Analysis of the taxis' operating conditions in the city and determination of the technical parameters of the electric vehicles

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Abstract: - The work has been done to study the operation of taxi vehicles in an average European city - Ruse. Referring to the strategic tasks in the White Paper till 2050 to the use of environmentally friendly road transport, had been made an evaluation of the qualities necessary for electric vehicles to be used as an alternative to the traditional taxi vehicles.

Key-Words: -taxis, electric vehicles, operating conditions, city passenger transport, optimization, ecology

1 Introduction

The establishment of the cities as an attractive centers for work and life has led to their expansion and increasing their population. Due to the large distances between the residential areas, workplaces, public attraction centers and various opportunities to the citizens, they have to move within the city in various ways. In the smaller towns generally the residents travel on foot, by bicycle/moped or car. In the medium-sized towns is used the public transport which includes buses, trolley buses and taxis. In the large and the largest cities, due to exhausted possibilities of the other types of transport, is used ground railway transport - trams, and underground - metro transport.

Of all the types of public transport only the taxi transport allows flexibility and choice of random destination, pick up and drop off point and the client is served at the highest level. The taxi services are operated by vehicles with diesel and gasoline engines, which most often can work with LPG or CNG. According to the determined in the White Paper transport development by 2050 one of the main tasks is to limit the use of such cars in the city centre areas and replace them with alternative, [3, 11]. At this stage the alternative vehicles can work with fuel cells, electricity and LPG or CNG. From these alternatives, at this stage, most suitable is the use of electric vehicles.

2 Operation of taxis in the conditions of an average city - Ruse, Bulgaria

2.1 Characterization of Ruse

Ruse is one of the biggest cities in Bulgaria. According to the last census in 2011 it takes the fifth place. With about 146 000 residents, it falls into the group of medium-sized cities with population of 50 000 to 350 000. During the day the residents do not travel large distances because both the length and width of the city does not exceed 20 km. They use public transport - buses and trolley buses, taxis and private vehicles - bicycles, motorbikes, cars. In recent years traveling by car has come up as the most preferred way to travel. Therefore, taxi transport is still well developed in the city. In 2011 the town has 130 taxi service companies registered as sole proprietors or limited companies (LTD and LLPC). They have a fleet of 650 cars. This shows that there are 4.45 taxis average per 1,000 residents in the city.

2.2 Characteristics of the taxis

The fleet mainly consist of new cars with prices up to 30 000 euro, brands Chevrolet, Dacia, Škoda, Daewoo, and Renault with four and five-door, according to the regulations in the country, (Table 1). They mainly work in 12 hours shifts with two drivers. There are also taxis with one driver who works selective or with regular customers. The work scheme is organized this way because 70% of cars

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are owned by large companies (leasing companies) and are rented/sold by instalments to the taxi drivers. The remaining cars are owned by the taxi drivers.

Table 1

Brand	%
Dacia	21.0
Shevroilet	25.2
Skoda	16.8
Daewoo	16.8
Renault	8.8
Lada	4.2
Opel	4.2
Others	2.9

According to Bulgarian legislation, vehicles used for taxis must be aged 10 years or less from the first registration. Complying with this requirement and with its own capabilities the ongoing taxi cars in the city are 16% new and 84% second-hand purchased up to 5 years old.

The fleet of taxis consists mainly of gasoline cars with engine capacity up to 1600 cm3 and diesel with engine capacity up to 1900 cm3, (Table 2), [8]. The most preferred fuel is CNG, due to its lowest price and availability of CNG stations spread across the city. The use of LPG has decreased in the recent years because of the higher prices and lower mileage traveled by taxis in the city. Vehicles operating only with diesel or gasoline fuel has almost none except the new cars without LPG equipment purchased with a lease warranty

Table 2

Fuel	% taxi cars
Gasoline/CNG	66
Gasoline/LPG	18
Gasoline A95H	2
Diesel	14

2.3 Taxi stands/parking features

Ruse Municipality has provided special places for taxis to stop and to meet their clients without being in conflict with the other drivers involved in the city traffic. The places are considered with the attractive centers as hospitals, schools, railway and bus stations, shops and city centre. The total number of the taxi ranks and parking places is 50 with a total 219 parking spaces, [8]. Therefore 33.6% of taxis are provided with places to stay and meet customers. This means that there are 1,5 taxi parking spaces per 1000 residents.

