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OVERVIEW

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The impact of COVID-19 on the market prospects of electric passenger cars

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Abstract

The outbreak of COVID-19 pandemic has caused changes worldwide in a dimension that has not been seen since the Second World War. This pandemic and the measures taken to moderate the negative consequences have affected almost all aspects of our life. Transport has been one of the most affected sectors. In general, the global car market is very sensitive to macroeconomic conditions. This applies especially to electric vehicles, which are still very dependent on financial support measures. A combination of travel restrictions, unemployment, and low oil prices could have significant impact on electric vehicles. This paper provides an overview of the development of electric vehicles and corresponding policies covering the period before and during the COVID crisis. Policy framework and the future development of the annual gross domestic product per capita have a significant impact on diffusion of battery electric vehicles. However, since the crisis is still ongoing, the full impact of the COVID crisis on mobility is still to be seen but the findings so far show rather favorable signs for electric mobility.

This article is categorized under:
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KEYWORDS
car sale, COVID-crisis, electric vehicles, emissions, policy

1 | INTRODUCTION

The outbreak of COVID-19 pandemic has caused changes worldwide in a dimension that has not been seen since the Second World War. This pandemic and the measures taken to moderate the negative consequences have affected almost all aspects of our life. Transport has been one of the most affected sectors. With the spreading of the coronavirus, most of transport activities were restricted. Major new trends associated with the pandemic were teleworking and the preferable use of private vehicles, as well as active mobility (Arribas-Ibar et al., 2021).

At the beginning of 2020, it was discussed that the sale of electric vehicles (EVs) could be especially affected by the COVID crisis. The major argument was the fact that electric vehicles are economically less attractive than conventional cars, mostly due to high investments costs, and dependency on different supporting policy measures. In the case of financial crises and increasing unemployment, it was argued that it would be more likely that some governments will spend less money to subsidize e-mobility. Moreover, in times of the threat of the global recession consumers may tend to buy cheaper conventional cars. Due to the variable conditions and limited travel possibilities with public transport, especially airplanes, cars should be able to cover mobility needs including for long travel distances. However, since electric vehicles have relatively short driving ranges and long charging times, conventional cars could be the more preferable option.

Since the transport sector is one of the major contributors to greenhouse gas (GHG) emissions worldwide, electric vehicles have been widely promoted and supported over the last decade. In literature, different aspects of e-mobility have been analyzed. In recent years, special focus was put on different types of electric vehicles (Ajanovic, 2015; Iclodean et al., 2017) and their economic (Ajanovic & Haas, 2020; Bubeck et al., 2016) and environmental assessment (Ajanovic & Haas, 2019a; Moro & Lonza, 2018). Many papers have stressed the importance of increasing the use of renewable energy sources (RES) in the transport sector and hence, ensuring that the electricity used in battery electric vehicles (BEVs) is generated from RES. A broad portfolio of scenarios related to the electrification of the transport sector was presented (International Energy Agency [IEA], 2017; IRENA, 2017). However, nobody counted on a COVID-19 crisis occurring.

Recently, the first papers were published which discuss different implications of this crisis on the transport sector. Abdullah et al. (2020) examines the changes that occurred in travel behavior due to the COVID crisis. Beria and Lunkar (2021) study the mobility dynamics and spatial distribution of people during lockdown on the example of Italy. Also, Cartenì et al. (2020) analyze mobility habits influenced by pandemic on the case of Italy. Consequences of COVID-19 for sustainability transitions research on electricity and mobility are discussed by Kanda and Kivimaa (2020) based on examples from the Nordic countries, Finland and Sweden. Borkowski et al. (2021) study the impacts of the crisis on economic activity with the special focus on the transport sector and changes in daily mobility patterns. To identify the early impact of COVID-19 on transport and logistic sectors, Zhang et al. (2021) have conducted worldwide survey trying to investigate how our society was prepared for a pandemic, which measures are taken to fight against pandemic, as well as what could be recovery measures and long-term strategies. Most of these papers are written during the first year of the pandemic, and they present early impacts of the COVID crisis.

The major goal of this paper is to discuss the current and the possible future impact of the COVID crisis on the electrification of passenger car mobility, considering the pre-COVID developments, as well as trends recognized during the first year of the pandemic. Moreover, the role of EV in the reduction of air pollution is discussed since this crisis has increased interest in health as well as awareness about the negative impact of air pollution.

In this paper in Section 2, the impact of the COVID-19 crisis on the over-all car market is analyzed. In Section 3 the major focus is put on electric vehicles. At first, the development of electric passenger cars before the COVID crisis is presented, including a discussion on supporting policy frameworks in the European Union (EU) countries, as well as an economic and environmental assessment. We start with data collection and documentation of the main global developments and key players on the EVs markets but our major focus is on the electrification of mobility in the EU. Using data collected, descriptive analyses as well as quantitative comparative analyses are conducted. Finally, the major changes related to EVs during the COVID crisis are documented. Moreover, the impact of the COVID crisis on air pollution as well as possible impact on the acceptance of electric vehicles is discussed. Finally, major conclusions are provided at the end of this paper.

2 | IMPACT OF THE COVID-19 CRISIS ON THE OVER-ALL CAR MARKET

The transport sector is responsible for about one-quarter of total GHG emissions. Over the last years the highest increase in emissions was in Asia, especially in China. Many cities worldwide are suffering from local air pollution. The high concentration of nitrogen dioxide, which is largely caused by road transport and power plants, can trigger different respiratory illnesses. How severe this problem is shows the fact that during 2020 about 2.6 million deaths are put in relation to COVID-19. However, this number is reletively low in comparison to the estimation that every year about 7 million people die due to diseases coused by air pollution (WHO, 2021).

In the EU despite a broad portfolio of measures implemented with the goal to reduce emissions caused by mobility, GHG emissions in the transport sector are still increasing. Figure 1 shows development of GHG emissions since 1990 in the EU by sectors. It is obvious that the transport sector was the only one with continuously increasing emissions in the

