

## Article

# Electric Vehicles Optimism versus the Energy Market Reality

Catalin Vrabie 

Faculty of Public Administration, National University of Political Studies and Public Administration, 012244 Bucharest, Romania; catalin.vrabie@snspsa.ro; Tel.: +40-723-689-314

**Abstract:** The promotion of new electric and hybrid vehicles is a worldwide strategy to reduce carbon emissions for a clean future environment in many countries. In Europe, development of the electric vehicle (EV) industry is a strategic direction of multiple car-producing companies, institutes, and governments, but how sustainable it is to shift fully to electric has yet to be seen. By making use of the statistic reports from the European Union, scientific literature, and mathematical calculation, the author wants to examine if what politicians see will be a matter of reality in the near future. It will be proved that, if all private transport become electric, energy consumption will increase to such a level that is impossible to be satisfied by the actual energy producing companies. While the EV industry is seen as an important step towards achieving environmental goals, and despite some positive assumptions made by few European Governments (e.g., Norway) according to which electrical cars will replace the fossil fuel ones in private transportation, the actual energy market trends are not able to support the demand for the next several decades. The author will focus on one European country, Romania, to provide it as a case study (Romania is a self-sustainable country with regard to energy production, producing roughly 124% of its needs.).

**Keywords:** energy market; electric vehicles; environment; electric vs. fossil; EV



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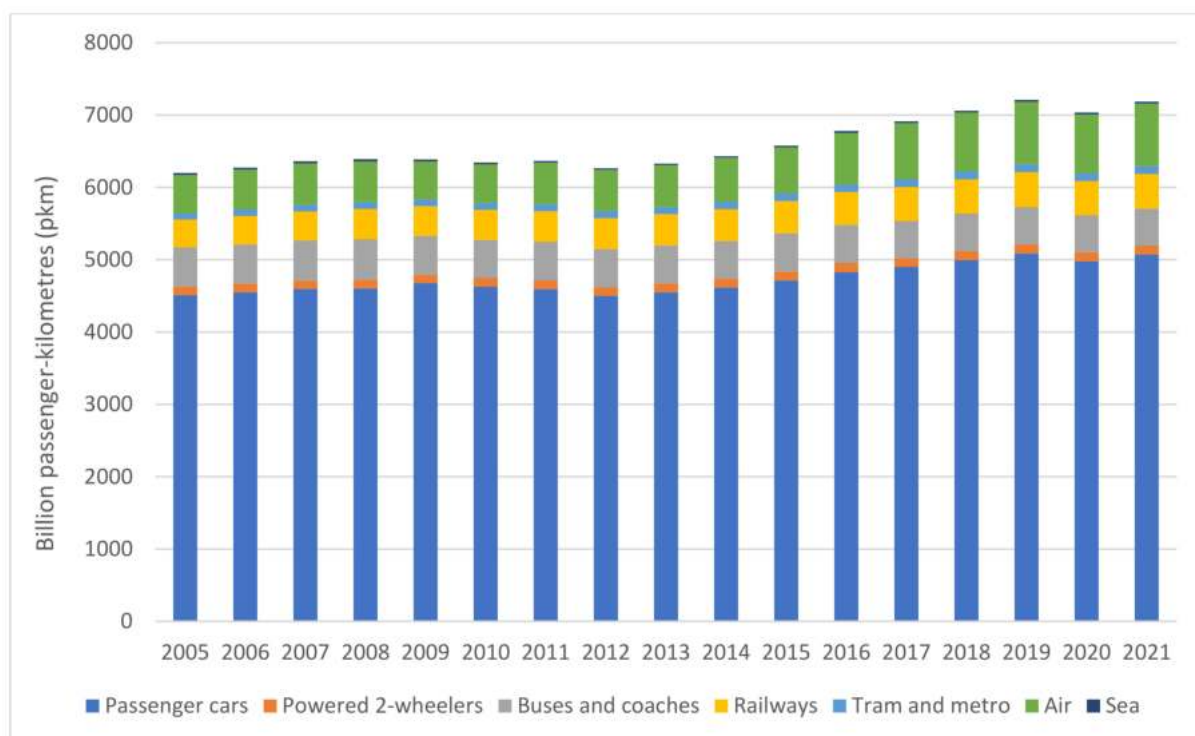


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## 1. Introduction

Transportation modes are very important for today's modern societies, with availability and costs of mobility means being a very important variable for daily life. Figure 1 shows the development of passenger transportation in Europe between 2005 and 2021; from the figure, one can observe that a huge proportion belongs to private transportation (passenger cars, as in chart)—a similar situation can be also found in North America and Australia [1,2].