The offered places from Ruse Municipality meet the organization of the taxi business in several European countries, where there are between 1 and 2.5 taxis per 1,000 residents..

3 Traffic researches in Ruse

Despite of the large number of taxis in the city, in the work had been done a research under realistic conditions, by a laboratory car with research equipment video VBOX (Racelogic) to record the main operating indices of the vehicle, [5,6,13]. The study took place in Ruse during the working days of the week. A random taxi had been chosen which work involves the transport of regular and occasional customers for daily work period. After the end of the study the data were transferred to a PC and processed with the program video VBOX.

The results from the study with one and two passengers are presented in Figure 1 and Figure 2.

For the whole study had been made a summary of the amount of passengers travelled by taxi (Figure 3).

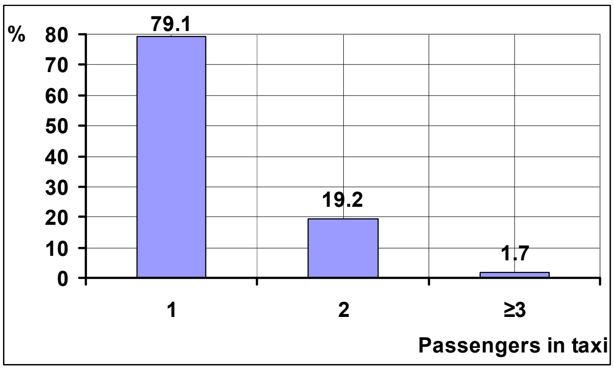

Figure 3. Amount of passengers in the taxi during the day

The results show that most of the runs had been made with one passenger - 79%, then with two passengers - 19% and on rare occasions by more than two passengers (3 or 4) - 2%.

After processing the information about the operating parameters recorded by the research equipment, the following results occur:

Shift duration - 12 h;

Average time per run - 15,2 min;

Average length of passenger run - 3,38 km;

Average travel speed - 21,3 km / h;

Average stay for a run - 80 sec;

Request awaiting stay time - 60% of the shift duration;

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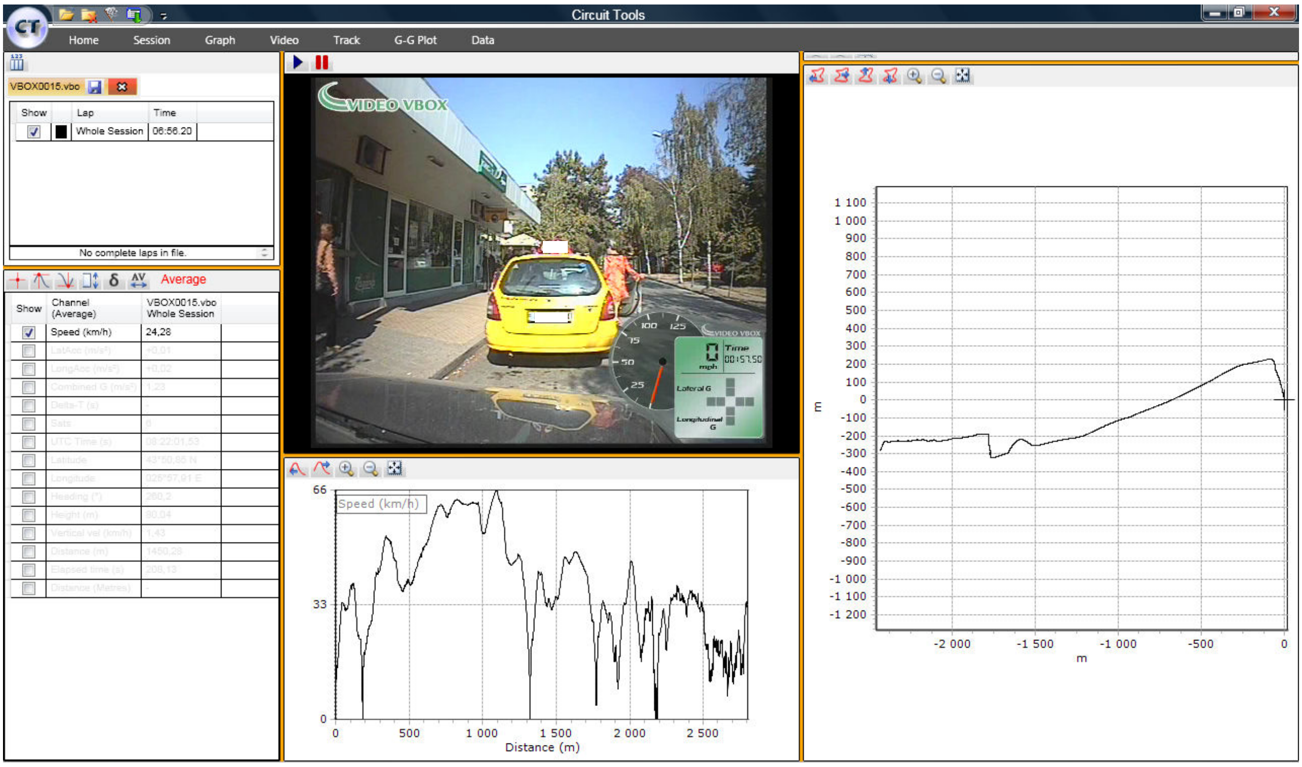