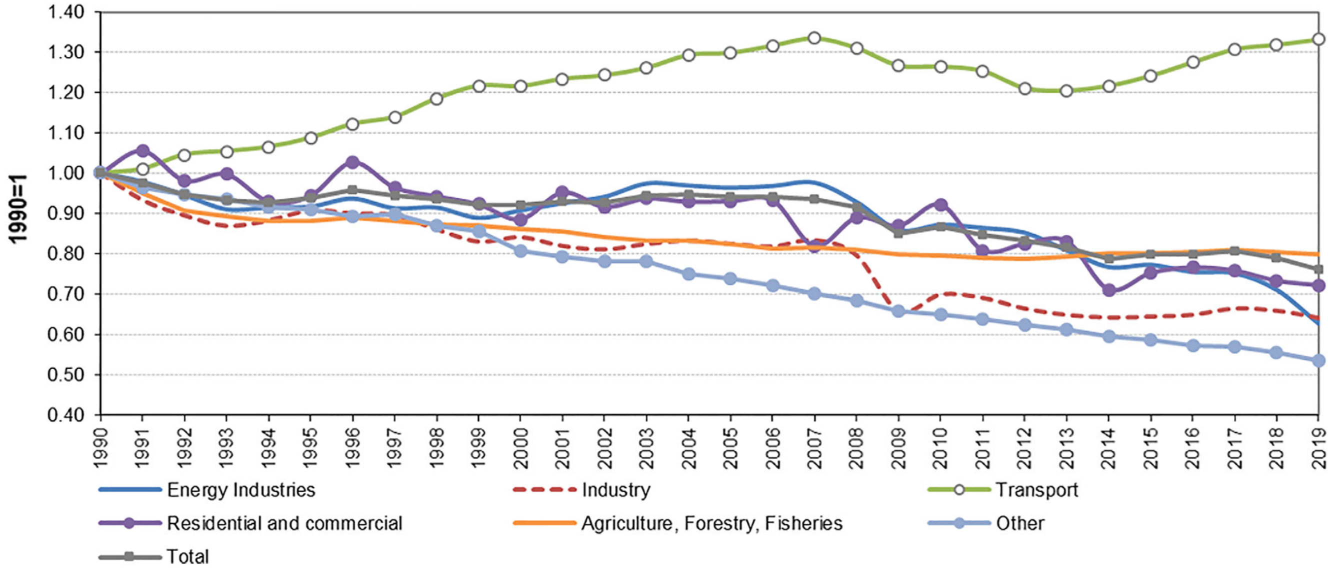

FIGURE 1 Greenhouse gas (GHG) emissions by sector in the European Union (EU) (SPB, 2020)

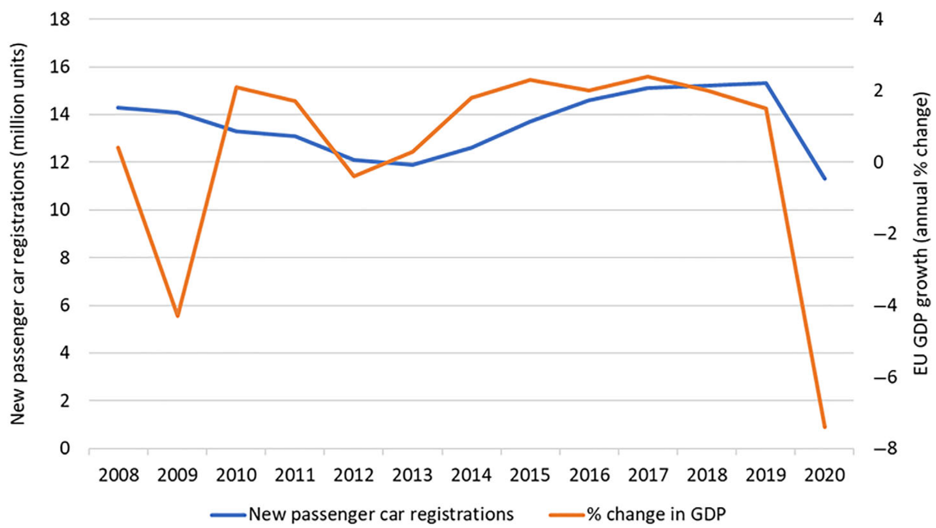

FIGURE 2 New passenger car registrations versus economic growth in the European Union (EU), 2008–2020 (ACEA, 2020a)

period 1990–2007. Slight decrease after 2007 is correlated with the decreasing new passenger car registrations due to the drop in annual gross domestic product (GDP) growth in the EU during the financial crisis.

The correlation between car ownership level and GDP, as well as between travel activity and GDP, is already presented in many scientific papers (Ajanovic et al., 2012; Dargay et al., 2007; Millard-Ball & Schipper, 2010; Wu et al., 2014). Figure 2 depicts the relation between real GDP and new passenger car registrations in the EU. It can be noticed that after financial crisis, in the period 2012–2017 with the increasing or stable GDP, vehicle sales were growing again. However, it can be also noticed that every decrease in GDP was reflected in reduction of new passenger car registrations. Especially strong reduction in GDP was in 2020 due to the COVID crisis, followed by the lowest number of new car registrations over the last decade. A remark on the economic crisis 2009: The major reason for the relatively low decrease in car purchases despite the decrease in GDP were comprehensive car scrappage payments provided by governments to support the car industry, for example, in Germany and Austria.

The declaration of a global COVID-19 pandemic by the World Health Organization (WHO) in March 2020 triggered a huge change in all segments of our life. With the goal to slow the increase of the COVID-19 infections, as well as to curtail the spread of the virus between different countries and regions, many governments all over the world have forced social distancing and put different restrictions on the most economic activities causing a huge decrease in GDP. Figure 3 shows global annual change in real GDP in the period 1940 to 2020. It is obvious that decrease in 2020 was the highest GDP decrease since the Second World War.

All these changes and developments have had huge impact on the transport sector. Already in the first days of the COVID crisis, most of the national and international flights have been canceled. Due to the lockdown measures, as well as changes in the life style, such as work in home–office, replacement of business trips with teleconferences, increasing preference for walking and biking, global demand for fossil fuels has exceptionally declined.

All these developments have impacted the global car market and the car manufacturing industry. Some of the car manufacturing plants were temporarily closed down and global car market experienced an extraordinary drop in the first months of 2020. Despite gradual recovery over the year, the decrease in car sales in 2020 due to COVID crisis was much larger than during the global financial crisis in period 2007–2009 (IEA, 2020b). Already during the first months of the pandemic, the number of new passenger car registrations decreased rapidly, especially in Asia, which was the first region affected by coronavirus. Figure 4 shows a drop in vehicle sales in the main car markets in Asia (China, Korea, Japan, and India), as well as in Europe for the first 2 months of 2020 in comparison with the same period in 2019. The decrease in car sales was the highest in China, about 44%.

Starting with the first lockdowns in Europe the number of new car registrations took decreasing trend in comparison with previous year. The largest fall in new car registrations in comparison with 2019 was in period March to May 2020. A slight increase in car registration on a year over year basis took place only in September, see Figure 5.

