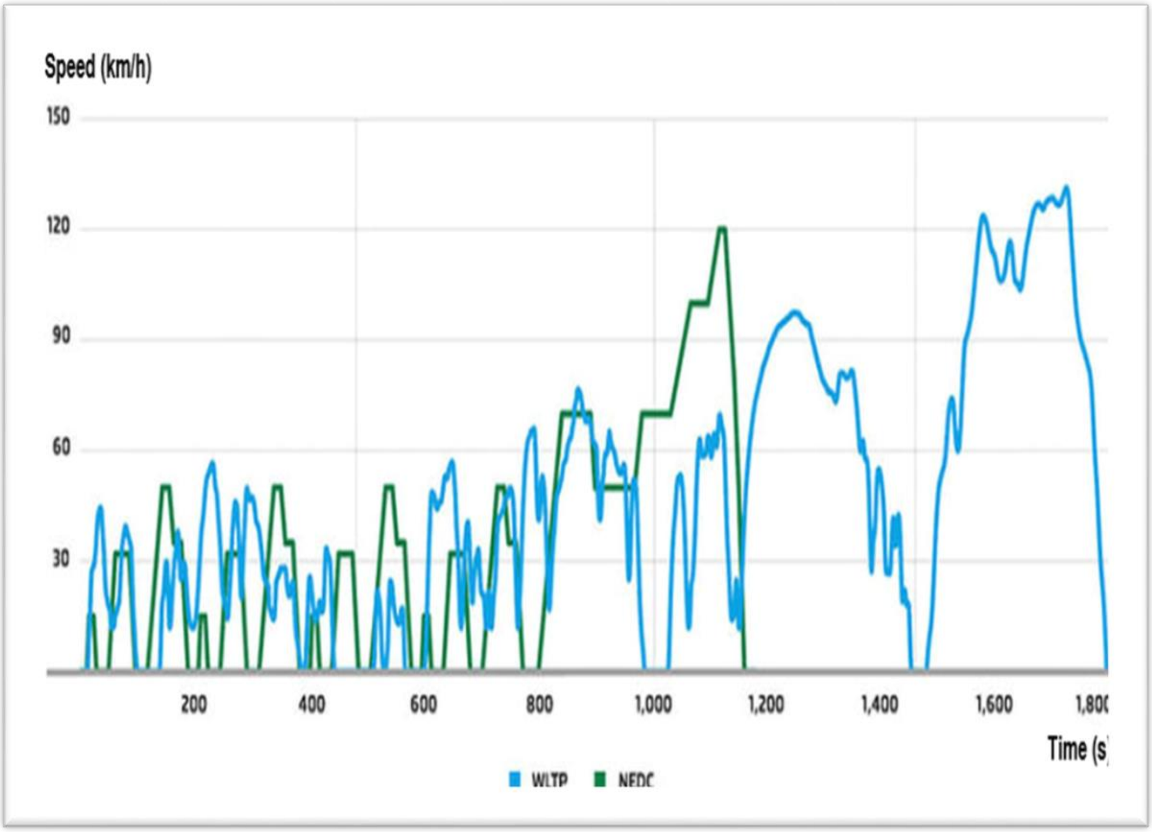

Figure 2. The framework conditions underlyng the measurements carried out by the WLTP and NEDC method, for the fuel consumption and CO_2 emissions of cars [9].

- the test is performed on a mix of routes composed of 1/3 in the urban environment and 2/3 on category 1-6 roads;
- random, constant accelerations and decelerations, in compliance with road traffic rules;
- the average speed in the urban environments is between 15-40 km/h, maximum 60 km/h;
- average speed on heavy, unpaved roads 60-90 km/h, and on the highway 145-160 km/h;
- the vehicles is equipped with a portable chemical emissions measurement system (PEMS), wich measures the amount of nitrogen oxide and carbon monoxide released into the atmosphere;
- test times: 90 -120 minutes;
- external temperature: between -7 and +35°C;
- the auxiliary equipment that must be switched on during the tests are taken into account.

The WLTP homologation methodology proves its efficiency and effectiveness, giving rise to more accurate and transparent values for comparing fuel consumption and CO_2 emissions for all car models. The actual fuel consumption and CO_2 emissions of cars are directly influenced by how they are driven [14, pp. 56-77]. In order to fit in the fuel consumption and implicitly for reduced emissions of noxes, certain car models with engines have to be improved.

