American Journal of Humanities and Social Sciences Research (AJHSSR)
e-ISSN :2378-703X
Volume-08, Issue-03, pp-180-190
www.ajhssr.com
Research Paper Open Access

COMPARATIVESTUDYBETWENTHERMAL ENGINE PROPULSION AND HYBRID PROPULSION

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

ABSTRACT: The academic paper describes in a concrete and elegant way a comparative study of two existing propulsion systems on cars. The authors have developed the concepts and technical aspects of the SWOT analysis, which highlights the qualities and shortcomings of the classic propulsion system with a thermal engine compared with a hybrid propulsion system. In this way, interested parties can learn about the advantages of hybrid propulsion systems installed in today's cars, which are defined by the electric motor/ motors installed in their propulsion systems. Finally, conclusions are presented in the field covered.

KEYWORDS :*car, thermal engine propulsion, hybrid engine propulsion, strengths, weaknesses, opportunities, threats.*

I. INTRODUCTION

Cars are now the most precious means by which man satisfies his mobility needs [1]. This is due to the great benefits they offer users. Sometimes cars turn out to be priceless collectors' items, owned by those who really know them [2]. In addition to technology, civilisation, comfort and ergonomics, they are dynamic and fast at moving material goods, goods or people through space. The appeal of cars to the masses has been determined by the harmonious shapes of their bodies, powerful engines and transmissions, and the new, modern, efficient and effective technology fitted to them, which has developed rapidly. The internal combustion engine vehicle[3, p. 18], [4, p. 153] is the backbone of the road transport system. Because of its popularity and simplicity of operation, it is still preferred by users over the electric car. Many drivers find it simpler and easier to fill up the tank with petrol, LPG or diesel, get behind the wheel and drive 1,000-1,200 km without worry or stress, rather than looking for an electric car charging station. If the thermal engine car also has as an alternative an electric propulsion unit powered by an electric traction battery, which is charged on the move or via the thermal engine, then all the problems of range stress are completely eliminated compared to a full electric car where the range and charging time, defined by the power of the existing stations on the route, must be taken into account. At present, the electric car has a number of disadvantages, which make mankind unprepared for electromobility. The hybrid car [5] is actually making the transition from the combustion engine car to the electric car [6]. Hybrid-powered vehicles first appear on the market with the production of the Japanese Prius [7] from Toyota in 1997, which became available worldwide in 2000. The Toyota Prius is one of the world's best-known and best-selling production hybrid cars and has proven its reliability qualities over time. Since the debut of this model, it is said that the hybrid car market has developed and has become very interesting, given the demands of customers in recent times. Initially, the hybrid vehicle market was not of great interest to the general public, as environmental protection requirements and low oil prices were not a big problem worldwide. With the tightening of environmental pollution requirements and rising oil prices, the hybrid market has started to become a priority for customers. After Toyota, Japan's Honda developed the Insight hybrid model in 1999, and since 2000 the industry has been increasingly producing and developing this technology.

The main objective of the research is defined by a comparative study highlighting the advantages and disadvantages of hybrid and conventional thermal engine propulsion systems on road vehicles, using SWOT analysis. From these analyses derive the specific objectives of the research which justify and disseminate the strengths, weaknesses, opportunities, threats of each type of propulsion system, as well as the state of sales of these vehicles compared to environmentally friendly propulsion systems (electric and hydrogen fuel cell cars), highlighting the appetite of the population of European countries for gasoline and diesel powered vehicles. The specific objectives also include an analysis of the "Dieselgate" scandal that took place in Germany at the major car manufacturer Volkswagen, and was highlighted in September 2015.

The contribution derives from the objectives established for this research and consists of the following arguments:

- the advantages of hybrid propulsion over conventional (combustion engine) propulsion have been highlighted;
- using SWOT analyses, the strengths, weaknesses, opportunities and threats for the two propulsion systems analysed were highlighted;
- discussions and interpretations of the two types of propulsion analysed were presented;
- an analysis of the "Dieselgate" scandal that emerged at the Volkswagen Group in Germany in September 2015;
- a current study of the sales of hybrid and conventional motor vehicles at European and national level was presented;
- presentation of the conclusions on the topic.

II. PRESENTATION OF THE THERMAL ENGINE CAR

The classic motor car debuted in 1769, when the steam engine was invented and used to transport goods or passengers [8]. After many attempts by Nicolas Joseph Cugnot, the French inventor who designed and created the world's first vehicle powered by a steam engine, on 29 January 1886 the German engineer Carl Benz of Mannheim registered the prototype of the first motor vehicle with an internal combustion engine. It is practically the first car in history to benefit from the great technological breakthrough that was the internal combustion engine, which revolutionised the automotive world.

Before long, the prototype was replacing the animal-drawn vehicles on the streets of the big cities, taking the world by storm. The world's first model of the modern automobile was thus created, the Benz-Patent Motorwagen, a perfect vehicle at the time, powered by a petrol engine. The car had a steel tube chassis, reached a speed of 16 km/h, was powered by a 954 cm3 single-cylinder engine with 0.74 hp at an engine speed of 400 revolutions per minute, and was patented as an invention in early 1886 by the Benz & Cie. company, a factory established in 1883. The car, built from parts made with revolutionary technology for the time and featuring an integral aesthetic, was not put on sale until two years later.