The COVID crisis has put huge stress on the car industry due to widespread shutdown of production, disruptions in global supply chains, quarantined workers, as well as reduced demand. The first effects of the crisis in China were also

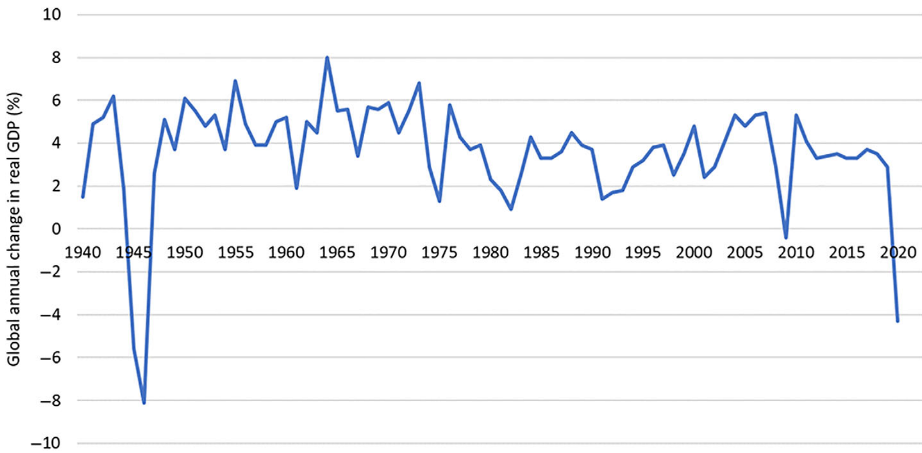

FIGURE 3 Global annual change in real gross domestic product (GDP), 1940–2020 (IEA, 2020a; STATISTA, 2021a)

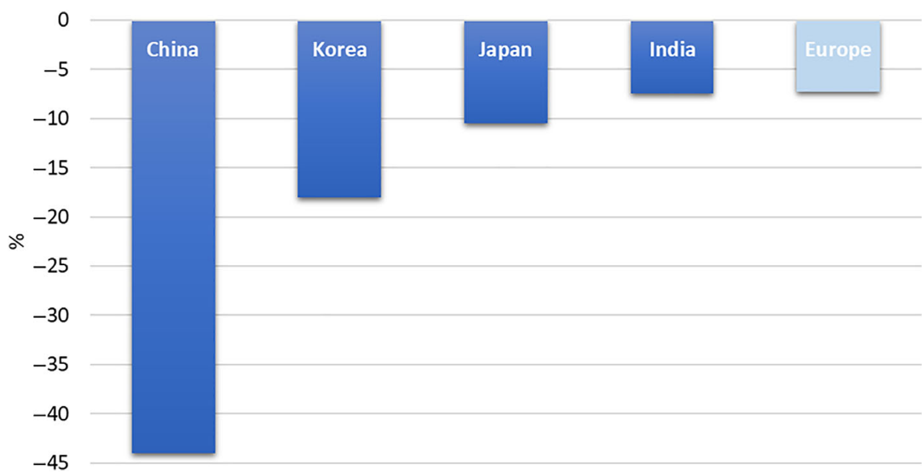

FIGURE 4 Car sale decline in selected countries/regions, January and February 2020 (IEA, 2021; Green Car Congress [GCC], 2021)

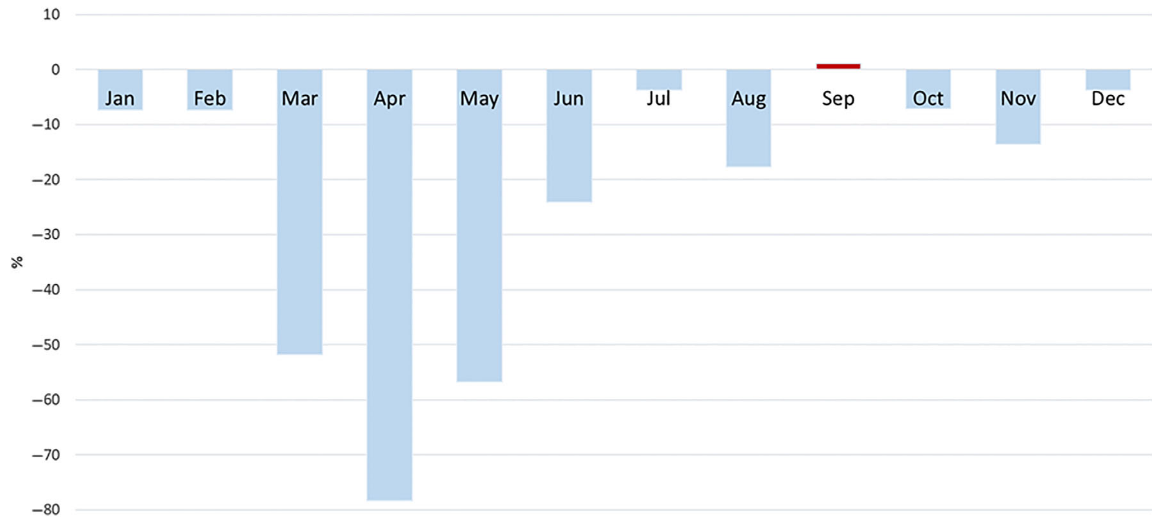

FIGURE 5 Percentage of European car sale increase/decrease in 2020 in comparison with 2019 (Bloomberg, 2021)

visible in the EU because the European automotive industry is largely based on components imported from Asia. In fact, the whole automotive sector is thoroughly internationalized and this crisis has caused massive supply disruptions (Rokicki et al., 2022). For example, the decrease in car production in Germany affected suppliers from different countries such as Hungary, Spain, Italy, and United States (Guan et al., 2020; Rokicki et al., 2022). In the EU countries, automotive factories have been closed during the crisis on average for about 30 days (ACEA, 2020b). In just the first half of 2020 the European auto industry has had a production loss of 3.6 million vehicles (ACEA, 2021a). In total in 2020, the EU passenger car market contracted by 23.7% to 9.9 million units as a direct result of the COVID crisis (ACEA, 2020c).

3 | DEVELOPMENT OF ELECTRIC PASSENGER CARS AND THE IMPACT OF THE COVID CRISIS

For a better understanding of the impact of the COVID crisis on e-mobility, in the following major developments related to electric vehicles before the crisis are documented as well as major challenges related to the deployment of EV such as policies, and economic and environmental issues. Finally, the major changes related to EVs during the COVID crisis are also documented.

3.1 | Development of electric cars before the COVID crisis

Due to the supporting policy framework, number of electric vehicles was continuously increasing over the last 10 years all over the world. Figure 6 shows development of the global electric vehicles stock. In 2019, global stock of EVs reached about 7.2 million. Number of BEVs was about two times higher than number of plug-in hybrid electric vehicles (PHEVs). The largest amount of all EVs was in China, about 45%, followed by the United States and Europe (IEA, 2020c). Although, in 2019, Europe was the region with about one quarter of global electric vehicle stock, there was very big difference in EV stock across the European Member States (ACEA, 2021b).

