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ELECTRIC VEHICLE TRANSITION: EUROPE'S CHALLENGES IN A GLOBAL CONTEXT

Abstract: The European automotive industry faces competitive challenges in light of electrification, driven by the rise of Chinese manufacturers and the reshaping of policies within the European region. Despite the high interest in the daily news, the topic remains fragmented into individual subtopics such as sustainability, supply chains and labour, and requires a data-supported and systematic analysis of the competitive challenges of the automotive industry. Therefore, this research's objectives were to review the current state of the global automotive market, analyze proposed solutions for maintaining the competitiveness of European manufacturers, and develop a projection of the global electric vehicle market's development. The research was based on a systematic review of the literature and the analysis of various data sources, incorporating the method of triangulation of sources to ensure the credibility of the results. Key findings indicate that European manufacturers face difficulties competing with affordable Chinese electric vehicles, which are increasingly entering the European market, due to high costs and limited access to key technologies such as batteries and semiconductors. Proposed solutions include investing in research and development, improving supply chains, and fostering closer collaboration with the energy and technology sectors. The market projection for 2030 suggests that electric vehicles will account for more than 57% of global annual sales, with China maintaining a leading market share, while Europe, due to delays in adapting to electric vehicle production, will gradually lose its share of the total sales in the industry.

Keywords: automotive industry, China, Europe, electric vehicles, automotive industry future

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Introduction

Over the course of more than a century, the automotive industry has become a key economic sector that contributes significantly to the development of the global economy. From the early days when automobile production was concentrated in a few key countries, the industry has gradually transitioned to a globally dispersed network of manufacturers. The first development breakthrough came in 1908 with Henry Ford and the introduction of mass production of the Model T, which brought cars closer to the wider population (Rae & Binder, 2024). Just few years later, the automotive industry of the United States of America (hereinafter: the USA) was responsible for 80% of global automobile production and became the showpiece in this segment, and they maintained their market share at this level until 1950 (Rae & Binder, 2024, Rodrigue, 2020). Later, Japanese manufacturers, especially Toyota, caused a new transformation in the automotive sector with their lean production strategy (Holweg, 2008), and the European automotive industry followed suit and managed to remain competitive for a long time, but soon faced challenges brought by new low-cost markets such as China (Bechmann & Scherk, 2009; Holweg, 2008; Sturgeon & Florida, 2000).

The Chinese market, which until 1975 produced virtually no cars, began to boom in the mid-1990s, thanks to a combination of low labor costs (Bowles & Dong, 1999), centrally planned economic policies, state subsidies, and a rapidly developing domestic industry (Holweg et al., 2009; Jia-Zheng & Broggi, 2023). Chinese manufacturers, who initially followed Western and Japanese models and tried unsuccessfully to compete in the market with their internal combustion engine (IC) cars (Jia-Zheng & Broggi, 2023; The Economist, 2020; Yang, 2023), soon found themselves at the forefront of new technology development, especially in the field of electric cars. By 2023, the Chinese automotive industry has become the largest car manufacturer with a share of 32% of total global production (ACEA, 2024a; OICA, 2024), with a significant share of electric cars (Cunningham & Sherter, 2024). Figure 1 (OICA, 2024; Rodrigue, 2020) shows the power relations of the historically most important car manufacturing countries between 1950 and 2020, noting that after the COVID-19 pandemic, China further strengthened its market share, while all other exposed countries lost between 1 and 2% of their market share. The USA is now responsible for just under 3% of global car production, Japan for around 10%, while the whole of Europe, including the United Kingdom, produces just under 19% (OICA, 2024). Germany remains the largest car producer in Europe, but it experienced a 25% decline in production volume at the start of the pandemic and has still not managed to reach the production levels of 4 years ago (German Association of the Automotive Industry, 2024; OICA, 2024).

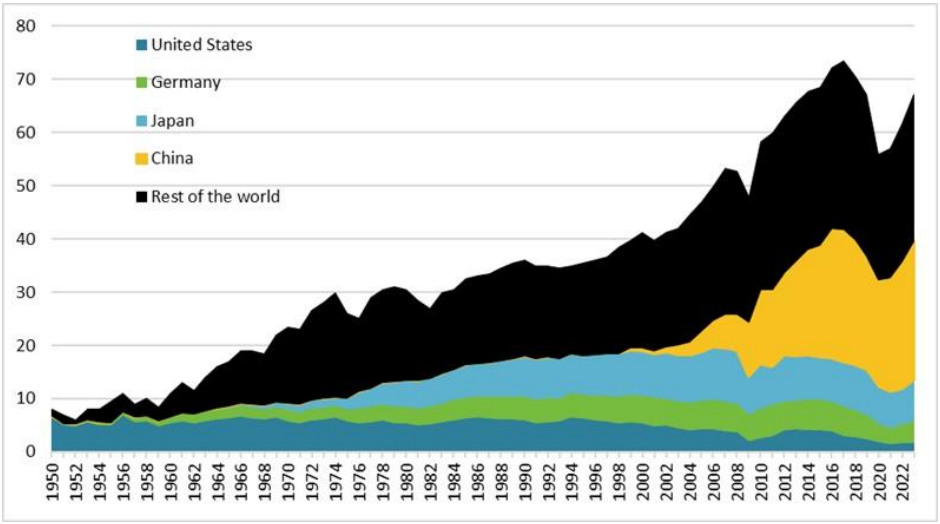

Fig. 1. Production of all cars (in millions), 1950-2023 (Source: OICA, 2024; Rodrigue, 2020)

In addition to the changes in the balance of power between car-producing countries, the last decades have also seen major changes in the type of propulsion system used in new cars. The twentieth century was marked by numerous questions and concerns about the increase in greenhouse gas (GHG) emissions, as a by-product of globalization, industrialization, and the increasing number and needs of people around the world (Chen & Wu, 2017; Emadi & Petrunic, 2015). In many cases, traffic and vehicles have been singled out as key pollutants (Kalghatgi, 2018), which are still largely powered by MNEs (IEA, 2024d). All this led to the Paris Agreement on Climate Change in 2015 at the 21st Conference of the Parties (COP 21), which was signed by practically all countries in the world (except the Vatican) (Fetting, 2020; United Nations, 2016). It is an international treaty that legally binds signatories to take action to combat climate change and served as the legal basis for the European Union (hereinafter: EU) to create the European Green Deal (European Council & Council of the European Union, 2020b). The treaty entered into force the following year after it was ratified by the appropriate number of countries, which at that time generated 55% of the world's GHGs (European Council & Council of the European Union, 2020a). This also created a legal basis and a commitment that directly threatened the existence of conventional cars with ICE, which largely operates on fossil fuels (Kalghatgi, 2022), even though new fuels for powering ICE were developed and introduced on the market in the period after its signature, which is much less harmful to the environment (Estevez et al., 2024; Kalghatgi, 2018). As an alternative, politicians and decision-makers have suggested the use of electricity in the automotive industry (Wellings et al., 2021), which has significantly gained recognition and penetrated the industry since the Paris Agreement (Meckling & Nahm, 2019; Raufi & Maniat, 2024), despite the opposition of many global car manufacturers (King & Labiak , 2024). European and American manufacturers, which have a rich automotive history associated with ICE, are now faced with a major technological transformation of the industry and a new global competitor, China, which, at least for

the time being, has a great primacy in the field of knowledge, technology and infrastructure related to electric cars (Vox, 2024), and is also by far the most successful in selling electric cars (see Figure 2; (IEA, 2024b)).

