

Comparison by economic indicators of vehicles with various driving systems

Todor Yonov
Department of Electrical Supply,
Electrical Equipment and Electrical
Transport
Technical University of Sofia
Sofia, Bulgaria
todyon@tu-sofia.bg

Yavor Lozanov
Department of Electrical Supply,
Electrical Equipment and Electrical
Transport
Technical University of Sofia
Sofia, Bulgaria
ylozanov@tu-sofia.bg

Abstract— Petrol / diesel engines have not undergone any major improvements over the last decades, and on the contrary, it has even become clear that the real parameters of the pollution caused by them have been criticized by society. The need for innovation and ecology in the sector is enormous and in recent years an increasingly massive attack on the market by new high-tech cars operating on both full throttle and mixed (hybrid) drives has begun. The cost of cars of the class that pollute less often the environment is too high for the ordinary citizen. However, sales of eco-cars are increasing every year, regardless of their price, and relocations by municipalities and states should become more appealing. This article will attempt to answer the practical question: Is there a financial justification for the use of an ecological car and how much would it cost an average Bulgarian citizen living in the central neighborhoods of a big city and averaging 15,000 km per year for a 5 year period.

Keywords— comparison, electric, classic and hybrid electric drive of cars, electric cars

I. INTRODUCTION

The hiding of data on real air pollution in big cities has become something of a "sporting malice" on the part of car manufacturers and sellers in an effort to maximize profits from car sales. As a result of several journalistic studies, the real problem of pollution caused by conventional cars using an internal combustion engine has become clear. Many of them, despite the certificates, emit more harmful substances than allowed and some manufacturing companies have been subjected to solid financial sanctions. Nevertheless, these cars remain the most affordable means not only for personal traveling but also for commercial and business activities in the most popular small and medium-sized businesses. Therefore, the chance of stopping their use just because they threaten the climate is very small. That is why in recent years more and more "ecological" cars have started to be offered on the market, working both on all-electric traction and on a mixed-traction - battery together with an internal combustion engine - hybrids. The price of rechargeable batteries and their relatively low performance, make the new environmentally friendly cars unprofitable for the mass consumer due to high initial investment. However, the sales of eco-cars, both worldwide and in our country, are growing with each passing year, despite the higher initial investment, and the relief from the municipality and the state should become more and more attractive. This article will try to answer the practical question: Is there a financial benefit from using an ecological car and what would be the total amount of initial plus operating costs for the average Bulgarian citizen living in a big city and traveling about 15,000 km per year for 5 years-annual period,

compared to the same costs for a car using a classic internal combustion engine.

II. MODELS OF THE CONSIDERED CARS AND THEIR TECHNICAL INDICATORS

Cars of approximately the same class, from the manufacturer Volkswagen, were selected for the comparison. For all of them, standard equipment without unnecessary extras has been chosen. A comparison will be made on the financial indicators of two types of cars with internal combustion engines - for fuel gasoline and the cheapest possible fuel - methane with cars with electric and hybrid driving systems. The task is to determine which type is the most economically profitable and which would offer the best balance between ecology and price. The following model are selected for the comparison:

- Volkswagen Golf 1.4 TSI BMT DSG using a gasoline engine with a power of 110kW.
- Volkswagen Golf GTE (hybrid) using mixed traction - electric motor (75 kW) and gasoline engine (110kW), providing system power of 150 kW.
- Volkswagen e-Golf (electric) The e-Golf is an all-electric version of the new generation of Golf models introduced by Volkswagen. It uses an all-electric drive system with a power of 85 kW and a battery capacity of 32 kWh.
- Volkswagen Golf 1.4 TGI BlueMotion - using a methane engine with a power of 81 kW.

III. CAPITAL AND OPERATING COSTS AND THEIR DISTRIBUTION

The following costs are taken into account when comparing different cars.