Figure 7 shows the number of the electric passenger cars in use in the EU by country in 2019. It is obvious that the largest amount of EVs was concentrated in six countries. In 11 countries, the number of EVs was below 2500 units (ACEA, 2021b).

Although, Germany had the highest total number of EVs, the share of EVs in the total German vehicle stock was just 1%. Mostly used vehicles were conventional internal combustion engine (ICE) vehicles powered by petrol, see Figure 8.

One of the reasons for the difference in EV use between countries is significant difference in GDP levels across Europe. The market uptake of EVs is correlated to a GDP per capita. In 2019, all EU countries with an EV market share

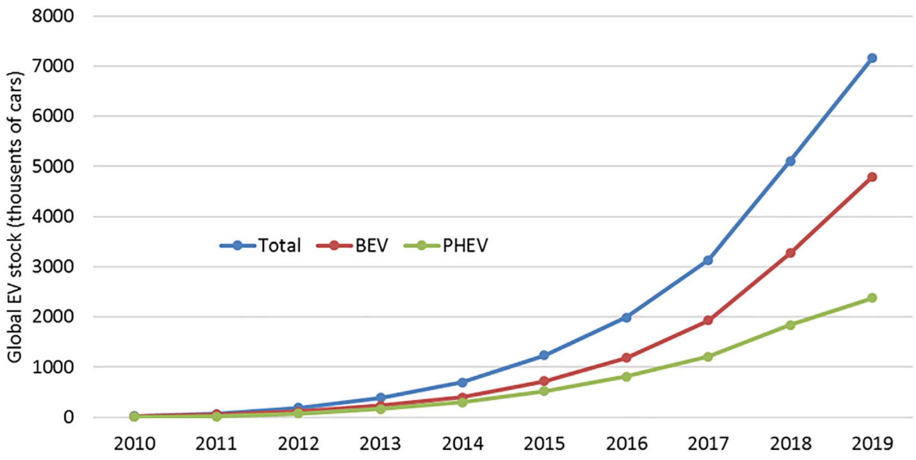

FIGURE 6 Global electric car stock (IEA, 2020c)

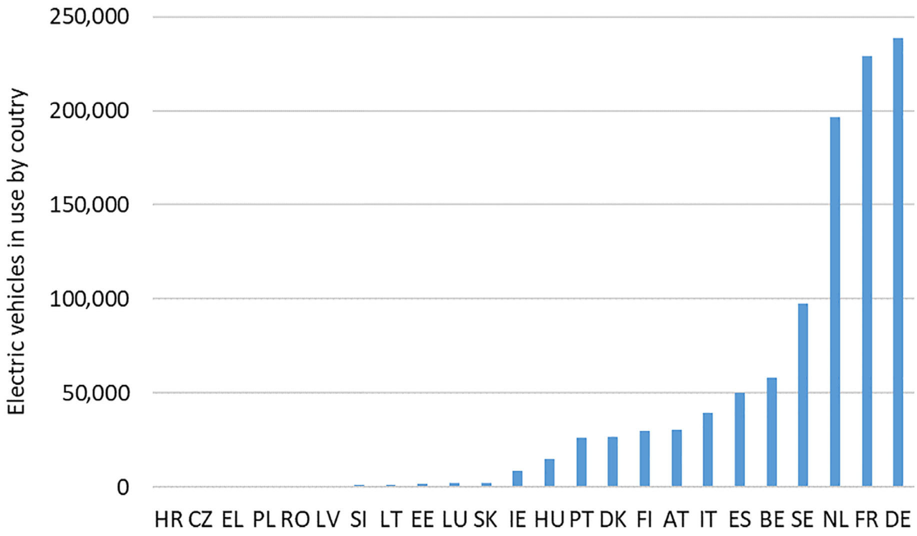

FIGURE 7 Electric passenger cars in use in the European Union (EU) countries in 2019 (ACEA, 2021b)

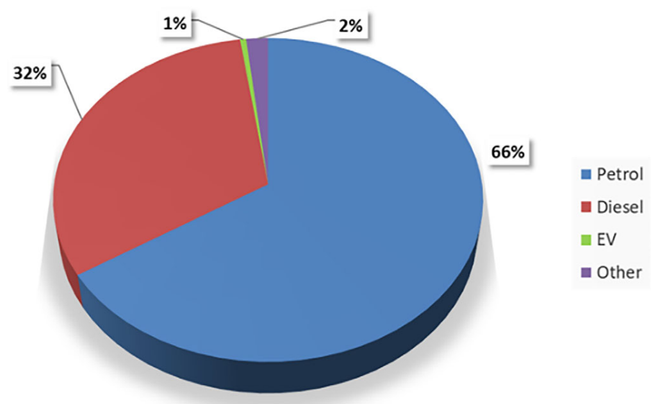

FIGURE 8 Share of passenger cars used in Germany in 2019 (ACEA, 2021b)

below 1%, mostly Member States in Central and Eastern Europe, have had a country GDP per capita below 30,000 Euro. Yet, about 80% of all EVs sold in the EU in 2019 were concentrated in six Western European countries with some of the highest GDPs per capita. Moreover, in 2019, 75% of all charging points in the EU were located in just four EU countries, the Netherlands, Germany, France, and United Kingdom, which cover only 27% of the EU's total surface area (ACEA, 2020d).

This clearly shows that the investment costs of EVs are one of the major barriers for the faster deployment of e-mobility across Europe (IEA, 2021; CG, 2021). However, due to the possible environmental benefits of EVs, many governments support their use with a wide portfolio of different policies and measures (ACEA, 2021c).

In the following, major policies implemented in the EU, as well as economic and environmental issues related to EVs are briefly documented.

3.1.1 | European policy framework

Low-carbon fuels in a combination with energy efficient automotive technologies play important role in achieving European policy goals regarding the reduction of energy consumption, as well as reduction of GHG and pollutant emissions. The currently mostly used fossil fuels should be gradually replaced by fuels based on renewable energy or low-carbon energy sources. This is one of the important strategies in the transition towards more sustainable transport system. Decarbonization of the transport is widely supported by different policy instruments applied on the different levels such as EU, national, or local level.

Currently, most of the policies implemented and targets set at the EU level indirectly support use of electric vehicles. For example, three key targets set in the scope of the 2030 climate and energy framework—(i) reduce GHG emissions (at least 40% in relation to 1990), (ii) increase the share for renewable energy (at least 32%), (iii) and improve energy efficiency (at least 32.5%)—contribute to the attractiveness of electric vehicles (European Commission [EC], 2021a).

With the increasing use of renewables in electricity generation the environmental balances of electric vehicles will be automatically improved. Moreover, electric vehicles are automotive technology with very high energy efficiency in comparison with conventional cars (Sanguesa et al., 2021).