According to UK FIRES 'Absolute zero' report [3], 'almost all of today's transport involves the direct combustion of fossil fuels in the vehicle'.



**Figure 1.** Passenger transport demand in Europe [4–7].

The invention of internal combustion engine did not only bring benefits but also side effects, as the use of fossil fuels has a negative impact on the environment [8–10]. The environmental problems we face today, especially in big cities [10,11], are due to traffic and foremost related to crude oil usage [12]. Crude oil is a fossil fuel [12] used for production of diesel, gasoline (petrol), and liquefied petroleum gas (LPG) [13–15]. Producing those fuels, as well as combusting them, leads to pollution because the carbon dioxide that was assimilated in prehistoric times is now eliminated in the atmosphere [16].

Government’s efforts to pursue climate change is seen as the main driver of the EV industry. Strategies on climate neutral energy, together with the development of the new electrical vehicle industry, is an international consensus. The European Union, which is seen as a global leader in reducing carbon dioxide emissions, developed the European Strategic Energy Technology Plan [17]. It also established, in 2005, the Emissions Trading System [18]. Furthermore, in 2009, the directive 2003/87/EC on improving and extending the greenhouse gas emission allowance trading scheme of the Community was amended by the 2009/29/EC directive [19]. All these initiatives are meant to strengthen the incentives for using alternative energy sources and also gives all actors involved in the process the incentives for further research and developments. The alternative energy sources such as solar energy and wind energy are unstable and intermittent during generation; thus, these valuable electric energies are difficult to apply continuously and stably. Hence, additional energy storage systems are needed to improve the utilization rate and stability, but at the same time, they increase the complexity of the operation [20].

Policy interest in using electrical vehicles is growing (Directive 2014/94/EU of the European Parliament and of the Council on 22 October 2014 on the deployment of alternative fuels infrastructure, European Commission—Clean Vehicles Directive, European Parliament—Regulation no 443/2009 of the European Parliament and of the Council setting emission performance standards for new passenger cars as part of the Community’s integrated approach to reduce CO<sub>2</sub> emissions from light-duty vehicles [21–24]) and citizens are starting to pay more attention to them [25–28]. With the encouragement of the government, people’s attitude towards electric vehicles has changed from wait-and-see to positive. Electric vehicles are now entering a virtuous circle, attracting more and more consumers.

It is known that EVs do not pollute during exploitation at the same level as internal combustion engines [29,30]; however, producing the energy needed for them to operate is a matter of concern. Shifting to EVs gives cities better chances to stay clean. This is why most of the solution to the policies, strategies, and direction of both public and private institution are targeting electrical means of transportation.

### 1.1. Research Objectives

The objective of this article is to provide to policy makers an easy understanding of the EV trends over the actual energy market. Furthermore, the author's intention is to present a multidimensional perspective on electric vehicles, focusing on relevant key points (e.g., multiple factor association) to researchers with a social science background (e.g., smart cities area) as well as technical.

The article contributes to existing scientific literature by offering readers an answer to the following research questions: What if we all shift to electric cars? How is it going to be? To answer, the author used calculation based on existing data and statistics hoping to foster debate in the policymaking arena such that the approach and focus become more appropriate to actually raise awareness on environmental issues vs. technical solutions.

### 1.2. Related Literature

After reviewing the research outlined in Sustainability (issues 2019–2021), Energies (issues 2019–2021), and the Journal of Cleaner Production (issues 2019–2021), one can conclude that much of the focus is placed on the benefits of EVs and little on the costs; efficiency; and the reasons for which, thus far, society is not fully stepping into the electric era.

Few studies have investigated the costs of shifting; among these, Fridstrøm [31] calculated the price of carbon, characterizing the trade-off between conventional and battery electric cars in Norway compared with the penalty incurred by automakers for not meeting their 2020/2021 target under EU Regulation. Furthermore, Rajper and Albrecht's [32] literature review revealed that "electric four-wheelers are not a feasible option in developing countries due to their high purchase price". The authors cited 126 relevant reports and articles related to barriers and opportunities on development of current technologies and today's cost structures of "going electric". Similarly, Kumar and Alok [32] compiled, using an integrative review protocol, 239 articles published across Scopus Q1 journals. The authors draw attention to relatively neglected topics such as charging infrastructure resilience as well as identifies much-studied topics such as total cost of ownership and purchase-based incentive policies.

