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THE AUTOMOTIVE INDUSTRY: ACCELERATING TOWARDS A MORE SUSTAINABLE FUTURE?

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Introduction

The automotive industry has shaped social, cultural, and economic history from the 1920's to the present days. The automotive sector has been the privileged place of experimentation and generalization of technological innovations and new forms of labor organization, such as Fordism[1], Sloanism[2] and Toyotism[3].

Since the first half of the 1900's the automobile has a been part of our everyday life; we use it to go to work, to go grocery shopping, to travel and it has become an essential for every family. In current times it is important that the industry can adapt and keep up with the evolution of the economy and society.

The automobile's main source of power has always been fossil fuels such as gasoline, diesel, LPG, and methane; however, in recent times due to the climate crisis and the elevated level of pollution produced by vehicles there has been the introduction of green options which minimize the emissions of CO2 (such as electric and hydrogen cars).

The climate change is a very serious issue which affects our world in its entirety.

Due to the Industrial Revolution the level of pollution has inevitably risen, leaving the current and future generations hopeless faced with the prospect of a miserable and gray future.

One of the main goals of our society is to build a green future instead of a gray one, and in order to do so each area of the industry is committed towards the use and introduction of new and sustainable technologies.

The following chapters will discuss the evolution of the automobile industry through time and the technologies available today to reach the goal of a sustainable future.

In particular, the document is divided in three chapters that address three different macro areas of the subject: analysis of the automotive industry, prices and customer preferences, and availability and prices of green fueled automobiles.

The first chapter provides a detailed background of the industry through an historical overview which will be followed by an analysis of the industry nowadays.

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[1] System of industrial organization and policy, implemented in 1913 by Henry Ford in the automobile factory he founded, the Ford Motor Company, which, based on the principles of Taylorism, aimed to increase production efficiency through rigorous planning of individual operations and stages of production, widespread use of the assembly line, a complex of labor incentives (higher wages, reduced working hours, etc.).

[2] Also known as "flexible mass production," refers to the modification of Fordism implemented by Alfred P. Sloan (president of General Motors from 1923) when he offered new models each year, and different makes, models, and prices for different niches in the market.

[3] In the organization of industrial production, a method that emphasizes stock reduction, lean production and quality control

The second chapter focuses on the availability of raw materials, the prices of the different fuels options and customer preferences, including a practical example of the average consumer when deciding on buying a city car.
The third and last chapter shifts focus on electric automobiles, comparing costs and performances with hybrid and gasoline options.
Overall the aim of the paper is to provide a complete picture of the automobile sector, showing how the climate crisis has influenced and continues to influence customer preferences, and comparing the more convenient options available in the market with a fair trade-off between price and sustainability.

CHAPTER 1: The automotive industry

1.1 Automotive industry background

Since its birth, the automotive industry is in constant evolution and is deeply linked to the economies of many countries.

During the first few decades of the 1900s, the United States was a country in economic growth, and many automotive industries were born in that period taking advantage of the favorable economy.

An example is the “Ford Motor Company” which understood the importance of the automobile in a rapidly developing country. In particular, the founder, Henry Ford, decided to design and market the “Model-T”, a car model accessible to all for its low cost, creating for the first time in history the phenomenon of “mass cars” and forever changing the global economy. Ford's car was a real success, thanks to the new production processes conceived by Ford himself, it was possible to bring its initial cost of 850 dollars up to 260 dollars, about 3000 euros today, and this effectively made the car a large-scale commercial product.

In the last decade of the 1800s, the automotive industry was already present in Europe with models based on carriages. In the 1900s more versatile and practical automobile models began to be produced, but the industry did not follow Ford’s steps. In Europe, automobiles were not a mass market product; they had higher costs than the US and could only be afforded by the wealthy elite created by the second industrial revolution.

During World War I automotive industries suffered a great halt, especially in Europe, but the conversion of production for this type of industry is quite simple, and, as the armies of the states involved in the "Great War", they equipped themselves with cars to create the so-called motorized troops.

The great evolution of the automotive industry is sensed especially in the first half of the 1900s which showed how it was able to both adapt to and influence historical events. The economic crisis of 1929-1933 caused many industries to fail, the car manufacturing industry suffered a decrease in production but it was able to adapt and survive in the market. With the rise of totalitarian systems in Europe, fascist and Nazi parties requested the creation and marketing of low-cost models of automobiles, in the form of pure propaganda in order to equip all citizens with a motorized vehicle, since the car until then was considered a luxury item. So began the "people's car" projects in both Nazi Germany and Fascist Italy.

Ferdinand Porsche was commissioned by Germany to work on the project and presented a new automobile model whose production cost was less than 1000 Reichsmarks (presented as the maximum ceiling since a worker on average earned about 130 Reichsmarks per month).

The project was finally made commercial in 1938, giving birth to the well-known Volkswagen automobile industry and the even better-known "Beetle".

Italy did exactly the same commissioning Giacosa to work on a project presenting a car with a cost that would not exceed 5000liras. In 1936, the Fiat 500 A was marketed, and even if the cost far exceeded the maximum ceiling established, it stayed in production till after World War II.
During World War II, the automobile industry underwent further development applying to the new models, and technical arrangements originally developed for military vehicles.

In the two decades following WW II, the automotive industry represented the leading industry in both Europe and the United States, the automobile became a status symbol, and cars began to be produced both as mass models, that is models that were accessible to everyone and brought about a huge social revolution in relation to transportation and the way people traveled, and models that were high-class and accessible only to a small circle of wealthy lovers of fine cars.
The commercial product put forward by that industry was, in addition to being a hugely successful commodity, a means that opened society to ideals of freedom of movement unseen in previous decades, the car made it possible to shorten distances and became the object of sporting passions for many people.

The Automotive industry became a fundamental component of the development of Western countries thanks to the continuous innovation, research, and consequent introduction of new technologies. The industry is strong also because it has the ability to avoid the problem of market saturation thanks to the production of an increasingly diverse product over the years.

The automotive market then saw new manufacturers, such as those from Japan, who around the 1960s entered the European market by offering very simple but very low-cost and affordable products. The evolution of the auto industry continued by passing through the oil production crisis of the 1970s-80s and the world market crisis that occurred a few years ago.

In the last few years, the automotive industry is in crisis. Many countries had to intervene through incentives for consumers to purchase new products, and through real "injections" of liquidity into industries that are running serious deficits, an example is Chryslers in the United States where the US and Canadian government offered their help.

The importance of the auto industry is therefore enormous in modern economies, especially because of the supply chain that is part of this large industry.

1.2 Analysis of the automotive industry

The automotive industry is one of the most crucial sectors of the European economy.
The Automotive Supply Chain includes all enterprises involved in the production of motor vehicles, starting with enterprises that produce raw materials (plastics, dyes, chemicals, paints, textiles, etc.), and ending with enterprises that produce automotive products.

The competitiveness of the sector is one of the priorities for Europe. The interest in supporting the competitiveness of the industry, therefore, lies not only in the important employment effects and economic effects directly related to the sector, but also in the important multiplier effect it has on the economy as a whole, as it is linked to so many other upstream sectors - including, for example, steel, chemicals, textiles - and downstream sectors - for example, ICT, repair services, and mobility services. The automotive industry turns out to be a key sector for strengthening the positioning of the European Union's global competitive scenario in manufacturing. The European Commission to realize its objectives is focused on two policies:

- Support the development of products and processes within a framework of common technical requirements within the European area (promoted by the United Nations Economic Commission for Europe), to reduce development costs and avoid duplication of administrative procedures;
- Fund the activities of research and innovation for the period 2014-2020, particularly in the area of green vehicles, decarbonization of traditional engines, safety, and information infrastructure.

In recent years, the automotive industry underwent organizational and strategic changes, especially because of the crisis brought by Covid-19, and the consequent microchip scarcity followed by the Ukrainian war in 2022, and the consequent energy crisis.

Since the advent of the pandemic in 2019, the automotive sector has been in crisis. Nowadays the energy price hike caused by the Ukrainian war has contributed to the delay in matriculations lagging 155,000 registrations in the first two quarters of 2022. The semiconductor shortage is not over yet even though there are signs of improvement. The prevailing logic in the industry is to keep

production volumes very low, with stop-and-go in factories still very frequent and raw material costs rising.

In 2021 it wasn't possible to produce 11mln vehicles globally, and probably almost 4mln in 2022. A recent study, conducted by Alliance Trade, shows that this electronic components crisis, lead to a loss of about 18mln vehicles all over the world, and the cost is estimated to be around 100milions euros between 2021 and 2022. Automotive manufacturers foresee no difficulty in meeting the 10 percent savings target set by the government, but the problem is mainly focused on rising prices, especially with the impending expiration of contracts with suppliers and their renegotiation for the next three years.

In 2021 the auto market closed with scarce results. Italy registered -24% in comparison to 2019 (together with an increase of 5.5% compared to 2020), and Europe registered a loss of -25.5% with respect to 2019, and a loss of -1.5%with respect to 2020. The causes of this slowdown of the industry have been identified as shortages of semiconductors and raw materials, essential in the manufacturing process.

The pandemic caused changes in the supply chain. The automotive industry has been halting assembly lines for nearly two months (because of the lockdown periods) sending a shutdown signal to chip suppliers because since no cars were produced, they didn't need any more chips.

At the same time, the electronics industry had a boom, people for a long period were stuck at home (rising of both distance learning and smart working) because of the lockdown, and the main consequence was an increase in demand for electronics, such as TVs, smartphones, computers, and so on. When later the automotive industry restarted there was a scarcity of chips due to the higher demand coming from both the auto and the electronic industries, causing the supply chain to slow down and the consequent delay in production.