2. Organizations measures

The use and implementation of the fuel consumption homologation procedure for vehicles wits spark ignition engines and compression ignition engines subject to experimental research requires separate management, defined by a specific procedure. The stages of the process (procedure) for determining the fuel consumption of motor vehicles obtained trhrough experimental research are briefly presented, as follows:

- mount the measuring device on the vehicle, according to the instructions for use, and put it into operation. A gratuated liter meter can be used if determinations are not made by filling the tank full. In this situation, the vehicles supply of fuel from its own tank is suspended;
- if the determinations are made by the method of measuring the amount of fuel consumed from the tanks, they are fed at full capacity;
- the car starts, accelarating and changing gear box, until the specified (30 km/h, 50 km/h, 130 km/h), wich as constant possible, in relation to the traffic values or by the conditions required by the road infrastructure along the entire route (the established travel itinerary);
- during the performance of experimental fuel consumption research, defensive driving rules will be followed as much as possible;
- the determinations in the urban environment will be made, as rule, on the same route for the two speeds (30 km/h, respectively 50 km/h);
- after completing the experimental routes, stop the vehicle and teh engine, read the amount of fuel consumed on the liter meter scale or fill the tank to the brim and calculate the fuel consumption, according relation (1).

The calculation formula through wich we determined the fuel consumption, is as follows:

$$Cmf = \frac{Cf}{d} \cdot 100 \qquad \text{[liters/100 km]} \qquad (1)$$

where,

C_{mf} represents the average fuel consumption;

C_f – the amount of fuel supplied (in litres), completed after traveling the route to fill the tank to full;

d – the distance in kilometers of the route traveled (read from the dashboard of the vehicle).

During the experimental research, the following conditions were observed:

- the test was carried out on routes composed of streets of all categories within the city of Sibiu and on the A1-Sibiu highway, over distances between 5-30 km;
- the accelerations and decelerations where not programmed, but were those required by the observance of road traffic rules, the principles of preventive traffic and ecological driving of vehicles;

- traffic speed on urban streets: 30 km/h, respectively 50 km/h, and on the highway 130 km/h (observing road traffic rules);
- the test time was between 15-45 minutes;
- the external temperature of the environment was between +20 and +25 °C;
- all auxiliary equipment that was started on during the tests (air conditioning, headlights, projector headlights, navigation system and the radio system);
- the experimental route, both urban and extraurban, was the same for all vehicles.

After processing the data on the standard fuel consumption, the results were analyzed and interpreted, and the research concusions were established based on them.

3. Results, discussions and specific conclusions

Experimental research was carried out on fuel consumption on cars with gasoline engines, with cylinder capacities in the [1,400-2,000] cm^3 range, with European pollution standards in the [Euro 3 - Euro 6] range, but also on motor vehicles with diesel engines, have cylinder capacities in the [1,500-2,000] cm^3 range, with pollution standards in the [Euro 3 - Euro 5] range. The experimental research was carried out for each type of vehicle, by traveling predetermined routes, in the city with a relatively constant speed of 30 km/h, respectively 50 km/h, and on the highway with a constant speed of 130 km/h. They were carried out at different time intervals, respecting the same external temperature and traffic conditions. In order to see if there are differences in fuel consumption, research was also done on a hybrid car, having the cylinder capacity of the thermal engine of 2,500 cm^3 and the European pollution standard Euro 6. Table 1 shows the urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption, experimentaly determined for cars with spark ignition engine.

Table 1. Urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption, experimentaly determined for cars with spark ignition engine.

The type and brand of the vehicle	European pollution standard	Urban consumption [l/100 km] at v = 30 km/h	Urban consuption [l/100 km] at v = 50 km/h	Extraurban consumption [l/100 km] at v = 130 km/h
TOYOTA RAV 4 2.5 hybrid car	Euro 6	4.2	6.2	8.3
VOLKSWAGEN JETTA 1.4 TSI car	Euro 6	5.6	7.9	4.8
VOLKSWAGEN JETTA 1.4 TSI car	Euro 5	7.1	8.7	6.8
DACIA LOGAN 1.4 MPI car	Euro 4	6.7	7.5	9.6
VOLKSWAGEN GOLF 1.6 car	Euro 4	8.7	9.9	5.6
FORD FOCUS ZX 4 SUA 2.0 car	Euro 3	6.5	9.4	6.3
DACIA SOLENZA 1.4 MPI car	Euro 3	7.2	8.3	5.6

Figure 3 shows the urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption, experimentaly determined for cars with spark ignition engine.