Henry Ford, one of the world's greatest inventors, built his first car powered by an internal combustion engine in 1896. After several attempts by the great Detroit industrialist, his first car for the masses was the Ford Model T, the car that started the four-wheel revolution in the US. Production began in 1908. The model's advantage was its low price, which made it popular and attractive to the masses. Production was 100% mechanised by the end of 1914, which made the car cheaper, so that by the end of production in 1927, over 15 million Model T cars had been assembled in European countries, the Australian continent and Brazil. In 1916, more than 50% of the world's cars were made by Ford under the Model T licence. The man who solved the controversy was Henri Ford who developed and fitted his Model T cars with the internal combustion engine, sparking an industrial and social revolution [9, p. 98].

In the first World War, the model is used for transporting troops, armaments, ammunition and other logistical operations. To highlight the role of this car, we recall that in France, during the first military interventions on the Marne, the French authorities requisitioned 600 taxi-type cars from the city of Paris, with which they quickly moved the 7th Infantry Division. The victory of the Anglo-French military also relied on the help of this car. After the First World War, more front-engined cars were built. The era of the 'retro car' ended with the onset of the Great Depression in 1929. New technologies, new concepts, new innovations in vehicle construction are introduced. Braking mechanisms are developed. Between 1920 and 1930, new car manufacturers appear: Chrysler (1925), Pontiac (1926), La Salle (1927), Plymouth (1928). Hermann Rieseler invents and develops the first mechanical clutch for car transmissions, to which he attaches a planetary gearbox and a torque converter. In this respect, the literature shows that the development and diversification of motor vehicles and their internal combustion engines (more massive, more powerful, more powerful, harder to break down, more energetic, etc.) has also forced the development of component parts, assemblies and sub-assemblies at a faster rate. The most studied were gearboxes and transmission systems[10, p. 3].

André Lefèvre asks the big car manufacturer Renault for an all-wheel drive version, and Renault refuses. Citroën subsequently accepted the variant in 1934. In 1873, Amédée Bollée invented the independent suspension system, which was not fitted to the Mercedes-Benz 380 until 1933. In 1929, the great financial crisis hits, and cars are increasingly hard to sell. In 1934, the major car manufacturer Chrysler creates the streamlined production model. Then World War II breaks out and car production stagnates, especially in Europe, which focuses its entire industry on war production. Panhard now manufactures more than 130,000 vehicles that rely on exploding carbon monoxide mixed with oxygen. By shifting factories to the war industry, the Americans are designing and putting into service all-wheel-drive vehicles with high cross-country and rough-terrain capability. This was the case for the major off-road vehicle manufacturer Chrysler, which began production and testing of road vehicles as early as 1941. In 1943, this type of car was successfully used by American troops.

III. PRESENTATION OF THE HYBRID CAR

Hybrid cars fall into two broad categories:

I. The Hybrid Electric Vehicle (HEV) has two types of engines powering the car: a combustion engine and one or more electric motors. Depending on the type of electric motor, it can provide propulsion independently of the internal combustion engine to increase efficiency and reduce emissions. The internal combustion engine can be powered by petrol (rarely diesel) or alternative fuels such as methane, methanol or LPG (liquefied petroleum gas). The control systems on hybrid vehicles switch the electric motors with the thermal engines without altering user comfort. To this end, the electronic control system has permanent access to data from the sensors of the internal combustion engine, the electric control unit, the state of charge of the batteries, etc. The management system analyses, regulates and controls the interaction between the two propulsion systems in real time [11]. The advantage of combining the two types of engine is that when descending a hill or decelerating, the heat engine stops or idles, while the electric motors operate in regenerative mode (electric generator mode), the kinetic energy thus obtained being sent and stored in the electric accumulators. In addition to the internal combustion engine (usually spark ignition, rarely compression ignition), hybrid vehicles have one or two electric motors that provide traction torque to the drive wheels and recover kinetic energy when decelerating or going downhill. They are called *regenerative hybrid propulsion systems*[12, pp. 10-12].

Depending on their performance or operating modes, hybrid vehicles can be classified as follows.

A. According to how the drive wheels are driven:

(a) Series hybrid. The heat engine drives an electricity generating set which produces the energy required to charge the electric traction battery. The stored electrical energy then drives the electric traction motor;

b) Parallel hybrid. Both engines (internal combustion and electric) drive the drive wheels. Here, the electric motor is used to supplement the energy generated by the internal combustion engine as required.

c) Series/parallel (combined) hybrid. Also called multi-mode hybrid propulsion system, capable of operating with both the combustion engine and the electric motor. It can also operate in both modes.

In all three cases, when decelerating or descending gradients, the thermal engine switches off and the electric motors go into regenerative mode.

B. According to the mode of operation of the engines:

a) Full Hybrid. It is the most developed system. In this case, the electric motor can individually drive the vehicle, and the vehicle can be driven in the so-called Electric Vehicle (EV) mode, i.e. fully electric, with certain limits on driving speed. The system has a high power output and operates at the nominal electrical voltage of 650 V, allowing it to contribute individually to providing traction for each mode of vehicle operation;

b) Mild Hybrid. Here the electric motor can only be used to support the performance of the internal combustion engine and cannot provide independent propulsion. The electric motor in this case operates at a voltage of max. 48 Vdc;

c) Micro Hybrid. The internal combustion engine is connected to a START&STOP mechanism.