The world after the pandemic is much more aware of the impact of climate change and the importance of a more responsible and sustainable behavior. For the automotive sector, this means switching from petroleum to electric cars. On June 27^{th,} 2022 the European Parliament approved the EU Commission's proposal to stop the sale of endothermic-powered cars starting from 2035.

The production of electric cars requires far more chips than a conventional car, thus exacerbating the shortage of these elements. All these factors combined have led to a major imbalance between supply and demand. Production is limited not only because of the lack of semiconductors but also raw materials, particularly those materials that the automotive sector had limited need of in the past, such as lithium and cobalt, that now have become fundamental with the electrification.

Another effect derives, as already mentioned, from the Ukrainian war, and is the rising price of energy, which has led to higher production costs, especially for industries for which energy is an important raw material. Energy bills in the future, according to the PFA director, are expected to double or even more, with energy weighing between 5 and 10 percent of production costs.

In order to deal with the crisis, car manufacturers revised the existing business model, which was characterized by a strong production push, and was based on higher volumes of production, turning it to lower production volumes. This new business model can be defined as a pull production model: the manufacturer produces more accessorized higher-end cars which are sold at more reasonable discount levels, where stocks are limited to those needed to fill showrooms and factories. The car is manufactured exactly as requested by the customer, and this new approach prevents the phenomenon seen in previous years in which there was an overproduction of cars that customers did not ask for, and that didn't match their desires, forcing sales at all costs, creating overcrowding in cities. This model is not only profitable for the producers but it is also socially sustainable.

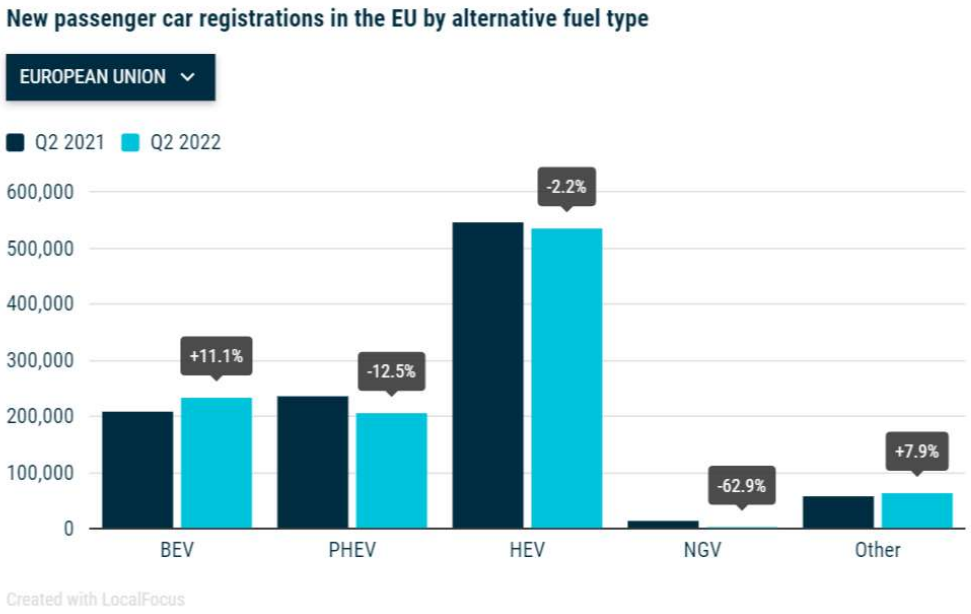
The transformation of the automotive sector requires greater attention from institutions both to support the change in the market and consumer behavior and, to protect the production heritage of the components sector which has always been an important and cutting-edge factor in the Italian industrial landscape.

1.3 Analytics of the industry based on alimentation

ACEA's quarterly survey of the passenger car market by fuel type covers the EU area (excluding Malta), enlarged to include EFTA (European Free Trade Association) and the United Kingdom. For the period January-June 2022, the area analyzed has about 5.6 million new registrations, 13.7 percent less than for the same period in 2021. During the period under review, gasoline car registrations registered a 22.1 percent decrease. Sales of diesel-powered cars also fell steadily (-32.1 percent), while overall, alternative-fueled cars grew by 5.3 percent.

VEHICLE TYPE	
BEV	Battery electric vehicle
PHEV	Plug-in hybrid electric vehicle
HEV	Hybrid electric vehicle
LPG	Liquified petroleum gas
CNG	Compressed natural gas
NGV	Natural gas vehicle

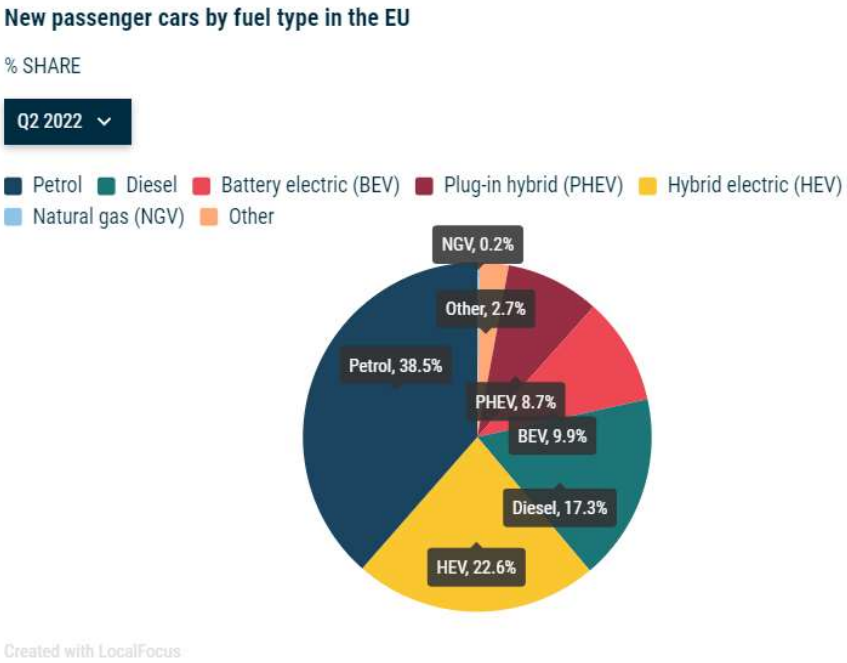
The table above shows the fuel types present on the market in 2021/2022.



The graph above[4] represents the percentage of new passenger car registrations in the EU by alternative fuel type. The graph compares the sales of the second quarter of 2021 with the sales of the second quarter of 2022.

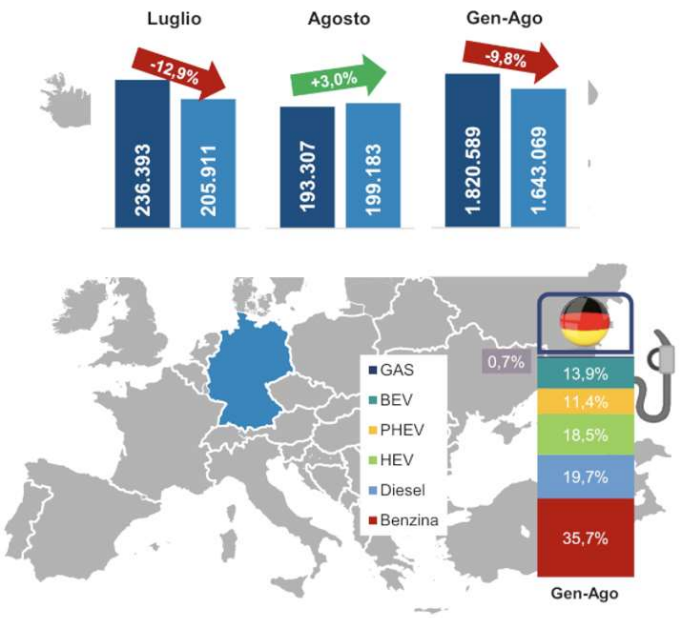
During the second quarter of 2022, it is possible to observe:

- an increase in the registration of BEV vehicles of 11.1% in the EU reaching 233.413 cars sold. Italy thought didn't contribute to the growth since it had a substantial loss of -19.6%.
- PHEV vehicles had a drop in units sold (decline in all key markets except for Spain);
- HEV slipped back by 2.2% during the second quarter of the year. However, due to the significant drop in sales of conventionally-fueled cars, they were able to expand their overall market share (+22.6%). The four main markets in the region recorded mixed results. France and Spain posted growth (+7.2% and +2.7%, respectively). Italy and Germany on the other hand witnessed declines (-9.3% and -6.5%, respectively).
- Registrations NGV dropped by 62.9%, with 4,983 units sold during this period. This fall was mainly due to the drop in Italy, which accounts for the vast majority of sales in the region.
- LPG vehicles recorded an increase in sales (+7.9%), reaching 64,152 units during the second quarter of the year. Three out of four of the largest markets in the region posted strong gains: Spain (+57.6%), France (+21.9%), and Germany (+10.3%). Italy on the other hand posted a decline (-5.1%).



[4] Graph sources: https://www.acea.auto/pc-registrations/passenger-car-registrations-6-1-eleven-months-into-2022-16-3-in-november/#:~:text=The%20strongest%20increase%20was%20observed,the%20same%20period%20last%20year.

The graph above shows the market share of the different types of car fuels in the second quarter of 2022 in the EU. Sales of battery electric vehicles continued to expand, accounting for 9.9% of total passenger car registrations. Plug-in hybrid cars accounted for 8.7% of the market share, despite a decline in the number of units sold. Petrol- and diesel-powered cars suffered significant drops during this three-month period, leading to a contracting market share (55.8% for diesel and petrol combined).