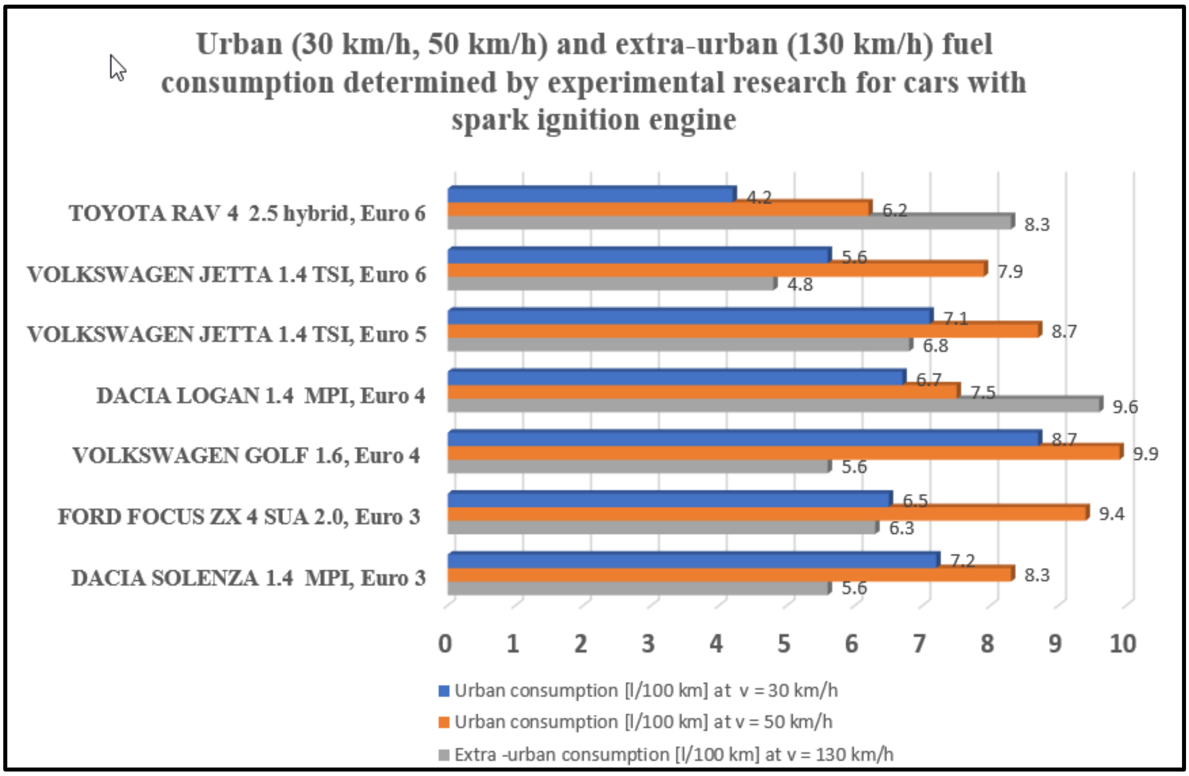

Figure 3. Experimentally determined urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption for cars with spark ignition engine.

Table 2 shows the **u**rban and extraurban fuel consumption approved by the manufacturer using the WLTP method for cars with spark ignition engine**.**

Table 2. Urban and extraurban fuel consumption approved by the manufacturer using the WLTP method for cars with spark ignition engine.

The type and brand of the vehicle	European pollution standard	Urban consumption [l/100 km]	Extraurban consumption [l/100 km]
TOYOTA RAV 4 2.5 hibrid car	Euro 6	4.4	4.7
VOLKSWAGEN JETTA 1.4 TSI car	Euro 6	6.9	4.5
VOLKSWAGEN JETTA 1.4 TSI car	Euro 5	9.7	6.0
DACIA LOGAN 1.4 MPI car	Euro 4	6.9	9.6
VOLKSWAGEN GOLF 1.6 car	Euro 4	9.9	5.6
FORD FOCUS ZX 4 SUA 2.0 car	Euro 3	10.7	7.6
DACIA SOLENZA 1.4 MPI car	Euro 3	8.3	5.6

Figure 4 shows urban and extra-urban fuel consumption approved by the manufacturer using the WLTP method for cars with spark ignition engines.

Table 3 shows the urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption, experimentaly determined for cars with compression ignition engine.