Figure 1. Results from the study with one passenger

Figure 2. Results from the study with two passengers

Driving with a passenger - 24% of the shift duration;

Driving without a passenger - 16% of the shift duration;

Average run for a shift - 163 km;

Maximum speed within the town - 77 km / h;

Maximum speed outside the city - 93 km / h.

4 Technical features for an alternative fleet of electric vehicles.

4.1 Main features of both parks.

The use of internal combustion engines in taxis is convenient in terms of rapid refueling, maintenance of proper temperature for the customer (heating during the winter and cooling by air conditioning during the summer), the opportunity to run higher mileage per charge - over 200-250 km with CNG, about twice more with LPG and about 500-600 km with liquid fuels (gasoline, diesel).

In recent years has begun mass production, promotion and implementation of electric transport in the cities. The technical characteristics of the electric vehicles allow them to travel average about 140-160 km per charge of battery, top speed - 130-140 km / h; noise - less than 65 dB; capacity - most often two people, but the larger ones - 4 people; charging time - normally – 4-8 h; fast charging 20-30 min; accelerating time - the same as the traditional cars, [1,7,14,15,16].

4.2 Scheme of the replacement of the taxi fleet with alternative fleet of electric vehicles.

Comparing the values obtained of the technical and operational indicators with the road conditions of Ruse and the technical characteristics of the alternative park of electric cars show a hypothetic possibility of exchanging the currently used automobile park for taximeter transports with an alternative park of electric cars to reduce fuel expenses and CO2 emissions in the cities, [1,16].

The key aspects in assessment of effectiveness of exchanging used automobile park for taxi transport with park of electric cars are:

-energy efficiency;

-environmental impact;

- economic efficiency;

-safety;

-charging, preserving and maintaining the alternative vehicles.

To determine the energy efficiency it is necessary to define the average consummation of energy for both parks (l/km and kWh/km). The basic factor which exercises influence on the average energy consumption are the characteristics of the vehicle (speed, maintaining, exc.) and the operating conditions(traffic, density of population, profile of the road, exc.)

For calculating the environmental impact of the alternative vehicles, two basic factors must be taken into account: greenhouse gases emissions during the utilization of the vehicles; noise emissions.

In defining the economic efficiency fixed and variable costs are valued.

Safety is defined by risk assessment for both alternative parks, [9,10,12].

Charging, preserving and maintaining the alternative vehicles is connected with, [2,4,12]:

-assessment of possible options and infrastructure for charging. For example a colon for charging electric cars(with normal charging of an electric car being 8 hours) can be used a day for full charge of three cars.

- defining the place for preserving. There must be taken into account all elements which are necessary for integrating the infrastructure such as: mains supply, charging systems, fire alarm systems, cocks, fire-extinguishers and others.