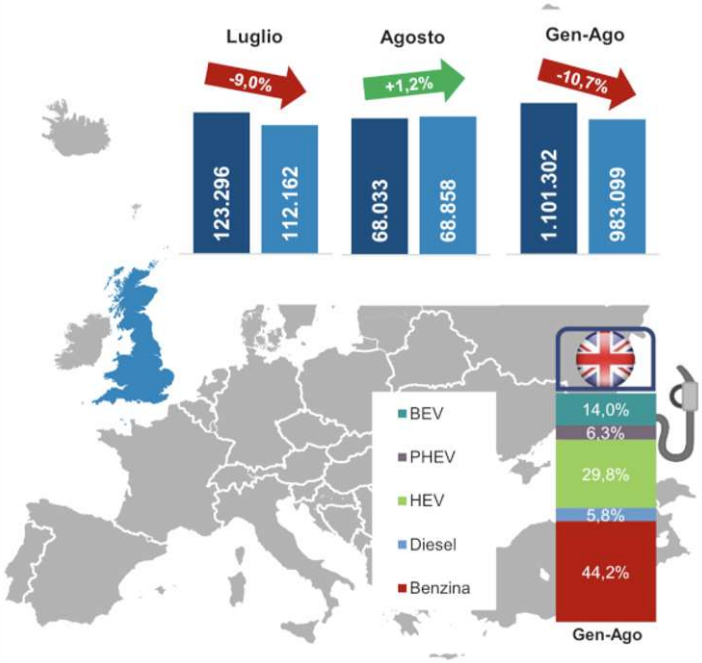
In Germany, on July 2022 205,911 cars were registered with a decrease of 19.9% compared to 2021. In August it registered a growth (+3.0%) with 199,183 sales compared to 193,307. During the first two quarters of 2022, the registrations had a decrease of 9.8%.

Private cars represent 36.1% of the market and company cars the remaining 63.9%.

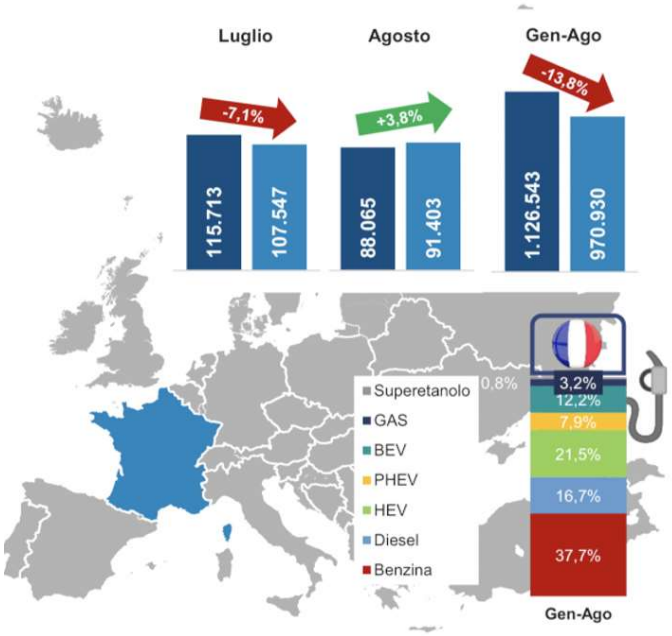
Hybrid vehicles represent 29.9% of the market of which 11.4% are PHEVs. Gasoline-powered cars are 35.7% of the market and diesel-powered cars are 19.7%. LPG cars are around 0.7% of the market. The share of electric cars is 13.9% which is the higher among the major markets. The average CO2 emission of new automobiles registered in the first 2 quarters of 2022 is 113.3 g/km.

In the United Kingdom, the automotive market registered a 9% decrease in registration on July 2022 and a 1.2% increase in August. In the first two quarters of 2022, the market closes with 983,099 automobiles sold (-10.7% compared to 2021). Private cars represent 53.2% of the market and company cars the remaining 46.8%.

Diesel-fueled cars have a cumulative share of 6.5% in the first two quarters of 2022, and gasoline cars 46%, (up 7.5 percent), non-rechargeable hybrids are 29.8 percent. Finally,

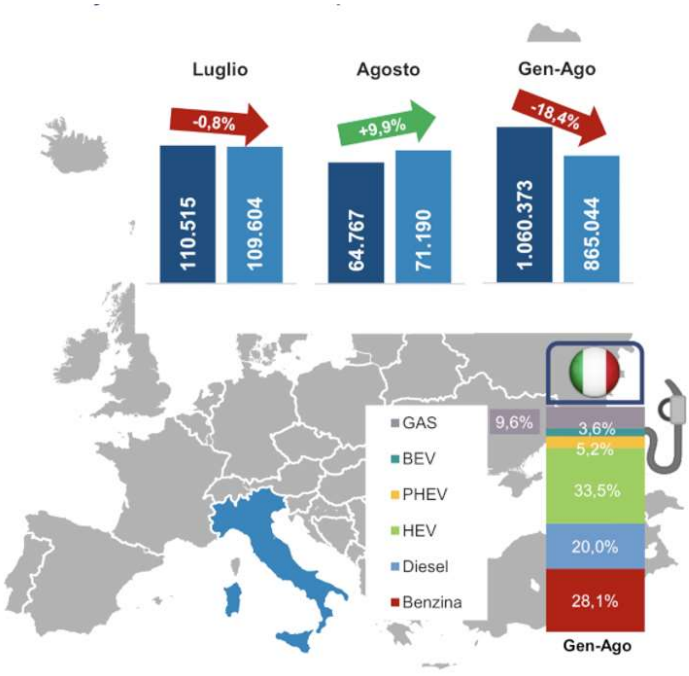


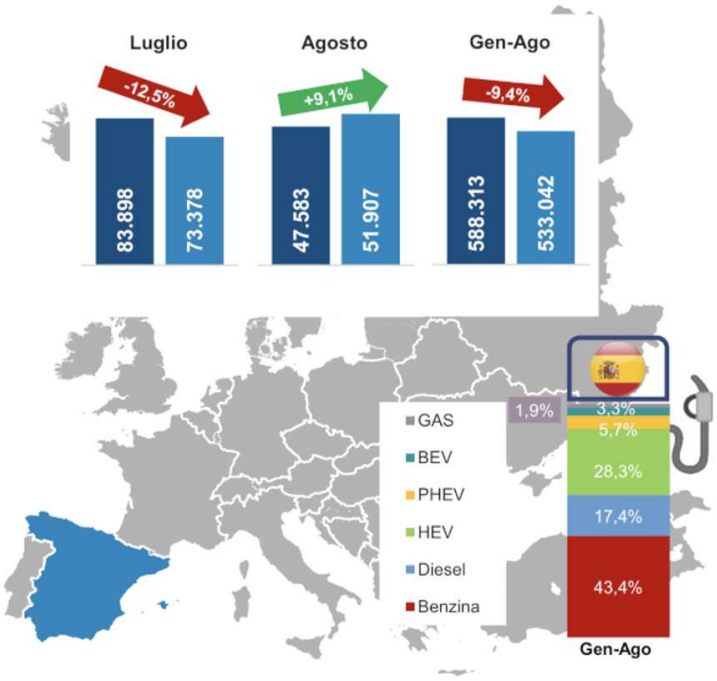
rechargeable hybrid cars account for 6.3% of the market, down 15.7%, and electric cars 14%, 48.8% more than January/August 2021.



In France, the car market in July shows a decline in sales, with 107,547 registrations, 7.1 % less than the same month in 2021, while August, with 91,403 new registrations, is up 3.8%. The first two-quarters of 2022 record a market decline of 13.8 %. Between January and August 2022, gasoline cars account for 37.7% of the total, (- 22.3), while diesel cars account for 16.7% of the market, (- 35.9%). Non-rechargeable hybrid cars have grown 8.9% since the beginning of the year, with a 21.5% share, while rechargeable cars, 7.9% of the total, are down 14.5%. Electric cars, 12.2 % of the total, are up 31.7% while gas cars, with a 3.2% share, are up 2.3%.

In Italy, the market car industry in July 2022 is down compared to the previous year (-0.8%). In August though there is an increase in registrations of 9.9%. In the first two quarters of 2022, registrations were 865,044, (- 18.4%). Gasoline-fueled car registrations were down by 26.8%, and diesel-fueled cars by 30.8%. Alternative fuel car registrations in the cumulative accounted for 51.9% of the market, (- 6.1%). Electric cars accounted for a 42.3% share in the first eight months of 2022, (- 4.2%). Among them, non-rechargeable hybrids are down 1.9%, with a market share of 33.5%. Rechargeable car registrations account for 8.8% of the market by early 2022 (- 11%). Among them, electric cars have a 3.6% share and decline by 20.2%, while PHEVs decline by 5.2% and account for 5.2% of the total. Finally, gas-powered passenger cars accounted for 9.6% of August's registered cars, of which 8.6% were LPG cars (+3.2%), and 1% were cars with CNG (-64.3%).