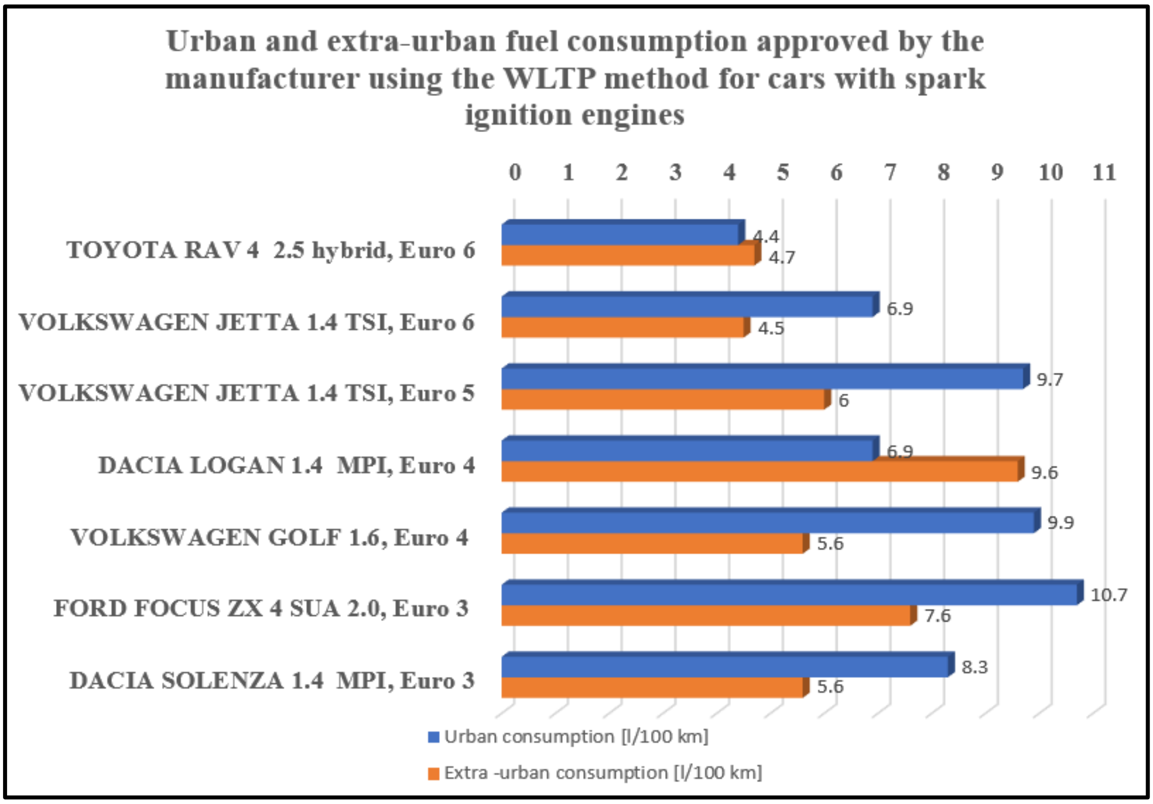

Figure 4. Urban and extra-urban fuel consumption approved by the manufacturer using the WLTP method for cars with spark ignition engines.

Table 1. Urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption, experimentaly determined for cars with compression ignition engine.

The type and brand of the vehicle	**European pollution standard**	**Urban consumption [l/100 km] at v = 30 km/h**	**Urban consuption [l/100 km] at v = 50 km/h**	**Extraurban consumption [l/100 km] at v = 130 km/h**
RENAULT CAPTUR 1.5 dCI car	Euro 5	7.4	13.6	4.9
VOLKSWAGEN JETTA 2.0 TDI car	Euro 4	9.0	15.8	4.7
RENAULT SYMBOL 1.5 dCI car	Euro 3	8.1	14.2	3.5

Figure 5 shows the urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption, experimentaly determined for cars with compression ignition engine.