Additionally, Trencher and Edianto [27] as well as Adhikari et al. [33] identified some barriers against electric vehicle use—among these, lack of infrastructure and economical/financial were the most important ones. Besides, Ewelina and Grysa [34] researched the assessment of the total cost of ownership of electric vehicles.

Xue et al. [35], after investigating the impact of energy transition on emissions of electric vehicles in Japan, concluded that greenhouse emissions are still a matter of concern. Moreover, Alex Moersen from Innovation & Tech Today [36] cited in his study The U.S. Department of Energy, who stated that "fully electric vehicles emit an average of 4450 pounds (2018.5 kg) of CO<sub>2</sub> each year. For comparison, conventional cars emit over twice as much annually. While EVs do produce fewer emissions, it is important to remember that this is not a perfect technology. People should not blindly assume that EVs are a no-emission super-technology"; this is mostly because the energy used by EVs also needs to be produced (extra details on this subject can be found in the Limitation subsection). Further, Tai-Ran Hsu, Professor and Chair of the Department of Mechanical Engineering at San Jose State University, stated in his research "On the Sustainability of Electrical Vehicles" published on the Proceedings of Green Energy and Systems Conference, 25 November 2013, Long Beach, CA, USA [37] that a "massive infusion of EVs to our society in a short time span will likely create a colossal demand for additional electric power generation much beyond what the US electric power generating industry can provide with its current generating capacity.

Additionally, such demand would result in much adverse environmental consequences if the current technology of electric power generation by predominant fossil fuels continues”.

Critical gaps regarding EV adoption, both from a technical approach but also from a consumer point of view, have been studied from early 2018, when Henry Lee and Alex Clark from the Harvard Kennedy School dedicated their research to challenges and opportunities for EV adoption [38]. Similarly, Nicholas et al. quantified and qualified the gap in charging infrastructure in the United States [39]. More recently, in 2021, Sanguesa et al. studied actual challenges and open opportunities—focusing mostly on battery technology trends [40], while a team of eight researchers from India studied consumer perception toward electric mobility trying to mitigate barriers and bridge the gaps on EV adoption [41].

The reviewed studies helped understand the whole diagram of what electrical vehicles are for today’s societies and how the actual energy market may or may not satisfy the potential new demand generated by the increasing number of EVs. Nevertheless, the cited authors are concerned about the effectiveness of EVs in regard to environmental issues and the impact of the increasing energy demand on the environment.

This article focuses on the extensive use of EVs, an idea that is largely promoted by some car manufacturers [42], mass media channels [43–47], and politicians [45,48,49]. The author starts with the assumption that replacing all private vehicles that run on fossil fuel with EVs is viable from both economic and environmental points of view.

In Section 2, three arguments will be developed, arguments that are meant to validate or invalidate the optimistic views on the future of electric cars. In doing so, the author starts by considering firstly the need of extra electrical power that must be produced in order to fulfill the consumption of the extremely new, huge market. Furthermore, the focus will change to environmental issues, calculating the carbon emissions that are to be saved by the shift and providing brief financial calculation in regard to EVs adoption. In Section 3, the Romanian case will be presented and, based on the same argument as in the previous section, the actual situation in the country and the chances to shift to electric cars in the near future will be discussed. Research limitations, actual barriers of going electric, as well as concerns regarding the shift will also be presented here. The Results and Discussion sections will present the relevant insights from the literature and from the analyzed data and statistics. Further, in the Discussion section, a policy implication of the study will be drawn. Finally, the last section presents the conclusions along with future research interest.

## 2. Method

There are many published papers (articles and reports) dealing with predictions of EVs’ electricity consumption, CO<sub>2</sub> emissions, and cost, with the consideration of input variables from the carbon intensity of energy sources to the uptake of different vehicle technologies, life-cycle factors, future travel demand, and the size of vehicles demanded. This article, however, used mostly calculations developed over figures and numbers taken from reports and statistics made on European ground, proving in a rather easy way that society is not yet able to fully shift to EVs, despite political goals.