Also, European Strategies documented in the White Paper 2011 have some important goals, which indirectly support electric vehicles, for example, the goal to completely remove conventional ICE cars from cities by 2050 (EC, 2021b). Conventional car could be to some extent replaced by other transport modes, such as public transport, bikes, and so on, but zero-emission vehicles, such as BEVs and fuel cell vehicles, will be an important alternative to conventional cars.

Moreover, the EC launched the European Green Deal in December 2019. According to this deal the EU should be transformed into a modern, resource-efficient and competitive economy. The EU should be climate neutral by 2050. To get there, emissions should be reduced by at least 55% by 2030, compared with 1990 levels (EC, 2021c; EC, 2021d). To reach this goal, it is necessary to make significant changes in the transport sector.

To reach the goal of at least 55% net emission reduction by 2030, the EC adopted the so-called "Fit for 55 Package" in July 2021. This package indicates e-mobility as a pillar for the decarbonization of the transport sector. According to it, the goal is to accelerate the rollout of charging infrastructure, to make use of electric vehicles easier and more accessible to consumers, and to establish a binding phaseout date for conventional fossil fuels (Noyens & De Rosa, 2021).

The European CO_2 emission performance standards for vehicles are indirectly supporting electrification of mobility. The EU Regulation (2019/631) sets European CO_2 emission targets for next years for newly registered passenger cars. These targets are defined in relation to the year 2021. From 2025 on, CO_2 emissions from new cars should be reduced by 15% and from 2030 on, by 37.5% (EC, 2021e). To reach these goals, it will be important to increase the use of zero-emission vehicles.

Besides many policy measures and goals set on the EU level, which are applicable to all Member States, majority of the EU countries have provided broad portfolio of supporting policy measures for electric vehicles on the national level. Mostly used policy instruments are tax benefits and purchase incentives. Electric vehicles, especially BEVs, are often exempted from acquisition and ownership taxes or have to pay lower taxes in comparison with conventional cars (ACEA, 2021c).

In addition to different monetary measures implemented across Europe, many countries have broad portfolio of nonmonetary measures implemented on the local level, for example, free or reserved parking spaces for EVs, possibility for EVs to use bus lines, possibility for EVs drivers to enter city center or emission free zones, and so on. All these measures should increase acceptance for EVs and accelerate their use.

3.1.2 | Environmental benefits of electric vehicles

Major reason for the political support and promotion of EVs is their significant contribution to the reduction of local air pollution and possible contribution to the reduction of the global GHG emissions.

The environmental performance of EVs has been already analyzed in many scientific papers, mostly based on Life Cycle Assessment and Well-to-Wheels analysis (Ajanovic & Haas, 2019b; Ozdemir et al., 2020; Xiong et al., 2021). The range of the total emissions caused by electric vehicles could be very broad depending on different assumptions such as kilometer driven, lifetime, consideration of battery replacement, and so on. However, common conclusion in many of the scientific papers is that total emissions of BEVs per km driven are very dependent on the primary energy sources which are used for electricity generation. Only in combination with electricity produced from renewable energy sources, such as wind or solar, EVs could provide full environmental benefits.

Nevertheless, electricity generation mix is very different across European Member States. Depending on the primary energy sources used, carbon intensity of electricity in the European countries is in the range between 13 and 900 gCO_2 per kWh. On average in the EU, carbon intensity of electricity generation is about 290 gCO_2/kWh (European Environmental Agency [EEA], 2022; see Figure 9).

Due to the different carbon content of electricity mix, environmental benefits of the EV use in different countries could be very different. For example, EV use in Sweden can significantly reduce local air pollution, as well as contribute to the reduction of the global GHG emissions. However, in countries with the very high share of coal in electricity generation mix, such as Poland or Estonia, EVs could contribute just to the reduction of local air pollution without significant benefits for the reduction of the global GHG emissions.

Increasing use of RES in electricity generation will contribute to better environmental performance of electric vehicles. However, replacement of old coal power plants with wind or solar plants required time and investments.

3.1.3 | Economics of BEVs

Economics of EVs is usually calculated based on the total cost of ownership (TCO) method considering all relevant parameters such as purchase price, energy price, other operating and maintenance costs, travel activity per year, vehicle lifetime, and so on. Depending on the assumptions made, in the most of the cases, EVs are still not competitive with conventional cars without different tax reductions and subsidies.

Currently, the major challenge is to improve battery performance and reduce their costs. Battery costs are correlated with battery capacity, which largely determines driving range and finally, the price of EVs. Figure 10 shows average driving range of BEVs and their corresponding price in the different car segments. Smaller car models, in the A segment, are relatively cheap but they have a short driving range, less than 140 km on average. On the other hand, larger

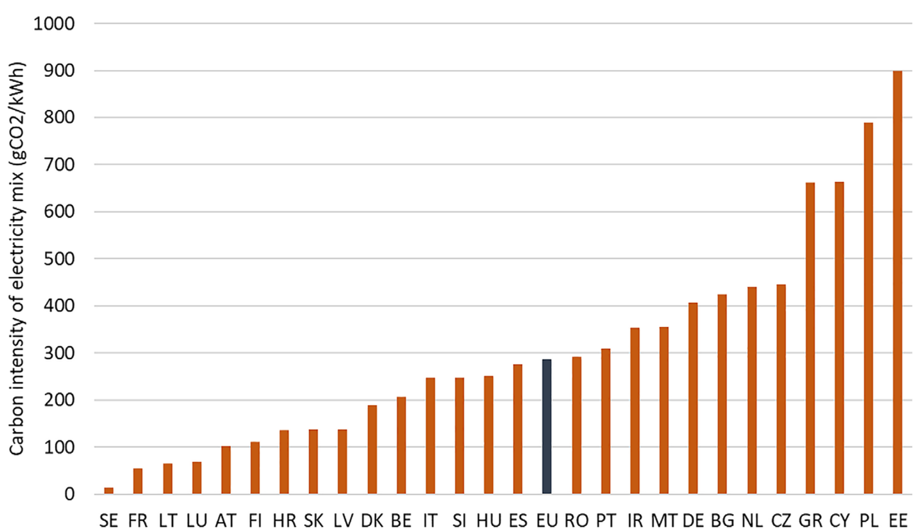

FIGURE 9 Carbon intensity of electricity generation in the European Member States, 2018 (EEA, 2022)