In Spain, in July 2022, passenger car registrations totaled 73,378, -12.5% compared to July 2021, while in August, with 51,907 sales, the market was up 9.1%. In the first two quarters of 2022, 533,042 new passenger cars were registered (- 9.4%). Gasoline-fueled cars accounted for 43.4% of the January/August market, (-17.3%), while diesel cars accounted for 20.3% of the total, (- 22.3%). This is followed by non-rechargeable hybrid cars, in the cumulative 28.3% of the market. Electric cars (3.3%, up 47.1% from January/August 2021) and PHEVs (5.7%, up 16.8%). Finally, gas cars account for 1.9 percent of the market, (+14.8%). Average CO2 emissions of new passenger cars stand at 122 g/km in the first eight months of 2022.[5]

[5] Focus **Autovetture Europa e Mercati Internazionali** settembre 2022.Rapporto mensile sull'andamento del mercato internazionale delle autovetture. https://www.anfia.it/it/

CHAPTER 2: Prices of electric, hybrid and gasoline automobiles starting from raw materials

2.1 Raw Materials

The automotive industry is one of the world's largest consumers of raw materials.
The production of automobiles requires a variety of raw materials; this includes aluminum, glass, and iron to produce steel and petroleum products used to make plastics, rubber, and special fibers. After the raw materials are extracted, they are processed into products that automakers or auto parts companies can purchase and use in the assembly process. As already observed, with the pandemic and the Ukrainian war the automotive industry had to deal with the scarcity of raw materials and the consequent rise in prices.

All in all, prices went down in commodity markets after the shock caused by the war in Ukraine. But currently, there is a price explosion for some particularly important commodities.

When taking into consideration electric cars some fundamental raw materials are the components of the batteries such as lithium and cobalt, which allow the battery to last more.
In the utmost years, raw materials prices have increased significantly, especially for the producers of electric cars. Despite a slight decline in the second quarter of the year, lithium (+640%), titanium (+169%) and nickel (+68%) costs are currently soaring compared to last year.
Cobalt is also up 53%, while the price of lithium is expected to increase tenfold in 2023; and to make matters worse, the costs of aluminum and chromium have also increased (respectively by 21% and 38%).

Despite rising commodity prices, sales of electric cars are not slowing down. In fact, they continue to climb. Statistics show that in the first quarter of 2022, registrations of plug-in cars increased by nearly 120%, overcoming obstacles such as the cost of lithium-ion batteries, which rose from $105/kWh to $160/kWh. Before Covid the situation was quite the opposite, in fact, in recent years there was a downward trend. Suffice it to say that, according to a Reuters analysis, the average price is down nearly 99% (from $7,500/kWh in 1991). The price was very close to achieving $100/kWh, considered the threshold to be reached to bring electric cars to the coveted price parity with endothermic cars. Apparently, however, customers have made more sustainable choices beyond economics. An example can be Tesla which broke another record, with more than 310,000

deliveries between January and March. China's Nio, XPeng and Li Auto also posted strong numbers, while the Wuling Hong Guang Mini EV, the small zero-emission car that is so popular in China, was still the champion of deliveries, approaching 100,000 units. For the queen of the Eastern market, the cost of the battery pack is about $1,500, which represents 30% of the entire EV.

All figures testify to the public's approach to sustainable mobility, especially when taking into consideration new drivers, many are making purchasing decisions that go beyond simple economics and prefer to drive an electric vehicle because it is better for the planet. They are taking a big step forward, even though it would be cheaper to continue with combustion engines.

The main reasons why electric cars are more sustainable

Electric vehicles have no CO2 emissions since they are powered with batteries instead of gasoline or diesel, and this element is common knowledge, what instead not many know is the life cycle of lithium batteries. Once a lithium battery has served its purpose, it is usually sent for disposal in special facilities to avoid any kind of contamination (since they contain pollutants such as nickel, cobalt, and manganese). The environmental benefits of recycling lithium batteries are many because new extraction and processing are avoided: the extraction of a single ton of lithium, for example, requires about 1,900 tons of water. In addition, recovery reduces the need for raw materials and pollution from emissions associated with manufacturing processes. And again, resources in primary metals and fossil fuels are saved, resulting in less energy expenditure. However, the disposal of lithium batteries has a quite high cost. Moreover, a used battery still has a residual capacity of around 75%, and while it is no longer adequate to effectively power an electric vehicle is, however, sufficient for other uses. For example, it can become a storage system for home photovoltaic

Figure 2: Critical Raw Materials in BEV and FCEV Technology

Technology	**Battery**	**Fuel cell**	**Electrolyser**		
Technology type	NCA	LMO		PEM	AEL
Critical raw materials	Lithium	Lithium	Cobalt	Iridium	Cobalt
Nickel	Manganese	Graphite	Platinum	Platinum	
Cobalt	Graphite	Platinum	Lithium	Nickel	
Graphite		Palladium		Raney-Ni	
		Titanium		Lithium	
		Strontium			

systems to store excess energy produced during the day and use it in the evening or to cope with peak demand in-home consumption.

Or, it can be connected to other batteries to form an industrial storage system, a reserve of electricity to be put back into circulation when needed, such as in the case of power outages or when grid withdrawal would be more costly. A company that is currently committed to the area of so-called second-life batteries is Enel X[6], which aims at finding useful solutions to develop an increasingly circular and sustainable economy.

Another typology of vehicles considered to be sustainable and much debated in recent years is hydrogen cars. In the graph above are reported the critical raw materials needed in the production of Electric Vehicles (BEV) and Hydrogen vehicles (FCEV). There are some minerals whose use cannot be avoided in either vehicle type. The most important ones are lithium and cobalt, which are needed for lithium-ion batteries used in both kinds of vehicles.

BEVs, however, need 8-16 times larger batteries, with an increasing size depending on the distance to be traveled. The supply of these two minerals is not a limiting factor even if it is dominated by very few companies. Almost half of lithium production comes from Australia, and Chile contains over half of the world's reserves, thus diversifying supply could increase supply security and offer opportunities for new markets in other countries.

Cobalt is even more problematic since 65% is derived from Congo, in which cobalt mines workers are subject to human rights abuses. Apart from raw materials used to produce batteries Hydrogen vehicles require many more materials for fuel cells and electrolysers (listed also in the table above).

Among all, the most important mineral is platinum required in fuel cells, and some electrolysers technologies. Platinum is a metal and is extremely rare (the global production is around only 200 tons a year), and its supply is highly concentrated. The same situation if not even more critical is for Iridium, another very rare mineral found almost exclusively within platinum ores and used to strengthen platinum alloys in electrolysers. The demand for platinum and iridium thought can be reduced up to 97% through prevention, extension, and recycling strategies.

[6] Enel X is the Enel Group company for the development of digital and innovative solutions in areas where energy shows high potential for transformation: homes, businesses, cities, electric mobility.

Thus, from a critical raw material perspective, FCEVs are not a sustainable application of PTX technologies[7]. Although both vehicle types require critical minerals, the scarcity of supply is far lower for BEVs considering the relative abundance of lithium compared to platinum.

Most importantly, as we transition towards a renewable-energy-based society and the demand for critical minerals rises, renewable electricity must be used as efficiently as possible to ensure a truly sustainable future.[8]

2.2 Buying a gasoline car in 2022

Over the past decade, regardless of the fuel type used, consumer prices have risen, although in different measures and with different trends. Let us first examine the prices of gasoline, diesel, LPG and methane. Gasoline and diesel are obviously tied together, so their trends are proceeding in parallel, liquefied petroleum gas (LPG) instead, while being partly aligned with the macro market trend, has exhibited behaviors at times opposite with respect to the other fuel types.

Overall, since 2010 it can be observed an increase in prices that stabilized towards the two-year period 2013/2014, followed by a decrease culminating in 2016 before witnessing a second ascent until 2018, the percentage change between the values at the end and beginning of the decade are quite heterogeneous.

Although there was an increase in all four cases, it is clear that the gasoline-diesel pair has risen by an order of magnitude more than LPG and methane as evidenced by the values that report +21% for gasoline, even surpassed by diesel, which is close to 30%, while liquefied petroleum gases have seen the final price per liter rise from 0.616 to 0.624 euros, for an overall change of just over 1%. One of the main reasons that can be found in this difference is attributable to the increase in excise taxes[9], which, starting in 2012, has clearly contributed to the final price, especially for diesel fuel.

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[7] PTX : Power-to-X technologies allow for the decoupling of power from the electricity sector for use in other energy consuming sectors including district heating and transportation.

[8] Data source: A Critical Case Against Hydrogen Vehicles: a raw materials perspective https://ptx-hub.org/a-critical-case-against-hydrogen-vehicles-a-raw-materials-perspective/

[6] Excise tax: Indirect tax with mediated collection that applies to certain goods (e.g., fuels, electricity, alcohol, cigarettes, matches) at the time of production or sale, and is paid by the producer or trader by transferring the burden to the consumer, i.e., by including it in the selling price.

In fact, looking at the numbers at the beginning and end of the period, the change from 0.423 euros per liter to 0.617 corresponds to a 45% increase that clearly overpowers LPG by 17%, while the comparison with gasoline appears milder considering the 30% t due to the change from 0.564 to 0.728 at the end of 2019.

Relative to the maximum values recorded in the past decade, there is uniformity in the peak points that occurred for all four fuels in the middle six months of 2012 during which gasoline and diesel touched 1.871 and 1.764 euros per liter, respectively, in September, four months after the price of LPG reached 0.889 in April.

On the other hand, on the lowest values, unlike the other two cases where January 2010, in addition to being the first value surveyed, was also the lowest value, for LPG the most favorable market moment for consumers was during March 2016 when the price fell as low as 0.542 euros per liter, following an overall decrease that had also affected gasoline and diesel anyway.

In 2019 while keeping the variations in the trends of the most popular fuel pair unchanged - closed with an increase in gasoline that almost doubled diesel as evidenced by 6.37% of the former compared to 3.27% of the latter, thus bringing the market prices to 1.585 and 1.519 euros per liter. Again, LPG was able to differentiate itself by two main aspects which are one a consequence of the other. First, the beginning of the year did not start with an increase (which for other fuels lasted until May), and second, the annual balance closed with a decrease of 5% (from 0.657 to 0.624 euros per liter) even though it was affected by the same upward trend that also occurred for other fuels starting in September.