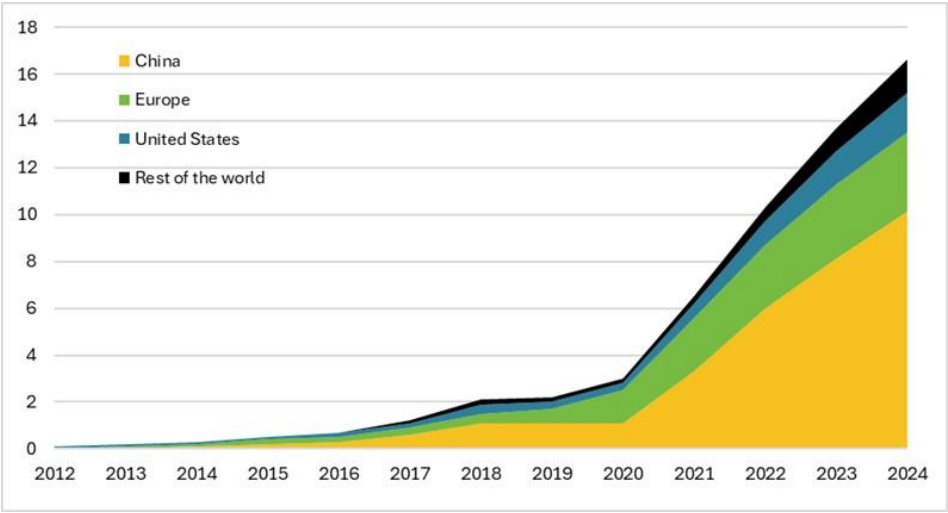

Fig. 2. Electric car sales (in millions), 2012-2024 (Source: IEA, 2024b)

With stricter environmental regulations and growing awareness of environmental problems, car manufacturers (and countries) around the world have begun to invest in the development of more sustainable vehicles (IEA, 2024b; BloombergNEF, 2024). Trends in the industry indicate a transition to electrification of the drivetrain (Shigeta & Hosseini, 2020), which, at least during the use phase of the car, does not pollute the environment (Requia et al., 2018) and in this respect is aligned with the global sustainability agenda of the Paris Agreement. The transition to the production of electric cars has thus become, at least in the current period, an inevitable and legally supported global project, which has brought with it many open questions and has seriously shaken economies strongly linked to the conventional automotive industry.

Numerous studies have examined barriers and challenges facing the European automotive industry; however, these challenges are often analysed in isolation – for example, sustainability (Khare et al., 2024; Schöggl et al., 2024), supply chains (Britsche & Fekete, 2024; Manello & Calabrese, 2019), and labour (Buigues & Lacoste, 2023; Pisková et al., 2024). Those studies do not cover the full spectrum of challenges that have brought the European automotive industry to its current state, and at the same time pose a real threat to the status that Europe has historically enjoyed in industry. To address this fragmentation, this study poses three research questions:

- **RQ1**: What are the key competitive challenges the European automotive industry is facing today?
- **RQ2:** What are the key pillars and directions for the revival of the European automotive industry?
- **RQ3:** What will be the development of the global automotive market, in the era of electrification of the drive, by 2030?

In light of the industry transformation and the loss of primacy of European car manufacturers, our study explores the current state of the automotive market (with a focus on electric cars) from the perspective of various stakeholders. The study primarily critically highlights the consequences that the European automotive market is facing due to the rise of China and various policy changes within the European area that encourage the development and production of more sustainable (especially electric) cars. The study also formulates proposals for the revival of the European automotive industry, including a prediction of the development of the European and global electric car market for the next few years. The results of the study will primarily provide insight into the current state of the industry, especially on European soil, while at the same time bringing concrete solutions that can serve as a starting point for the re-establishment of a competitive automotive market in Europe.

Materials and Methods

The research was based on a systematic literature review and secondary data analysis, using a combination of qualitative and quantitative research methods. The data acquisition process was carried out in three main phases (See Figure 3), which provided data for a comprehensive overview of the current state and development of the European (and global) automotive industry in the context of electrification and competitive challenges. This was followed by the selection of proposals for the revitalization of the European automotive industry and the development of a projection of the global automotive market.

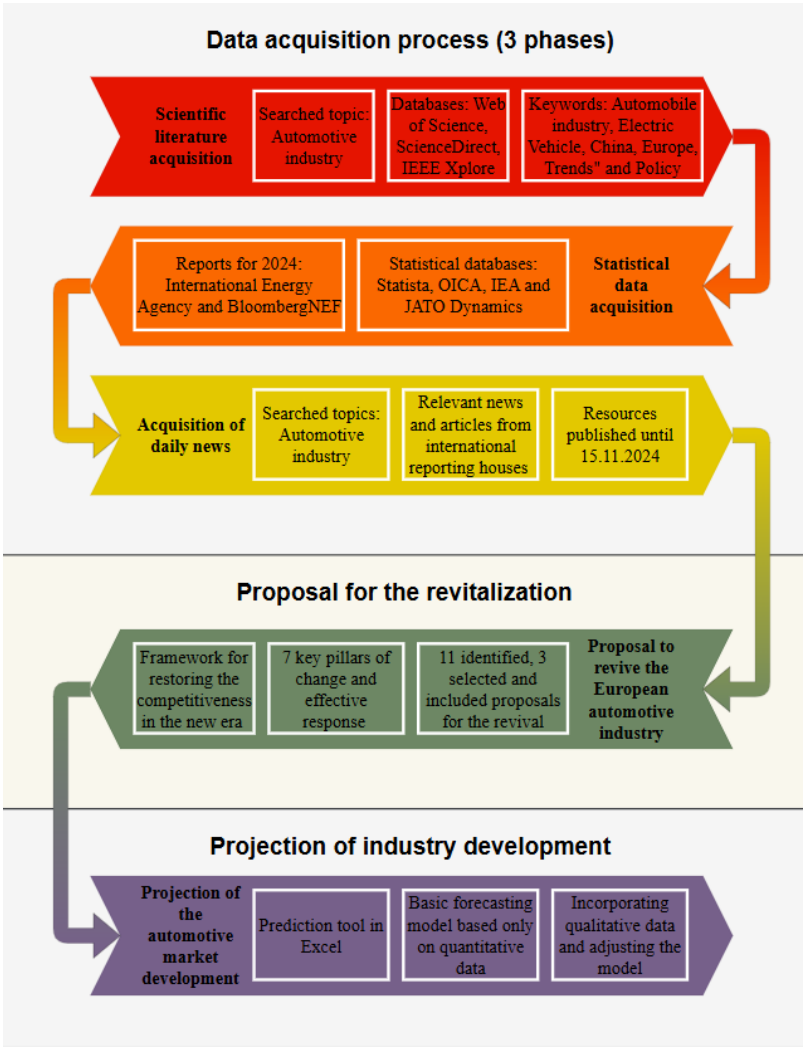

Fig. 3. Presentation of the research process (Source: Own)

Data acquisition

In the first phase, we conducted a comprehensive review of the scientific literature using three central academic databases: Web of Science (hereinafter: WoS), ScienceDirect (hereinafter: SD), and IEEE Xplore. We searched for relevant sources using predefined combinations of keywords related to the research area, such as: "Automobile industry", "Electric Vehicle", "China", "Europe", "Trends", and "Policy". To ensure the accuracy and relevance of the results, we also used some Boolean operators (AND and OR) between the keywords. In addition, we also restricted ourselves in terms of language, with results in English, and the time frame (due to the research topic), which was set to results published between 2015 and 2024 (including the start and end years). This allowed us to select the most relevant sources, thereby optimizing the quality and efficiency of the literature search. In the aforementioned databases, we obtained a total of 1587 results, which were reduced

to 258 documents in the first phase of sectioning by removing duplicates and irrelevant documents. The remaining documents in the literature pool included journal papers, conference papers, books, book chapters, review papers, and editorials. The process of selecting the included publications is shown in Figure 4.