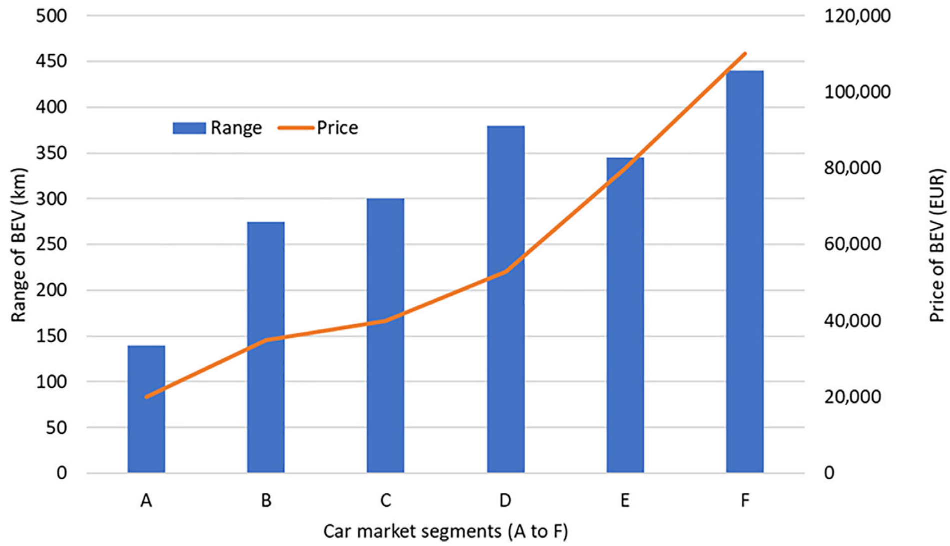

FIGURE 10 Range and price of battery electric vehicles (BEVs) by market segment, 2020 (T&E, 2020)

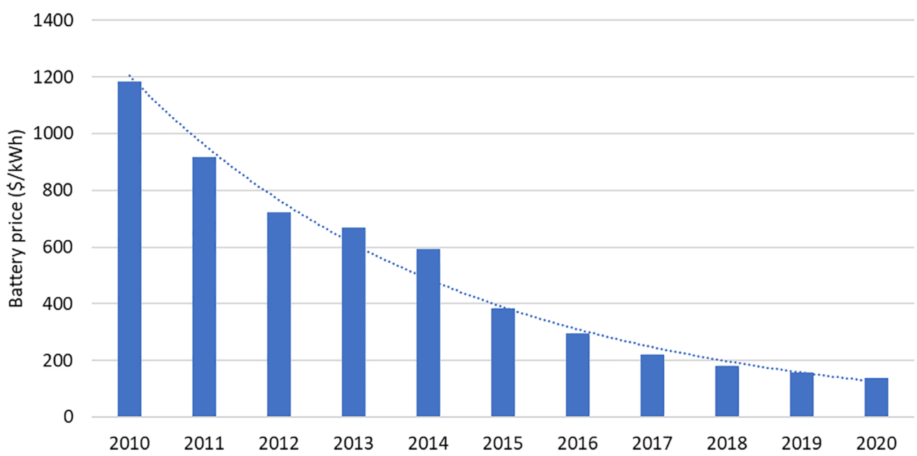

FIGURE 11 Volume-weighted battery pack prices (BloombergNEF, 2020; WinAck, 2022)

car models, in the F segment, have the highest driving range, on average about 440 km, but their price is over 100,000 Euro (T&E, 2020).

However, over the last decade, very significant progress in the reduction of the battery prices have been reached (see Figure 11), and further improvements could be expected (BloombergNEF, 2020; Ritchie, 2021).

The high impact of the investment costs of vehicles on the total mobility costs per kilometer driven could be reduced with increasing car use. However, due to limited charging infrastructure, the number of km driven with EVs is usually lower than those of conventional cars.

The impact of electricity prices is still relatively low in comparison with the high impact of investment costs. In the EU, household electricity prices were relatively stable over the last few years (Eurostat, 2022). However, the economic attractiveness of electric vehicles is also dependent on the development of oil prices. With increasing oil prices, EVs are becoming more competitive on the market. However, oil prices are very volatile over time and dependent on a range of different supply and demand conditions, including the geopolitical situation, import diversification, environmental protection costs, or tax levels (Eurostat, 2022).

With the combination of different policy instruments, further reduction of battery prices and improvement of battery characteristics, such as energy density and lifetime, attractiveness of EVs could be higher.

3.2 | Impact of the COVID crisis on battery electric cars

The impact of the COVID crisis on EVs can be measured in several ways but most obvious is the development of the number of new EV registrations. The relatively good progress in electrification of mobility was suddenly stopped at the beginning of 2020. With the first lockdowns in China, supply restrictions for the car industry have started all over the world.

Since China is the world leader in the supply and demand of e-mobility, the spread of the virus in China had a significant impact on the EV market. On the one hand, demand for EVs was reduced due to the behavioral change caused by the crisis, for example, social distancing and travel limitations were enacted, auto shows had been called off and car stores were closed. On the other hand, there were many disruptions in EV supply chains including material and component supply, as well as vehicle production and distribution channels (Kalaitzi et al., 2019; Wen et al., 2021). China is also the global leader in lithium-ion battery production, which is the core component of EVs. However, some of the key raw materials used in battery production such as cobalt, nickel, manganese, have to be imported to China (Wen et al., 2021). In addition, most supply chains were hit by the COVID crisis. For example, in May 2020, the import of cobalt was almost completely stopped due to the export restrictions in the Congo and the port closures in South Africa during April 2020 (Wen et al., 2021).

Although reduction in import dependency of fossil fuels is seen as one of the benefits of e-mobility, this crisis has shown how sensitive the EV supply chains are. The electric vehicle industry is very dependent on imported raw materials. Unfortunately, the intensive mining of these raw materials, especially lithium, cobalt, and nickel, is already causing social and environmental problems in South America and Africa.

However, in contrary to early expectations, EVs were less affected by COVID crisis than conventional cars. Figure 12 shows increases and decreases in total car and EV sales in selected countries/regions in 2020 in relation to 2019. Globally, in 2020, car sales of conventional ICE vehicles were about 17% lower than in 2019, but the sale of EVs was about 45% higher than in previous year. Actually, in the major EV markets, sale of EVs in 2020 was higher than ever before. Especially interesting was development in Europe. In Europe, electric car sale in 2020 increased by about 130%.

Due to such development, Europe become world leader in EV sales in 2020, see Figure 13. During 2020, the policy support for EVs was very strong, especially in Europe. Besides purchase incentives, regulatory instruments were very successful. In the EU, the CO_2 emission regulations for cars have significantly contributed to electrification of the passenger cars. Car manufacturers were motivated to offer more EV models, as well as to improve their performance. In addition, battery costs were reduced. The average global price for batteries in 2020 across all EV segments reached $137 per kWh (BloombergNEF, 2020).