In 2022 due to the Ukrainian war, gasoline, diesel, and methane prices increased exponentially. Since February 23rd 2022, oil, which started at 87 euros per barrel, has risen 12.6%. But the price of refined products on the Mediterranean marketplace has broken all records with gasoline jumping 17% to 0.77 euros per liter and diesel fuel to 0.8 euros per liter, (+29.6%). The difference between these values and the more than 2 euros per liter shelled out by motorists these days depends on VAT and excise taxes (53 percent of the final price of gasoline) and industrial revenue. In the last few months of 2022 starting from July fuel prices started decreasing again thanks to the decision of the government to cut the excise taxes which was extended till November 18th. Since the end of June, the price of gasoline has fallen by more than 24 cents per liter, a decrease of 11.7%; diesel fuel has fallen by more than 22 cents per liter, a decrease of 10.9 %. This is based on the weekly data from the Ministry of Ecological Transition, according to which the prices of gasoline and diesel fuel decreased to 1.692 euros per liter and 1.880 euros.

PREZZI MEDI PRATICATI SELF (€/L) NAZIONALE 26/10/2022						
	Agip Eni	Esso	Api-IP	Q8	Tamoil	No logo
Benzina	1,696	1,698	1,7	1,682	1,679	1,688
Diesel	1,873	1,886	1,882	1,877	1,874	1,885
PREZZI MEDI PRATICATI SERVITO (€/L) NAZIONALE 26/10/2022						
	Agip Eni	Esso	Api-IP	Q8	Tamoil	No logo
Benzina	1,901	1,857	1,897	1,864	1,770	1,742
Diesel	2,078	2,044	2,068	2,051	1,962	1,935
GPL	0,781	0,801	0,782	0,784	0,786	0,769
Metano *	2,524	2,897	2,555	3,031	2,381	2,378

Elaborazione Quotidiano Energia sui dati alle 8:00 di ieri dell'Osservaprezzi del Mise *Prezzi metano in €/kg

PREZZI ITALIA QE (€/L) 26/10/2022		
	Self Service	Servito
Benzina	1,692	1,840
Diesel	1,880	2,024

As it can be observed from the table above[10] diesel fuel costs more than gasoline (almost a 20 cents difference). Prices that, it is worth remembering, are such a result of the cut in excise taxes[11] that burden fuels. The reasons why diesel is more expensive are to be found in the typical uses of the different fuels. Diesel fuel is used in economic activities, earthmoving machinery, industrial engines, and trucking, sectors that in the most acute period of the pandemic suffered a contraction only to experience a rapidly recovering demand and, therefore, a surge in fuel consumption.

The war in Ukraine had a decisive role too because until before the conflict the European Union imported about 30% of its diesel fuel from Russia. Sanctions decided by European authorities forced a gradual cut in imports from Moscow, including those of oil and refined products.
The overtaking of diesel prices over gasoline starts from there. In addition, the consistent increase in gas prices has led many industrial activities to increase diesel consumption.

In summary, therefore, diesel is less available, and in the face of a demand that has increased in recent months, prices have risen, surpassing gasoline. The situation is currently very delicate, a sudden increase in demand or a shock in production or distribution would cause surges far worse than what we have seen so far.

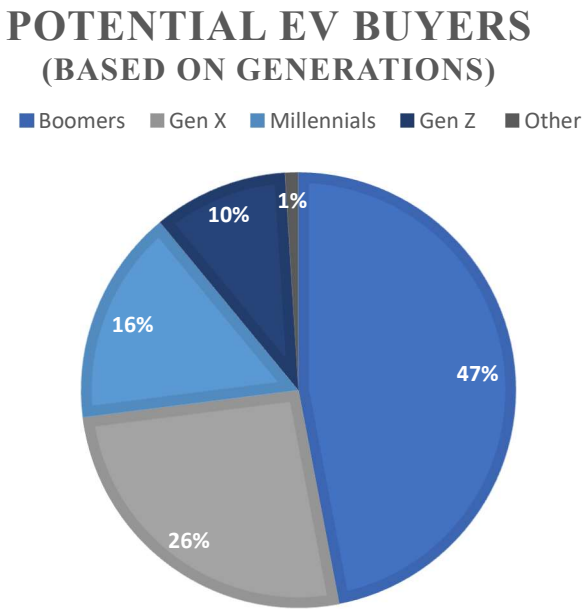
[10]Mercato dei carburanti https://www.mise.gov.it/it/mercato-e-consumatori/prezzi/mercati-dei-carburanti

2.3 Economic insight, customer preferences

According to the latest EY Mobility Consumer Index in the Italian sample of more than 300 interviewees, 73% of potential buyers are oriented toward purchasing electric vehicles.
This is up from 2021, which recorded 63%. Italy is the country with the highest percentage among those involved in the EY survey, recording a global average of 52 % compared to 42% in 2021.

Specifically, 23% of potential car buyers plan to buy an all-electric car in 2022, a sharp increase from last year (9%), but in line with the global average recorded this year of 20%.
In contrast, 22% would buy a plug-in hybrid, a slight increase then (21%) from 2021, where the global average is 10%. Finally, 28% would buy a hybrid car compared to a global average of 21%.

The EY Index shows that among those who say they are potential EV buyers, 47% are Boomers, 26% are part of Gen X, 16% belong to Millennials, and 10% belong to Gen Z, (as shown).



In Italy, among those intent on purchasing an electric car this year, 43% live in a rural area, 18% live in a medium-sized city, 18% live in the city center of a large city, 12% live in a small town, and 9% live in suburban areas of a large city. In addition, according to this year's data, 36% of individuals surveyed say they could charge their electric vehicle at home daily, 21% several times a week, 20% once a week, 13% never, and 10% occasionally.

Regarding data on purchase intentions in the country, 38% of individuals say they are likely to purchase a car (according to the previous year's survey it was 56%) compared to a global average of 45%. Specifically, it shows that 5% of the Italian population surveyed are likely to buy a used car, while 33% would like to buy a new car.

In Italy in 2022 there is a reduction of about 17% in the number of monthly trips made for work purposes compared to before Covid-19; the reduction recorded in 2021 was about 6%. At the global and European level, there is a decrease of -11%. The average reduction in non-work-related travel is about -9% compared to before Covid-19. The European average showed a -7% reduction while the global average was -8%.

In the current year, compared to the period before Covid-19, in work-related travel there was a decrease of -16% in personal car use, -22% in private two-wheeled vehicle use, and -12% in personal city mobility use. The overall average is broken down as follows: in work-related travel there was -11% in personal car use, -13% in private two-wheeled vehicle use, and -10% in personal city mobility use.

In work-related travel there is also a decrease of -30% regarding the use of shared city mobility, +6% use of cabs, -30% use of car sharing/car clubs, +3% of people who used car rental, and -29% use of public transportation. The overall average is broken down as follows: in business travel there was -11% use of shared micro-mobility, -9% use of cabs, -8% use of car sharing/car clubs, +5% of people who used car rental, and -15% use of public transport.

It is predicted that today compared to before Covid-19 there will be a decrease (-16%) in personal car use, -22% in personal 2-wheeler use, -18% in micro mobility use, +6% in cab use, -30% in car sharing/car club use, +3% in car rental use, and -29% in public transportation use.
The overall average is broken down as follows: -11% in personal car use, -13% in personal 2-wheeler use, -10% in micro mobility use, -9% in cab use, -3% in car sharing/car club use, +5% in car rental, and -15% in public transportation use.

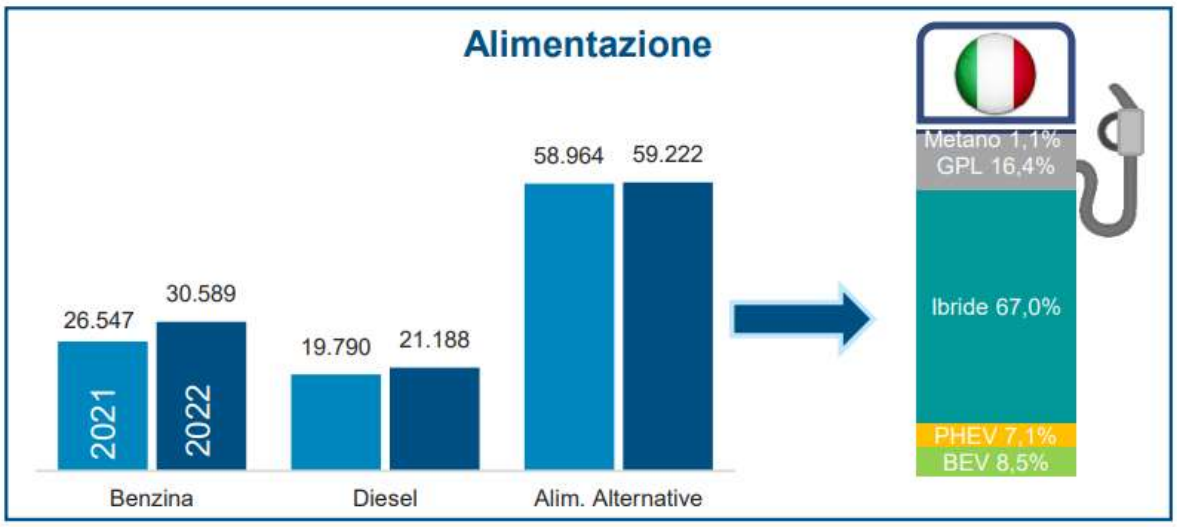
2.3.2 The data recorded on car registration September 2022.