The author, starting his research from today’s energy market figures and comparing with EV consumption, will demonstrate that reaching zero emissions anytime soon is not an easy task.

There were developed three arguments meant to answer the following questions:

- What is the extra need of electrical power to be produced for covering the needs of fully shifting to EVs?
- Is the reduction in carbon emissions important enough to fully step into the “e-era”?
- Is it economically efficient for today’s societies to make the shift?

To answer, the main method was by calculation based on statistics provided openly by governmental sources. Firstly, the extra need of energy was taken into consideration. Environmental impact as well as financial consideration were also compiled to round up the approach. To verify the results, the author took Romania as a case study (as stated in the

Abstract, Romania is a self-sustainable country in regard to energy production; therefore, it is considered relevant for the study).

### 2.1. The Extra Need of Electrical Power to Be Produced

If the EU is considering replacing the whole fleet of vehicles on the roads today with EVs, there will be a huge increase in electricity demands to cover the needs.

The European Union imported 507.2 million tons of crude oil in 2019 and produced 19.8 million tons in the same year, summing 527 million tons of total oil consumption in the year before the COVID-19 pandemic [50] (the author considers the year of 2019 more relevant for the study because after the COVID-19 pandemic started and the lockdown was imposed, the total amounts of carbon emitted decreased sharply); 47.7% of this amount (251.37 million tons) went to road transport [50].

After converting the data from the table above (Table 1), one can see that the average thermal energy content in crude oil is 10.69 KWh/liter.

**Table 1.** Measurements units' conversion.

1.	1 barrel (b) of petroleum = 42 US gallons
2.	1 barrel (42 US gallons) of crude oil = 5,691,000 Btu (British thermal unit)
3.	1 US gallon = 3.8 L
4.	1 KWh (kilowatt-hour) = 3412 Btu
5.	1 L of crude oil = 38.5 megajoules
6.	1 KWh = 3600 kilojoules (3.6 megajoules)

Source: Compiled from (1) U.S. Energy Information Administration [51] and (2) Iowa State University [52].

This gives 2,687,145 GWh of thermal power going to road vehicles in the EU per year. Electric engines are more efficient than their fossil-fuel counterparts. An EV drive system is only responsible for a 15% to 20% energy loss compared with 64% to 75% for a fossil-fuel engine [53]. Assuming that the electric vehicles use the energy with four-times greater efficiency to their counterparts (a reasonable round number), it would take 671,786 GWh of electrical energy to replace oil consumption.

Total net electricity generation in the EU was 2,780,000 GWh in 2019 [54] (year before COVID-19 pandemic started) and 3,785,973 GWh in 2021 [55]; therefore, the increase in yearly electricity demand would be approximately 24.16% if we take into consideration the year 2019 (or 17.74% if we consider year 2021 as a reference)—few concerns regarding this figure will be provided in the Results section.

### 2.2. The CO<sub>2</sub> Emissions Calculation

On average (taking into consideration the final products after oil refining—diesel, gasoline, and LPG, as seen on Table 2), each liter of oil contains 627.59 g of carbon (Formula (2)).

$$C/l_o = \frac{\sum_{i=1}^n C_{gi} \times W_i}{\sum_{i=1}^n W_i} \quad (1)$$

$$C/l_o = \frac{720 \times 0.835 + 652 \times 0.750 + 454 \times 0.550}{0.835 + 0.750 + 0.550} = 627.59 \quad (2)$$

where

$C/l_o$  = Carbon per liter of (crude) oil;

$C_g$  = Grams of carbon (column 3 as in Table 2);

$W$  = Weight (column 1 as in Table 2);

$n$  = Number of elements (three, in our case (There are many other products that can be extracted from (crude) oil but, for the sake of our study, which is focused on fuels only, only those three were taken into consideration. However, in this formula, one can add many other compounds that will give a more accurate result.), as can be seen in Table 2).

**Table 2.** Carbon emission calculation (per liter).

	Fuel	Weight (Per Liter)	Carbon (%)	Carbon (g)
		1	2	3 = 1 × 2/100
1.	Diesel	835	86.2	≈ 720
2.	Gasoline (Petrol)	750	87	≈ 652
3.	Liquefied petroleum gas (LPG)	550	82.5	≈ 454

Source: Ecoscore Belgium [56].