In the comparison, it was suggested that the period of operation is 5 years or 75,000 km (15,000 per year), and these conditions are the standard warranty period. Energy sources and insurance prices are accepted at the time of the survey. Cars with internal combustion engines are accepted as the base price of the initial investment, as the so-called capital investments. It is based on the hypothesis that cars powered by classic fuels - gasoline and methane are purchased without a bank loan, and for hybrid and electric vehicles, the options with and without leasing are considered. The capital investment is the value of the car at its sale and whether external financing is needed, in the form of a lease or a bank loan, leading to the necessary additional monthly (or annual) costs. Secondly, the value of the various compulsory operating costs that each user incurs when using a personal vehicle is

determined. Such costs are the obligatory warranty service, parking fees, the necessary fuel for traveling the set distance, the obligatory insurances in our country, and the optional but desirable "FULL CASCO CLAUSE", municipal and state taxes.

The total operating costs are all monthly or annual amounts that the owner pays during the operation in the considered 5-year period.

It includes liability insurance - it is mandatory for all motor vehicles moving in the country. Full casco clause insurance - although not mandatory, it is highly recommended and even mandatory for leasing and new cars. Additionally, such insurance is required under a lease agreement. Annual fuel consumption - it is assumed that a car travels about 15,000 km per year, for which fuel costs are calculated accordingly at the average market price. The calculations are made with the average prices of gasoline A95 and methane gas taken from the average price for the region of Sofia from [1]. The price of electricity for an electric car is from [2]. Mandatory warranty service at an authorized/official/service center - in the case of Volkswagen. All warranty cars should be inspected by a manufacturer, every year or depending on the mileage. The prices and frequency of the services are provided by the official importer of VW for the country - Porsche Holding Bulgaria. Annual parking fee - it should be emphasized that determining these funds is very difficult. It depends on the location of the home and the work of the car owner. A common practice for most consumers is the annual parking subscription, as the most budget alternative. But this is not always possible in our country. Here for the calculations is accepted the hypothesis for one paid parking near the workplace or home with a fee of BGN 150 per year. Unfortunately, when parking in a blue or green area, it is difficult to determine the funds, so here they are not taken into account. Annual tax - according to art. 52 (1) of [3], tax is levied on all vehicles registered for traffic on the road network in the Republic of Bulgaria. In Art. 55 it is specified that for cars the municipal council determines the amount of the tax with an ordinance, according to the engine power, adjusted by a coefficient depending on the year of production. The tax is calculated according to art. 55 (1) of the Local Tax Act and art. 41 of the ordinance of the SOC for determining the amount of local taxes and fees. The method of calculation is given in [3].

A. Results from the comparison analysis

The values of the cars, in case of normal equipment without specialized extras, is taken from the catalog of the manufacturer/dealer. They are given in Tables 1 to 4. Column B of the tables shows a decrease in the price over the 5-year period. This is because within each subsequent year it decreases with the accepted depreciation in our country. Depending on the so-called basic insurance value, the value of the insurances also decreases, according to the catalogs of the insurers. The value in the 5th year gives data on how much the owner is supposed to receive when selling the respective car.

The insurance costs include civil liability insurance or full casco clause insurance for the period of 5 years. These data, as well as the depreciation, are according to the data of the insurance company recommended by the importer of Volkswagen for Bulgaria. It should be borne in mind that the cost of fuel, parking subscription and taxes are assumed to be approximately constant.

