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Tires for Electric and Hybrid Cars

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Abstract:
The scientific paper presents an original study and the authors personal opinions on the technic, economic and scientific acceptance of tires for electric and hybrid vehicles. From its context, readers can learn about changing automotive tire requirements, tire innovations and the latest tire technologies from leading tire manufacturers for the age of electromobility. Then, the main tread compounds in the composition of car tires and the latest trends in electric/hybrid vehicle sales in Europe and Romania are presented. At the end of the paper, a J. D. Power case study on the satisfaction of car owners with the tires they use is presented and the conclusions of the research are drawn.

Keywords: *electric and hybrid cars, technical parameters, rolling compounds, low friction, sales trend electric vehicles, case study.*

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I. INTRODUCTION

Both electric cars and low-emission hybrid cars are the progress towards sustainable and durable mobility of the modern road transport system, ensuring in the most efficient way possible the future mobility needs of humanity. It gives us new insights into hightech, sustainable tires that keep vehicles on the move for a zero emission future. While we don't really need to reinvent the wheel, we do need to rethink many aspects of the tire as we know it to ensure optimal performance. Electric and hybrid drive vehicles are heavier than conventional ones, put more torque on the road when moving, and ideally should be much quieter for passengers. Then, of course, there are the expectations everyone has of tires: safety on wet and dry roads, precise handling, short braking distances, prevention of hydroplaning, maximum mileage and, especially important for electric cars, very low rolling resistance. Increased weight means longer braking distance, instant torque means high tire wear. Compared to cars with internal combustion engines, electric propulsion technology reduces engine noise, emissions, maintenance and running costs. However, one consequence of the many benefits of electric vehicles is the significant increase in weight. Their batteries are heavy, and this weight puts additional strain on the tires of electric cars. The torque of electric cars also has a positive and a negative side. On the one hand, it means instant maximum torque and instant acceleration, but on the other hand, this instant torque puts extra pressure on the tire and tire wear.

II. LITERATURE REVIEW

Labeling of car tires in the European Union is done according to the provisions of Regulation EC/1222/2009 [1, pp. 46-58], which provides that all tires, whether summer, winter or all season, intended for use on passenger cars, light commercial vehicles, trucks, coaches and buses, and which were manufactured after July 1, 2012 and are sold in the European Union, must, starting from November 1, 2012, be required to bear a sticker or be accompanied by a label visible at the point of sale. From May 1, 2021, the energy label undergoes some changes, with the European Commission aiming to increase safety, as well as energy and environmental efficiency with the new (EU) regulation 2020/740 [2, p. 1].

New tires for trucks, coaches and buses do not necessarily have to be accompanied by a sticker or label, but the information should be available at the point of sale and online. The information should also be on the invoice or documents accompanying the tires. New features of the new labeling of car tires in line with EU requirements are [3]:

- Classes C1 (passenger car tires), C2 (light commercial vehicle tires) and C3 (heavy commercial vehicle tires) are introduced;
- A new pictogram in the shape of an ice pillar is introduced to indicate whether the tire has grip on ice valid for C1 (touring) tires;

- Tires adapted for snow will have the 3PMSF symbol (3PMSF) both on the label and on the sidewall of the tire;
- The adhesion and braking indicators are now divided into 5 classes (A to E);
- Classes are introduced for the rolling noise indicator (A, B and C) in addition to the decibel indicator;
- Under the new regulations, the label must also include the name of the tire manufacturer as well as a unique tire type identifier;
- It also introduces a QR code with a link to the European Database with explanations specific to the energy label – EPREL (European Product Registry Labelling) .

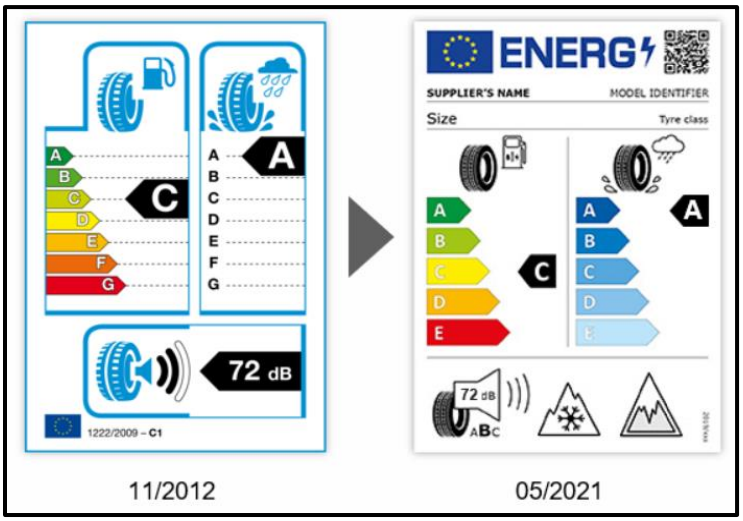

Figure 1. New tire labeling under EU rules [3].

The label information on car tires, as required by the new EU regulations, is as follows [3]:

A. Fuel efficiency class. The tire's fuel efficiency class or energy efficiency (fuel consumption and CO_2 emissions) is directly influenced by its rolling resistance. The rolling resistance of tires directly influences the fuel consumption of the vehicle in all types of transport. In terms of fuel consumption of a fully equipped vehicle, the difference between two grades, e.g. A and B, can be up to 3 l/100 km. Energy efficiency is measured according to the new European regulation, by measurements to be carried out on ramps. The grades awarded will correspond to the measured values expressed in kg/t. Grades may be A to E.

B. Wet adhesion class. Wet grip (braking test) is one of the most important benefits a tire offers. Wet braking testing involves measuring performance - on deceleration between 60 and 20 km in emergency braking. Between two grades, e.g. C and B, the braking distance decreases by 15%, or 4.5 meters, for a truck decelerating from 60 km/h to 20 km/h in 30 meters. At a speed of 80 km/h a car has a wet braking distance 6 m better when equipped with class A tires than with class C tires. The difference between A and E is 18 m. Here's how braking on wet surfaces is measured: data is collected on test tracks previously covered with a 0.5 - 2 mm layer of water. Ambient and soil temperatures can vary between 5-35 ºC. The characteristics of the test route (the material with which the test route is covered, the coefficient of friction on the asphalt, etc.) may also vary within the limits imposed by law. Vehicles recommended for testing may be both trucks fully equipped with tires of the type to be tested and vehicles designed specifically for testing (trailers). Grades may be A to E.

C. External rolling noise class and value. Rolling noise is taken into account to measure the level of exterior noise produced by the rolling of tires (exterior noise). All these factors influence the impact of transport on the environment and are becoming increasingly important, especially for the transport sector operating in urban environments. The noise classes change from the 3 lines into A, B and C.

D. Winter efficiency. In the new label, in addition to the 3PMSF symbol, we will also find an icon in the shape of an iceberg which indicates whether the tire provides adequate adhesion on ice.

III. TECHNICAL PARAMETERS TO BE CONSIDERED FOR ELECTRIC/HYBRID VEHICLE TIRES

Tire load index. Purchasing tires that can withstand the weight of electric vehicles is always important, but it is crucial when purchasing them. Effectively, due to the weight of electric vehicles, you may need a tire that can handle the additional weight. Sometimes a standard tire with additional load is sufficient.

Figure 2. ContiSilent technology [13]**.**

The noise. Electric cars are usually much quieter than vehicles with internal combustion engines. Therefore, the noise generated by tires interacting with the road is more important for users of electric or hybrid

vehicles. Thus, consideration should be given to choosing a tire that features a technology that can absorb rolling noise, such as ContiSilent™ (Figure 2), which uses a special foam layer inside the tire that can reduce interior noise by up to 9db.