In September 2022 the automotive market is up in relation to the previous year. In the month, about 111,000 cars were registered, up 5.4% compared with the same month in 2021. In the cumulative first nine months, there were 976,221 registrations, (down 16.3%). Taking into consideration registrations by fuel in detail, gasoline-powered cars closed September with an increase of 15.2%, and a market share of 27.6%; diesel fueled cars also grew (up 7.1% on September 2021), rising to a market share of 19.1 %. In the first nine months, gasoline passenger car registrations declined by 23.7% and diesel cars by 28%.

Alternative-fuel car registrations accounted for 53.4% of the market in September alone, with volumes essentially stable compared to the same month in 2021 (+0.4%) and a market share of 53.4%. In the cumulative, alternatives drop by 5.4%, while still maintaining a higher market share than in the same period of 2021 (52.1%, compared to 46.1% in the first nine months of last year). Electric cars accounted for 44% of the September market, up 4.2%, while, over the nine months, they have a 42.5% share and down 3.3%. Among them, mild and full hybrids increase by 35% in the month and reach a 35.7% share, while in the cumulative, they are up slightly (+0.5%) with a market share of 33.9%. Rechargeable car registrations decreased by 34.2% in the

month (market share: 8.3%) and by 15.7% in the cumulative (market share: 8.6%).
Among these, electric cars have a share of 4.6% and decline by 40.3% in the month, while the plug-in hybrids decline by 24.8% and account for 3.8% of the total market (in the cumulative both are down, -23.8% and -8.6%, respectively).

Finally, passenger cars that run on gas cars account for 9.3% of September's registered cars, of which 8.7% are LPG cars (-1.9%) and 0.6% are CNG cars (-71.2%).



Since the beginning of 2022, the LPG cars are up 2.6% and CNG cars are down 64.9%. Based on these statistics' hybrid cars are currently the ones preferred by customers (as shown also in the graph)[12], the percentage of hybrid cars registration on September 2022 is far higher than any other fuel type. The first time it happened nationwide was in the first quarter of 2021 where hybrid and electric car registrations surpassed those of gasoline, diesel, LPG and CNG, and since then they remained on top of the rankings.

2.3.3 A question then arises: why are hybrid cars preferred by customers?

First, it is important to understand the mechanism behind this type of alimentation. Hybrid cars are vehicles with a single propulsion system, but dual core electric-thermal powertrains. The first hybrid example was the Toyota Prius, launched back in 1997 and to date the best-selling hybrid car ever. Hybrid cars can be classified according to the ability of the hybrid propulsion system to store electrical energy, we mainly have 3 kinds:

- full hybrid (full hybridization): engine and batteries allow the car to travel in electric autonomy, usually at low to medium speed and for limited distances. They are considered perfect for the city environment, so for example people who drive often in the city and do not have to get crazy mileage on the highway.
- mild hybrid (light hybridization): the electric part supports the thermal part and allows the vehicle to optimize the trip, especially when accelerating, improving fuel consumption and performance.
- minimal hybrid (minimal hybridization): simply put less electricity, more gasoline; in this case, the mileage in pure electric mode is severely limited.

The main advantages of buying an hybrid car are:

- Fuel consumption can be greatly reduced and performance optimized;
- The initial expense is amortized through savings on fuel purchase;
- And most importantly fewer polluting emissions: the amount of CO2 in the atmosphere is reduced by as much as 70-80% in some hybrid engines.

[12] Focus Italia Mercato Autovetture settembre 2022. Rapporto mensile sull'andamento del mercato italiano delle autovetture. https://www.anfia.it/it/studi-e-statistiche

Another advantage that the average Italian driver appreciates is about the payment of the car tax bill. In fact, the amount is calculated considering the power output of the heat engine, without evaluating the horsepower delivered by the electric powertrain. In short, the tax duty costs less with hybrid cars. Moreover, in five Italian regions (Lombardy, Veneto, Lazio, Campania and Puglia) newly registered hybrid cars are already exempt from paying the car tax (but only for a few years).

Another positive factor is the benefits in city traffic: these models can often enter LTZs (Limited Traffic Zone) without paying any toll charges or paying less than other vehicles.

Although the positives are undoubtedly many, there are some weaknesses that don't go unnoticed. The first is that for those who travel long stretches of highway, they do not feel any real savings. If we travel a road for many kilometers at a speed of 130 kilometers per hour, the powertrain used will always be the combustion one. The ideal terrain for these vehicles is the city, where braking and restarting finally generates the savings compared to other cars. Many cab drivers, in fact, have adopted it.

The second is price. On average, a hybrid car costs 40% more than a gasoline equivalent, so those intent on buying one need to calculate well the costs/benefits of this hi-tech choice. Let's also keep in mind maintenance, which is more expensive because of the technologies employed and the huge deployment of electronics.

The third sensitive point is precisely the battery, the pride of hybrid technology. In the event of a failure, intervention could be very expensive and therefore not for all pockets.

2.3.4 Fiat Panda case, Italian’s favorite car

FIAT (Fabbrica Italiana Automobili Torino) is an Italian company founded in 1899 in Turin, Italy by a group of Turin businessmen headed by Giovanni Agnelli. Since then, the growth of this company never stopped, and it became a symbol of the Italian working class making the history of this country. According to the statistics, FIAT nowadays produces the best-selling model in Italy, the Panda Hybrid. Let us take this model into analysis by comparing the 3 different variants (hybrid, gasoline, LPG) the producer offers.

The table below reports the 3 variants and their main characteristics.

Car Model	Listed price	Emissions	Fuel consumption (100km)	Tank capacity
0.9 twin air Turbo 85hp (gasoline)	15.000	132 g/km	6.9liters	35liters
1.0 Hybrid 70hp (Mild Hybrid Gasoline)	15.400	111 g/km	4.9liters	38liters
1.2 LPG 69hp (LPG)	16.100	119g/km	7.7liters	30liters

Three engines are available for the Fiat Panda. At the top of the offering is the 0.9 Twinair turbocharged 85hp gasoline, available only in combination with all-wheel drive versions.
For those who prefer LPG there is the 69hp 1.2 Fire, and completing the offering is the 70hp 1.0 FireFly with mild-hybrid technology.

In terms of fuel consumption, the renewed Panda hybrid needs only 4.9 liters of gasoline to travel 100 km, while for the gasoline variant we are around 6.9 l/100 km. As for the LPG variant, it takes 7.7 liters of gas to travel 100 km.

As far as fuel expenses are concerned, if we consider the current prices of gasoline and LPG :

- Filling up the gasoline version costs around 59.15 euros (11.661 euros per 100km)
- The hybrid version costs around 64.22 euros (8.281euros per 100km)
- The LPG version costs around 23.4 euros, (6.006 euros per 100km)

Regarding taxation we will have:

- Around 219.3 euros per year for the gasoline version;
- Around 44.505 euros per year for the LPG version, provided that they comply with EEC directives on pollutant emissions, are subject to the payment of a quarter of the motor vehicle tax prescribed for corresponding gasoline vehicles.
- Hybrid cars depending on the region do not pay stamp duty in the first years up to five years total, and on average, the cost of tax duty for this type of car is around 45.15 euros per year (a reduction of 75% is applied for electric and hybrid vehicles based on the region).

Let us take as an example an average annual mileage of 15.000 kilometers and calculate how much a driver spends in fuel:

- The owner of the gasoline version spends around 1749.15 euros;
- The owner of the hybrid version spends around 1242.15 euros;
- And the owner of the LGP version spends around 900.9 euros.

Looking at all these data it is quite evident that buying a gasoline car in 2022 is not convenient. The vehicle itself is cheaper than the other alternatives (400 euros difference with the hybrid model, and 1,100 euros with the LPG version) but considering the annual cost of stamp duty and the annual cost of gasoline (all calculated above) the FIAT Panda 0.9 twin air Turbo is definitely more expensive.

On the other hand, regarding the issue of emissions, the hybrid version is the greenest, if we consider that a mild hybrid on average reduces emissions and fuel consumption by up to 15%.

In the market, of course, there are better alternatives which will be covered in the next chapter on full hybrid and electric.

CHAPTER 3: Focus on electric automobiles

3.1 Switching to an electric/full hybrid car in 2022

As already anticipated in previous chapters, in 2022 there exist valid alternatives with respect to fossil fuels. The alternatives we are referring to are hybrid and electric cars. In the previous chapter, we compared mild hybrid cars with classic gasoline and LPG cars, but it is important also to make a comparison between full hybrid and electric cars in order to understand which one is more convenient.

The increasingly frequent blocking of diesel cars and the unstoppable development of the green sector of the Automotive industry have led to a growing interest in hybrid and electric cars.
The main reason is that these vehicles save on fuel expenses, not to mention the strong contribution from the environmental point of view. But what is the difference between the two types? And which one is more convenient for a potential buyer?

Full hybrids remain de facto cars equipped with both an internal combustion engine (solely and exclusively gasoline) and one or more electric units. Which, combined with a dedicated battery pack, allows for short stretches (on the order of a handful of kilometers) to proceed even in electric-only mode. This system is often referred to as a parallel hybrid because both motors, the electric and the endothermic, are connected to the traction axle. It means, as pointed out earlier, that both "participate" in the traction of the vehicle. This is never done simultaneously unless the electric motor is placed separately on another axle (usually the rear axle). In this case, they can concurrently concur in traction, effectively realizing an electrified all-wheel system.

Looking at the market, almost all full hybrid cars have only one electric motor, located almost always inside the gearbox. A transmission that is always of the automatic type. A clutch interposed between the two powertrains can disconnect them, allowing driving in electric-only mode.