II. Plug-in Hybrid Electric Vehicle (PHEV). A full hybrid electric system with a traction battery of sufficient capacity to enable the vehicle to travel long distances using only the electric motor. The traction battery can also receive power from an electric socket (household outlet) connected to an external source. When the electrical energy in the traction battery runs out and is not recharged from an external source, the vehicle operates in Full Hybrid mode. The plug-in mechanism further reduces emissions and fuel consumption compared to a Full Hybrid. This is due to the longer range of the more efficient traction battery, allowing the car to run longer in electric mode. Today, new plug-in hybrid propulsion systems are seen as the transition to new technologies based on the electric vehicle with a Range Extender Vehicle (REV) unit, i.e. a vehicle with a heat engine driving a generator to charge the electric traction battery, without participating in the actual propulsion of the vehicle. This type of vehicle provides the electric power needed for medium-distance journeys with minimum fuel consumption and emissions. If the car is forced or driven in an aggressive/sporty way, if the route is one with frequent and steep ramps, if outside temperatures are low, if the air heater is used for heating in winter or the air conditioning is used for cooling the passenger compartment in summer, the capacity of the electric traction battery is substantially reduced and the range of the vehicle is reduced.

IV. COMPARATIVE STUDY ON THE TWO TYPES OF PROPULSION

Because of environmental pollution, since the mid 20^{th} century, the authorities of highly developed countries around the world have made environmental issues a top priority and are developing laws, regulations and directives to support, reduce and remediate the damage caused by pollutants released uncontrollably into nature in order to prevent future environmental contamination. The conference held in the summer of 1992 under the auspices of the United Nations in Rio de Janeiro, Brazil, highlighted a new approach to energy resources. It emphasised the use of renewable resources. Since then, terms such as environmental pollution, renewable resources and green energy have become increasingly common, and automotive specialists, engineers and researchers are looking for solutions to improve the operation of internal combustion engines and reduce pollutant emissions. Globally, the 8th decade of the last century is starting with major problems with the level of environmental pollution from harmful gases from cars, with research and design of clean gas engines becoming more than necessary. Researchers and engineers have been challenged to find solutions to make the car fuel efficient and high efficiency[3, p. 3].

Experts estimate that, in addition to the environmental problems created by the noxious emissions from cars' combustion engines, carbon-based fuels will be significantly reduced in the next 30-40 years. For this reason, viable solutions must be found to provide the energy needed to power road transport and other means of transport, thus ensuring mankind's need for mobility [13, p. 6].

In this respect, in order to highlight the advantages and disadvantages of a propulsion system with a conventional engine (thermal engine), compared to those of a hybrid propulsion system, we propose below to carry out a SWOT analysis in order to present their strengths, weaknesses, opportunities and threats.

4.1 SWOT analysis for the combustion engine car

After the end of the Second World War, the car develops, becomes interesting and attractive to people all over the world. The appeal of cars to the masses was determined by the harmonious body shapes, powerful engines and transmissions, which developed rapidly.

Table 4.1: SWOT analysis of the thermal engine car. Strengths (S).

S. Strengths	Proposals for development/ consolidation
S_1. Robustness of engines - *parameter showing vigour, strength and physical endurance.*	Use of electricity from renewable sources only; use of modern, non-polluting manufacturing technologies; use of environmentally friendly raw materials and manufacturing materials (carbon fibre, ceramics, plastics, light metals, etc.); public information and education.
S_2. Durability of engines - *cars with a combustion engine last for over 135 years.*	Allocate financial resources for research and development of efficient, clean, high power, small thermal engines made of environmentally friendly materials.
S_3. Simplicity of the heat engine operating principle - *the heat engine converts heat into mechanical work based on a thermodynamic cycle using a fluid.*	Improving the performance of thermal engines through research into the operating principles of the engine mechanism, gas distribution and ignition, fuel supply, cooling, lubrication and exhaust systems.
S_4. High range - *consumes fossil fuels, does not depend on battery power like electric cars.*	Increasing the range of cars by: decreasing fuel consumption; increasing fuel tank capacity; decreasing car weight; defensive driving; making journeys and transport routes more efficient and well planned; carrying out maintenance work on time; using original spare parts, materials and supplies.
S_5. They are more popular than hybrid or electric vehicles - *they enjoy remarkable popularity among users.*	This popularity needs to decrease in order to steer the population towards the purchase of environmentally friendly vehicles (hybrid, electric or hydrogen fuel cell). The following actions are needed to achieve these goals: lowering the cost price of electric cars; increasing the range of electric batteries in green cars; keeping the price/kWh of electricity low; reducing the charging times of electric batteries; increasing the number of electric filling stations on the road in non-urban areas; maintaining and increasing eco-bonuses and incentives by the authorities for the purchase of electric vehicles; informing and educating the population.
S_6. Quick refuelling to tank full - *filling a fuel tank can be done quickly and easily.*	Improve the technical performance of refuelling pumps; increase the number of refuelling stations on the route.

Table 4.2: SWOT analysis of the thermal engine car. Weaknesses (W).

W. Weaknesses	Elimination measures
W_1. They are not environmentally friendly - *they emit noxious emissions (CO, NOX, HC, PM, CO2) into the atmosphere.*	Informing and educating the population; increasing annual taxes and charges for owners of vehicles with pollution standards below Euro 4; restricting access to congested urban areas for vehicles with engines with pollution standards below Euro 4; increasing the purchasing power of the population; tightening environmental legislation.
W_2. High refuelling costs - *depend on and consume only fossil fuels.*	Keeping fuel prices low; healthy economic growth through investment in industry, transport, etc.; increasing people's purchasing power.

W. Weaknesses	Elimination measures
W_3. High maintenance costs - *internal combustion engines require highly complex maintenance work.*	Using original, quality spare parts at a low price; increasing vehicle reliability; keeping maintenance rates low; providing service units with quality, high-performance SDVs and diagnostic equipment; training staff.
W_4. Dependence on carbon - *based fuels - requires frequent refuelling.*	Increasing vehicle autonomy; training and educating the population to move towards electromobility.
W_5. Reduced comfort for vehicle passengers and road users - *the large capacity heat engine produces loud noises and vibrations during operation.*	Building quieter engines; improving the performance of suspension and propulsion systems; sealing and anti-vibration of vehicle bodies; better dynamic balancing of all moving parts, components or organs on vehicles; reducing the speed of traffic; applying the principles of defensive driving.
W_6. Low efficiency motors - *about 30% compared to over 90% of electric motors.*	Use of high quality and high efficiency fossil fuels; improved combustion principles of fossil fuels in internal combustion engines.