IV. THE ROLLING COMPOUNDS IN CAR TIRES

While other tire components provide some of the overall tire performance, most of it comes from the tread area and the specific tread compound. This should come as no surprise, as the tread is the only part of the tire connected to the road. In the following I will present the compounds in the most important component of a car tire: the tread and the performance attributes of the tread compounds. The graph in Figure 3 shows the material distribution inside a tire: chemical components account for 84% of the total tire. Most of them are located within the tread compound to provide all the requirements expected from the tire tread. While other tire components provide some of the overall tire performance, the majority come from the tread area and the specific tread compound. This should come as no surprise, as the tread is the only part of the tire connected to the road. Each tread is generally divided into three components: the tread cover (ends), the tread base and the tread wings/sides (Figure 4). The tread base is the essential part as it creates a link between the tread and the tire casing. The tread is designed with a high grip property and binds well with the rubber casing on the belt or in the head. The tread cap is typically made with a higher-grip, abrasion-resistant rubber compound that works with the tread base and tread design to provide traction, rolling resistance and mileage. In rare cases, the tire's tread cap contains two different compounds placed horizontally/vertically (depending on performance expectations) relative to each other. The tread flange is the transition component between the tread and the sidewall. It connects the tread to the sidewall area of the tire. Similar to the tread base, the fender compound is adhesively designed to connect the tread area to the sidewall. While three-component treads are typical, some manufacturers are able to produce tires without a tread lug. The advantage of a treadless tire is ease of production: it can be extruded on a less advanced machine.

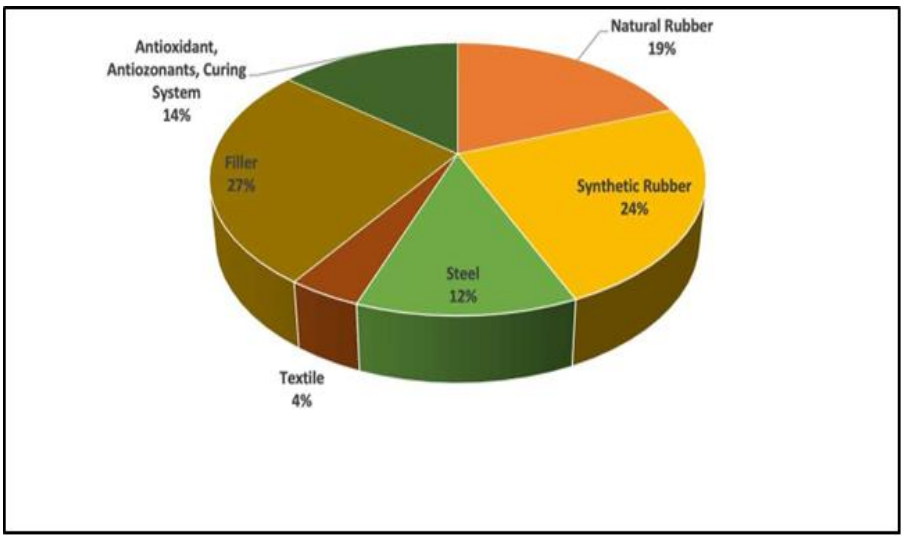

Figure 3. Material distribution inside a tire [4].

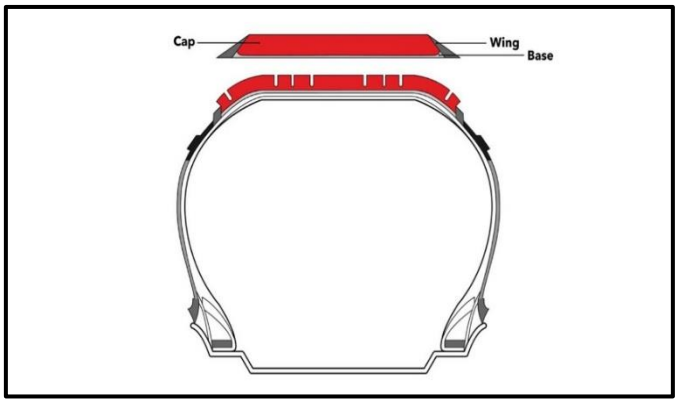

Figure 4. Material distribution inside a tire [4].

Since most performance characteristics are affected by tread compounds, engineers concentrate on wear, wet resistance, rolling resistance and resistance to cutting and chipping. When I refer to tread compounds, I'm probably referring to the tread cap, as it is the single component that contributes enormously to performance. A typical tread cap consists of natural rubber (NR), synthetic rubber (SBR), butadiene rubber (BR), filler (probably carbon black, silicon and/or both) and additives (usually oil, accelerating agent, conditioner, hardener, antiozonants and antioxidants).

Components in the structure of a car tire can be [4]:

- ***Natural rubber*** is produced from plants grown mainly in Southeast Asia and is classified as a polymer. It is an essential raw material used in the creation of over 40,000 products. The properties of natural

rubber include high strength and the ability to be stretched many times without breaking. Natural rubber compounds are highly flexible, good electrical insulators and are resistant to abrasions and cuts.

Table 1 highlights the advantages and disadvantages of natural rubber compared to other types of rubber shown in Tables 2 and 3.

Table 1. Natural rubber advantajes and disadvantages [4].

Advantage	**Disadvantage**
Tear strenght	Aging resistance
Wear resistance	Fatigue resistance
Impact resistance	Ozone resistance
Low-heat generation	Dispersion

Table 2. Styrene butadiene rubber advantages and disadvantages [4].

Advantage	**Disadvantage**
Quality and processing	Impact
Aging	Heat generation
Less surface friction	-

Table 3. Butadiene rubber advantages and disadvantages [4].

Advantage	**Disadvantage**
Impact resistance	Tear resistance
Wear resistance	-
Fatigue resistance	-

Table 4 show the typical formulation for a passenger tire.

Table 4. The typical formulation for a passenger tire [4].

Component of Tread	**PPHR**
Natural rubber	20
Butadiene rubber (BR)	25
Styrene butadiene rubber (SBR)	75
Silane	12.5
Silica	80
Carbon black	10
Oil	13
Zinc oxide	2.5
Sulfur	17
Other curling	3
Antiozonants	2

Synthetic rubber is an artificial elastomer. It is a by-product synthesized from petroleum. The first synthetic rubber was invented in 1910 and has been widely used in the tire industry since 1950. Both natural and synthetic rubber have high tear strength, good low-temperature flexibility and high tensile strength. Natural rubber has higher tensile strength, higher tear strength and low odor. At the same time, synthetic rubbers have excellent heat resistance and lower temperature resistance compared to natural rubber, making it beneficial for tire performance. The two main synthetic rubber polymers used in the manufacture of tires are butadiene rubber (BR) and styrene butadiene rubber (SBR). These polymers are used in combination with natural rubber. The physical and chemical properties of these rubber polymers (Tables 2 and 3) determine the performance of each tire component as well as the overall performance of the tire (rolling resistance, wear resistance and traction). In Table 4, it can be seen that 75 pphr of SBR and 25 pphr of BR can be used depending on the performance objective. The fillers are designed to fill microscopic holes in the tread compound and improve the overall performance of the tread compound. Carbon black and silicon are two of the fillers used in a typical tire. Both materials can improve tear strength, tensile strength and abrasion resistance, which ultimately improve wear and grip performance. Silica can also improve rolling resistance with minimal compromise. While carbon black is an effective filler and significantly improves the overall wear performance of a tread compound, it cannot improve the target conflict between wear, wet and rolling resistance.