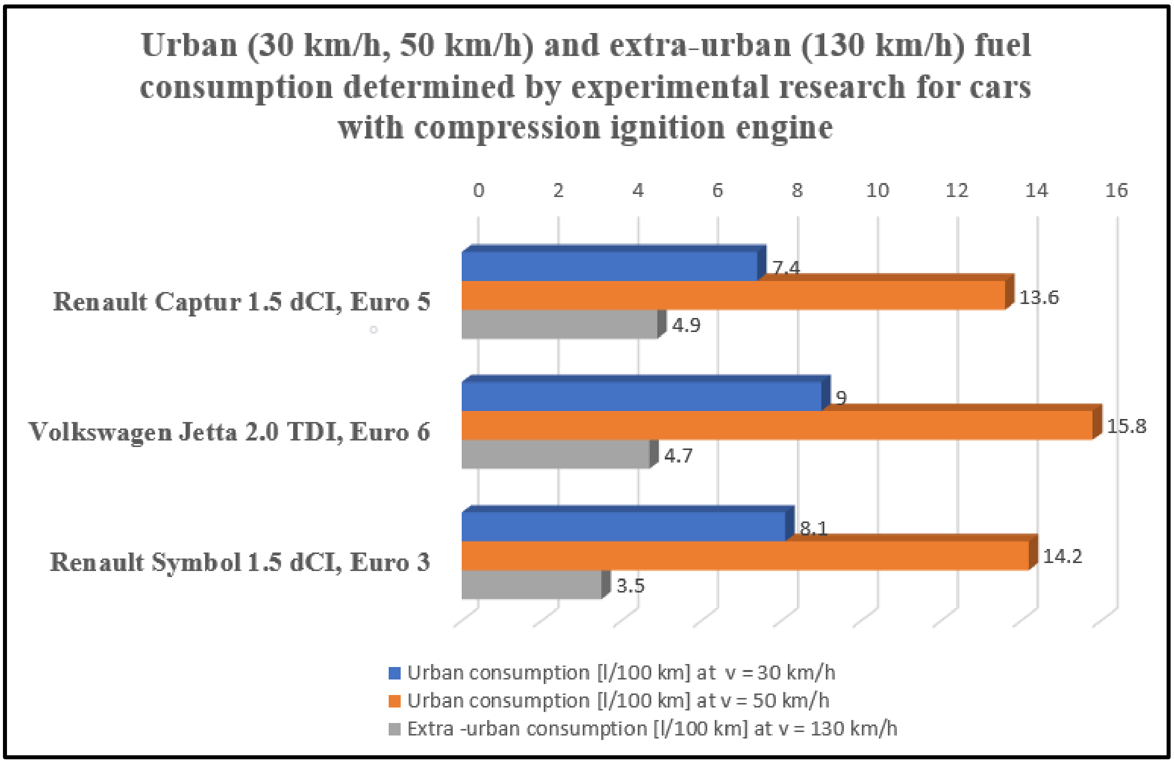

Figure 5. Experimentally determined urban (30 km/h, 50 km/h) and extraurban (130 km/h) fuel consumption for cars with compression ignition engine.

Table 4 shows the urban and extraurban fuel consumption approved by the manufacturer using the WLTP method for cars with compression ignition engine.

Table 4. Urban and extraurban fuel consumption approved by the manufacturer using the WLTP method for cars with compression ignition engine.

The type and brand of the vehicle	**European pollution standard**	**Urban consumption [l/100 km]**	**Extraurban consumption [l/100 km]**
RENAULT CAPTUR 1.5 dCI car	Euro 5	4.7	4.9
VOLKSWAGEN JETTA 2.0 TDI car	Euro 4	6.9	4.7
RENAULT SYMBOL 1.5 dCI car	Euro 3	5.3	3.5

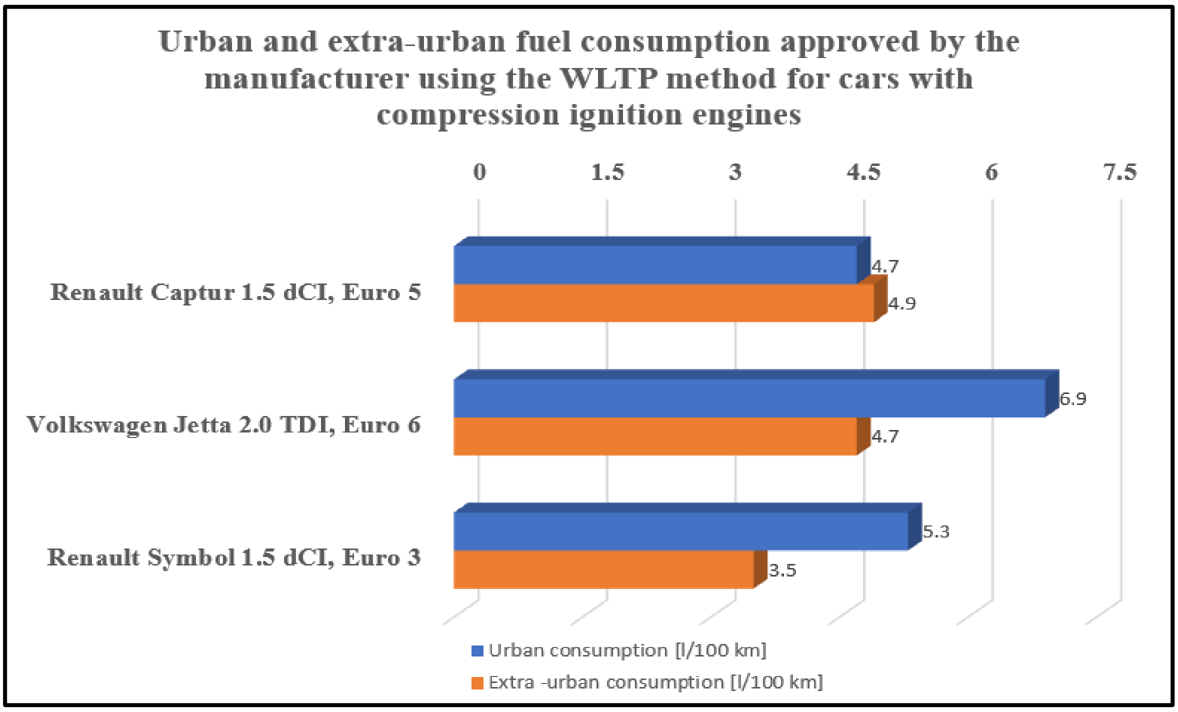

Figure 6. Urban and extra-urban fuel consumption approved manufacturer using the WLTP method for cars with compression ignition engines.

Figure 6 shows the **u**rban and extraurban fuel consumption approved by the manufacturer using the WLTP method for cars with spark ignition engine**.**

For each car studied, the following experimental data resulted (table 1, graph 3) for cars with spark ignition engines and (table 3, graph 5) for cars with compression ignition engines, the results, discussion and specific conclusions being as fallows:

a) For the Toyota RAV 4 - 2.5 hibrid, Euro 6 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 4.2 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 6.2 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was de 8.3 l/100 km.