By this calculation, one can see that the carbon reduction from avoided oil consumption in road transportation (assuming there is no increase in other activities to compensate) would be 157.76 million tons of carbon per year (before considering the increased electricity use) (Formula (3)).

$$C/\text{year} = 251,370,000,000 \text{ L} \times 0.62759 \text{ Kg/L} = 157,747,298,300 \text{ Kg} \quad (3)$$

Converting the information from Table 1, we find that one single liter of (crude) oil provides 10.694 KWh. This allows us to find that the carbon emission per KWh of electricity is 58.69 g (Formula (4)).

$$C/\text{KWh} = 627.59\text{g}/10.69 \text{ KWh} = 58.686 \text{ g/KWh} \quad (4)$$

Assuming that the 24.16% of extra electricity (as proven in Section 2.1) comes from existing sources, then the total increase in carbon emission from increased electricity consumption would be 39.43 million tons of carbon per year. Thus, the net carbon emission reduction would be 118.33 million tons (Formula (5)).

$$\text{Carbon emission reduction} = 157.76 \text{ Mt} - 39.43 \text{ Mt} = 118.33 \text{ Mt} \quad (5)$$

Total EU carbon emitted in 2019 was 2900 million tons [57]—one needs to remember that the year of 2019 is considered, by this study, more relevant because after the COVID-19 pandemic started and the lockdown was imposed, the total amounts of carbon emitted decreased sharply and, by that, the 2021 figures might present a distorted picture. Therefore, the net decrease at the European level of carbon emissions would be approximately 4.08%. However, for filling in data with the latest values, in 2021, the total EU carbon emissions were 2600 million tons [58] meaning a net decrease of 4.55%.

### 2.3. The Cost Calculation

The average (including tax) of passenger cars in the EU today is 30,485 EURO [59].

According to Enel X—a global company involved in producing charging docks for electric vehicles—the average price for an EV is around 46,000 EURO [60]; of course, this will come down with the economy-of-scale. However, the “average” 30,000 EURO internal combustion car price today also includes many heavy vehicles that push up the average price. Small petrol vehicles, which are more common than medium-sized and large engines in the majority of European Member States [61], are good candidates for replacing EVs and are cheaper at 10,000 EURO on average [61]. By that, one can observe, at today’s costs, that EVs price is 36,000 EURO more than equivalent petrol vehicles. Scaling the market up is still to be seen a cost difference of roughly 20,000 EURO for economy-of-scale EVs [62–64]. This means 10,000 EURO marginal cost over fossil fuel.

There are two cost cases to be considered here:

Cost case 1 (Cc1): replacing the whole passenger car fleet instantly;

Cost case 2 (Cc2): replacing only the old vehicles with electric cars.

### 2.3.1. Cost Case 1

For the “instant” switch (Cc1), around 292 million vehicles [65] have to be replaced immediately, and all fossil fuel cars will lose all their value. The author will not further discuss this scenario, considering it unreasonable.

### 2.3.2. Cost Case 2

For the “gradual” shift, where fossil fuel vehicles are running until the end of their useful life, we only need to consider the marginal increase in cost over a business-as-usual case—33% of the total amount [66], which is, for our study, 973 billion EUROS (one third of the total number of cars [65] multiplied by the marginal cost over fossil fuel).

Despite the fact that the figure is yet very high, the Cs2 seems more reasonable, so it deserves being further developed; however, one can see that this is the most optimistic scenario. The effective cost of carbon reduction is approximately 8222.77 EUROS per ton of carbon per year (marginal increase in cost/net carbon emission reduction, Formula (6)).

$$\text{Effective cost of carbon reduction} = \frac{973 \text{ bn EUROS}}{118.33 \text{ Mt}} = 8222.77 \text{ EUROS/t} \quad (6)$$

This figure, amortized over a ten-year vehicle life (320,000 km at roughly 32,000 km/year [67]), gives 822 EUROS per ton of avoided carbon.