However, silica can improve wet performance or rolling resistance without compromising wear. This is why performance and ultra-performance tires are silica-based compounds.

Having all the advantages of silica, it has a complex manufacturing process and poor performance in transmitting electrical energy. For tires with silica content of more than 50 parts (most UHP tires), the tread base will extend over the tire surface to maintain the transmission of electrical energy from the vehicle to the road. Figure 5 shows an example of this type of design.

- ***Additives.*** As mentioned earlier, different additives can be added to the tread cap for different performance characteristics.
- ***Antioxidants.*** Antioxidants, together with antiozonants and hardening systems, account for about 14% of a car tire. Antioxidants are necessary to prevent tire breakdown. They also protect tires from environmental factors such as exposure to different temperatures and oxygen.
- ***Antiozonants.*** An antiozonant is an organic compound that prevents or delays ozone damage. Most importantly it prevents the degradation of elastomers inside a tire.
- ***Balsams.*** Balsams are used to improve dispersion of fillings, to facilitate mixing and to reduce the viscosity of the green compound. The most common conditioners are oils, fatty acids or their mixtures. In recent years, tire companies have tried to replace synthetic oil with natural oil with some success.

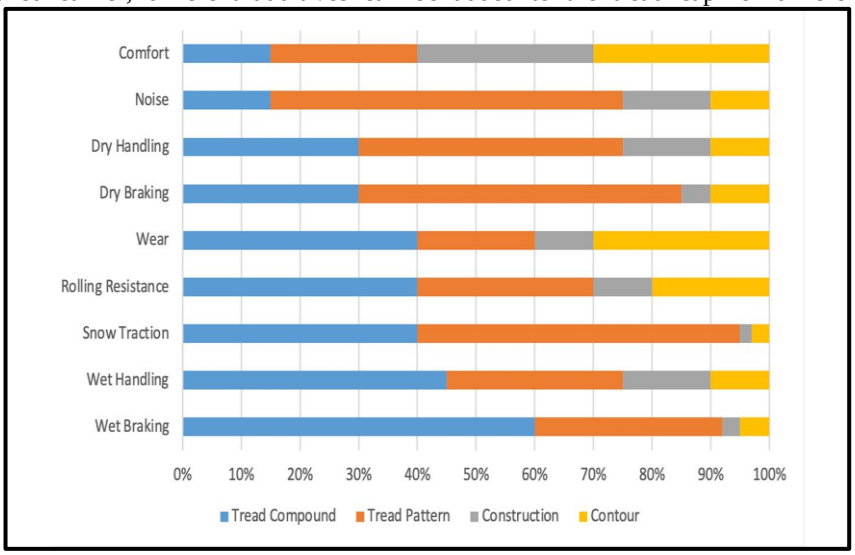

Figure 6. Performance attributes and contribution of each tire component [4].

- ***Hardening systems.*** The sulphur and zinc oxide are essential ingredients for the transformation of rubber into a tire during vulcanization or hardening. Hardening systems shorten the vulcanization time and affect the length and number of cross-links in the rubber matrix that are formed during the hardening or vulcanization of tyres. For example, according to the data shown in Table 4, a typical silica-based tire uses 4 pphr of antioxidants, 2 pphr of antiozonants, 13 pphr of oils (conditioner), and small amounts of hardening materials such as anhydride and zinc.
- ***Compound and performance tread.*** The expectations from the tread compound are high. Consumers want a safe tire - it stops in the right place at the right time. They want comfort inside the car, precise steering and good handling. They also like to save money at the gas station. Figure 6 shows the performance attributes and contribution of each tire component. As shown, most tire performance is influenced by tread compound, including traction, wear and fuel efficiency (rolling resistance).

V. THE DIFERENCE BETWEEN TIRES FOR ELECTRIC/HYBRID AND HEAT ENGINED VEHICLES

The difference between electric car tires and regular tires is huge. Hence the need to reinforce electric car tires so that they cope better with the higher braking and cornering forces. In particular, the sidewall of the tire is much stiffer, so an electric car tire deforms less when cornering. This ensures superior steering precision. Also due to the high mass of electric cars, hydroplaning is much reduced when passing through water. Because of this, the channels that drain water are narrower, which improves grip on dry roads as well as efficiency. This, in turn, is a key feature of an electric car, which is why tires designed for them have the lowest rolling resistance possible.

Another feature of electric cars is the nature of the electric motor - it has huge torque at low revs. This makes the demands on the drivetrain much more intense, and the tires have to provide both high durability and superior grip. Last but not least, rolling noises are much more annoying in an electric car, especially at city speeds (30-50 km/h). This is because engine noise is negligible and wind noise only becomes noticeable at higher speeds. Therefore, tires for electric cars have a layer of sound absorbing foam inside. Recently, however, the sound-absorbing treatment is also available on some tire designs for combustion cars. It is therefore not a good idea to fit a regular tire on an electric car. If you do, the car's handling will suffer, as will its range. In addition, it will wear out more quickly and offer diminished performance. But here's what happens if you try the opposite - fitting a tire designed for electric or hybrid cars on a car with a combustion engine. Not a good idea. Apart from the fact

that it will cost an unjustifiably high price, it will offer no significant advantages, only drawbacks. For example, the car's cornering performance will worsen significantly - the car's low mass and narrow drainage channels will cause the car to corner at much lower speeds, with dramatic consequences for safety. In addition, the higher sidewall stiffness will affect cornering grip. The only other advantage - reduced rolling noise - can also be found on a tire for combustion cars, if you opt for a model with sound absorbing foam.

VI. LOW FRICTION TIRES FOR ELECTRIC/HYBRID VEHICLES

We frequently ask if there are differences between EV tires and classic tires. The answer is yes. EV tires are specifically designed for electric or hybrid cars. Electric vehicle tires take into account battery weight, torque difference and rolling resistance to provide a better end-user experience. One of the first tires developed for electric cars is the Michelin e.Primacy. Thanks to good rolling resistance management, this profile offers 7% more range, i.e. about 30 km for a vehicle with a range of 400 km. Goodyear has recently introduced a tire called Goodyear ElectricDrive GT, specifically designed for use as a replacement tire on electric cars. This high-performance all-season tire offers an improved tread designed to be both durable and optimized for quieter driving. This new tire from Goodyear is specifically tailored to the unique requirements of electric cars and aims to deliver an optimal driving experience in terms of performance, durability and acoustic comfort. Continental with AllSeasonContact 2, Bridgestone with Ecopia EP500 and Hankook with IonEvo also offer European EV certified profiles.
The rolling resistance of a tire becomes even more important for electric cars. Tires with low rolling resistance can help extend the range of an electric vehicle by up to 12%, which is not too much for a car with a range of 130 km, but for newer cars with a range of over 400 km, a tire with an EU ”A” label could benefit from an extra 50 km of range per charge compared to a ”C” tire. Tire developers at Continental in Hanover took up the challenge and designed tires specifically for electric cars, buses and trucks.