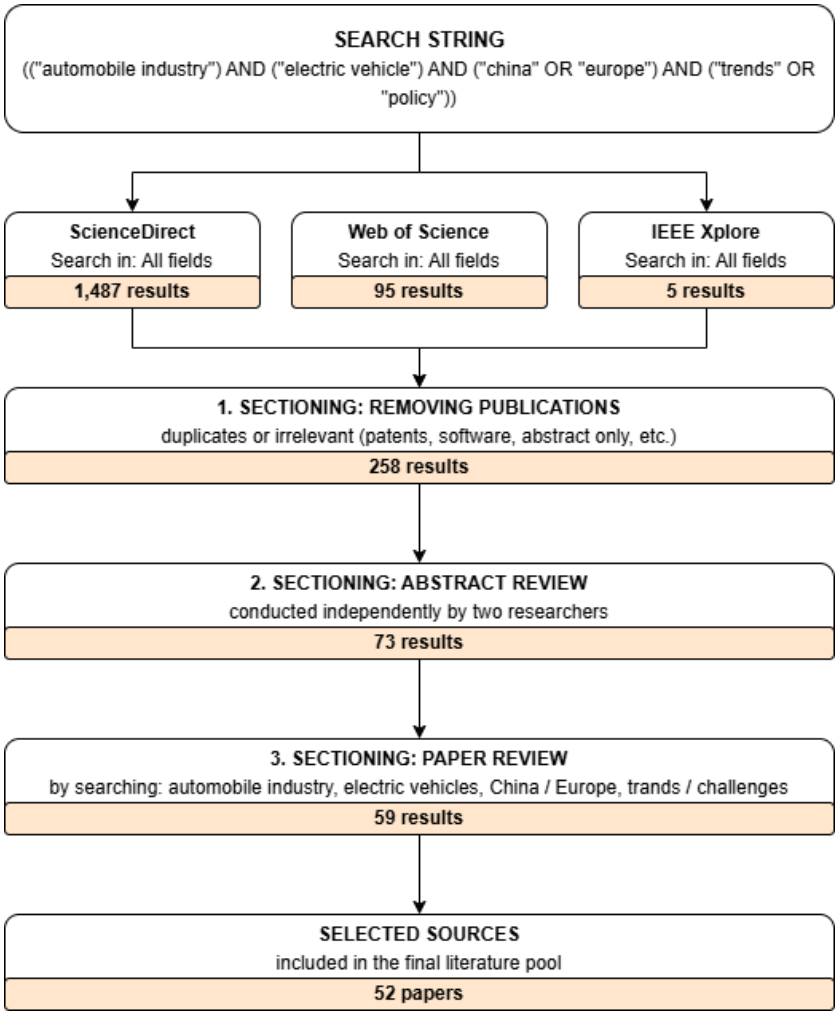

Fig. 4. Electric car sales forecast (in millions), by 2030 (Source of data used: IEA, 2024b; Input data was processed using the Excel "Forecast" function, and the results were adjusted according to trends, policies, and other predictions)

To build the final literature pool of the 52 documents, the authors independently assessed the title and abstract of individual documents, and where necessary, also the content of the document. To determine the relevant documents to include in the final pool, we used the following inclusion criteria:

- Publications addressing the automotive industry (e.g. suppliers, value chain, industry structure, competitiveness, industrial policy) as a substantive part of the research;

- Publications in which electric vehicles are a materially relevant topic, including transition, industrial strategy, batteries/charging ecosystems, or related policy and competitiveness impacts;
- Publications explicitly involving China and/or Europe as the geographical context;
- Publications identifying or evaluating trends and/or challenges shaping the automotive transition (e.g., technology change, cost pressures, supply chain risks, infrastructure constraints, regulatory uncertainty, market entry).

The second phase of the review involved the analysis of statistical data to accurately quantify the state of the industry. The analysis was conducted based on three main data sources: International Organization of Motor Vehicle Manufacturers, International Energy Agency and JATO Dynamics. Special attention was paid to the analysis of the latest reports on electric vehicles for 2024 from the International Energy Agency and BloombergNEF, which represented an important source of current data and industry development projections.

In the third phase, we also included a review of relevant news and articles from national and international reporting houses or outlets that related to the topic under study, limiting ourselves to material published until November 17, 2024. News and articles from both public (Voice of America, Deutsche Welle, The Slovenian Press Agency, BBC) and private (The Guardian, Euronews, Pro Plus, CBS News, The Brussels Times, The Economist, Forbes) media were used, with the criterion for including an individual media being its overall public reliability of the information, and for a news or article, the support of the publication by traceable sources.

All three phases were utilized to implement data triangulation, systematically comparing evidence from different source types to support credibility and validity, and to identify and address inconsistencies (Bans-Akutey & Tiimub, 2021). Triangulation was done as a structured cross-source verification process. First, we identified the study's key themes and claims from the systematic literature review, grouping them by theme. Second, each claim was matched with quantitative indicators from major secondary datasets (e.g., EV sales/stock, production volumes, prices), and we checked consistency across datasets where overlapping measures existed. Third, we reviewed time-bounded media reporting from selected public and private outlets to confirm the contemporaneity of trends and to detect recent policy/industry events not yet captured in academic publications. Convergence across at least two source types was considered stronger support; divergences were documented and resolved by verifying original definitions, time windows, and geographic scopes, and by prioritizing primary or official statistics over commentary. The final synthesis reflects only claims that could be confirmed or transparently qualified based on this cross-source comparison.

Drafting a proposal for the revival of the European auto industry

The development of the proposal for revitalizing the European automotive industry was based on the analysis of eleven identified proposals that addressed the key challenges of electrification, competitiveness and sustainable development. The process was structured around criteria that included a holistic approach to the issue, the integration of concrete and feasible solutions, and the adaptability and readiness of the proposals for imme-

diate implementation. Special attention was paid to those that combined several dimensions of improvement and enabled systemic changes, including technological, economic and political aspects.

In the process of synthesis and development of our proposal, three of the aforementioned eleven proposals were selected and used, all of which are based on the seven key pillars of change and enable an effective response to the existing situation and preparation for future trends in the industry. Thus, the final result was a proposal that provides a framework for restoring the competitiveness of the European automotive industry in the era of electrification of the powertrain and its adaptation to global market dynamics and sustainability requirements.

Creating a projection of the development of the global automotive market

The basic quantitative projection was first generated in Microsoft Excel using the built-in Forecast Sheet tool, which applies exponential smoothing through the FORECAST.ETS function. The baseline time series used to build the model comprised (i) annual data on electric cars sold and (ii) annual data on the shares of electric-car sales, disaggregated by the individual areas considered (Europe, the US, China, and the rest of the world). Point forecasts for 2025-2030 were computed using the FORECAST.ETS function, while 95% confidence intervals were calculated using the FORECAST.ETS.CONFINT function (confidence level = 0.95), with lower and upper bounds derived as forecast ± confidence interval. Because the input data were annual (2010–2024; frequency = 1 year), seasonality was set to 1 (no seasonality), and the dataset contained no missing observations or duplicates. The resulting baseline outputs were then adjusted and refined in accordance with trends, policies, developments in related industries, and projections reported by other authors. The final projection was therefore based on a combination of quantitative forecasts and qualitative scenario adjustments.

Results and discussion

Although there is no official database recording the number of all registered vehicles in the world, based on various related databases, we can estimate that the number of vehicles today is around 1.5 billion units (Bonnici & Stevens, 2024). However, such an enormous global market is currently in the greatest transformation since the rise of ICSs, with sustainability and electrification of the drivetrain becoming its key development pillars (Jetin, 2020).

Global electric car market

The IEA forecasts that electric car sales will reach approximately 17.5 million units in 2024, representing a growth of more than 28% compared to the previous year. If the forecast is fulfilled and the current size of the vehicle fleet (see Figure 5; (IEA, 2024c)) is met, the global number of registered electric cars will exceed 65 million by the end of 2024, with approximately 60% of all registrations in China, 25% in Europe and 10% in the USA (IEA, 2024d).