The size of the battery pack is quite significant and obviously affects the overall weight of the car, which tends to increase by at least 100 kg compared to a similar non-HEV version. The battery recharges both during deceleration phases (release and braking) by obviously taking advantage of energy recovery; and through the heat engine, which "gives up" some of its energy. The discharge and charge phase is rather rapid, so that the system is efficient.

The preferred habitat for this car model is the city, where it happens that the time spent in the car is a lot, but the distance traveled is instead very little, "sustained" even by decidedly low hourly averages.

An environment where acceleration and braking are the order of the day, rather than steady paces. For this reason, full hybrid cars are favored by taxi drivers, who have gradually abandoned diesel engines over the years. Compared to cars with similar power, the fuel economy and emission reduction is around 30%.

The electric car has only an electric motor, and unlike hybrids has no endothermic motors. The electric motor on cars made its first appearance in the first half of the 19th century with the electric carriage made by Robert Anderson, while the first prototype electric car was made by Thomas Parker in 1884, using special high-capacity batteries he designed. To understand when the electric car was born, it should be pointed out that in the late 19th and early 20th, the electric car engine could undoubtedly be considered one of the preferred methods of transportation, certainly more comfortable than the fuel-powered cars of the time.

Unfortunately, the development of this technology of the electric was limited by the knowledge of that period, and the maximum speed that a vehicle equipped with an electric motor could reach was only 32 kilometers per hour.

The electric car is driven by an electric motor that uses the electrical energy stored by the lithium-ion battery and transforms it into the mechanical energy needed to move the car. The electrical energy stored by the lithium-ion battery is transferred to the motor by the inverter. This device converts the direct power from the accumulator into alternating current and sends it to the motor. When the accelerator is released, the auto-electric motor acts as a generator and recharges the battery; an identical function is activated when braking.

This type of alimentation is suitable for those who have the possibility to charge the vehicle (preferably overnight) either at home or in the surrounding areas, live near a charging station, or near a shopping center where in some cases you can charge for free, and have low daily mileage (between 100km and 300km), and are willing to schedule half-hour stops when taking longer trips.

The autonomy of an electric car is strictly related to the battery capacity, therefore is also strongly influenced by the outside temperature. At very low temperatures, for example -10° the range drops by 25% compared to that at 23°.

Let's talk about prices

Taking as examples two city cars which are the Renault Clio E-tech full hybrid and the Fiat 500 electric. In the table below are reported the characteristic of each.

Car Model	Listed price	Emissions	Consumption (100km)	Capacity
Renault Clio E-tech full hybrid 140hp (91 gasoline, 49 electric)	21.600	94 g/km	4.2 liters	39liters
Electric Fiat 500 70kw, 95hp	26.500	0	13 kWh	257km

The first thing that leaps to the eye is the price difference. Between the 2 cars, in fact, there is a gap of 8.350 euros due to the higher cost of production of all-electric cars.

The thing on which electricity makes a difference, though is consumption. In general, it can be said that powering an electric car costs less than powering an hybrid car, as compared to traditional gasoline or diesel cars.

Recharging a 100% green car using the household electrical outlet costs about 20/22 cents per kWh (with one kWh you will drive 4 to 7 km depending on the car's consumption). However, the cost of charging increases by going to public charging stations (about 50 cents).

To get an idea of how much it costs to recharge an electric car and what advantages the choice brings in terms of mobility, just think that with 3€ of recharging you can travel even 100 km.
As mentioned earlier, a lot depends on the size of the car. Those who buy an electric SUV may spend as much as 15€ to travel the same distance.

The owner of a Clio full hybrid will spend around 65.91 euros to fill up the tank, and to travel 100km would spend on average 7.098 euros.

All in all, while paying a higher price at purchase (ranging from 8.000€ to 15.000€ more than traditional cars), driving an electric car has many advantages. These are environmental benefits, which translate into big savings in the short and long term for the motorist as well.

The electric car is not only less expensive in terms of fuel price, but it also produces zero emissions compared to cars that are considered to be "green". By bringing back the data on the table the Fiat 500 electric produces 0 CO_2 emissions, and instead, the Renault full hybrid produces 94 g/km, which even if is considerably less than a normal gasoline or diesel-powered car, is still pollutant.

Maintenance should also be considered. For hybrid cars, the control of the electric motor can mean extra expenses on the coupon. On the other hand, technology applied to 100% electric motors can result in more expensive professional interventions, although in general the maintenance expenses of a fully electric motor are minimal. Given the fact that the mechanical wear and tear is minimal, the engine is super simple and does not need adjustment, does not overheat and therefore does not use coolants or lubrication and filters.

3.1.2 State eco-incentives for the purchase of electric cars

New incentives for the purchase of low-emission cars were launched on November 2nd.
The DPCM of August 4th provided a 50% increase in bonuses for plug-in electric and hybrid models, but only in favor of individuals with an ISEE (Indicator of Equivalent Economic Situation) up to 30.000 euros.

Specifically, the following amounts can be enjoyed:

- 7,500 euros with scrapping (or 4,500 euros without scrapping) for the purchase of new vehicles with emissions in the 0-20 grams per kilometer carbon dioxide range (in fact, electrics) and with a list price of 35,000 euros or less excluding VAT;
- 6,000 euros with scrapping (or 3,000 euros without scrapping) if the purchase is for a car with emissions in the 21-60 grams per kilometer carbon dioxide range (the plug-ins) and with list price of 45,000 euros or less excluding VAT.

The incentive is always provided in the form of a discount on the list price, while a car up to Euro 5 emission class must be returned for scrapping.

To take advantage of the subsidy, which must be applied for no later than December 31st, a form certifying the household's ISEE declaration must be attached at the time of purchase.

New incentives are provided for car rental companies as well. However, for car rental companies the discounts are lower, namely:

- 2,500 euros with scrapping and 1,500 euros without scrapping for vehicles in the 0-20 g/km emission range (electric cars);
- 2,000 euros with scrapping and 1,000 euros without scrapping for cars in the 21-60 g/km emission range (plug-in hybrid cars).

All motor vehicles must pay motor vehicle taxes. There are, however, various facilities and exemptions, arranged by the autonomous regions and provinces, which benefit mobility with low (or no) emissions, and which can last forever in the case of electric cars in some regions, or for three years or five years, and thereafter at a reduced amount.

The process to obtain the exemption is automatic: when the hybrid or electric car is purchased, computer systems immediately grant the owner an exemption or facilitation on the payment of automobile taxes. Taking as an example the region Lazio:

- No car tax, for hybrid cars, for the first three years after registration;
- Electric cars and electric motorcycles and mopeds do not pay tax duty for five years from the date of first registration. Thereafter, owners of electric cars living in the region must pay a car tax equal to one-fourth of that due for corresponding gasoline cars, while electric motorcycles and mopeds pay the full amount.

This means that if a potential buyer purchases an electric Fiat 500 in Lazio they will not pay circulation taxes within the first five years, and in the following years, it will be equal to (let's say the car has 95hp) around 45 euros per year.

3.2 Comparing electric and gasoline (3 different types of vehicles)

For our analysis we consider a city car, a compact car, and a midsize SUV, each available in both electric and gasoline-powered versions. Starting right at the purchasing price the Fiat 500 electric Action version (190 kilometers of claimed range) has a starting price of 26.500 euros, 7.850 euros more than the one powered by the 1.0 three-cylinder gasoline engine (mild hybrid).
Even if it costs more to buy, maintaining the electric version is cheaper. The price of the first service of an electric Fiat 500 is 105,05 euros, 85 euros less than that of a 500 with a heat engine.

A difference that on average is maintained throughout the scheduled maintenance of the two models.

Continuing by taking as an example the Opel Mokka, a compact crossover available in thermal or 100% electric versions. The Mokka-e (322 kilometers of range) has a starting price of 36.050 versus 23.050 for the 101-horsepower 1.2 turbo gasoline. The electric, on the other hand, is more economical when it comes to scheduled maintenance: the cost of a Mokka-e's first service is 100 euros, compared with 150 euros for the gasoline version.

The gap narrows in the premium world. Purchasing a Volvo XC40 Recharge (418 kilometers of range and 408 horsepower) requires 56.300 euros, 5.550 euros more than the most powerful gasoline version (250-horsepower B5 Awd). The cost of the first, second and third service at the parent company (annual or once 30 thousand kilometers have been covered) is for the electric one 100 euros for the first and 80 euros for all the others, while for the gasoline version the prices go up quite a bit: 330 euros for the first scheduled maintenance, 500 for the second and 330 for the third.

When it comes to insurance, the average savings for the liability of an electric car is between 10 percent and 15 percent, which is not at all significant when compared to tax duty. In fact, the ownership tax - amounting to 136, 198 and 350 euros per year for Fiat 500, Opel Mokka, and Volvo XC40 - is free for zero-emission versions for five years (after which 25% of the value of the tax will be paid), and in some regions such as Lombardy and Piedmont, it is not paid for the entire life cycle of the vehicle. For charging the possibilities are many and different depending on whether one decides to refuel one's electric car by taking advantage of the domestic network (prices today range between 20 and 22 cents per kilowatt but are expected to increase over the course of the year by as much as 40 percent due to high energy prices) or the public network (with costs averaging between 30 and 50 cents per kilowatt). In the former case, full charging will cost about 15.8 euros for the Volvo XC40 Recharge, 10,12 euros for the Opel Mokka-e, and 5.69 euros for the Fiat 500. Considering an average gasoline price of about 1.7 euros per liter, filling up our cars will cost 91 euros for the Volvo, 88 for the Opel Mokka, and 60 for the Fiat 500.