The greater weight of these vehicles comes down to their batteries, which weigh more than a full tank of fuel for an internal combustion engine. Hybrid vehicles not only have an engine but also an electric motor, plus a fuel tank and powerful batteries on board. The extra weight is offset by the increased load-bearing capacity of the tire casing, as indicated on most of these tires by the XL symbol on the sidewall. This is also demonstrated by the higher load index of the tires. There are currently discussions within the industry to standardize tires with even higher load capacities, which would likely have an XL+ symbol. Maintaining the wear caused by high torque when running relatively low requires changes to both the tread pattern design and the compound used [5]. Very low rolling resistance is achieved by a mixture of tread compound, tire design and construction - and in particular the sidewall - as well as by keeping the overall weight to a minimum. An electric car is much quieter than a model with a combustion engine, so it is essential to minimize tyre rolling noise. This can be achieved by adding a foam compound to the tire, using what Continental calls ContiSilent technology. At its tire plant in Timisoara, Romania, tire maker Continental produces tires for electric cars. The ContiContact, made in Romania, offers not only low rolling resistance but also excellent braking performance and low noise emissions.

At first view, these special products look perfectly normal. The tread pattern and sidewall design, as well as the information on the sidewall, are similar to the conventional models. And since almost all these tires for electric and hybrid vehicles are original equipment versions, the mandatory and standard sidewall information is also joined by an OE (original equipment) code. Continental also produces tires for commercial vehicles, tailored to electric drive needs, such as the Conti Urban HA3 for electric line buses. Meanwhile, at the 2018 Frankfurt Motor Show, the company unveiled a prototype tire for electric trucks, with a specially designed tread pattern and sidewall. In keeping with the *"tall and narrow"* notion, wherever practical, large-diameter tires can help maintain rolling resistance. A 205/65 R 22 tire, for example, has a very low rolling resistance, just for the large size.

Figure 7. Electric vehicle (EV) tire marking [14]**.**

Continental's first tire for electric vehicles, the Conti.eContact, was originally introduced in 2012; this model is currently approved for use on the Smart EQ Forfour. Likewise, other model series developed to meet the requirements of electric vehicles and hybrids include the EcoContact 6 with its ultra-low rolling resistance and reliable performance - a popular choice as original equipment for electric and hybrid models. And Continental's portfolio

also includes the ultra-high-performance SportContact 5 - an energy-efficient tire for sportier electric cars such as the Tesla Model S. In total, Continental currently manufactures around 100 tire models suitable for electric and hybrid vehicles.

According to the author's research, the large American car manufacturer Tesla, predominantly uses tires from the following car tire manufacturers [6]:

- Michelin Pilot Sport 4S;
- Continental ProContact RX;
- Hankook Ventus S1 Evo3 (Figure 7);
- Pirelli Winter Sottozero 3;
- Michelin PS Cup 2;
- Michelin Primacy MXM4.

Depending on the size of the rims chosen at the initial order, the tire will be one of these patterns. Note that some of these tire profiles are profiles that also equip factory-built thermal vehicles. For easier recognition by users, tires fitted to electric/hybrid vehicles are marked as shown in Figure 7.

VII. ELECTRIC CAR SALES TREND IN THE EUROPEAN UNION

It is very important to consider this aspect because, whether the market for electric cars increases or decreases, sales fluctuations will exponentially influence the market for electric car tires, especially as a car uses two sets of tires according to European standards depending on the season (summer/winter). Interest in electric cars is waning among Europeans, who increasingly prefer hybrids.

Here are the best selling cars in Europe in 2024 [7]: After three years of uninterrupted growth, Europeans' interest in electric cars is starting to wane. Only 1.3% more electric vehicles were sold in 2024 compared to the same period in 2023. Interest in electric cars wanes. The removal of subsidies for the purchase of electric cars at the end of 2023 in Germany, the continent's largest market, has halted the growth of this type of motorization (Figure 8) [8], [9]. American brand Tesla, is still the market leader in electric cars. But the Model Y, which is the best-selling EV in Europe in 2024, is down more than 9% on the first half of last year. However, sales of electric cars have continued to grow in some major EU countries. For example, interest in EVs in France has increased, mainly due to the "social leasing" scheme. The share of electric cars has also increased in Italy and Belgium thanks to tax breaks for businesses.

Figure 8. German car sales trend in 2023 compared to 2024 [13]**.**

The European Commission plans to make electric cars the majority by 2035. Hybrids among EU's best-selling cars. More than 5.7 million new vehicles were sold in Europe in the first half of this year. This represents an increase of around 4.5% compared to the same period in 2023. However, sales are still far from pre-pandemic levels. However, hybrid-powered vehicles are seeing significant growth. More than 22% more hybrid cars were sold in the first 6 months of this year than in the first half of 2023.

The best selling cars in Europe in 2024 are hybrid models , which in the first half of the year had a now 29.2% share of the market. Which means that one in three cars sold had a combined electric and thermal engine. At the same time, sales of gasoline and diesel models continued to fall in most European countries, while in Germany and Italy they were on an upward trend, accounting for 35.3% and 12.9% of the market respectively. In this uncertain climate, hybrid pioneer Toyota topped the charts in the first half of the year (+20.7%), notably with the Yaris assembled in France, and its market share reached 7.8%, on a par with the Hyunday-Kia group. Volkswagen grew 4.1%, mainly thanks to its Skoda and Cupra brands. Stellantis (+0.5%), saw its market share fall to 18%, mainly due to lower sales at Peugeot. The Renault group is up slightly (+2%), thanks to its Dacia and Alpine brands.

VIII. ELECTRIC CAR SALES TREND IN ROMANIA

Statistics show that in July 2024 Romanians bought up to 68% fewer electric cars compared to last year, blamed on inflated prices and the lack of a social aid such as RablaPlus of more than €10,000 as it was until last year. According to the data the best-selling electric car in July was the Tesla Model 3, with 168 units, up 15% on last year. The Dacia Spring, which has dominated the market for the past two years, was only the second best-selling electric car with 67 units sold and a 92% decline. In third place was the Hyundai Kona, with 56 units. Dacia has a decline of -16%, Toyota (up 9%) and Hyundai (up 40.2%), while the best-selling models were Logan (down -4.2%), Duster (up 24.5%) and Sandero (down -13.6%). The electric segment in Romania becomes irrelevant if we look at the sales figures which are in a continuous decline in the first 6 months of 2024. Despite these decreases, 4,962 electric cars were registered in Romania in the first four months of 2024. In three of the four months of 2024 analyzed in this report, there was an increase in electric vehicle registrations compared to each corresponding month in 2023.