The trend of the evolution of the fuel consumption of the Toyota RAV 4 car, 2.5 hybrid, Euro 6, during the two urban routes and on the higway, was an increasing one. Fuel consumption increases with increasing speed. In the urban environment, by reducing the traffic speed from 50 km/h to 30 km/h, fuel consumption drops from 6.2 liters/100 km to 4.2 liters/100 km, the percentage of decrease beign 32.25%. The car manufacturer approved the fallowing fuel consumption using the WLTP method: urban consumption - 4.4 liters/100 km; extra urban consumption – 4.7 liters/100 km (table 2 and graph 4). Experimentally, in the erban environment (50 km/h) and in the extra urban environment, real fuel consumptions higher than those approved by the manufacturer where obtained. The increase compared to the consumption approved by the manufacturer is 24.19% in urban at a speed of 50 km/h and 45.78% in the extraurban environment.

b) For the Volkswagen Jetta 1.4 TSI, Euro 6 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 5.6 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 7.9 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was de 4.8 l/100 km.

The trend of the evolution of the fuel consumption of the Volkswagen Jetta 1.4 TSI, Euro 6 car during the two urban routes was an increasing one. Fuel consumption increases with increasing speed. When driving the route an the highway, the fuel consumption decreased. In the urban environment, by reducing the traffic speed from 50 km/h to 30 km/h, fel consumption drops from 7.9 liters/100 km to 5.6 liters/100 km, the percentage decrease being 29.11%. The manufacturer approved the folowing fuel consumption – 6.9 liters/100 km; extraurban consumption – 4.5 liters/100 km (table 2 and graph 4). Experimentally, in the urban environment at 50 km/h and the extraurban environment, real fuel consumptions higher than those approved by the manufacturer were obtained. The increase compared to the consumption approved by the manufacturer is 12.6% at speed of 50 km/h and 6.25% in the extraurban environment.

c) For the Volkswagen Jetta 1.4 TSI, Euro 5 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 7.1 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 8.7 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 6.8 l/100 km.

The trend of the evolution of the fuel consumption of the Volkswagen Jetta 1.4 TSI, Euro 5 car during the two urban experimental routes was an increasing one. Fuel consumption increase with increasing speed. On the highway route, fuel consumption dropped to 6.8 liters/100 km. In the urban environment by reducing the traffic speed from 50 km/h to 30 km/h, fuel consumption decreased from 8.7 liters/100 km, the percentage of decrease under these conditions beign of 11.49%. The car manufacturer approved the folowing fuel consumption using the WLTP method: urban consumption – 9.7 liters/100 km; extraurban consumption – 6.0 liters/100 km (table 2 and graph 4). Experimentally, in the urban environment at 50 km/h, real fuel consumptions was obtained 10.3% lower than the one aprproved by the manufacturer, and in extraurban environment a consumption 11.76% higher than the approved one.

d) For the Dacia Logan 1.4 MPI, Euro 4 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 6.7 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 7.5 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 9.6 l/100 km.

The trend of the evolution of the fuel consumption of the Dacia Logan 1.4 MPI, Euro 4 car, when driving the two urban routes and on the highway, was an increasing one. Fuel consumption increases with increasing speed. In the urban environment by reducing the traffic speed from 50 km/h to 30 km/h, fuel consumption drops from 7.5 liters/100 km to 6.7 liters/100 km, the percentage of decrease under these conditions beign of 10.66%. The car manufacturer approved the following fuel consumption using the WLTP method: urban consumption – 6.9 liters/100 km; extraurban consumption - 9.6 liters/100 km (table 2 and graph 4). Following the experimental research, in the urban environment at speed of 50 km/h, a real fuel consumption was obtained 8% higer than the one approved by the manufacturer, and in the extraurban one equal to the approved one.

e) For the Volkswagen Golf 1.6, Euro 4 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 8.7 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 9.9 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 5.6 l/100 km.

The trend of the evolution of the Volkswagen Golf 1.6, Euro 4 car, in the framework of the experimental research when traveling the two urban routes, is an increasing one. Fuel consumption increases with increasing speed. In the extraurban environment, when traveling on the higway, fuel consumption dropped to 5.6 liters/100 km. In the urban environment, by reducing the traffic speed from 50 km/h to 30 km/h, the fuel consumption drops from 9.9 liters/100 km to 8.7 liters/100 km, the percentage decrease under these conditions beign 12.12%. The car manufacturer approved the following fuel consumption using the WLTP method: urban consumption – 9.9 liters/100 km; extraurban consumption – 5.6 liters/100 km (table 2 and graph 4). As a result of the experimental research, both in the urban and in the extraurban environment, fuel consumptions identical to those approved by the manufacturer were obtained.

f) For the Ford Focus ZX4 USA, Euro 3 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 6.5 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 9.4 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 6.3 l/100 km.