Table 4.3: SWOT analysis of the thermal engine car. Opportunities (O).

O. Opportunities	Development/fruitment meeasures
O_1. People's need for mobility - *arose as a result of human needs for personal or goods mobility.*	Orientation of the population towards environmentally friendly means of transport (bicycles, scooters, electric vehicles); use of electric trams, trolleybuses, buses and minibuses; electrification of all transport vehicles.
O_2. Permissive environmental legislation - *in some countries, environmental legislation still allows polluting vehicles to circulate, but minimum standards have been created for noxious emissions.*	Tighten environmental legislation.
O_3. It is the product of research - *substantial funds invested in research.*	Continue research into the development of technologies in the field of electromobility, safety, ergonomics and comfort of electric cars; allocate the necessary resources to research in this field.
O_4. It benefits from cutting-edge pollution technology - *today's car benefits from the latest advances in science and technology.*	Intensify research in this directions.

Table 4.4: SWOT analysis of the combustion engine car. Threats (T).

T. Threats	Mitigation/ reduction/ countermeasures
T_1. Depletion of energy resources - *depletion of fossil, carbon-based fuels.*	Decrease of average fuel consumption; development of alternative energies from renewable sources; use of alternative fuels (ethanol, methanol, butane, liquefied natural gas).
T_2. Rediscovering other energy sources - *the electric motor, hydrogen fuel cells.*	Discovering other sources of energy - the electric motor, hydrogen fuel cells.
T_3. Evolution of technology - *the emergence of new propulsion technologies.*	Development of new, more efficient and economical propulsion technologies for thermal engins for motor vehicles.
T_4. Rising carbon fuel prices - *few carbon fuels, high price.*	Keep fuel prices at a reasonable level.
T_5. Global warming - *pollution of the environment through the release of noxious gases into the atmosphere by conventional motor vehicles, which has destroyed the ozone layer.*	Tighten environmental legislation; use of alternative fuels; use of electric or fuel cell transport; public transport.

4.2 SWOT analysis for the hybrid car

The hybrid vehicle is considered to be the interface, the transition from internal combustion engine to electric propulsion. It is a temporarily viable alternative found by researchers to the internal combustion engine car [14]. This type of car has the advantage that, in addition to the internal combustion engine, it has 1-2 electric motors, which contribute to or even provide propulsion. If the battery can be charged from a mains electricity supply, has a long range and can provide the energy to power the 1-2 electric motors without starting the internal combustion engine, then the hybrid car demonstrates maximum efficiency and effectiveness. In addition to all these aspects, user satisfaction increases, as it saves money and does not have to worry about frequent refuelling with petrol. In the following, a SWOT analysis has been carried out, showing the advantages and disadvantages of the hybrid car.

Table 4.5: SWOT analysis of the hybrid car. Strengths (S).

S. Strenghts	Proposals for development/ consolidation
S_1. They are environmentally friendly - *low emissions of CO, NOX, HC, PM, CO2 at EU standards.*	Use of electricity supply only from renewable sources in PHEVs; design and use of thermal engines with lower pollution standards.
S_2. Low fossil fuel consumption - *the electric motor(s) provide traction in conjunction with the combustion engine.*	Increasing electric battery capacity and vehicle range in electric mode; building and using more efficient electric generators/motors; improving how electric resources are managed in propulsion systems.
S_3. Increased user comfort - *the large capacity heat engine has reduced operation due to the electric motors taking over the load, and vibration and noise are reduced.*	Limited operation of the thermal engine; increased role of the electric motor in traction; defensive driving of the vehicle; better dynamic balancing of all moving parts and components on the vehicle; use of lightweight materials in the manufacture of vehicle parts and components.
S_4. High reliability - *a low failure rate.*	Use of high quality maintenance materials, spare parts and original materials; defensive driving of the vehicle; timely and quality execution of maintenance and servicing work; training of maintenance personnel.
S_5. Increased tractive power - *1-2 electric motors providing traction simultaneously with the thermal engine.*	Improving the technical performance of electric motors; decreasing the weight of the vehicle; increasing the share of electric motors in the traction of the vehicle.
S_6. They do not require specialised off-grid power supply infrastructure - *they have their own battery charging system. The exception is the plug-in hybrid variant.*	Improving the efficiency of electric motors in electric generator mode.
S_7. Low maintenance costs for electric motors - *electric motors do not require regular adjustments and technical maintenance.*	Equipping service units with SDVs and diagnostic equipment for electrical traction systems; training of staff performing overhauls, technical maintenance and servicing.
S_8. Low operating costs in urban areas - *in urban areas it relies on electric traction and the price of electricity is lower compared to fossil fuels in relation to the distance travelled.*	Increasing the capacity and range of electric traction batteries; maintaining the price per kWh of electricity (for PHVE vehicles); reducing the weight of hybrid vehicles.
S_9. They can only operate as an electric vehicle - *only those equipped with the (EV) function, if the speed does not exceed 40 km/h, and plug-ins have a longer range in this mode (60-80 km).*	Increasing the capacity and range of electric traction batteries; lowering urban driving speeds from 50 km/h to 30 km/h; applying the principles of defensive driving.
S_{10}. Recovers electrical energy and stores it in electrical batteries - *when going downhill and during regenerative braking.*	Efficient charging and storage of electrical energy; application of defensive driving principles; avoidance of braking during deceleration.
S_{11}. It eliminates certain transmission components from the design - *no clutch and manual transmission gearbox, the torque-speed characteristic of electric motors ensures maximum torque at any speed.*	Development of continuously variable transmissions (CVTs); development of electric traction motors and their efficiency through reduced electricity consumption.