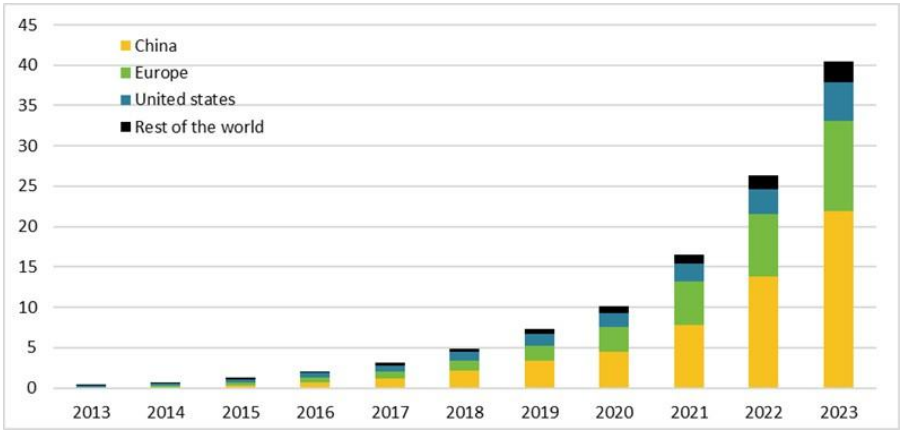

Fig. 5. Publication selection and literature pool process (Source: Own)

Despite the slowdown in the automotive manufacturing industry following a major downturn during the COVID-19 pandemic (Nundy et al., 2021; Wen et al., 2021) and a period of semiconductor shortages in the industry (Xiong et al., 2024), electric vehicles continue to maintain their appeal in the market today and are increasing their sales exponentially compared to previous periods. Figure 6 (Ritchie, 2024) thus shows how electric cars are gradually taking market share from non-electric cars in sales.

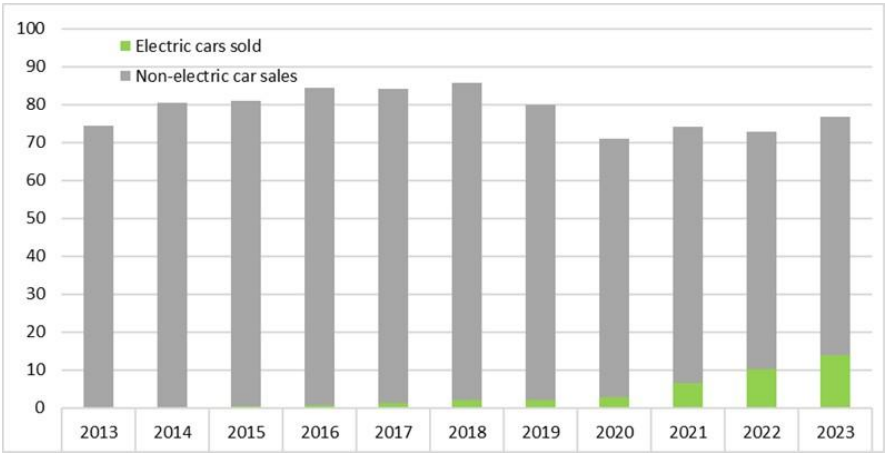

Fig. 6. Global electric car fleet (in millions), 2013–2023 (Source: IEA, 2024c)

In 2024, the share of electric cars sold is expected to exceed 22% of all cars sold worldwide, and in the following year this share is expected to rise to over 25% (IEA, 2024d). The reason for this growth is mainly due to constant progress in battery technology (Sanguesa et al., 2021), which is reducing the price of battery electric cars in particular (Gorzelany, 2024) and increasing overall performance (JATO Dynamics, 2022; Mohammadi & Saif, 2023; Ralls et al., 2023), which in turn directly affects the maximum range of vehicles (Colak & Irmak, 2023). As a result, these cars are becoming increasingly attractive to end customers, and the growth in demand is no longer solely due to policymakers' policies and various financial incentives (BloombergNEF, 2024). Today, we can already find electric cars on the market that are competitive with cars with ICE (JATO Dynamics, 2023).

Until the period of mass electrification, the automotive industry was considered an industry led by well-known players, manufacturers who had established themselves on the market since the beginning of the 20th century. However, the trend changed significantly with the period of mass entry of electric cars into the market and introduced new manufacturers (Ferràs-Hernández et al., 2017; Kohlmann, 2024), such as BYD, Tesla, Li Auto, Guangzhou Automobile and the like (Irle, 2024; Kohlmann, 2024). Practically all new-age manufacturers are now present exclusively in the production (and sale) of electric cars, where they are not technologically lagging behind or lacking in knowledge compared to established manufacturers such as VW Group, BMW Group and Toyota (Ferràs-Hernández et al., 2017), and at the same time they own the largest market shares in sales. For example, Roman Irle (2024) in his report on the analysis of the electric vehicle market (which mainly includes cars) found that Tesla and BYD were the most successful companies in the market in terms of sales at the beginning of 2024 (see Figure 7; (Irle, 2024)), with the Tesla Model Y being the best-selling vehicle in all vehicle categories, not just electric cars. The report also highlights the rapid growth in sales and the spread of infrastructure, which in 2024 indicates a growing demand for electric cars worldwide.

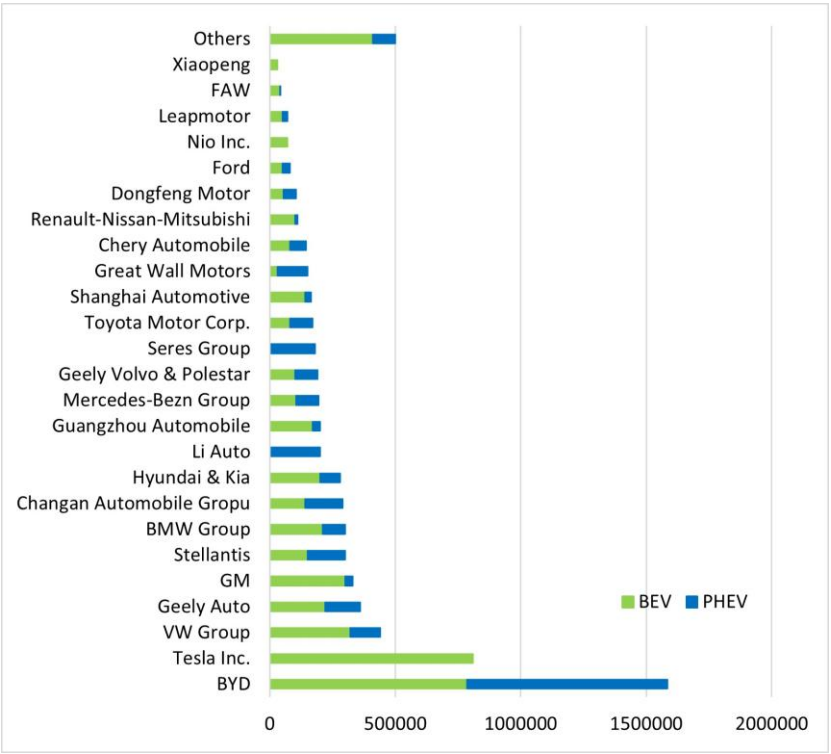

Fig. 7. Number of cars sold worldwide by engine type (in millions), 2013-2023 (Source: Ritchie, 2024)

However, not all electric cars are designed the same in terms of engine technology (Alosaimi et al., 2021; Sanguesa et al., 2021). There are several types of electric cars (and classifications) on the market, and at least for now, there is no unified global division between the aforementioned vehicles. At the moment, according to the general classification (Sanguesa et al., 2021), plug-in hybrid electric cars and battery electric cars are the most prosperous on the market (see

Figure 8; (IEA, 2024c)). Both variations have significantly increased their market share in recent years, mainly thanks to technological and developmental advances in batteries, which are their key component (Kumar et al., 2023).