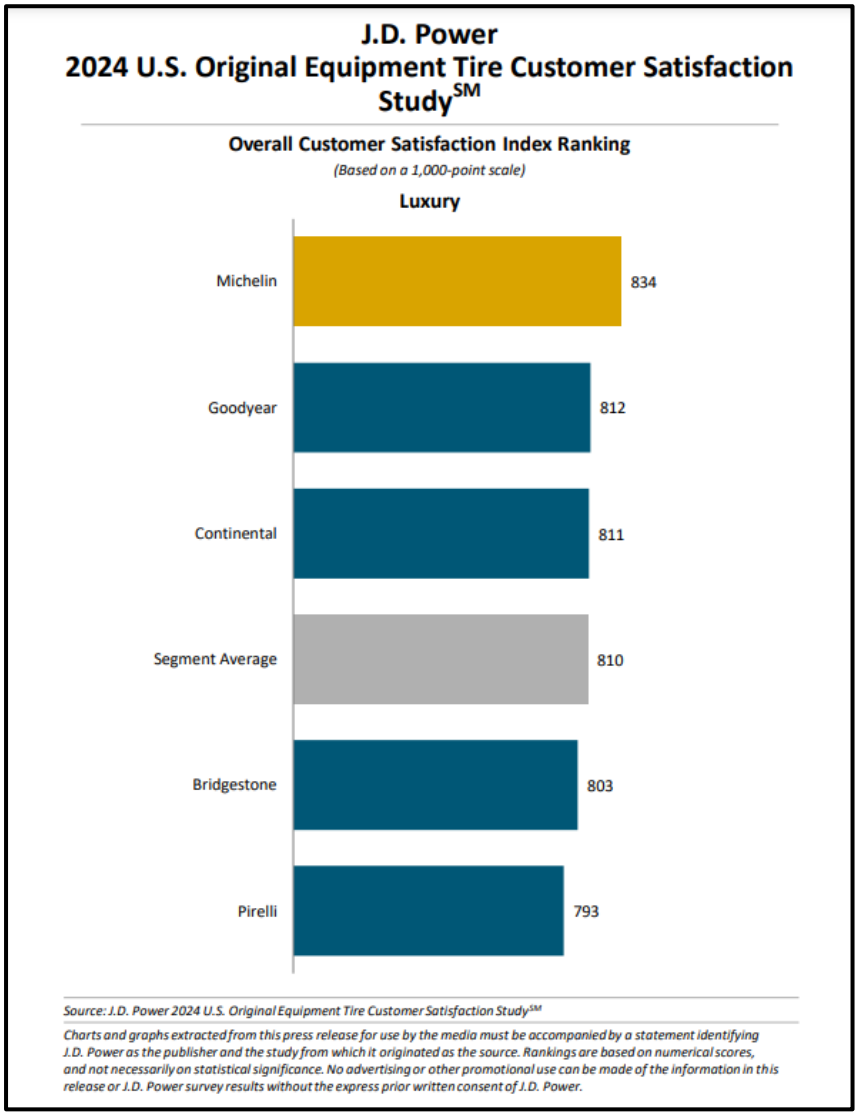

Figure 9. J.D. Power 2024 U.S. Original equipment tire customer satisfaction study℠ luxury [12]**.**

The month of March 2024 is an exception, with 853 electric cars registered compared to 1,137 in March 2023. However, the trend of electrification of the car fleet in Romania remains on an upward trend. The first month of the year saw a 60% increase in sales compared to January 2024, followed by a moderate increase in February 2024, up 17% compared to February 2023. March 2024 saw a 25% drop in registrations compared to March 2023, but April of this year again brought a 1.7% increase compared to the same month in 2023. Thus, 4,962 electric cars were registered in the first four months of 2024, including 276 LCVs. Overall, however, the top three positions remain unchanged. The Dacia Spring remains the leader in purchases made by Romanian drivers who have decided to use an electric vehicle, with 1,490 vehicles registered in the first four months of the year, representing 30% of all electric cars registered in 2024. In second and third place in the top rankings are the Tesla Model 3 and Tesla Model Y. For the first time, the month of April brought another electric vehicle close to the podium in addition to the already established three, namely the Renault Megane E-Tech, which had 53 registrations, compared to 59 for the Model Y.

IX. J.D. POVER, DRIVER SATISFACTION WITH IN SERVICE TIRES. CASE STUDY

J.D. Power an american data analytics, software, and consumer intelligence company founded in 1968, released a study [10] on car owners' satisfaction with the tires they run. One part of this study addresses a less mentioned issue, namely that owners of electric cars are generally surprised at how quickly tires wear out on

their cars, while they expect them to have a similar life expectancy to those on combustion cars. The satisfaction gap with original equipment tires between electric vehicles (EVs) and gas-powered vehicles is widening, as EV owners say their tires are wearing faster, according to the J.D. Power 2024 U.S. Original Equipment Tire Customer Satisfaction Study,[SM] released today. The study shows that EV owners have similar expectations of tire wear as do owners of gas-powered vehicles, despite EV tires naturally wearing faster due to greater vehicle weight and higher torque.

The widening satisfaction gap between EVs and gas-powered vehicles highlight an opportunity for tire manufacturers and automakers to educate EV owners on the differences in performance, said Ashley Edgar, senior director of benchmarking and alternative mobility at J.D. Power. Additionally, because of the inherit conflict of maximizing vehicle range and optimizing tire wear for EVs, tire manufacturers and automakers need to work together to overcome the challenge without completely sacrificing tire performance in other areas, especially as the EV market continues to increase [10].

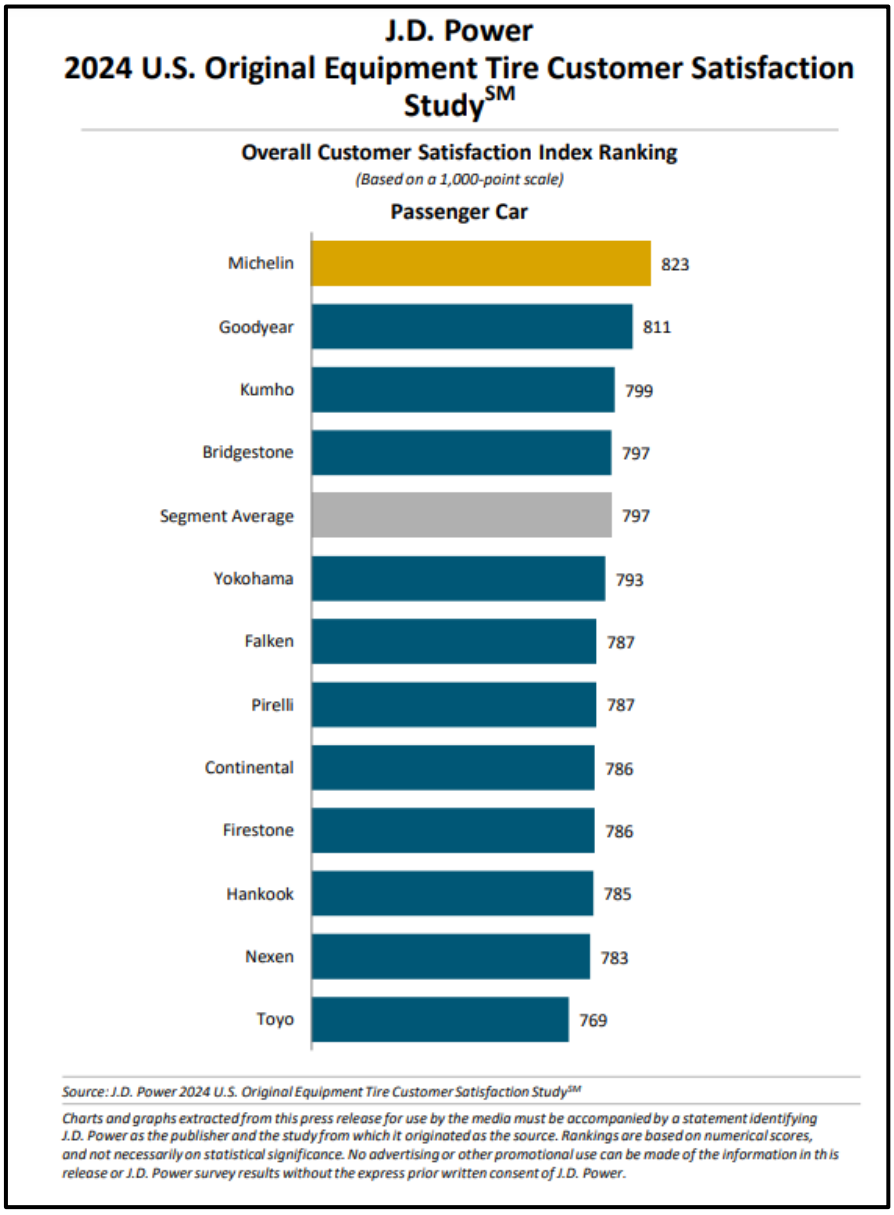

Figure 10. J.D. Power 2024 U.S. Original equipment tire customer satisfaction study[SM] passenger car [12].