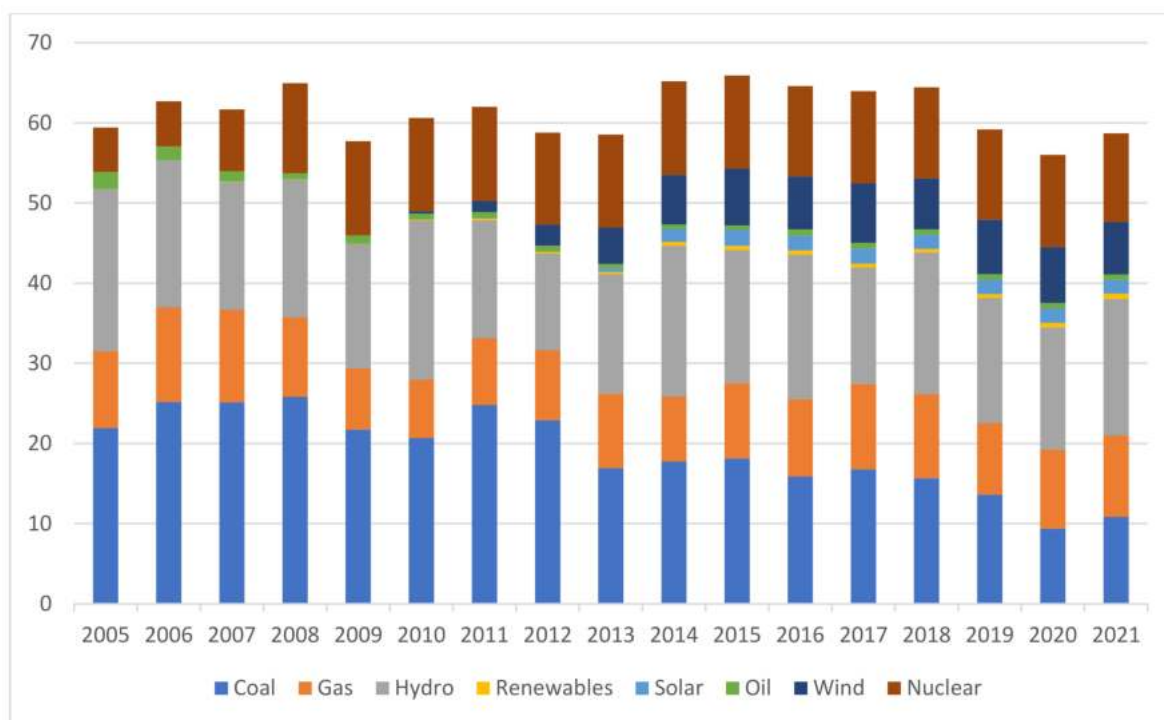
The current industry estimates the cost of coal power plant carbon capture and sequestration (CCS) to be 78 EURO/ton of captured carbon [68,69]. For the enhanced oil recovery, carbon has an economic value of 39 EURO/ton [70]. Therefore, taking into consideration the amount of energy produced by burning coal versus the energy used by internal combustion cars, the net cost of CCS is approximately 39 EUROS per ton (these figures might not scale linearly, but that goes the same for the marginal electricity costs [71]; therefore, approximations are valid). Compared with this study’s estimated value of 822 EUROS per ton of carbon, shifting to EVs is more expensive—and that was considering the optimistic scenario.

## 3. Romania—Country Profile

The total electricity (meant to fuel up the whole industry) produced in Romania today is 56,200 GWh [72] and it comes from 187 hydroelectric power plants [73], 1 nuclear-electric power plant [74], 11 power plants using coal [75] and 37 using gas or oil [76], 962 photovoltaic parks [77], and a significant number of wind turbines together with other sources such as geothermal and biogas power plants (Figure 2) (Romania is a self-sustainable country in regard to energy consumption and produces roughly 124% of its actual needs Invalid source specified).

By the end of 2021, in Romania, there were registered 8,749,390 vehicles [78,79], of which about seven million do fit in our analysis (being possible to be replaced by EVs—we excluded from the total number motorcycles, vehicles for transport of passengers, and vehicles for transport of goods) consuming roughly 6.88 million tons of oil (diesel and gasoline) per year [80].

According to the information from Table 1, converting all this into electrical energy means a rough amount of 73,547 GWh (30.86% more than production capacity). The difference (17,347 GWh) would be, most probably, covered by consuming the oil no longer in need by cars—to do so, the existing capacity needs to be extended. However, if so, the pollution at the national level will not disappear. If there is an extra pressure on the renewable sources (which, as per today, produce about 60% of the total amount of electrical energy (Figure 2)), it means they need to produce three times more energy as today—a very unlikely scenario for the next couple of decades.