The trend of the evolution of the consumption of the Ford Focus ZX4 USA, Euro 3 car during the two urban routes was an increasing one. Fuel consumption increased with increasing speed. When driving the route on the highway, fuel consumption decreased. In the urban environment, by reducing the traffic speed from 50 km/h to 30 km/h, fuel consumption drops from 9.4 liters/100 km to 6.5 liters/100 km, the percentage of decrease under these conditions being of 30.85%. The car manufacturer approved the following using the WLTP method: urban consumption – 10.7 liters/100 km; extraurban consumption – 7.6 liters/ 100 km (table 2 and graph 4). Following experimental research in the urban environment (50 km/h) and the extraurban environment (130 km/h), real fuel consumption lower than those approved by the manufacturer were obtained. The decrease compared to the consumption approved by the manufacturer is 12.14% at a speed of 50 km/h and 17.1% at a speed of 130 km/h.

g) For the Dacia Solenza 1.4 MPI, Euro 3 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 7.2 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 8.3 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 5.6 l/100 km.

The trend of the evolution of the fuel consumption of the Dacia Solenza 1.4 MPI, Euro 3 car during the two urban experimental routes was an increasing one. Fuel consumption increases with increasing speed. In the extraurban environment, when traveling on the highway, fuel consumption dropped to 5.6 liters/100 km. In the urban environment, by reducing the traffic speed from 50 km/h to 30 km/h, fuel consumption drops from 8.3 liters/100 km to 7.2 liters/100 km, the percentage of decrease under these conditions being of 13.25%. The car manufacturer approved the following fuel consumption using the WLTP method: urban consumption – 8.3 liters/100 km; extraurban consumption – 5.6 liters/100 km (table 2 and graph 4). As a results of the experimental research, both in the urban environment and in the extraurban environment, fuel consumptions identical to those approved by the manufacturer were obtained.

h) For the Renault Captur 1.5 dCI car, Euro 5

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 7.4 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 13.6 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 4.9 l/100 km.

The trend of the evolution fuel consumption of the Renault Captur 1.5 dCI, Euro 5 car during the two urban routes was an increasing one. Fuel consumption increase with increasing speed. In the extraurban environment, when driving on the highway, fuel consumption dropped to 4.9 liters/100 km. In the urban environment, by reducing the traffic speed from 50 km/h to 30 km/h, fuel consumption drops from 13.6 liters/100 km to 7.4 liters/ 100 km, the percentage of decrease under these conditions being of 45.58%. The car manufacturer approved the following fuel consumption using the WLTP method: urban consumption – 4.7 liters/100 km; extraurban consumption – 4.9 liters/100 km (table 4 and graph 6). Following the experimental research, in the urban environment (50 km/h) a higher real fuel consumption was obtained than the one approved by the manufacturer. The increase fuel consumption in the urban environment compared to that approved by the manufacturer is 24.19%. In the extraurban environment, a fuel consumption identical to that approved by the manufacture was obtained.

i) For the Volkswagen Jetta 2.0 TDI, Euro 4 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 9.0 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 15.8 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 4.7 l/100 km.

The trend of the evolution of the fuel consumptionof the Volkswagen Jetta 2.0 TDI, Euro 4 car during the two urban routes is an increasing one. Fuel consumption increases with increasing speed. In the extraurban environment, when traveling on the highway, fuel consumption dropped to 4.7 liters/100 km. In the urban environment, by reducing the traffic speed from 50 km/h to 30 km/h, fuel consumption drops from 15.8 liters/100 kmto 9.0 liters/100 km, the percentage of decrease under these conditions being of 43.03%. The car manufacturer approved the following fuel consumption using the

WLTP method: urban consumption – 6.9 liters/100 km; extraurban consumption – 4.7 liters/100 km (table 4 and graph 6). Following the experimental research, in the urban environment (50 km/h) a higher real fuel consumption was obtained than the one approved by the manufacturer. The increase in fuel consumption in the urban environment compared to the consumption approved by the manufacturer is 56.32%. In the extraurban environment, a fuel consumption identical to that approved by the manufacturer was obtained.

j) For the Renault Symbol 1.5 dCI, Euro 3 car

- when traveling the urban route with speed of 30 km/h, the fuel consumption was 8.1 l/100 km;
- when traveling the urban route with speed of 50 km/h, the fuel consumption was 14.2 l/100 km;
- when traveling the route on the A1 – Sibiu highway, the fuel consumption was 3.5 l/100 km.

The trend of the fuel consumption evolution of the Renault Symbol 1.5 dCI, Euro 3 car during the two urban routes is an increasing one. Fuel consumption increases with increasing speed. In the extraurban environment, when traveling on the highway, fuel consumption dropped to 3.5 liters/100 km. In the urban environment, by reducing traffic speed from 50 km/h to 30 km/h. Fuel consumption drops from 14.2 liters/100 km to 8.1 liters/100 km, the percentage of decrease under these conditions being of 42.95%. The car manufacturer approved the following fuel consumption using the WLTP method: urban consumption – 5.3 liters/100 km; extraurban consumption – 3.5 liters/100 km (table 4 and graph 6). Following the experimental research, in the urban environment (50 km/h) a higher real fuel consumption was obtained than the one approved by the manufacturer. The increase in fuel consumption in the urban environment compared to the consumption approved by the manufacturer is 62.67%. In the extraurban environment, a fuel consumption identical to that approved by the manufacturer was aobtained.