-maintaining is connected with strict enforcement of the prescribed norms for vehicles as well as with the places for charging and their preserving.

When we are comparing the economic efficiency, it can be started with counting the cost per trip i.e. the amount the customer pays per trip which is determined whether it is for an electric car(1) or an automobile(2) with an engine.

$$C_e = C_{Le} * L + C_{Te}T + C_{tax}, \text{ euro}; \quad (1)$$
$$C_a = C_{La} * L + C_{Ta}T + C_{tax}, \text{ euro}, \quad (2)$$

where $C_{Le}$and$C_{La}$are the costs for one traveled kilometer by the customer with an electric car and an automobile with an engine, euro/km;

C_{Te}andC_{Ta} – costs for a one- minute stop be the customer with an electric car and an automobile with an engine, , euro/min;

C_{tax} is the initial fee that the customer must pay when he gets into the taxi, euro;

L and T are the traveled paid mileage and the paid stop with a customer on the route, in km and min.

In the tariff for the paid mileage and stop are accounted the fixed and variable costs in taxi activity which can e expressed as follows:

- *Fixed costs*

$$P_{Fix} = P_{p\square r} + P_{le\square s} + P_r + P_{Adm} \text{ , euro.} \quad (3)$$

where are:

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$P_{p\square t}$ - costs for garage/parking;

$P_{le\square s}$ - costs for the vehicle's rent;

Pr - costs for on the air(using the radio station to receive requests);

P_{Adm} - administrative costs.

- *Variable costs*

$$P_{V\square t} = P_{\square} + P_{Ins} + P_{T\square x} + P_{Re\,g} + P_{Fuel} + P_{En} + \\ + P_{B\square t} + P_{S\square l} + P_{Ser} + P_{W\square s} + P_{Ot} + P_{Ac} \text{ ,euro} \quad (4)$$

where are:

$P_{\square}$ - costs of acquiring vehicles, which are amortized for n_A years;

P_{Ins} - insurance costs;

$P_{T\square x}$ - tax expenses;

$P_{Re\,g}$ - registration costs;

P_{Fuel} - fuel expenses;

P_{En} - energy costs;

$P_{B\square t}$ - battery costs, which are amortized for $n_{B\square t}$ years;

P_{ser} - cost of service (oil cost(engine, transmission, grease), tires, spare parts, labor(cleaning, repair, technical view, diagnostics) and for the charging stations and electric cars).

$P_{W\square s}$ - washing and cleaning the vehicles costs;

P_{Ot} - costs for other activities;

P_{Ac} - car accidents costs;

$P_{S\square l}$, - taxi driver's salary costs.

$\sum D_{Exp}$- emitted greenhouse gases costs(CO2, NOx, CO, CH, PM, Qbat) and noise (QNoise) for automobile with counted stands at traffic lights and junctions shown in [2]

$$\sum D_{Exp} = D_{exp_{CO_2}} Q_{CO_2} + D_{exp_{NO_x}} Q_{NO_x} + D_{exp_{CO}} Q_{CO} \\ + D_{exp_{CH}} Q_{CH} + D_{exp_{PM}} Q_{PM} + \\ D_{exp_{B\square t}} Q_{B\square t} + D_{exp_{Noise}} Q_{Noise}, \text{ euro} \quad (5)$$

- General costs for an automobile and park with n cars

$$P_{\square} = P_{Fix} + P_{V\square t} + \sum D_{Exp} \text{ , euro,} \quad (6)$$

$$P = \sum_{i=1}^{n} (P_{Fix} + P_{V\square t} + \sum D_{Exp})_i \text{ , euro.} \quad (7)$$

Comparing the costs for an electric car (5)and automobile with an engine(6) we get:

$$\Delta = P_e - P_a, \text{ euro} \quad (8)$$

If$\Delta > 0$ the automobile with an engine is more effective, because the costs per trip are less. If $\Delta = 0$costs per trip in both vehicles are equal their efficiency is the same. In the third case $\Delta < 0$the electric car is the most effective.

So if we get$\Delta \leq 0$, then the electric car turns out to be economically and ecologically more effective and can be successfully used as an alternative to taxis. Otherwise a compromise can be made because of the better ecological and noise indicators.