J.D. Power says the big problem is the lack of awareness among electric car owners that their cars can naturally generate more accelerated tire wear, and that this is due to the heavier weight of these cars and the higher torque delivered instantly to the wheels that causes this wear. Some very heavy and very powerful cars, such as the Rivian R1T and R1S, can in some cases generate complete tire wear in as little as 6,000 miles, the equivalent of 10,000 km, a CDK Global study indicated earlier [11]. At this rate, changing tires on electric cars is similar to changing the oil in gasoline-engined cars, the study concluded at the time [11]. They indicate in the second part of the study that tires specifically designed for electric cars would be less susceptible to accelerated wear, as their manufacturers put in different rubber compounds that are more resistant to the weight and high torque applied to the contact patch. Several manufacturers already have such tires, they are usually more expensive, but their longer life on electric cars ensures that the investment pays off. It is suggested that electric cars need special tires. Partially, judging physically, it's true on very heavy cars, around 2.5 tons and more, and in our world there are many electric cars that weigh 2.7-2.8 tons and more in their own mass. Yes, the high weight can cause them to wear accelerated, and on a Rivian of 3.1 tons dead weight it's really likely that regular tires will wear faster [10]. In lighter electric cars, however, the difference should be

smaller. The problem with accelerated wear and tear in many electric cars to date has been the lack of proper torque management when starting off, even in compact city cars. For example, the first-generation Fiat 500e was notorious for hissing under almost all hard acceleration without the car counteracting this effect, and this inevitably led to a situation where within a year the front tires were completely worn out, even if you didn't overdo it at the driving pace. And in general, intense acceleration will naturally lead to faster wear, as the high torque has to be transferred somehow to the asphalt. The problem can be avoided by more tempered acceleration, at least as a general average, or, if the car still performs like the super sporty combustion versions of yesteryear, the owner will have to accept that the tires will also need to be changed more often, just as they do on those more powerful combustion models. So, many electric cars may experience faster tire wear, which is perfectly explainable physically, but can also be minimized by driving style. JD Power's study, however, puts more emphasis on the fact that an overwhelming number of the more than 31,000 owners who were surveyed responded that they expect their tires to last as long as combustion cars.

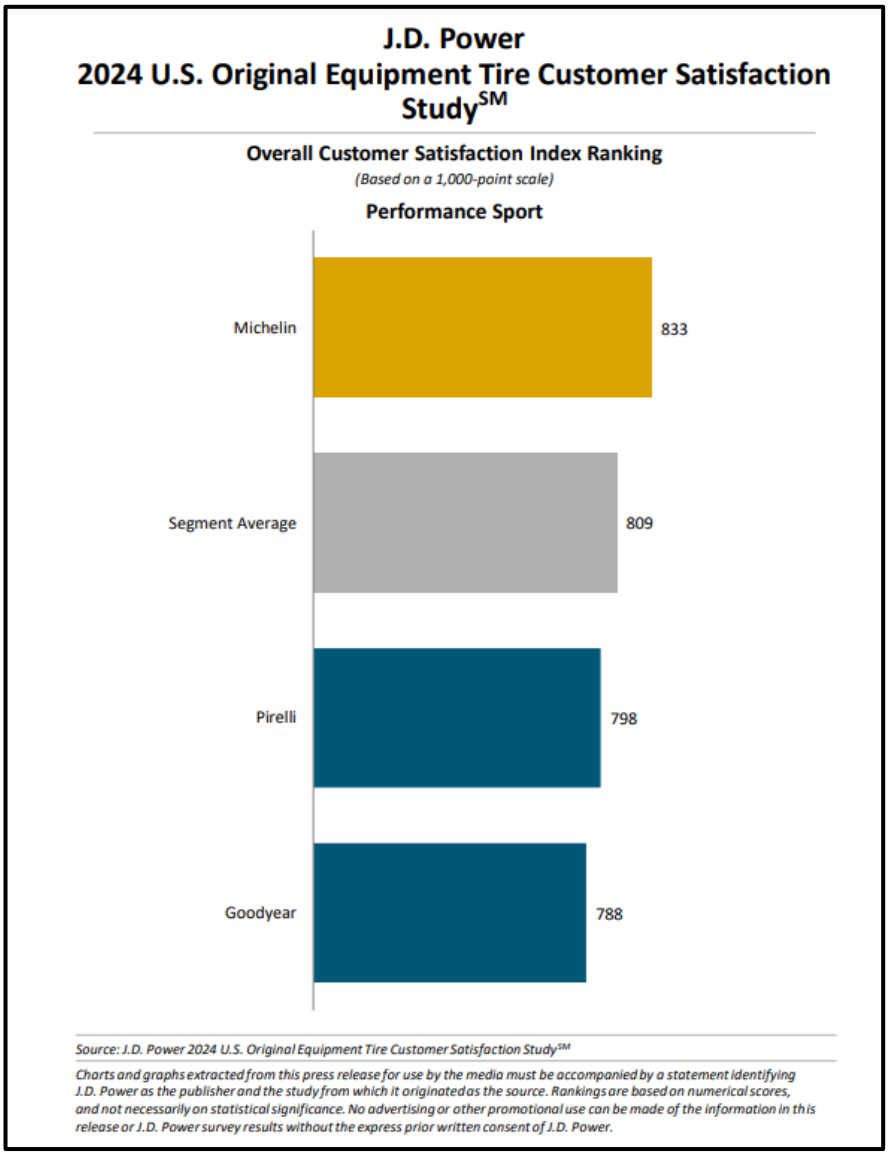

Figure 11. J.D. Power 2024 U.S. Original equipment tire customer satisfaction study℠ performance sport [12]**.**

New-vehicle owners today expect more than the absence of tire problems. They also have high expectations for tire appearance and performance, such as tire wear and ride. But to exceed owner expectations, what other considerations should tire manufacturers and original equipment manufacturers (OEMs) also incorporate into their products?

The Solution [12]: the J.D. Power U.S. Original Equipment Tire Customer Satisfaction Study℠ provides insight into new-vehicle owners' satisfaction with their original equipment tires after 1 and 2 years in service. The study examines overall customer satisfaction with tires, as well as tire problems experienced, relative importance of tire attributes, tire replacement behavior, and recommendation and repurchase intentions of vehicle owners.

The Benefits [12]: subscription to this study will provide tire manufacturers and OEMs with overall industry-level information, as well as by vehicle segment, tire brand, OEM, and individual model.

Study information includes [12]:

- Product strengths/weaknesses for each brand, both in owner satisfaction and quality;
- Performance variations by OEM and tire brand for each OEM;
- Impact of owners' experiences with original equipment tires on repurchase intention;

- Tire brand/product recommendation;
- Owners' impressions of tire brands;
- Tire Pressure Monitoring System (TPMS) incidence rates and behaviors

2025 Key Dates;

- Fielding: July - December 2024;
- Publish: March 19, 2025;
- Press Release: March 20, 2025.

Press Release & Award Information [12]: awards will be presented to the highest-ranked tire brand in each of four vehicle-based tire segments: Luxury, Passenger Car, Performance Sport, and Truck/Utility. We'll continue to rank brands based on the second year of ownership.