Table 4.6: SWOT analysis of the hybrid car Weaknesses (W).

W. Weaknesses	Elimination measures
W_1. They are complex - in addition to the internal combustion engine, it has one or two electric motors and related equipment.	Simplification of the electrical traction system; simplified diagnostics; simplified maintenance work.

W_2. They are 10-14% heavier - *extra electrical components (cables and electric motors, batteries for electric thrusters).*	Use of lightweight construction elements (carbon, plastic, aluminium, light alloys).
W_3. They are slow to start - *continuously variable gearboxes, but also the extra weight of vehicles due to additional elements (traction batteries, electric motors, additional electrical equipment), make them slower to start.*	The use of more powerful motors (electric and thermal); the reduction of vehicle weight through the use of lighter materials; the development of smaller, lighter and more efficient electric traction batteries.
W_4. They are dependent on a specialised refuelling infrastructure and long charging cycles - *only those with an open hybrid system, i.e. vehicles that also have a plug-in charging system connected to the external electricity grid.*	Allocation by the authorities of the necessary funds and development of the charging station network (only for PHV); equipping all charging points with powerful charging stations (over 100 kW; 400-500 Vdc), which substantially reduce charging time; gradual transition of conventional charging stations to partial equipping with electric charging stations.
W_5. High cost price of batteries at replacement - *traction battery made of expensive materials and technologies.*	Use of cheap and quality materials and cheap manufacturing technologies for traction batteries; lower price per 1/kwh for traction batteries.
W_6. Plug-in hybrids are economical for the first 20-60 km out of 100, after which they revert to the function of a normal hybrid vehicle - *the drive accumulator needs to be recharged.*	Increase the autonomy of electric traction batteries.
W_8. High purchase price - *additional electrical and electronic equipment (10-50%).*	The European states' authorities to maintain incentives for the population to purchase an electric/hybrid vehicle (eco-bonuses); lowering the cost price per 1/kWh for electric traction batteries; lowering the purchase price of electric vehicles.
W_9. Reduced range on one charge cycle of electric accumulators in winter - *in cold weather, when starting hard and climbing ramps the electric accumulators discharge quickly.*	Defensive driving of the vehicle; more efficient and better capacity electric traction batteries; more efficient electric motors.
W_{10}. Requires investment to provide power infrastructure - *plug-in only.*	Allocation by the authorities of the financial funds needed to develop the infrastructure for charging electric accumulators; gradual transition from conventional filling stations to electric filling stations; development of service units dedicated to this type of vehicle and equipping them with specific logistics, training and instruction of service staff.

Table 4.7 SWOT analysis of the hybrid car. Opportunities (O).

O. Opportunities	Development/ fruitment measures
O_1. Global warming - *pollution of the environment through the release of noxious gases into the atmosphere by internal combustion engine vehicles, which have destroyed the ozone layer.*	Lowering the minimum chemical noxious emissions threshold for the pollution standard for motor vehicles with internal combustion engines.
O_2. Environmental legislation - *environmental legislation prohibits the use of vehicles with thermal engines below a certain European standard, which are environmentally unfriendly.*	Strengthening environmental legislation, which is sometimes permissive on noxious emissions from internal combustion engines.
O_3. It has emerged as an alternative to the classic car - *classic cars pollute the environment and the hybrid vehicle benefits from a higher level of technology.*	Continue research into the development of technologies in the field of electromobility, safety, ergonomics and comfort of hybrid/electric cars; allocate the necessary resources to research in this area.
O_4. Attractive ecobonuses are granted on the purchase of such a new vehicle – *country specific environmental legislation policy.*	Strengthen environmental protection legislation; maintain eco-bonuses.
O_5. Half or zero taxes and charges on purchase and/or parking - *local authorities give incentives for free purchase or parking to encourage people to buy such cars.*	Exemption from paying annual taxes to local authorities; eco-bonuses when buying a new car; free and dedicated parking spaces with refuelling stations.

O_6. It benefits from well-thought-out and developed transition technology - making the switch from conventional to electric vehicles.	Develop and streamline hybrid technology; allocate resources for hybrid vehicle research.

Table 4.8: SWOT analysis of the hybrid car. Threats (T).

T. Threats	Mitigation/reduction/countermeasures
T_1. Depletion of energy resources - *depletion of fossil, carbon-based fuels needed for thermal propulsion.*	Maintaining or lowering the price of electricity (for PHVs); developing alternative energies from renewable sources for PHVE vehicles; lowering the consumption of energy resources; using alternative fuels for thermal engines (ethanol, methanol, butane, liquefied natural gas).
T_2. Evolution of technology - *the emergence of new propulsion technologies.*	Increasing GDP per capita; strengthening the national currency against interbank market currencies; measures to halt currency growth in the interbank market; development of technologies and full transition to electromobility.
T_3. Rising carbon fuel prices - *few carbon fuels, high price.*	More economical vehicles; use of alternative fuels.
T_4. Global warming - *pollution of the environment by the noxious gases released into the atmosphere by conventional cars, which have destroyed the ozone layer.*	Tighten environmental legislation; use of alternative fuels; use of environmentally friendly means of transport; shifting the population towards public transport.
T_5. The financial crisis is reducing customers' interest in buying these vehicles - *high purchase price, low living standards, authorities' failure to provide attractive eco-bonuses.*	GDP growth; rising living standards and purchasing power of the population; advantageous leu/currency ratio; measures to curb currency growth on the interbank market.