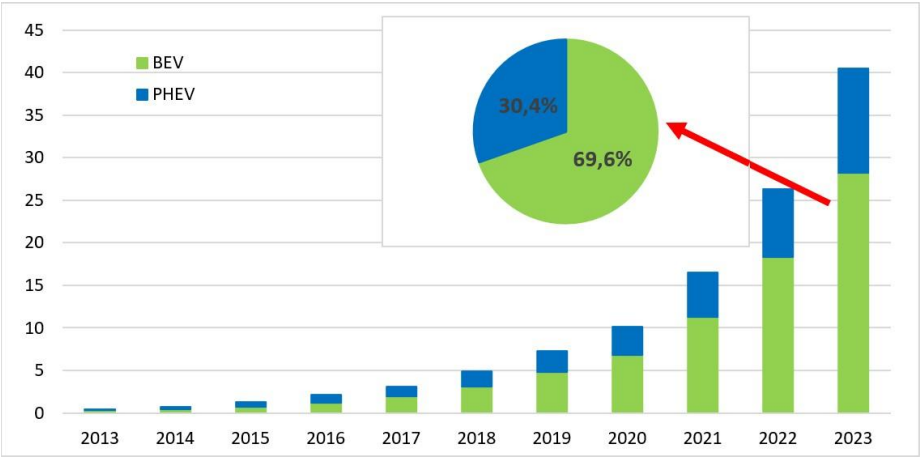

Fig. 8. Global electric vehicle sales by manufacturer, first half of 2024 (Source: Irle, 2024)

The rise of the Chinese automobile industry

As already mentioned, the automotive industry today is still heavily dependent on the production of cars with ICE, where market primacy remains in the hands of European manufacturers (Ritchie, 2024). Nevertheless, there are significant shifts in the market towards the electrification of the drive in the industry, where Europe still has not really found the right strategy to compete with the Asian, and especially the Chinese, manufacturing market (Khaleel et al., 2024). The aforementioned situation would probably not have been very problematic if, especially after the Paris Agreement and the European Green Deal, a consensus had emerged in the world on the transition to more sustainably powered vehicles, with electric vehicles becoming the central topic of the industry (Logan et al., 2020). Chinese manufacturers have thus seized the opportunity given to them, as they benefited from a combination of several factors that placed them on a pedestal of development in the automotive industry.

The first factor that helped China get to where it is today is the organization of the country. The management and leadership of the country strongly resemble socialist systems, which, in addition to their weaknesses, also have many advantages. Central planning and the ability to consistently follow strategies are two of these (Dreyer, 2016). Based on both, China carefully and thoughtfully outlined the development of the automotive industry and stood alongside Europe and the USA, which rely on more bureaucratically complicated management systems.

During its general economic rise, China also massively adopted partnerships in the form of joint ventures with European and American automobile manufacturers (Barnes, 2017; Holweg et al., 2009), which, in addition to development, enabled it to massively import foreign knowledge and experience from various industries into its market (Barnes, 2017; Jin & Wang, 2021). In this way, they gradually acquired all the key pieces of the puzzle for the successful development of their companies. In their study, Jia-Zheng & Broggi (2023) highlight the importance of internal internationalization in the development of the Chinese automobile industry, which led to the development of the entire automotive supply chain in China and the country

and opened the door for companies in the 21st century for subsequent external internationalization.

In addition to the aforementioned factors, China currently has the greatest advantage in the electric vehicle market in the development and knowledge of batteries, which are undoubtedly a key component of most electric cars and ultimately represent as much as 40 % of the production price of electric vehicles (Vox, 2024). The production of batteries and battery components for the majority of all electric vehicles in the world takes place in China (Ridgwell, 2023), since, according to Yang (2023), the latter is also the most efficient. Similar to electric vehicles, they have secured their market dominance with the help of enormous state investments, tax reductions and incentives related to battery research and development (Bhutada, 2023). In all this, it is also important to note that China in many cases has control over the scarce raw materials for battery production (Garcia-Herrero, 2022), which also simplifies the supply chain and makes it more resilient for their production. All of the above allows Chinese manufacturers to be practically the only ones on the market today to offer competitively priced electric cars that are at the same time technologically comparable to cars from European and American manufacturers. And while a few years ago they produced cars mainly for the needs of the domestic market, today they are gradually expanding into foreign markets, including the USA and Europe with much more demanding consumers.

Current status and challenges of the European automotive industry

The European automotive industry faces serious competitive challenges in 2024, also due to the development of the Chinese automotive industry. Not efficient inclusion in electrification means that it is more difficult for European manufacturers to produce affordable electric models, which, for example, allows Chinese manufacturers to enter the European market more easily. Since the price is an important factor that discourages many car buyers from buying electric cars, we have seen a lot of EV price reductions lately. However a study by JATO Dynamics (2023) finds that the average selling price is decreasing only among Chinese providers, while in Europe (and the USA), for example, the average price has not decreased or has even slightly increased in the last 5 years (see Figure 9; (JATO Dynamics, 2023)).

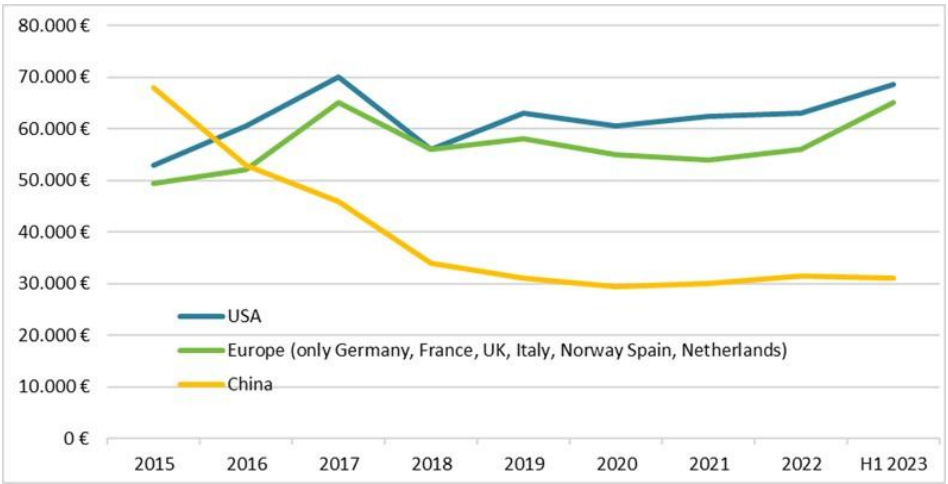

Fig. 9. Global electric car fleet by engine technology (in millions), 2013–2023 (Source: IEA, 2024c)

Between 2015 and 2023, the average selling price of a battery electric car from Chinese manufacturers decreased by approximately 55 %, while in the observed European region the average price increased by more than 30 % (JATO Dynamics, 2023). In Germany, as a European automotive superpower, today the prices of battery electric vehicles remain 20 % higher than the prices of comparable vehicles with ICE, even when subsidies and rebates are included in the price (Cingari, 2024). As a result, Chinese manufacturers are taking advantage of the current situation, as shown by the fact that they increased their exports of electric cars to Europe to more than 40 % (European Parliament, 2024).