5 Conclusion

An analysis has been made to the taxi activity in medium town in Bulgaria, Ruse, in which are evaluated the operational indicators for work of the taxis. Taking into account the requirements, set in White paper 2011 Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system and the existing on the market electric cars, the possibility of exchanging the used automobile park for taximeter transports with alternative park of electric cars is evaluated. As a result is proposed a method for comparing the efficiency between two park vehicles.

References:

[1] Asdrubali,F., F. Rossi, F. Cotana, G. Galli, C. Buratti, G. Cellai, A. Nicolini, M. Filipponi, A. Marri, (2009): GREEN POST: Report on Energy/Environment Impact, Economic cost effectiveness and Safety Guidelines, Funded by IEE, CIRIAF, Perugia, Italia. 2010.

[2] Евтимова, В., Д. Симеонов, Изследване на сезонните колебания във вида на постъпващите заявки в център за спешна медицинска помощ, Известия на Съюза на учените, Русе, 2001г., том 1, серия 5, стр.102-107, ISSN 1311-9184.

[3] EC. White paper 2011"Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system" Brussels. 2011.

[4] Колев, Н., В. Евтимова, Някои изследвания относно натоварването на специализиран сервиз за обслужване на леки автомобили, Пета научно-техническа конференция с международно участие "Транспорт, екология – устойчиво развитие", ЕКОВАРНА '99, Технически университет – Варна, 13-15 май 1999 година; Сборник

доклади, том 6; стр.164-168, ISBN 954-20-00030.
[5] Lyubenov D. Research of the stopping distance for different road conditions. III International conference – Transport problems 2011, Katowice, Poland. p. 199-205.
[6] Marinov, M., J. Gelkov, D. Lyubenov. A study of vehicle movement parameters during overpass and overtaking. International Conference "Quality and reliability of technical systems", Nitra, 2010, p. 278-283.
[7] Наредба № 34 от 6.12.1999 г. за таксиметров превоз на пътници (Издадена от Министерството на транспорта. Обн. ДВ. бр.109 от 14 Декември 1999г., изм. ДВ. бр.50 от 20 Юни 2000г., изм. ДВ. бр.95 от 21 Ноември 2000г., изм. ДВ. бр.30 от 22 Март 2002г., изм. ДВ. бр.107 от 9 Декември 2003г., изм. ДВ. бр.29 от 9 Април 2004г., изм. ДВ. бр.111 от 21 Декември 2004г., изм. ДВ. бр.23 от 18 Март 2005г., изм. ДВ. бр.58 от 15 Юли 2005г., изм. ДВ. бр.46 от 6 Юни 2006г., изм. ДВ. бр.99 от 8 Декември 2006г., изм. ДВ. бр.103 от 7 Декември 2007г.)
[8] Община Русе. Обща справка на фирмите за таксиметрови превози. Русе.2011.
[9] Пенчева, В., А. Асенов. Оценка на ефективността от използването на електромобили в градски условия. РУ „А. Кънчев", Русе. 2011.
[10] Пенчева, В., Д. Грозев, А. Асенов. Изследване режима на работа на таксиметровите автомобили в условията на град Русе и оценка на възможни решения за използване на алтернативни на автомобилите с ДВГ транспортни средства. НТК ЕКО-Варна'09. Златни пясъци. Варна. 2009.с. 19-23, ISBN 954-20-00030.
[11] Pencheva, V., H. Beloev. European policy for urban mobility, transport sector status and air pollution in the in urban areas. Beograd, Serbia.2011.
[12] Pencheva V., D. Grozev. Time's movement model for taxis during the client requests. Crimea.Ukraine.2011.
[13] Software User Manual. VBOX Tools ver. 1.2.2007. – http://www.racelogic.co.uk.
[14] Страница за електромобили. http://www.electro-machines.ru/category/tematika-stati/ekspluatatsiya-elektromobilei.
[15] Страница за електромобили. http://dig.by/book/export/html/129.
[16] Шаранкова, В. Управление на мрежа от зарядни станции „Национален оператор". Fullsharger Bulgaria. София. България. 2011. http://www.smartcitybg.net/presentations/18.%20Vesela%20Sharankova.pdf

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