TABLE I. EXPENSES FOR VW GOLF 1.4 TSIBMT DSG

Initial costs		Operational costs			Total	
A	B	C	D	E	F	G
1	42845	2090	2185	2205	6480	540
2	36418	2016	2185	2126	6327	527
3	32133	1829	2185	1927	5941	495
4	27849	1643	2185	1728	5556	463
5	23454	1483	2185	1556	5224	435
Total per 5 years		9061	10925	9542	29528	492

TABLE II. EXPENSES FOR VW GOLF 1.4 TGI BLUEMOTION

Initial costs		Operational costs			Total	
A	B	C	D	E	F	G
1	45600	2205	1256	3421	6882	573
2	38763	2126	1256	3282	6664	555
3	34209	1926	1256	2947	6129	510
4	29642	1728	1256	2613	5597	466
5	25082	1555	1256	2320	5131	427
Total per 5 years		9540	6280	14583	30403	506

TABLE III. EXPENSES FOR VW E-GOLF

Initial costs		Operational costs			Total		Lease	
A	B	C	D	E	F	G	H	I
1	75785	3472	413	62	3947	328	6660	883
2	64417	3332	413	158	3903	325	6660	880
3	56838	2990	413	249	3652	304	6660	859
4	49260	2650	413	158	3221	268	6660	823
5	41681	2352	413	249	3014	251	6660	806
Total per 5 years		14796	2065	876	17737	295	33300	850

TABLE IV. EXPENSES FOR VW GOLF GTE

Initial costs		Operational costs			Total		Lease	
A	B	C	D	E	F	G	H	I
1	74555	3421	1529	147	5097	424	6660	979
2	63371	3292	1529	442	5263	438	6660	993
3	55916	2947	1529	259	4735	394	6660	949
4	48460	2612	1529	1125	5266	438	6660	993
5	41005	2320	1529	259	4108	342	6660	897
Total per 5 years		14592	7645	2232	24469	407	33300	962

In the above tables the following designations are made:

A – years from manufacturing;

B – cost of the car at the particular moment. For each following year, after the first year, the residual value /depreciation / is reported, according to the insurance rules;

C - values of the compulsory insurance according to the warranty requirements for most cars sold in Bulgaria;

D - fixed costs that includes fuel, parking subscription on an annual basis and vehicle tax;

E - value of the annual mandatory maintenance, carried out in a specialized service of the importer-trader;

F - total annual costs;

G - average monthly expenses;

H - annual lease expenses;

I - total monthly expenses together with the leasing installment.

In this case, the only variable costs are fuel and electricity. The formation of the price of fuels consists of three main components - firstly, customs duties, excise, and taxes, secondly - the cost of processing the raw material and, thirdly, the price of raw materials for fuel production on international markets. For the first two components, no significant changes are expected, so only the third - raw material price is variable. But in total it does not have a significant impact on a normal market. Electricity prices also do not change significantly. Here, however, we cannot take into account the significant difference between charging electric cars at home and fast charging stations, assuming that the owners of such cars will charge them only at home. This is based on the assumption that the electric car is mainly a city car and it travels up to about 150-200 km per day. If there is a need for transitions over longer distances, it will be necessary to charge public stations, for which the price is formed as - BGN per minute or BGN per kWh. The cost of such a charge is usually three times higher.

B. Analysis of the obtained results

- The smallest initial investment would be paid by a consumer of a car with gasoline fuel;
- The biggest initial investment is made by a consumer of a hybrid car;
- The differences on an annual basis between electric and petrol car are very small, as the electric car is more expensive on an annual basis by 6%;
- The difference on an annual basis between the cheapest - gasoline and the most expensive - hybrid / is 36% or more;
- The amounts for fuel, although drastically higher in the petrol car compared to the other car models, turned out to be a small item in the total costs in the specified period;
- The most significant impact for consumers in our country is the high initial investment and insurance costs, which cannot be avoided when buying a new vehicle;
- - The methane car, which many drivers, especially taxis, consider a cheaper alternative to conventional diesel and gasoline, does not show a serious financial benefit compared to them, as far as we are talking about a new car and not one bought "old" or additionally equipped with a gas installation. The difference in costs is only 4%. Additionally, the costs for the mandatory inspections of the methane system are not taken into account here;
- The analysis of the results so far does not take into account the additional costs in the presence of a bank/leasing loan. When they are taken into account,

the difference in costs increases and it is not in favor of hybrids or electric cars.