European battery car manufacturers are therefore not competing on the market with prices in 2024, which is why we can now observe a sharp decline in sales and, consequently, registrations, especially of battery cars, in Europe. In the EU-28, a 36 % decline in registrations of the aforementioned cars was recorded in August 2024, which is the largest decline since 2017 (Munoz, 2024). An even greater decline was recorded only in the EU area, where a drop of almost 44 % was recorded; the plug-in hybrid market suffered a little less in the EU, which experienced a "mere" 22 % decline. At the same time, the European automotive market is also facing a decrease in the number of registrations of cars with ICE, as a result of which there were 18 % fewer registrations of all cars in the EU area in August (ACEA, 2024c). The EU's automotive crisis therefore does not only encompass the electric vehicle market, but is embedded in the entire industry in its region, and the United Kingdom is not recording any better results either.

The reasons for the European car crisis stem from several reasons, which are much interconnected and directly affect the above-mentioned price uncompetitiveness in the electric car market. European manufacturers are not satisfied with the fact that technological development and the sustainability agenda of the European Green Deal have brought different critical technologies to the industry than we knew in the past. Semiconductors and advanced software are probably the most represented technologies and if we add to this the trend of electric cars, we can highlight the batteries that power the latter cars as a critical technology (Cornet et al., 2023). In all of the above, Europe is in the worst position by far in terms of availability and technological progress compared to China and the USA. Lacking policy strategic focus on the future development of car manufacturing also does more harm than benefit to European car manufacturers.

The battery market and supply chain are currently dominated in all respects by China (Bhutada, 2023), which, except for obtaining raw materials for battery production such as lithium, holds all the reins in its hands (see Figure 10; (Cornet et al., 2023)). This gives their electric car manufacturers much greater reliability, resilience and flexibility in providing batteries at an incomparably lower price than European ones. At the same time, China still has a cheaper labor force, which further reduces the cost of battery production (and ultimately cars) (JATO Dynamics, 2023), which is why it is not surprising that Europe has the most expensive batteries on average compared to China and the USA (IEA, 2024a).

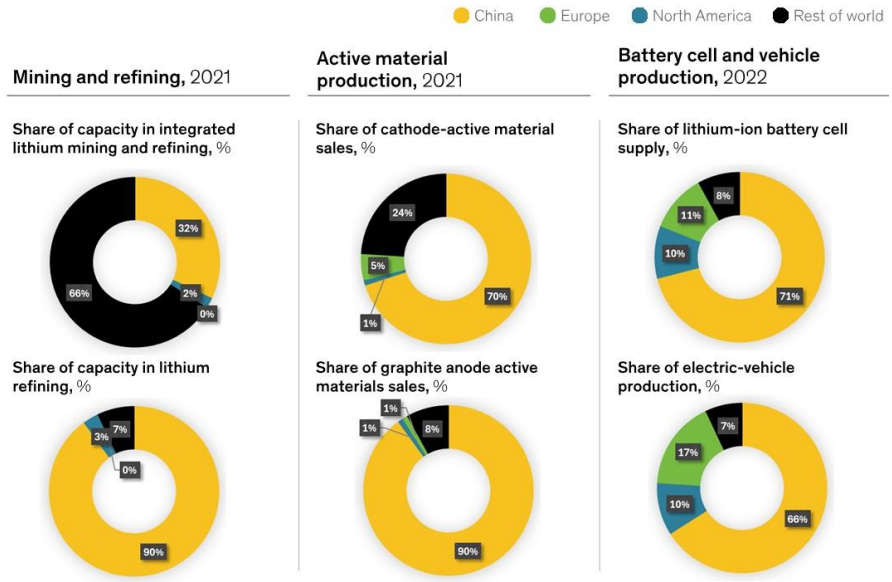

Fig. 10. Average selling price of a battery electric car, 2015-2023 (Source: JATO Dynamics, 2023)

Semiconductors are another key technology of the modern automotive industry, 70% of which is produced in Asia (mainly Taiwan, South Korea and China) (Zandt, 2024), but in terms of ownership, the USA owns the majority of manufacturing companies (mainly in Taiwan) (Ravi, 2024). Both the USA and China have established themselves as key countries in the field of semiconductors to date, controlling over 55% of the global share of their sales. On the other hand, Europe has the aforementioned share of less than 10%, and the demand for semiconductors in this region primarily comes from the automotive industry. The latter was responsible for more than a third of all semiconductor demand in Europe in 2020, which is much more than the automotive industry in the USA (10%) or China (7%) (Frieske & Stieler, 2022). The European automotive industry is in an extremely unenviable position, as the main consumers of semiconductors are located in their territory, while Europe remains a relatively small player in the production and sale of semiconductors. This fact makes the European automotive industry much more exposed to price pressures and general risks in the supply of another key component for car production.

With the development of modern cars equipped with numerous smart technologies, software is also one of the most important factors in the development of the industry. By 2030, the value of the automotive software market is estimated, according to various sources, between 32 and 46 billion US dollars, which is mainly a result of developments in the field of autonomous driving, assistance systems and the greater use of sensors and telematics in modern cars (Burkacky et al., 2023; Kanekal & Ravikumar, 2024). As with batteries and semiconductors, Europe is again lagging behind in the automotive software market, which they are clearly aware of and want to solve through numerous initiatives and improved cooperation between European vehicle manufacturers (European Commission, n.d.; Kastelan et al., 2020).

In addition to new critical technologies in the automotive industry, charging infrastructure is also becoming increasingly important due to the increasingly rapid transition to electric vehicles. The latter, or lack thereof, is in many cases one of the main barriers that prevent individuals from purchasing an electric vehicle (Krishna, 2021), and studies already indicate a connection between the density of charging stations in a given area and the number of electric cars (Peng et al., 2024). Today, we still have 10 times more private than public charging stations around the world, which is proving to be a problematic situation, especially in more densely populated urban environments (IEA, 2024d). In 2023, Europe (including Turkey and the United Kingdom) had approximately 800 thousand public electric charging stations available, of which every 8 stations is a fast station. Globally, this is still only 20% of all stations, with China having around 70%, achieving much higher coverage of charging infrastructure than Europe (IEA, 2024d). However, there are relatively large differences in the number of charging stations and the number of stations in relation to the number of electric vehicles within Europe. The Netherlands and Luxembourg in particular are two examples of good practice in Europe today when it comes to charging stations (see Figure 11; (Yanatma, 2023)). Nevertheless, ACEA (2024b) found that the EU needs as many as 8 times more charging points per year if it wants to achieve its CO_2 targets. No matter that, researches have proven that majority of EVs are being charged at home during off-peak hours since this is significantly cheaper than fast charging or even public charging stations and also much more in favour of electricity grid.

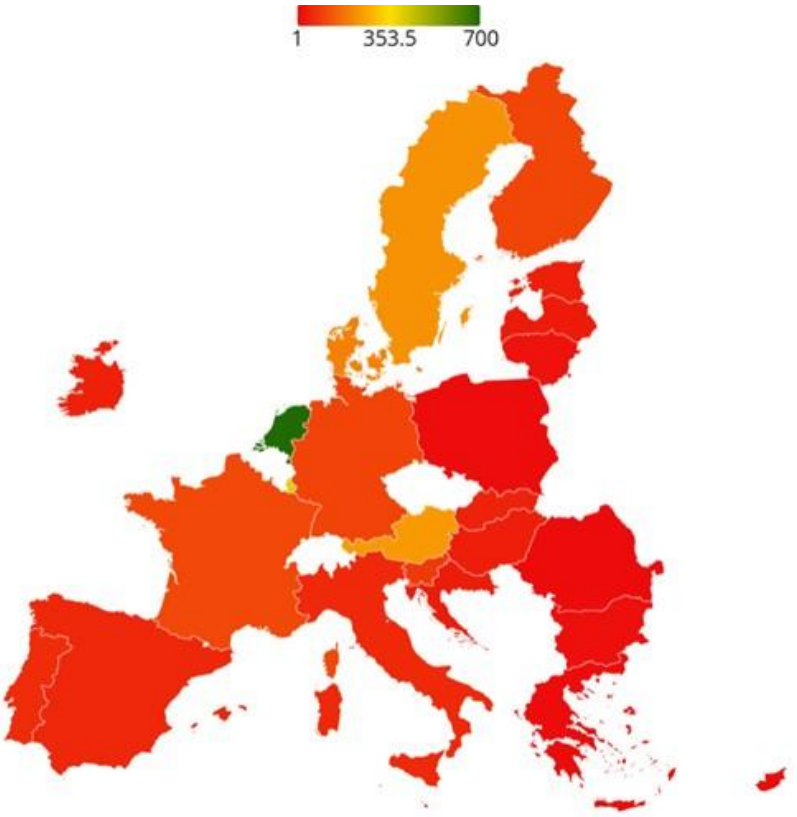

Fig. 11. Critical parts of the battery supply chain are concentrated in China (Source: Cornet et al., 2023)