However, there are significant differences across Europe. In 2020, largest number of new EV registrations was in Germany mostly due to significant increase in purchase incentives, from 3000 € in 2019 to 9000 € in 2020 (ACEA, 2019; ACEA, 2020e). The major European EV markets in 2020 are shown in Figure 14.

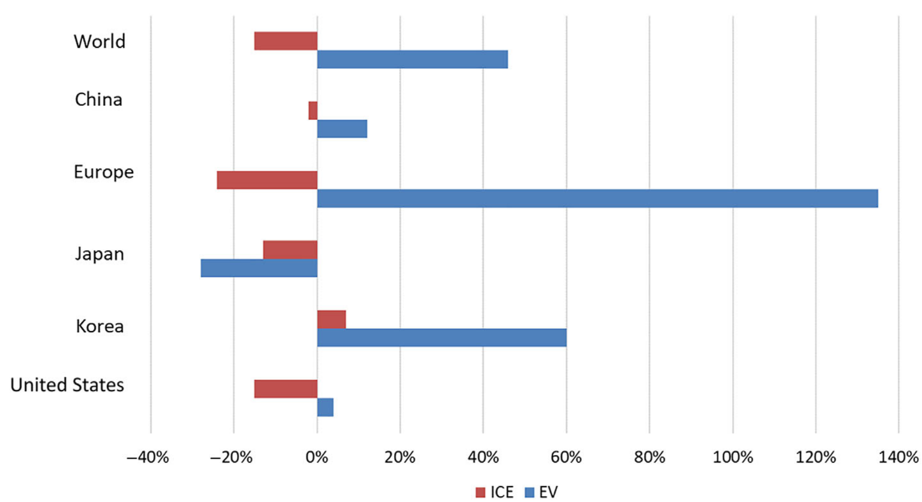

FIGURE 12 Increases and decreases in total car and electric car sales in selected countries/regions in 2020 in relation to 2019 (IEA, 2020b)

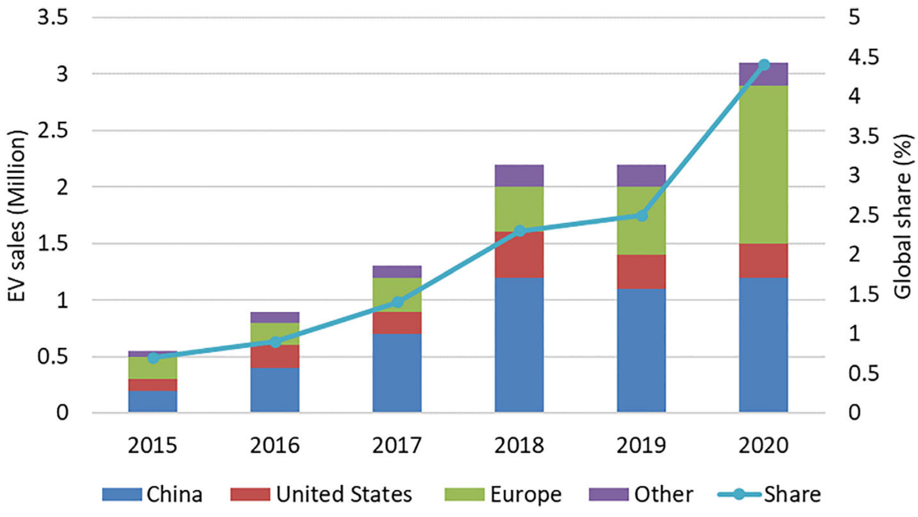

FIGURE 13 Global electric car sales (IEA, 2020b)

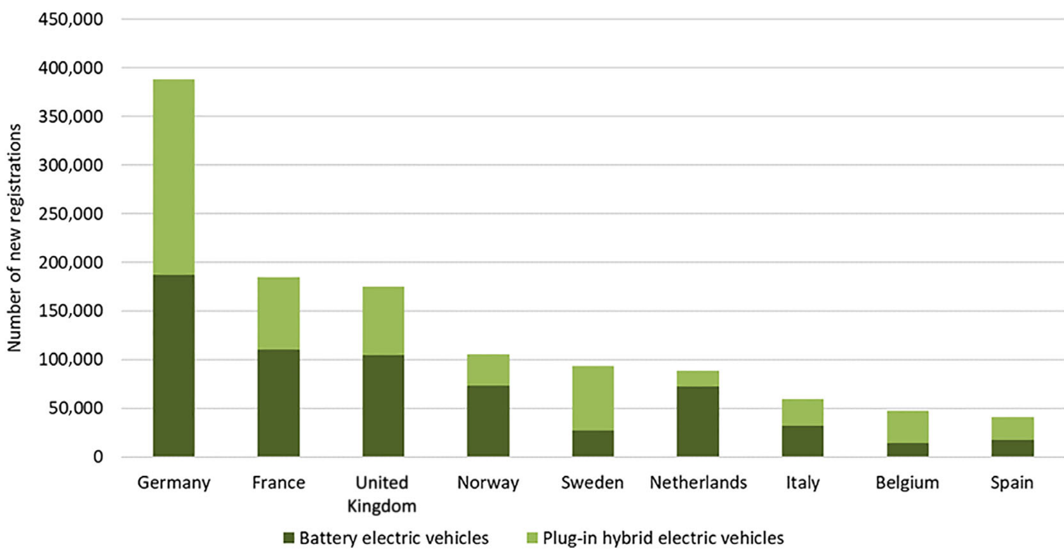

FIGURE 14 New registrations of electric cars in selected European countries in 2020, by type (STATISTA, 2021b)

Many factors contributed to increasing registrations of EVs in 2020. The IEA (2021) has identified the following pillars for the resilience of EV sales during the crisis: (i) supportive regulators framework, (ii) additional incentives, (iii) increasing number of EV models, and (iv) the reduction of battery costs.

The number of new EV models in 2020 increased by 40% in comparison with 2019 (IEA, 2021). In addition, in 2020, the average cost of batteries decreased by about 13% over the previous year, see Figure 11. Due to this, in some countries, EVs are becoming more competitive with conventional cars on a TCO basis.

Moreover, one of the reasons that in spite of the crisis and the decrease in annual GDP, the total number of EVs at the end of 2020 was higher than in 2019, is that the majority of new cars are bought through corporate channels, which are less sensitive to the crisis (T&E, 2020). Moreover, one of the reasons for such development is the fact that the majority of new cars are bought through corporate channels, which are less sensitive to crisis.