**Figure 2.** Electricity production by source in Romania (TWh) [72].

## 4. Findings

### 4.1. Barriers to Electric Vehicle Acceptance

After in-depth research made over the cited articles on potential EVs buyers, we discovered a couple of barriers to EVs acceptance as follows (we present the most significant one in regard to the present analysis):

- **Vehicle range.** A pure electric vehicle would need to be able to travel 500 km on a single charge [7,26,33,81]. Fuel efficiency is the most important criteria when buying a new car. For the time being, gasoline and diesel are at the forefront of the choice made by potential buyers. Despite the advances in R&D of new types of batteries, reaching an autonomy higher than 250 km for private cars is still far. Nevertheless, the running speed of the vehicle, as well as the total weight and outside temperature, are significant factors that influence the energetic performance of the batteries, as it has been demonstrated in very recent studies [82–85].
- **Charging station infrastructure [26,27,86].** The number of charging stations is still very small and they are built by different companies who do not follow same technological standard, which narrows down the chances for drivers to adventure on their travels. Moreover, most owners charge their vehicles at home or at their workplace, which diminishes the initiative for potential buyers.
- **Purchasing costs [7,33].** The high upfront costs make EVs less attractive than the classical ones. One of the reasons for this might be the fact that the industry is still in its early stages. In order to help citizens adopt EVs, some countries are providing generous grants and incentives; however, despite all that, buyers are still reluctant.
- **Limited Battery Life [3,7,33,87].** Average lifespan, in terms of number of charging/discharging cycles, is between 200 and 2000. Adding to that, the fact that the most expensive part of the car is the battery, roughly 50%, and most of them built with today's technology do raise environmental concerns after they are replaced, again discourages potential buyers to step into the electrical era. At present, the electrolyte of lithium batteries used in electric vehicles is flammable, which has the hidden danger of ignition and electrolyte leakage. Although the solid-state battery with high energy

density can overcome these defects and achieve a longer endurance distance, it has not yet achieved mass production and high cost [88].

- Lack of consumer knowledge [7,89]. Studies made between 2018 and 2020 show that, even if the general perception on EVs improved, the industry is still facing big resistance from consumers and their will to understand the latest technological developments.

These barriers are to be seen from the buyer perception and they should be added to the general idea of the present article. However, one can easily see that they will postpone even more the transition to EVs. The author's intention is to study car buyers' attitudes in regard to EVs and to publish the results as well—to do that in the present article would have taken too much space and also might have shifted the focus from the energy supply industry, as the primary support for the existence of EVs, to consumer behavior.

#### 4.2. Concerns

Following the calculation made in Section 2.1, the author argues about the fact that the European Union (or any developed member states inside the Community) is able, at the moment of this research, to compensate the (potentially new) demand of electricity. In some countries (e.g., Romania), this new demand is bigger than the EU average of  $\approx 25\%$ .

Forcing the production of electricity by converting the oil that is today used by cars will not solve the global pollution issues; however, it will take pollution out of the big cities.

### 5. Discussion

Less environmental pollution is seen as the main benefit of having an electric car [7]. If we consider this as the target, EVs are not the only available option. In the UK FIRES 'Absolute zero' report [3], the authors present the problem as being indeed the petrol/diesel engines—a problem that must be undertaken by 2030. However, they failed to provide multiple solutions to it (e.g., hydrogen-fueled cars), with the whole report being focused on electrical vehicles.

EVs seem to be useful for local private transportation—especially micropersonal mobility vehicles [90]. For the longer distances, however, up to few hundreds of kilometers, internal combustion engines seem to be the best option at hand, probably together with hydrogen-fueled vehicles, especially if we are to speak about passenger and goods transportation services. Most of the urban life worldwide is now dependent on public transportation services. In this regard, governments are starting to pay higher attention to more sustainable transportation options. While electric buses are one option, as we saw, it is not the best one. In a report made by Bloomberg in November 2021 [91], they also put a bet on hydrogen, but this is a subject to be researched.

Except very few car manufacturers, most of them have allocated only a small percent of their effort into electric vehicles, e.g., Volkswagen AG, the largest on the European market [92], has only given 12.5% of its effort to EVs (under the latest plans, the strategic target of one million electric cars (of roughly 8,88 million cars, Audi included) is expected to be reached at the end of 2023 [93]) to EVs, and this fact is giving a certain stability to the internal combustion engine market.