V. DISCUSSIONS AND INTERPRETATIONS

SWOT analyses on the two types of propulsion were carried out based on information from the literature, the online environment and the experience of the author. They show that there is an urgent need to introduce new propulsion sources, new technologies, as a cleaner and less polluting alternative to freight and passenger mobility. The alternative must in future ensure low to zero chemical and noise emissions.

After 100 years of domination by internal combustion engines, September 2015 made automotive history with the outbreak of a scandal known to us as the "Volkswagen Scandal" or, as specialists and those who wrote about the phenomenon at the time called it, Dieselgate. The occasion showed us how limited conventional engines have become, the dangers they pose to the environment and the need to develop new powertrains for cars that comply with the requirements in the field and with the pollution standards issued by the European Community. The Volkswagen Group was considered at that time to be the number one group in the world. The question is whether this statute was built on correct, ethical and moral principles. On September 18, 2015, one day after the opening of the Frankfurt auto show, where German manufacturers on home turf were wowing the world with their plethora of ecofriendly four wheeled novelties, the world's toughest environmental protection agency, the EPA (U.S. Environmental Protection Agency) officially demonstrated, with conclusive evidence, that automaker Volkswagen was guilty of manipulating fuel economy tests for diesel engines and polluting the environment with them.

Of course the accused, the Volkswagen group, has admitted its guilt. It was not a question of human or design error, but of deliberate action, a gross violation of ethical and moral principles, a tampering with laboratory tests relating to the atmospheric emissions of nitrogen oxides (NOx) by diesel engines. Nitrogen monoxide is a toxic gas which is responsible, among other things, for global warming, giving rise to the so-called greenhouse effect. During tests, nitrogen monoxide emissions sometimes reached 40 times the maximum permissible limit.

The first question mark over the environmental performance of Volkswagen's TDI engines was raised in 2013, when major discrepancies between measurements taken during laboratory research and those taken in the field under real conditions were observed during independent tests. Volkswagen managers have promised to take action on the matter, claiming that it is all due to functional or even design errors. By their attitude, they violated professional ethics, because the reality was different. The software that rigged data on diesel cars sold in the US had been installed since 2009. Worldwide, more than 11 million Volkswagen vehicles and several million Audi and Skoda vehicles were found to have this software installed. According to calculations made by experts in the field, by using this software, the vehicles that had it installed had eliminated polluting emissions into the atmosphere similar to around 20 million cars. The EPA has fined the German company $18 billion for the non-compliance and taken it to court. Software installed on these vehicles was seen by car manufacturers as a cheaper solution than investing in viable technological solutions. In some countries, engines were subsidised on the basis of the low levels of air pollutants reported with the software. In Europe, for example, engines emitting less than 95 g/km of CO_2 receive substantial subsidies from the countries where the cars are sold.

With this software installed in its diesel cars, the Volkswagen group - and not only - has built its popularity on an ethically and morally incorrect, unprincipled basis, which has ultimately diminished it. The question is frequently raised in people's perceptions as to whether a Volkswagen giant committed illegalities in order to achieve world supremacy. In order to prevent further circumventions of existing legislation on vehicle type approvals, the EU has agreed and adopted new rules to strengthen and supervise the market for manufacturers of cars with polluting engines.

VI. THE STATE OF SALES OF CAR IN EUROPE

An According to the data presented in figure 1, in October 2023 there is a significant increase of +14,6% in new car sales and registrations (855,484 units)[15].

This is the fifteenth successive month of relevant double-digit percentage increases for three of Europe's largest car markets: France +21.9%, Italy +20% and Spain +18.1% [15]. Although these European countries have achieved great success in the car sales market, one of the strongest countries with an unrivalled car industry, Germany, has seen modest year-on-year growth of only 4.9%[15].

Figure 1 shows the growth trend for new cars in Europe from 2021-2023. In the first nine months of 2023, new car registrations in Europe increased by 16.7% (9 million units) [15].