Award recipients are recognized in vehicle-based tire segments based on the different needs of customers in each segment. As a result, index weights for the index factors Tire Ride, Tire Traction/Handling, Tire Wear, and Tire Appearance are different for each of the four award segments.

Luxury [12]: Compact Premium Car; Compact Premium SUV; Large Premium Car; Midsize Premium Car; Midsize Premium SUV; Small Premium Car; Small Premium SUV (Figure 9).

Passenger Car [12]: City Car; Compact Car; Compact MPV; Compact SUV; Large Car; Midsize Car; Midsize SUV; Minivan; Small Car; Small SUV (Figure 10).

Performance Sport [12]: Compact Premium Sporty Car; Compact Sporty Car; Midsize Premium Sporty Car; Midsize Sporty Car (Figure 11).

Truck/Utility [12]: Large Heavy Duty Pickup; Large Light Duty Pickup; Large Premium SUV; Large SUV; Midsize Pickup.

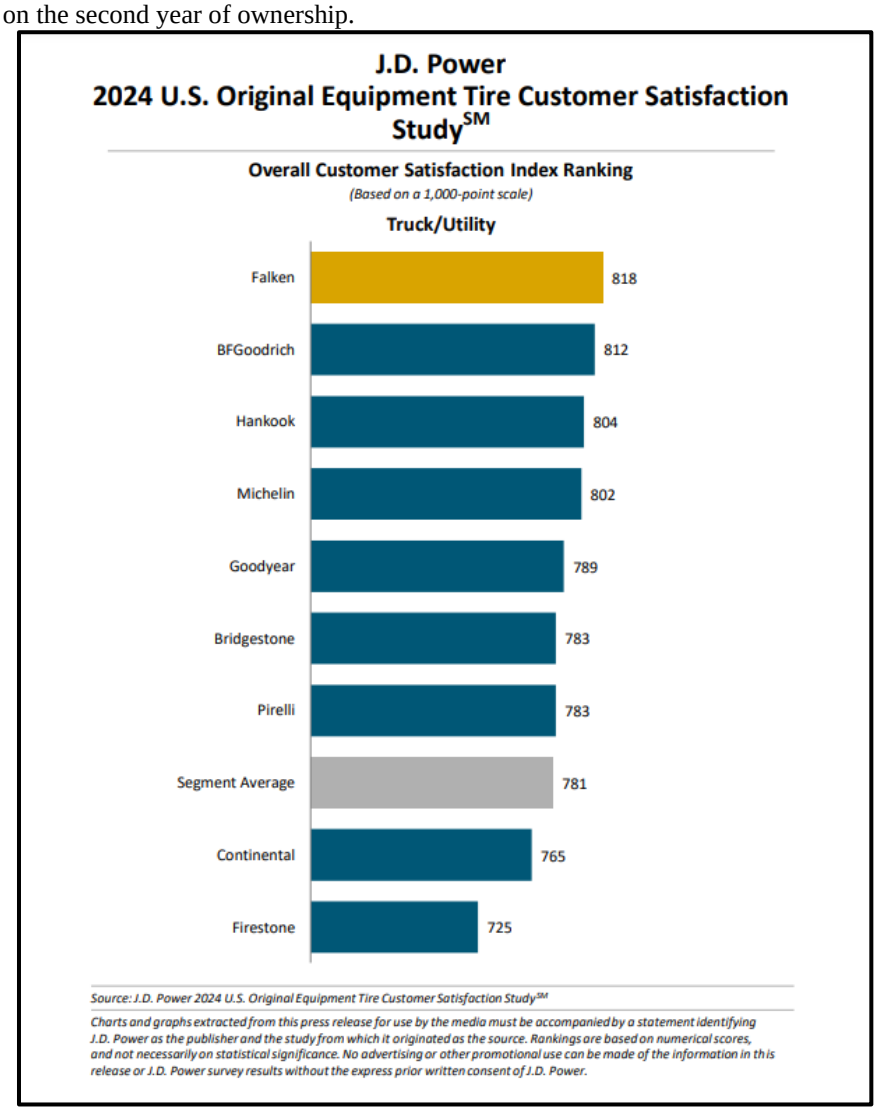

Figure 12. J.D. Power 2024 U.S. Original equipment tire customer satisfaction study℠ truck/utility [12].

Profiled Brands [12]: These brands are intended to be profiled in the 2025 study by BFGoodrich; Bridgestone; Continental; Cooper; Dunlop; Falken; Firestone; General; Giti; Goodyear; Hankook; Kumho; Michelin; Nexen; Nitto; Pirelli; Toyo; Vogue; Yokohama (Figure 12).

Study Rankings show that [10]:

- Michelin ranks highest in the luxury segment (Figure 9) for a 21st consecutive year, with a score of 834. Goodyear (812) ranks second and Continental (811) ranks third;
- Michelin ranks highest in the passenger car segment (Figure 10) with a score of 823. Goodyear (811) ranks second, followed by Kumho (799) ranks third;
- Michelin ranks highest in the performance sport segment (Figure 11) with a score of 833;

- Falken ranks highest in the truck/utility segment (Figure 12) with a score of 818. BFGoodrich (812) ranks second and Hankook (804) ranks third;

X. CONCLUSIONS

The tires that equip electric or hybrid vehicles are the only point of contact between the vehicle and the road, making them a critical factor in ensuring a safe and enjoyable driving experience. From improving safety and extending tire life to improving fuel efficiency and providing a smoother ride, the benefits of proper tire pressure are crucial. To increase the longevity of EV tires, maintenance is particularly important. As with other tires, you should regularly check the air pressure of your electric vehicle tires and adjust them if necessary. Proper wheel alignment will reduce tire wear and should be checked every 6 months, or sooner if you hit a curb, pothole or other obstacle. An expert can check for excessive wear, especially on the inside edge of the tire, and recommend aligning or rotating as necessary.

A major factor to consider when it comes to electric vehicle tires is energy efficiency. Because electric vehicles rely on battery power, it's important to minimize energy consumption to maximize driving range. Special low rolling resistance tires can help reduce energy consumption and increase the distance an electric vehicle can travel on a single charge. These tyres are designed to minimize the amount of energy needed to move the vehicle, which can help extend the vehicle's range and reduce the total cost of ownership. Another important factor to consider when it comes to electric vehicle tires is weight. Electric vehicles are typically heavier than their gasoline counterparts due to the extra weight of the batteries. This means that tires must be able to handle the extra weight and provide sufficient support and stability. Specialized electric vehicle tires are designed with this in mind, using materials and construction techniques that can withstand the increased weight and provide a smooth and comfortable.

There are other factors to take into account when it comes to choosing tires for electric cars: wet and dry grip, noise and ride comfort can all be important considerations, but in the end, the most important criterion is still wear (the resistance to tread erosion). Some electric vehicle tires are even designed with specific performance characteristics in mind, such as increased grip for sportier handling or increased stability for a more comfortable ride. Specialized electric vehicle tires are designed with this in mind, using materials and construction techniques that can withstand the increased weight and provide a smooth and comfortable ride.alignment or rotation, as appropriate.

Continental develops innovative technologies and services for the sustainable and interconnected mobility of people and their goods. The technology company founded in 1871 provides safe, efficient, smart and affordable solutions for vehicles, cars, traffic and transportation. Continental achieved sales of €44.5 billion in 2019 and currently employs more than 230,000 people in 59 countries and markets.