The global electric car market is showing strong and consistent growth, but the weak performance and lack of competitiveness of European manufacturers and the rise of plug-in hybrids as an intermediate path between electric and hybrid vehicles indicate that the transition to fully electric battery vehicles, especially in Europe, could take longer than expected (Cingari, 2024). In recent months, numerous layoffs and factory closures have been announced in the automotive and battery manufacturing sectors across Europe, also due to the aforementioned reduced interest in electric cars but also due to lower demand for cars in general which is on the other hand consistent with the goal of moving focus from personal vehicles to public transport, active and reduced mobility as well as sharing cars. In 2024, some European automotive companies highlighted the high costs and increasing competition from Asia potential layoffs and factory closures in Germany (24ur, 2024; King, 2024). However, the numerous consequences of the European automotive crisis are also being felt by individual stakeholders in the supply chain. The French tire manufacturer Michelin has already announced the closure of at least 2 factories in France by 2026, while the German car parts supplier Schaeffler has announced the reduction of number of employees in Europe (STA, 2024). All of these announcements have a fair impact on the European economy, especially considering the fact that European automotive suppliers have already eliminated almost 86,000 jobs since the beginning of the coronavirus pandemic (The Brussels Times, 2024).

Suggestions for improvements for the European automotive industry

The European automotive industry must rapidly adapt to an evolving market characterized by disruptive forces—from the electrification of powertrains to the shift toward software-defined vehicles. By synthesizing insights from McKinsey & Company (Cornet et al., 2023), Boston Consulting Group (Waas et al., 2023), and KPMG (Silberg et al., 2024), we have derived seven key pillars that form the basis for restoring competitiveness—especially in the electric car market (see Figure 12; (Cornet et al., 2023; Waas et al. 2023; Silberg et al., 2024). These emphasize leveraging core strengths in customer understanding, product design, and brand identity; ensuring cost efficiency and speed; securing resilient, circular, and sustainable supply chains; and investing in competitive battery, semiconductor, and EV technologies. In addition, strategic partnerships, particularly in key markets like China, and a supportive industrial ecosystem are crucial to counteract market disruptions.

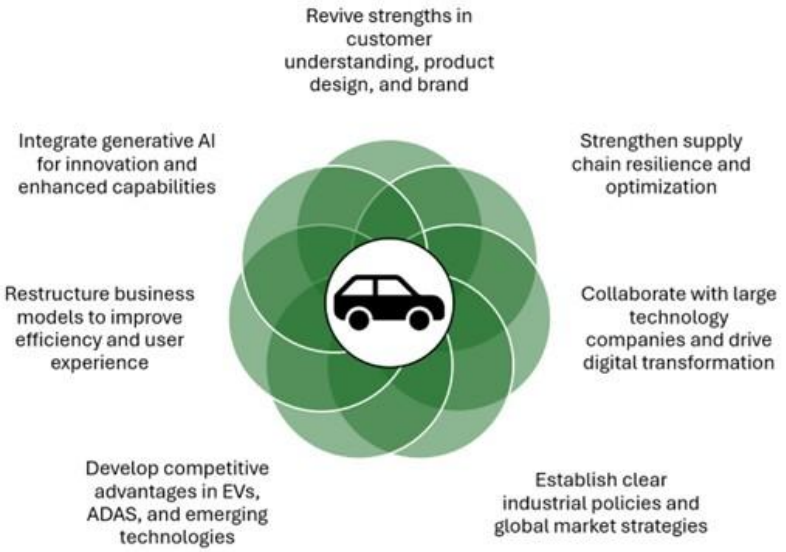

Fig.12. Publicly accessible charging points per 100,000 inhabitants, 2022 (Source: Yanatma, 2023)

To navigate the ongoing digital transition, European automakers must urgently close the software skills gap and integrate advanced driver assistance systems with strong regulatory support. Applying artificial intelligence across vehicle design, testing, and broader manufacturing processes is also essential to enhance productivity and innovation. Collaboration with large technology companies and emerging tech start-ups will drive the development of new digital solutions and innovative business models such as direct-to-consumer sales and integrated e-commerce platforms that can transform traditional value chains. Equally critical is the need to optimize supply chains by adopting dual-sourcing strategies and establishing long-term partnerships to secure key raw materials and components, thereby reducing global dependencies.

A clear and unified industrial policy, underpinned by active government support, will be instrumental in stabilizing the sector amid global trade challenges. Establishing local ecosystems to build sustainable competitive advantages and restructuring business models to enhance efficiency and customer experience are pivotal for long-term success. By integrating advancements in battery and EV technologies, reinforcing supply chain innovations, and harnessing AI-driven transformations, the European automotive sector can secure a more resilient and competitive future in the electric vehicle arena. Another opportunity of generally lower demand for cars is also to focus from personal vehicles to public transport, active and reduced mobility as well as developing new business models of shared mobility instead of focusing just on re-engineering conventional car manufacturing industry. Replenishing ICV with EV also does not make much sense if there is no sufficient and stable supply of sustainable energy, therefore re-powering EU must go hand by hand with re-engineering car manufacturing.

Projections of the development of the automotive market

Based on the current state of the market, the dynamics of power relations, trends and other projections, we have developed our projection showing the sales ratios in the global automotive market. Our observations so far, the speed of change in the automotive market

and the policies indicated by various global powers are leading to a gradual, but not complete, shift of the automotive market towards electric vehicles. Despite the growth in the popularity of electric cars, sales of non-electric vehicles remain significant, although declining. By 2030, annual sales of electric cars are expected to represent 57% of total car sales (see Figure 13), but the transition will not be as rapid as some more optimistic projections have predicted (Saragea et al., 2021).

Our projection shows that, mainly due to existing international agreements (Paris Agreement, European Green Deal, etc.) and clearly outlined policies for the transition of new vehicles to alternative and more environmentally friendly fuels (Chen et al., 2024; Razmjoo et al., 2022), car manufacturers will produce (and sell) the majority of electric cars from 2029. However, a similar transition on the market would probably be much faster in industries that do not have such a strong tradition of conventional products as the automotive industry.