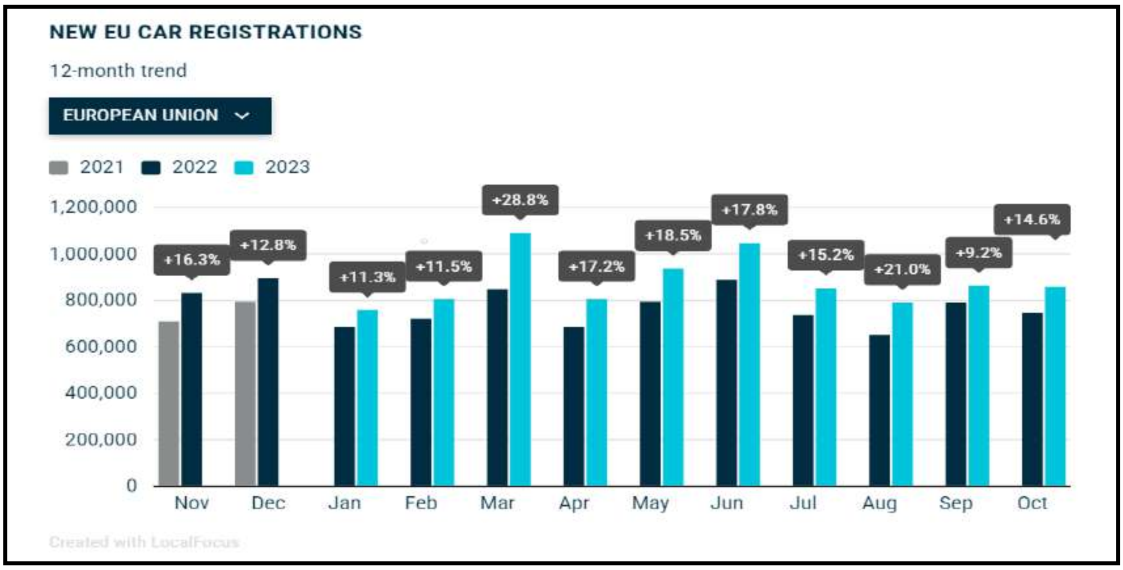

Figure 1. The growth trend for new cars in Europe from 2021-2023[15].

During this period, there were increases in registrations of new cars, with the exception of Hungary, where there was no significant increase. The largest markets with significant increases between January and September 2023 are Italy with +20.4%, Spain with +18.5%, France with +16.5% and Germany with +13.5%[15].

The preferred mode of transport for European drivers remains the gasoline-powered vehicle, which now dominates the car market, although this segment saw a decline of 33.4% in October 2023 (Figure 2).

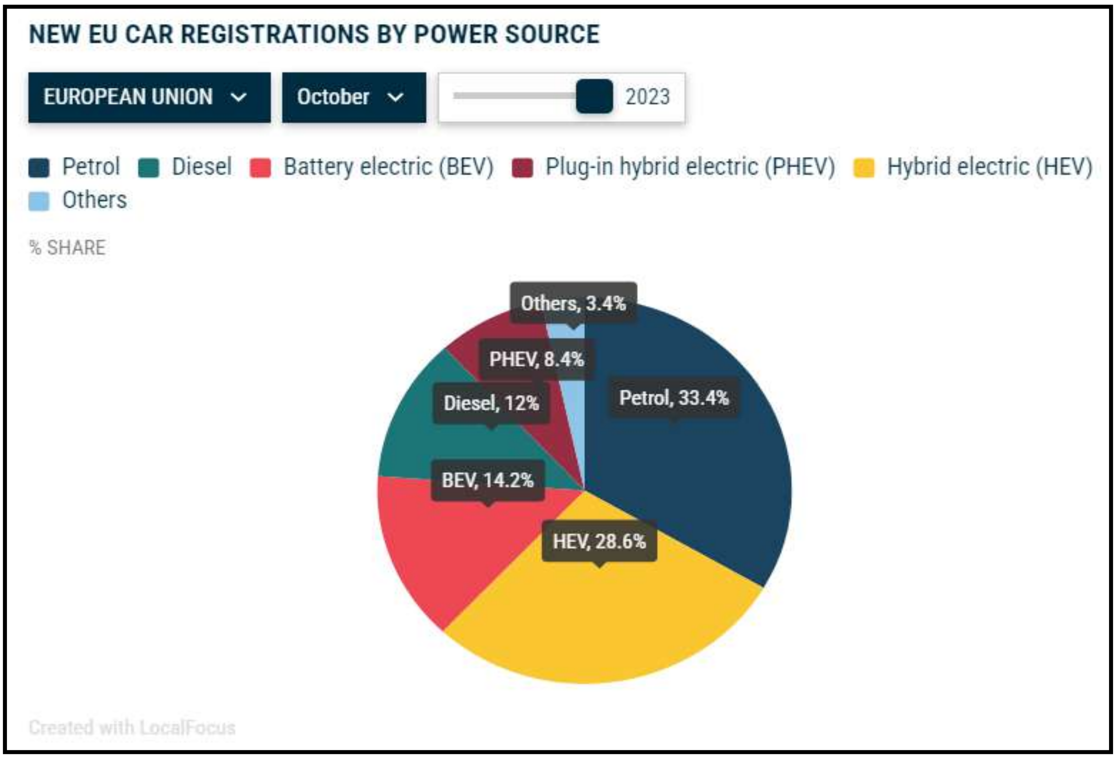

Figure 2.The situation of motor vehicle registration in European Union by power sources, on October 31, 2023[15].

Also from the graph shown in Figure 2, the European market share for hybrid electric vehicles (HEVs) increased by 28.6% and for plug-in hybrids (PHEVs) by 8.4%, all of which ranked second in sales after electric vehicles[15]. In the Romanian car market, sales increased by 36% in October 2023 for hybrid cars. In the first ten months of 2023 their market share in Romania increased by +30.1%.[15].

VII. CONCLUSIONS

The fundamental element that ensures the sustainability of change and is the solution to all road transport problems is innovation and technology. Current trends in the sustainable and sustainable development of this sector are the development of electric and hybrid vehicles, which will gradually replace combustion engine vehicles. Hybrid vehicles are the intermediary between thermal and electric vehicles. At present, the electric vehicle is the most efficient and viable replacement for the internal combustion engine vehicle. A sustainable and durable future of the road transport system cannot be ensured unless all sources of environmental pollution are limited or even eliminated.

The classic motor car has reached its peak - meaning decline is now upon us - while the electric car is winning the competition. More and more countries are banning the use of polluting cars. The imposition of ever higher taxes and charges for the use of such vehicles, the banning of low-pollution diesel vehicles (Euro 1-3) from certain areas of major European cities is not a random phenomenon, but an increasingly consistent reality. This is driving the citizens of those cities to move towards electromobility.