Furthermore, in the EU with the implementation of new passenger car CO_2 emission targets, pressure on the car industry was extremely high. Under the CO_2 regulation, automakers must reduce their overall fleet emissions to 95 gCO_2/km by 2020/2021. CO_2 emissions standards played a significant role in promoting EV sales contributing to the largest annual sale increase in 2020. Many countries, for example, Germany, France, and Italy, increased purchase incentives for EVs in 2020 so that in the EU EV sales were higher in 2020 than before the crisis (ACEA, 2020e;

IEA, 2021). In the EU, the purchase incentives for BEVs were in the range from 1500 € to 10,000 € (e.g., Germany 9000 €, Slovakia 8000 €, Romania 10,000 €; for more detail, see ACEA, 2020e).

As a response to the COVID crisis but also to more and more visible environmental problems caused by human activities, many governments intensified the support of EVs and in general the decarbonization of the energy and transport system. One such example is the European Green Deal.

3.2.1 | The impact of COVID-19 on emissions and role of electric vehicles

One positive impact of the COVID crisis was that already with the first lockdowns the pollution concentration decreased drastically. Measurements from the European Space Agency's Sentinel-5P satellite showed that through January and February 2020, levels of nitrogen dioxide (NO_2) over cities in Asia and Europe were lower by 40% than in the same period in 2019 (CIHAN University [CU], 2020).

The largest amount of NO_2 is caused by road transport and power plants, which in higher concentrations can trigger different respiratory illnesses. According to the WHO, 9 out of 10 people breathe air containing high levels of pollutants. WHO estimates that due to diseases caused by air pollution each year die about 7 million people, largely as a result of heart disease, pulmonary disease, lung cancer, and acute respiratory infections (WHO, 2021).

Recently, the European Public Health Alliance warned that people living in polluted urban areas have a higher risk from COVID-19 (European Public Health Alliance [EPHA], 2020; T&E, 2020). Similar conclusions are also derived from the study on victims from the severe acute respiratory syndrome virus showing that patients in regions with higher air pollution level have had 84% higher probability to die than patients living in regions with low air pollution (Cui et al., 2003; T&E, 2020).

During the lockdowns, caused by COVID, all over the world, air quality has improved due to the restriction of travel activity as well as of whole economic activities. This was an opportunity to develop more healthy habits for ourselves and for the environment (Bennett, 2021), leading to the increasing awareness of the negative impact of air pollution and, finally, to the increasing interest in and acceptance of electric vehicles (Middleton, 2020). From this point of view, the COVID crisis can be seen as a trigger for the accelerated electrification of passenger transport (Nieuwenhuijsen et al., 2022).

However, with the increasing awareness about negative impact of emissions and pollutions on our health, total emissions of EVs also become a matter of some debates. Since EVs produce no tailpipe emissions, their non-tailpipe emissions are of special interest, for example, emissions caused by brake and tire. Since EVs are heavier than conventional cars, they are blamed for higher tire pollution (Daellenbach et al., 2020). Nonetheless, brake pollution could be reduced by use of EVs since they use “regenerative breaking” and this process reduces the need to use the breaks and, finally, reduces particle emissions (Barisione, 2021). Yet, the emissions from breaks and tires should be regulated and reduced for all vehicle types. In general, considering primary and secondary particle pollution, EVs cause less particulate matter $PM_{2.5}$ and PM_{10} (particulate matter less than 2.5 and 10 μm in diameter, respectively) than conventional gasoline and diesel cars (Barisione, 2021; OECD, 2020).

Moreover, EVs can reduce noise pollution, what is very important considering the fact that in the EU about 100 million people have been impacted by harmful noise level above 55 dB during the day and 60 million people by noise level above 50 dB at night (Rokicki et al., 2022). Due to high population density, cities tend to be hotspots of air and noise pollution, as well as currently also COVID hotspots (Nieuwenhuijsen, 2020; Nieuwenhuijsen et al., 2022).

However, in the discussion on environmental benefits of EVs, the upstream emissions from electricity generation must be considered as well. Unfortunately, they are currently not included in the supporting policies for EVs, for example, EU's emission standards (Gan et al., 2021). This is especially a problem for countries which have electricity generation largely based on coal, for example, China. In China, 85% of electricity generation is from fossil fuels, mostly from coal, about 90% (Ji et al., 2012). Due to this fact, average CO_2 emissions of EVs in China are almost the same as those of new gasoline cars with even higher emission factor for $PM_{2.5}$ (Ji et al., 2012).

If the accelerated use of EVs is not followed by increasing share of renewable energy sources in electricity generation, it will cause an emission transfer from roads and vehicles to power plants. This means that high concentration of emissions in urban areas could be decreased using EVs, but at the same time the emission level will be increased in the regions in which electricity generation plants are located.

4 | CONCLUSIONS AND OUTLOOK

Transport has been one of the most affected sectors by the COVID crisis. With the spreading of the coronavirus, many transport activities were restricted and the number of overall car purchases worldwide decreased. However, in spite of the many challenges, the global sale of EVs reached a new record in 2020. Moreover, while from 2018 to 2019, the number of new EVs stagnated, it increased by about 40% from 2019 to 2020. In Europe alone, the number of new EVs has more than doubles. Supporting policies were fundamental for the progress of electrification of mobility especially in Europe. Many European countries have recognized the threat of the increasing emissions and have provided very generous purchase incentives for EVs.

Without policy intervention, it could be expected that emissions and car sale trends will soon return to their previous course after the crises. To avoid this, it is necessary to enable continuous support for electric vehicles as well as increasing investment in renewable energy and electrified transport. Already in 2021, about €250 billion have been spent on electric vehicles and associated infrastructure. It was an increase of 77% and a new record. Retaining this trend, investments in the EV sector could soon overtake investments in renewable energy (BoombergNEF, 2022). However, in 2021, the largest amount of the global investment in electrified transport was concentrated in just a few countries—China, United States, Germany, United Kingdom, and France.

Government incentives are still fundamental to stimulate the purchase of EVs. However, in the case of the possible financial crisis, which could come follow the COVID crisis, for many countries, especially countries with a low GDP, it will be more difficult to provide supporting measures for electric vehicles. Although decreasing battery prices and an announced ban on ICE vehicles are making future development of EVs very promising, it is important to have further research on resilience assessment of the whole electric vehicle supply chain.

In addition, it is of very high importance that parallel to the promotion of electric cars there is also a use of RES in electricity generation as pushed by governments. Currently, excess electricity generation from RES does not anywhere exist, except on a few days of year in some countries. Hence, to avoid the trap of green washing by means of promoting the so-called green vehicles, it has to be ensured by highly credible sources that in the near future all electricity used in EVs comes from RES. Finally, since the crisis is still ongoing, the full impact of the COVID crisis on mobility is still to be seen, but the findings so far show rather favorable signs for electric mobility.

AUTHOR CONTRIBUTIONS

Amela Ajanovic: Conceptualization (equal); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); resources (equal); writing – original draft (equal); writing – review and editing (equal).

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