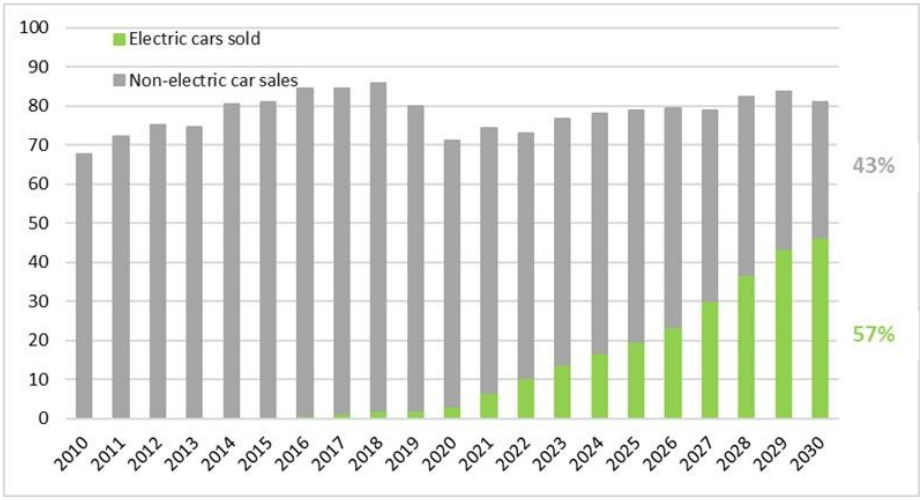

Fig. 13. Proposals to improve the competitiveness of the European automotive industry (Based on sources: Cornet et al., 2023; Waas et al. 2023; Silberg et al., 2024)

In the coming years, China is expected to dominate the electric car market, with its market share gradually decreasing slightly to 55% in 2030 (see Figure 14). This is not surprising, as China currently has a leading role and advantage in the segment, which it is expected to exploit in the future by massively exporting its manufactured cars to major foreign markets such as Europe and the USA (He et al., 2022; Mauritzen, 2024). It is also expected that Chinese automotive exports to the US will be hampered for at least the next few years due to strong opposition to imports of Chinese products, announced increased import duties, and the general escalation of the trade war with China, which we can observe from the new US administration. (Chen et al., 2025; Robinson & Thierfelder, 2024). Chinese manufacturers will likely have much less difficulty importing cars to the European market, which is at least for now less restrictive, despite some countermeasures already implemented by the EU (Deutsche Welle, 2024). However, it is European car manufacturers who will most likely suffer direct losses due to price uncompetitiveness, therefore new business models need to be prioritized.

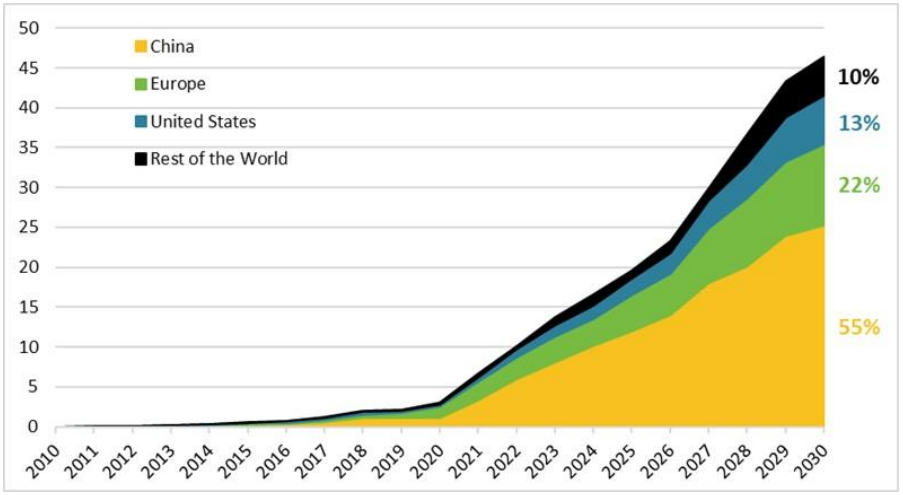

Fig. 14. Forecast of the number of cars sold in the world by engine type (in millions), by 2030 (Source of data used: IEA, 2024d; Input data was processed using the Excel "Forecast" function, and the results were adjusted according to trends, policies, and other predictions.)

The European automotive industry will probably gradually develop its range of electric cars in the coming years and start competing with Chinese low-cost vehicles, but its delayed reaction has practically already decided the winner for the era of electric mobility (Baturin, 2024). European manufacturers will therefore have to look for other forms of market advantage in the future or, to remain competitive, focus on a specific niche within the electric car market, as today their research and development will be heavily focused only on cars with ICE (Corradi et al., 2023). However, we can currently observe negative consequences related to the gradual loss of market share and global dominance in the industry that Europe has had in recent decades, mainly at the expense of the green and sustainable transition that Europe has set as a central development goal (Möring-Martínez et al., 2024) and has undertaken in a suboptimal manner. Strong factors of re-waking EU car manufacturing can also be identified in more subjective factors such as e.g. EU identity and relating EU jobs and strong industry with consumption of domestic goods. Due to trade wars and fast changing world order focusing on dismounting hard achieved democratic principles and international collaboration based organizations, average EU consumer will most likely be more interested to buy European car instead of a car from USA or China. This subjective factor might have crucial role and can be seen as one of the potential solutions to aforementioned challenges of the EU car manufacturing.

Conclusion

The research problem addressed in this article addresses the competitive challenges facing the European automotive industry as a result of the transition to electrification of the powertrain. European manufacturers, which have enjoyed a leading position in the internal combustion engine market for many years, are facing difficulties due to the speed and scale of the transition to electric vehicles, while at the same time, they are being pressured by increasing competition from Asian manufacturers, especially China. Key findings of the study include identifying delays in the development of affordable electric vehicles, lack of access to key technologies such as batteries and semiconductors, and the projected

development of the global automotive industry, which does not bring optimism among European automakers. China has gained an advantage through strategic planning, state subsidies and large-scale investments in battery technologies, which makes it difficult for European manufacturers to remain competitive. While European manufacturers such as VW Group still lead the luxury vehicle segment, the more affordable segments that are gaining popularity are increasingly belonging to Chinese manufacturers such as BYD and Li Auto. Electrification has thus exposed shortcomings and the need for changes in the European supply chain of key components to maintain competitiveness.

As a result, the European automotive industry risks losing its global market share, which would have negative effects on its entire economy. The lack of affordable electric vehicles is also an obstacle to achieving the European Green Deal goals, which are based on the Paris Agreement. Analyses of studies of the proposals for improvement highlight the need for more coordinated action between the public and private sectors and investment in key technologies. At the same time, research shows that the transition is only possible with strong political support, which China has been exploiting as a competitive advantage for several years.

Our projection of the automotive market development until 2030 indicates that the share of electric vehicles will reach more than half of the total annual vehicle sales globally by the end of the period (57% to be precise), with China's market share in the electric vehicle segment decreasing slightly to reach 55% by 2030. This demonstrates China's existing strategic advantage, driven by large investments in R&D, dominance in battery supply chains and lower production costs. European markets, although projected to show growth in electric vehicle sales, are lagging behind due to high prices and inadequate infrastructure. In the long term, this is a warning that without radical adjustments in the areas of policy, price competitiveness and supply chains, the European automotive industry risks losing even more market share. The projection also suggests that the transition to full electrification will be slower than some other more optimistic forecasts have assumed, offering Europe an opportunity to establish alternative strategies and perhaps place greater emphasis on the development of technological niches such as hydrogen propulsion or advanced vehicle software solutions.

The research has some limitations. One of them is that it focuses on secondary sources, which means that the results depend on the quality and accuracy of the data used. The analysis also did not include a detailed review of policy decisions at the level of individual European countries, which could shed more light on the differences in approaches and success of electrification. Another limitation is the limited access to data on Chinese strategies and practices due to the often lack of transparency as well as not focusing on social factors such as commitment to local producers and European lifestyle.

Future research is recommended to focus on comparative analyses between individual European countries, which could more accurately assess the impact of different national policies on electrification as well as to focus on investigating perception and commitment of potential European EV customers. An in-depth study of the impact of supply chains and the possibilities for reducing dependence on foreign suppliers as well as expanding the network of potential suppliers is also needed. In addition, it would be useful to explore the potential of alternative technologies, such as hydrogen technologies or even nuclear fusion, which could represent a long-term competitive advantage for Europe. To drive change, further research must include collaboration with industry and decision-makers to develop

strategic guidelines that will enable an effective transition to a more sustainable automotive industry.

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