4. Final conclusions

By reducing the speed of motor vehicles in the urban environment from 50 km/h to 30 km/h, fuel consumptions has actually decreased in the case all analyzed cars (for spark ignition and compression ignition engines).

Trough experimental research on the fuel consumption of cars, differences between the consumption approved by the manufacturer and the actual consumption are demonstrated.

In my opinion that higer fuel consumption obtained through experimental research (other than that approved by the manufacturer) is due to the phisical wear and tear of the organs, elements and fueling instalation of car engines (most cars have a large number of actual kilometers traveled) but the gap it can also be justified by the policies of the car manufacturing companies wich, upon homologation, establish economic consumption with the aim of favoring sales (the advantage being for the purpose and on side of marketing). Figure 7 shows the 6 age segments of cars in the car park in Romania and the variations from 2022 compared to 2021.

If we refer to the wear and tear of the engines of road vehicles wich creates high fuel consumption, wich in turn generates chemical noxes (CO, CO_2, HC and NO_X) in proportion, taking into acount the composition of the national motor vehicle fleet wich is predominantly constitued by motor vehicles purchased by the population second-hand so that, on December 31, 2022, Romania owned over 10 million vehicles (10,005,408 units), and 1/3 road vehicles (2.43 million they are more than 20 years old) [15], traveling on the country's roads in an uncertain technical condition, consuming fuel beyond the norm and chemically polluting the environment affecting the habitats and life of living beings.

All these nonconformities are carried out in the conditions where vehicles less than 10 years old to not reach the percentage of 20% from the total national fleet of road vehicles (1/2 of the total number of vehicles in Romanian road traffic, i.e. approximately 4 million, are betwen 10 and 20 years old) [15].

According to statistics as of May 2, 2023, Romania is among the countries with the oldest fleet of vehicles in Europe.

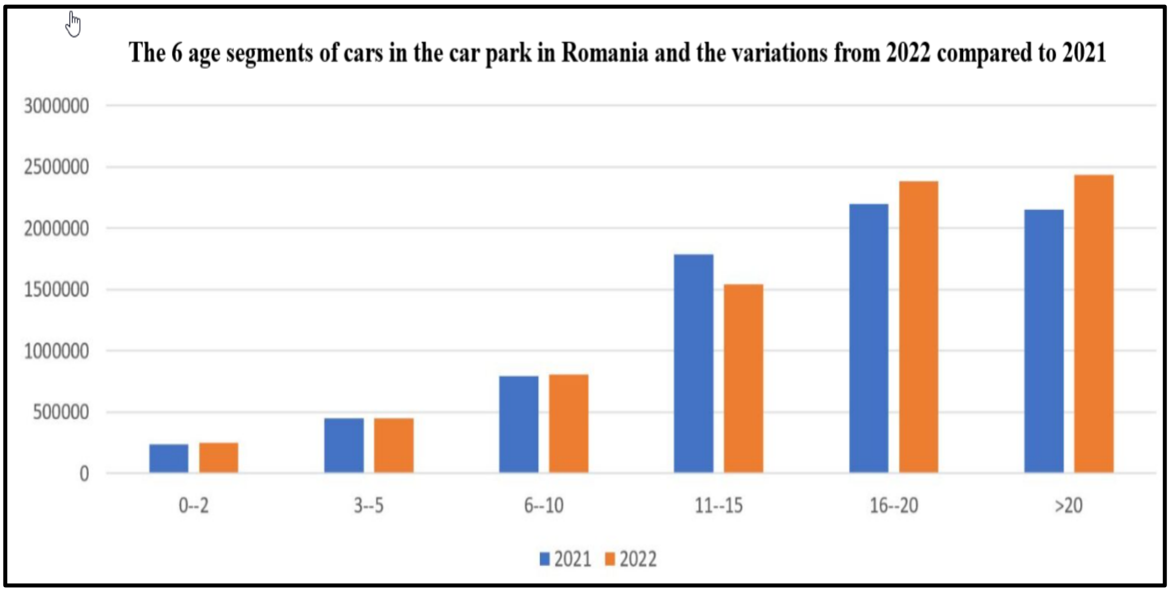

Figure 7. The 6 age segments of cars in the car park in Romania and the variations from 2022 compared to 2021 [15].

The average age of the national vehicle fleet at this time was 15.1 years [16].

For both spark ignition and compression ignition engines cars, fuel consumptions is influenced by travel speed, driving style and engine speed.

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