Pulling the sums after three years of car ownership with an average mileage of 15 thousand kilometers per year, the owner of the electric Fiat 500 will have spent 28,656 euros (26,500 euros for the purchase, 316 euros for the coupon and recharging at home about 940 euros of energy and about 900 euros of insurance). The owner of the 500 with a gasoline engine, on the other hand, will have spent 24,288 euros for the same period (18,650 euros for purchase, 570 euros for couponing, 1,140 euros for insurance, 408 euros for tax duty, and 3,520 euros for fuel). After six years the difference tapers off, while the overtaking of the electric comes after nine years when the savings for those who bought an electric 500 is about 2,600 euros compared to the thermal one.

For the Opel Mokka-e after three years of use, the owner will spend a total of 39,314 euros (36,050 for purchase, 1,224 euros for energy for charging, 1,740 euros for insurance, and 300 euros for coupons). For the gasoline version, the expenditure over the three-year period is 30,101 euros (23,050 for purchase, 4,207 euros for fuel, 1,800 euros for insurance, 594 euros for tax duty, and 450 euros for coupons). In the ninth year, the electric is still below: the total cost is 45,840 euros versus 44,204 for the thermal.

With the Volvo XC40, the convenience comes almost immediately. After three years, the owner of the electric version will have spent 60,073 euros (56,300 purchase of the car, 260 euros for coupons, 1,800 euros for insurance, and 1,714 euros for energy), while those who buy the gasoline XC40 will have spent 60,800 euros (50,750 for the purchase, 5,891 euros for gasoline, 1,950 euros for insurance, 1,160 euros for coupons and 1,050 euros for the tax). At six years the savings of the electric is as much as 7 thousand euros and at nine years even 13 thousand euros. Certainly, the renewal of government incentives for the purchase of zero-emission cars would have further changed the game.

3.3 The reality of our world and the truth about a full electric future

The issue that remains in all the cases we analyzed is quite obvious, an electric car in 2022 is still considerably more expensive than any other type of alimentation. Despite all the incentives and the savings in terms of fuel, in the long run the average buyer in need of a city car would probably have trouble in spending more than 20,000 euros. Many, in fact, prefer to purchase used or low cost cars given the limited use they have to make out of it.

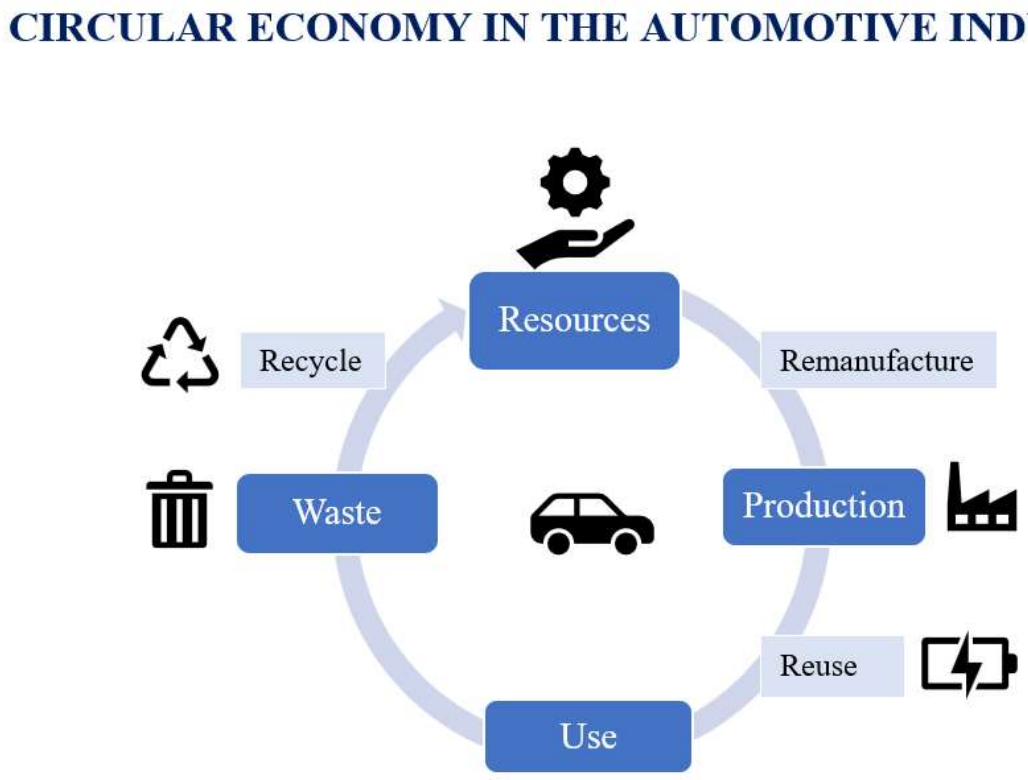
As alternatives there are electric micro cars like the Citroen AMI, which despite a design that could be described as questionable, is considered very convenient and efficient for micro city travelling. The purchase price is around 6,000/7,000 euros, which is pretty inexpensive, but comes with many negative aspects. First among all the maximum velocity is about 45km/h which means that it cannot get on the freeway even for small tracts. It only has 2 seats, it is not very spacious and is designed only for very small traveling since the autonomy is about 75kilometers.

All and all this kind of vehicle is great for younger people, elderlies or people who need a vehicle only and exclusively for city commuting and do care about environmental impact, but it cannot be considered as a substitute for a car.

After a careful analysis we realize that building an electric future in the automotive industry does not begin from the offering of lower prices because even if feasible it will take years.
It begins instead with the sensibilization of the customers on the topic of environmental impact of CO2 emissions. When deciding whether buying a vehicle the customer should not only choose based on pure monetary aspects, but must also take into consideration the impact of their choice on the world. Rather than a purely economic choice it also becomes an ethical choice, because it is important that the customer knows that a gasoline car will probably have more power (in term of

hp) and better performances with respect to an electric one, but still chooses the electric model putting the environmental issue first which means making a conscious choice and a further step towards the circular economy. In the automotive industry, circular economy practices concern four main areas, which are:

- Remanufacturing, used components are repaired and then deployed in used cars or sold in the aftermarket;
- Recycling, where raw materials are extracted out of used components and utilized in new vehicles or other industries;
- Product life extension, reusing the parts of the vehicle until the end of their lifespan (until they are no longer functioning).
- And lastly, sustainable material use, incorporation of innovative, eco-friendly materials such as bio-plastics into new cars.



The journey to make electric fully sustainable is still in its beginnings. Although electric cars are not responsible for carbon monoxide emissions during their use, their Carbon Footprint is still elevated. Indeed, one must consider the sum of emissions produced from manufacturing and throughout the vehicles' life cycle, including their disposal.
Therefore, electric cars can have an important environmental impact, depending on how they are made.

A factory that makes extensive use of renewable energy to make electric motors will reduce most of their lifecycle CO2 emissions at baseline.
Another element to consider about electric cars is their power supply. While it is true that they do not directly emit carbon monoxide into the atmosphere, it is also true that electric cars must be powered. Their emissions, therefore, will depend on the composition of the energy sources in the circuit to which they are connected for recharging. An electric grid that relies primarily on fossil fuels will negate the benefits of going electric by shifting the source of pollution from the car to energy production. It is fundamental in the recharging as well the usage of renewable resources.

With the very intent of reducing the environmental impact, the program Fit for 55% was born.
It consists of a set of proposals to review and update EU regulations, and implement new initiatives to ensure that EU policies are in line with the climate goals agreed upon by the Council and the European Parliament. It refers to the EU's goal of reducing net greenhouse gas emissions by at least 55 percent by 2030.

The program, of course affects also the automotive industry, the goal by 2035 is the full electrification of vehicles. This is a titanic technological and manufacturing plant conversion challenge, but automakers are investing heavily in these new green mobility technologies to make themselves ready for the change. In addition to the proposal to ban the sale of new gasoline- and diesel-powered cars after 2035, the Commission has stipulated that by 2025 member states must install charging points for electric vehicles no more than 60 kilometers apart on major roads.
It is estimated by the Commission that the expenses on charging points on public and private land throughout Europe will be of 80-120 billion euros by 2040.

It is clear from what we have seen so far that the shift to electric transport cannot happen without trade-offs. This is a delicate shift that needs to be approached carefully by institutions.
There is significant room for improvement, and the characteristics of electric motors make them, today, the best candidates to replace combustion engines. A growing number of experts agree that their environmental impact can be very limited, provided they are made and charged using energy from renewable sources.

Conclusions

In conclusion it is safe to state that electric automobiles are to date the most environmentally friendly choice. In Europe during their use they were responsible for lower emissions in comparison to combustion engines. Pollution in electric cars is geenrated during the production and disposal processes of the batteries. The energy production process itself is what can make a difference, and is where the automotive industries need to shift their focus prioritizing renewable energy sources since the greener the energy production, the lower the emissions.

In countries dependent on nonrenewable sources for energy production, electric cars will have a negative impact on the environment, but no greater than cars with internal combustion engines.
The higher performance of electric motors means lower energy consumption for the same number of miles driven. Looking forward, due to the process of decarbonization, their performance will be increasingly better.

The electrification process must be looked at in its entirety and must be considered in constant evolution, buying an electric car now is a long-term investment for the future.
As of today the future outlook, while complex, seems however pretty positive.
Climate change awareness has had its results, exspecially on younger generations, but there is still a long way to go. Electric vehicles in 2022 cannot be considerd as perfect substitutes for fossil fueled cars, it is undeniable that they differ in many aspects, but it is also undeniable that they can be considered as evolutions of the classic fuelled car.

Gasoline and diesel cars have headed the automobile industry for many years, revolutionizing the trend is complex but part of a much needed economic and social evolution.

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