It is felt that the authorities of the European countries must legislate to force urban and interurban public transport organisations and freight and passenger transport operators to renew their fleets with new, modern, environmentally friendly vehicles, while at the same time taking measures to decommission and scrap old, polluting, physically and morally worn-out cars. To this end, it is necessary to tighten up environmental legislation on pollutants from the combustion engines of motor vehicles.

Until fossil fuels are exhausted and mankind has completely switched over to electromobility, it is very important to improve combustion processes and to design more efficient, high-performance catalytic converters (catalytic converters) for the use of cars with thermal engines in order to reduce chemical pollution as much as possible. It is also necessary to maintain or increase the value of eco-bonuses to the general public for the purchase of environmentally friendly vehicles, while at the same time eliminating the incentives offered for the purchase of internal combustion engine vehicles.

Efforts to popularise and educate the population in the field of electromobility must be stepped up. In order to make electric vehicles as attractive as possible to users, the authorities must increase the number of facilities for access and use of hybrid/electric vehicles (e.g. dedicated and free parking spaces, free or cheap electricity for charging, reduced or zero tax, dedicated traffic lanes, free and easy access in certain areas of cities, charging stations in home parking lots, extension of charging stations on all categories of roads, reduction of charging time, maintenance of advantageous eco-bonuses for customers when purchasing a new electric car, etc.).

It is also necessary to keep electricity prices low, gradually replace fossil liquid fuels used in conventional engines with environmentally friendly liquid fuels (biofuels), gradually switch from carbon-based fuel stations to electricity and hydrogen filling stations, and switch to the production and use of hydrogen-powered vehicles (fuel cells).

In order to meet its current mobility needs, mankind needs to invest rapidly in the power supply infrastructure for plug-in hybrids and electric cars, increase the power of charging stations, while increasing the range of electric cars through the use of new electric battery manufacturing technologies, which will increase the storage capacity of electric energy, thus solving the problem of inactivity due to the short range of electric cars. Plug-in hybrid propulsion systems are considered to be the transitional solution to new technologies, based on the electric vehicle with a REV unit, i.e. a vehicle equipped with a heat engine driving a generator to charge the electric traction battery, without participating in the actual propulsion of the vehicle.

Reducing the purchase price and weight of electric vehicles is more than necessary. This can be achieved by using cheaper and lighter materials (aluminium, polymers, carbon fibre, etc.) in the manufacturing process.

In order to become truly efficient, hybrid and electric vehicles need to increase the range of their electric batteries, the traction power of their motors and the efficiency of their generator charging.

In order to increase the reliability of environmentally friendly vehicles, high quality, original spare parts and materials must be used in the maintenance process, and maintenance work must be of very high quality and carried out within the time limits set by the manufacturer. These objectives can only be achieved by reducing costs, working times and training of electromobility specialists.

All these aspects are considered to improve the social, health and environmental conditions of people, the quality of service and management in road transport and, not least, road safety, ergonomics and comfort of modern environmentally friendly means of transport.

REFERENCES

[1] Descoperă.RO, „Science," 14 September 2007. [Interactiv]. Available: https://www.descopera.ro/stiinta/930366-automobilul-revolutia-continua. [Accesat 31 August 2023].

[2] A. Boroiu și A. Țîțu, Systems Reliability and Maintainability Management, Experimental Data Processing Collection., A. P. House, Ed., Bucharest, 2011.

[3] B. Grunwald, Theory, calculation and construction of engines for road vehicles. Revised and Completed. Second Edition., D. a. P. P. House, Ed., Bucharest, 1980.

[4] N. Nicolae, Thermodynamics and heat engines, D. a. P. P. House, Ed., Bucharest, 1971, p. 270.

[5] M. Babescu, Electric and hybrid vehicles, P. P. House, Ed., Bucharest, 2009, p. 278.

[6] Dexonline, „Dexonline," 2023. [Interactiv]. Available: https://dexonline.ro/definitie/electromobil. [Accesat 31 August 2023].

[7] R. Staunton, C. Ayers, J. Chiasson, T. Burress and L. Marlino, "Engineering Science and Technology Division," 16 May 2006. [Online]. Available: https://www.engr.uvic.ca/~mech459/Pub_References/890029.pdf. [Accessed 31 August 2023].

[8] E. Eckermann, World History of the Automobile (ilustrate publishing house), E. Society of Automotive Engineers, Ed., 2001.

[9] S. Boncu and A. Holman, "Traffic and urban environment sustainability," *Social Psichology*, vol. 25, pp. 87-101, 2010.

[10] F. Petrescu și R. Petrescu, Thermal engines (First edition), 2011.

[11] M. Eshani, Y. Gao and S. Gay, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles, Fundamentals Theory and Design," *CRC Press Ed*, 2005.

[12] C. Andreescu și D. Cruceru, „Recovery of the kinetic energy of motor vehicles.," *Auto Test Magazine*, vol. 115, pp. 10-12, 2006.

[13] G. Neamțu, Contributions on the integration of knowledge management in the sustainable development of road transport. Doctoral Thesis., Bucharest, Romania: National University of Science and Technology POLITEHNICA Bucharest, Faculty of Industrial Engineering and Robotics, 2023.

[14] G. Neamțu and A. Țîțu, "Level of atmospheric pollutions from the hybrid vehicle," in *New Technologies, Development and Application V - 8th International Conference NT-2022; 23-25 June*,, Sarajevo - Bosnia Herțegovina., 2022.

[15] ACEA, "News," 21 November 2023. [Online]. Available: https://www.acea.auto/pc-registrations/new-car-registrations-14-6-in-october-battery-electric-14-2-market-share/. [Accessed 07 December 2023].