- - In addition, it should be borne in mind that the life of the batteries used in hybrids and electric vehicles cover only the warranty period. Therefore, at the residual value, if we consider only what the insurers give, where the data is mainly used, incorrect results will be obtained due to the depreciation set there only for cars with internal combustion engines. For the other cars - electric and hybrids, additional funds must be provided for the purchase of a new battery, the value of which is about 30% of the funds for a new car.

C. Comparison by ecological factors

Table 5 shows the emissions of the various vehicles. It should be borne in mind that the comparison is made for the harmful emissions emitted in the city, affecting a large part of the population in a large settlement. The emitted harmful emissions related to the production of fuels and electricity are not taken into account here, as far as the production capacities are usually exported outside the settlements.

TABLE V. CARBON DIOXIDE EMISSIONS ONLY FOR THE 5-YEAR PERIOD

Автомобил	CO ₂ , gr/km	CO ₂ , kg/year	For 5 years, kg
Golf 1.4 TSI BMT DSG	116	1740	8700
Volkswagen Golf GTE	38	570	2850
Volkswagen e-Golf	0	0	0
Volkswagen Golf 1.4 TGI BlueMotion	95	1425	7125

The table shows that methane cars emit only 18% less CO₂ than gasoline ones. Nevertheless, methane cars lack much of the chemicals emitted by conventional engines, but carbon dioxide is still present in large quantities. In hybrids, the reduction of harmful emissions is 67%. In the case of electric cars, there is no emission of harmful emissions.

IV. CONCLUSION

The best balance between practicality, dynamics, and environmental friendliness is the hybrid car. It emits significantly fewer emissions than conventional cars, especially when driving short distances (urban conditions), and provides about 4-5 times more mileage than the electric car on a long journey. The average annual costs for it are the highest and although hybrid cars have been known since the beginning of the last century, technological investments in their development have aroused interest only in the last 15 years, due to the increased environmental thinking of the population in the West. world.

The high price, as well as the lack of sufficiently developed infrastructure for charging the batteries, limit their application, although this does not prevent electric cars from entering our country on a larger scale. The main disadvantage is still the relatively low mileage, about 150-200 km on a single charge, and the time required to charge - from 20 minutes to about 1 hour to charge up to 80%. In our country to travel a distance of about 500 km. at least 2 charges are required or about 1-1.5 hours more time. Even in places where

fast battery charging stations are available, the prices are significantly 2.5 to 7 times higher than for home charging. Another disadvantage of home charging is the need for a power outlet near the parking space. On the other hand, the use of an electric car as a city car and with the possibility of home charging has many advantages over other cars - it does not need parking in the blue and green areas, and for cars with internal combustion engines, and stopping in such areas is with a pretty solid price of 2 or 1 BGN / hour.

In our country the average gross salary according to data for January 2021 is BGN 1454. In case of taxation - 1200 BGN. Or the monthly expenses for a petrol and methane car are about 42% of the salary, for electric cars - 25% and 71% / with leasing /, for a hybrid 34% and 79% respectively. In many cases, leasing or a bank loan can be a significant burden on the family budget for many years. Last but not least is the residual value of electric cars. Here it is determined by tables of insurers. But this is not the value that the owner will receive when selling. Because the life of car batteries of 5 and more years is coming to an end. And this is widely known. Therefore, when selling a hybrid or electric car, the buyer will ask for a discount of at least 50% of the price of the battery.

It should be noted that in the last years 2018 - 2021 we have adopted several "Investment program for climate -

electric cars" with direct support for the purchase of electric cars with BGN 20,000, and hybrids - BGN 10,000. But this program covers only the state administration and direct support to private users is still a long way off. If such support reaches them, it will make the electric car a desirable replacement for classic cars, as the price of the initial investment is not so big difference, and when buying a typical city car, the prices will actually equalize. In this situation, the monthly costs for an electric car already purchased without a bank loan will be 25% of the average salary, compared to 42% for petrol or methane cars.

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