Between 1999-2019, Continental invested around € 1.8 billion in its Romanian activities. All 5 Continental business areas are represented in Romania. Continental has seven production facilities and four engineering centers in Timișoara, Sibiu, Carei, Nădab, Brașov and Iași. Continental is a partner in a joint venture in Iasi and has a tire distribution center in Bucharest. Continental had about 20,000 employees at the end of 2019, a third of whom are engineers and computer scientists in its research and development centers, and will continue to hire as future projects come on stream.

With equivalent use, electric and hybrid car tires do not wear out faster than thermal car tires. Some drivers may have this impression in dynamic driving. The weight of the vehicle and the high torque available on electric cars can test the tire rubber.

The lifespan of an electric vehicle tire can vary depending on its use. In general, the lifespan of an electric vehicle tire is the same as for a thermal vehicle, i.e. 30,000 to 60,000 kilometers. To maximize the life of electric car tires, check tire pressure regularly and prefer straight starts. Retreaded tires can be used on the electric car. Most road car users think that tires wear out much faster on electric vehicles than on conventional ones. In reality, as always, this depends on several criteria related to driving style. Tests have shown that in a similar comparison, electric vehicles with 2-wheel drive systems can reduce tire mileage by a quarter, but with 4-wheel drive electric vehicles, tires last 10% longer. Laboratory tests have shown that the biggest impact on tire wear will always be the driver and the style (mode) in which he or she drives the vehicle. Sporty driving wears out tires whether you are driving an electric vehicle or not, so the benefits of rolling resistance or traction can easily be negated. If possible, replace your tires with original equipment models that were not just designed for the needs of electric vehicles, but were specifically made to fit the exact model you drive.

When repairing a tire intended for electric or hybrid vehicles, it is possible to repair the tire with a plug. As with a conventional tire, for the damage to be repairable, it must be located on the tread. In the case of sidewall damage, tires are not repairable. In any case, it is important to consult a professional.

Normal tires are not recommended for electric and hybrid cars. That's why tires for electric cars need stronger sidewalls to cope with the weight. These special tires also reduce interior noise by up to 40% and rolling resistance by 20%. The same is true of hybrid cars, which have at least one electric motor in addition to the

conventional engine, plus a fuel tank and powerful batteries on board. The extra weight is offset by the increased load-bearing capacity of the tire casing. In addition, they are designed to have a lower rolling resistance.Some of these tires have a special foam strip inside for increased noise comfort. Because of these special features, tires for an electric car are more costly than normal rubber.

Specialized tires for electric vehicles can help improve energy efficiency, increase driving range and make your ride more comfortable and stable. By selecting the right tires, you can ensure that your electric vehicle performs at its best and delivers a smooth and enjoyable driving experience.

Dacia Spring is still the most popular electric car in Romania, with a total of 17,350 registrations, representing approx. 39% of the total electrified car fleet in the country.

The decrease in eco-bonuses by the governments of European countries, which are still considered as a substantial help for the population when buying a new electric car, is the main reason for the decrease in purchasing power and consequently the decrease in the sales trend of electric and hybrid cars. This aspect puts a negative imprint on the sustainable and sustainable development of mankind's transition to electromobility.

Regarding the case study J.D. Power, the U.S. Original Equipment Tire Customer Satisfaction Study measures tire owner satisfaction in four areas (in order of importance): tire ride; tire wear; tire traction/handling; and tire appearance. The study includes four vehicle segments: luxury; passenger car; performance sport; and truck/utility. The study is based on responses from 31,414 owners of 2022 and 2023 model-year vehicles and was fielded from August through December 2023.

REFERENCES

[1] E. Parliament, "REGULATION (EC) No 1222/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2009 on the labelling of tyres with respect to fuel efficiency and other essential parameters (Text with EEA relevance)," *Official Journal of the European Union,* vol. L 342, pp. 46-58, 22 December 2009.

[2] E. Parliament, „REGULATION (EU) 2020/740 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of May 25, 2020 on the labeling of tyres with respect to fuel efficiency and other parameters, amending Regulation (EU) 2017/1369 and repealing Regulation (EC) No 1222/2009," *Official Journal of the European Union,* vol. L 177, p. 1, June 5, 2020.

[3] Anvelopeshop.ro, „New tire labeling," Anvelopeshop.ro, 2021. [Interactiv]. Available: https://www.anveloshop.ro/etichetare-anvelope. [Accessed August 21, 2024].

[4] Anvelope.ro, „The science behind tread compounds on passenger tires," Anvelope.ro, 26 August 2021. [Interactiv]. Available: https://www.anvelope.ro/blog/compusi-de-rulare.htm?srsltid=AfmBOooACdL2UKaBgjSHMV8bmxRUON2L1MTJPxRDoMtGxq8ee6V1dGsj. [Accessed August 21, 2024].

[5] A. Schlenke, Interviewee, *Special tires for electric cars.* [Interviu]. August 20, 2020.

[6] Anvelopelider.ro, „Buying tires for electric vehicles (EVs) and hybrids," Anvelopelider.ro, 2024. [Interactiv]. Available: https://www.anvelopelider.ro/anvelope-masini-electrice-hibride. [Accessed August 21, 2024].

[7] R. Țuțulan, Promotor.ro, 18 July 2024. [Interactiv]. Available: https://www.promotor.ro/stiri-auto/care-sunt-cele-mai-vandute-masini-din-europa-in-2024. [Accessed August 21, 2024].

[8] LeFigaro.fr, „La part des voitures électriques neuves recule encore en Europe," Le Figaro.fr, 2024 July 2024. [Interactiv]. Available: https://www.lefigaro.fr/conjoncture/la-part-des-voitures-electriques-neuves-recule-encore-en-europe-20240718. [Accessed August 24, 2024].

[9] Autolatest.ro, „The electric car market in Romania is collapsing! Sales in July are 68% lower than last year," Autolatest.ro, 06 August 2024. [Interactiv]. Available: https://autolatest.ro/stiri/piata-de-masini-electrice-din-romania-este-in-colaps-vanzarile-din-iulie-sunt-cu-68-mai-mici-fata-de-cele-de-anul-trecut/. [Accessed August 21, 2024].

[10] J.D.POWER, "EV Owners Uninformed of Faster Tire Wear, Leading to Lower Satisfaction, J.D. Power Finds," J.D. POWER, 25 March 2024. [Online]. Available: https://www.jdpower.com/business/press-releases/2024-us-original-equipment-tire-customer-satisfaction-study. [Accessed August 21, 2024].

[11] C. Global, "EV Service: Today and Tomorrow," CDK Global, 31 October 2023. [Online]. Available: https://www.cdkglobal.com/insights/ev-service-today-and-tomorrow. [Accessed August 21, 2024].

[12] J.D.POWER, „U.S. Original Equipment Tire Customer Satisfaction Study," J.D.POWER, 07 July 2024. [Interactiv]. Available: https://www.jdpower.com/business/automotive/us-original-equipment-tire-customer-satisfaction-study. [Accessed August 21, 2024].

[13] Continental, „Special tires for electric cars. News," Continental, 20 August 2020. [Interactiv]. Available: https://www.continental.com/ro-ro/presa/comunicate-de-presa/anvelope-speciale-pentru-masinile-cu-tractiune-electrica/. [Accessed August 21, 2024].

[14] PiataAuto.md, „Electric car owners surprised by how quickly their tires wear out, JD Power study shows," PiataAuto.md, 03 April 2024. [Interactiv]. Available: https://piataauto.md/Stiri/2024/04/Proprietarii-de-masini-electrice-sunt-surprinsi-de-cat-de-repede-se-uzeaza-anvelopele-lor-indica-un-studiu-JD-Power/. [Accessed August 21, 2024].