Tesla, on the other hand, being the most recognized EVs brand in the world and the one that managed to reignite public interest on the subject, is allocating all its efforts to the research and development of electric cars. However, its success—over 910,000 units in 2021 (46% of the total EVs sales) [94]—is far behind the market, which, in the same year, was as big as 66.7 million units [95]; in fact, the company started to make a profit in 2020, after 17 years of activity [96]. The 'Tesla effect', as it is sometimes called in the media [97,98], is seen as a major driver of EVs' acceptance [7], and that itself might be seen as (only) 'fashion' [99], being unable to solve real problems [100]. In regard to revenue, in 2021, Tesla's annual revenue was 17.8 bn US\$ [96], foreseeing a growth of 21.4% till 2026, while for Volkswagen AG, revenue for the twelve months ending 30 September 2021 was \$302.665 bl US\$, a 21.76% increase year-over-year [101], out of an overall global revenue

of 2.7 trillion US\$ [102]. These figures show again the stability of the internal combustion engine car market facing the leading company of electric cars.

However, according to a report of the International Energy Agency, the increased number of EVs models is an important driving force [103] as well as the decrease in battery price, which, by Bloomberg, ‘in 2030 will be close to half of what they are today, but it may not be smooth sailing to get there’ [104].

This article provided both theoretical and practical implications of EVs general adoption and, by summing up the results, at first, a policy opportunity could be shifting focus from ‘electric’ to ‘green’ (or maybe more convenient ‘sustainable’) transportation that will include hydrogen-powered vehicles; by doing so, the public will have a broader palette of transportation means to choose from.

## 6. Conclusions

### Limitations

Intentionally, the author neglected the carbon emissions from refining. Producing vehicle fuel out of crude oil increases the carbon emissions by roughly 40% [105], which increases the carbon emissions from  $\approx 5\%$  [106] to  $\approx 7\%$ . There are many other factors that can be included in the analysis that will increase or decrease both cost and emissions. A full accounting would take hundreds of pages.

Even if considering better options of replacing fossil plants altogether with nuclear, wind, or any other green energy producing plants, it is merely impossible to estimate the impact on the environment of those plants: hydroelectric power plants need a dam to be constructed and sacrifice the surrounding environment (e.g., the Egyptian Aswan Nile Dam [107], the Chinese Three Gorges Dam on the Yangtze River [108]); nuclear power plants produce radioactive waste that is very difficult to deal with [109].

Despite the fact that the cost for building a charging station is easy to estimate (Table 3), the author was unwilling to calculate and integrate the costs of building the whole infrastructure of charging stations across Europe (not even only across Romania)—this will be a topic to be addressed in a future article. However, from the user perspective, extension of charging points has the highest influence on the decision to not buy an electric car [26].

**Table 3.** Cost estimation for building EV charging stations.

Cost of ***	Type	Home Charger (120/220 V AC, 11 kW)	Commercial Light Charger * (120/220 V AC, 22 kW)	Commercial Heavy Charger ** (380 V AC, 50–350 kW)
Charging Time to Full		(8–10 h)	(8–10 h)	(1 h)
1.	Infrastructure	$\approx 5000$	$\approx 5000$	$\approx 14,000$
2.	Equipment	$\approx 500$	$\approx 6500$	$\approx 50,000$
3.	Advertising/security/protection	$\approx 300$	$\approx 500$	$\approx 1000$
4.	Software	$\approx 25/\text{month}$	$\approx 50/\text{month}$	$\approx 50/\text{month}$

\* Also used in private environments where owners possess more than one EV; \*\* More than two cars simultaneously, fast charging; \*\*\* Prices are showed in EURO. Source: Compiled and adjusted from Future Energy [110], Golab et al. [111], and Webasto [112,113], Enel X [114].

The author did not take into consideration personal perception of potential buyers of an electrical vehicle. However, a couple of articles and studies are describing those factors as well [7,81,87,115–117]. Among them, the author of the present article would like to cite Statista ‘In-depth: eMobility 2021’ [7], who promote the idea that one of the most important benefits in buying an EV is the collective effort of reducing pollution. Despite that, as stated previously, fuel efficiency is seen as ‘the most important criteria’ for buying a new car, with gasoline and diesel leading the figures by far.

The target is to fully shift to zero emissions by 2050 but electric vehicles are not as efficient as promoted by mass-media both in terms of costs as well as regarding carbon emissions. Moreover, given the current EU power mix, the conclusion is clear: so far, no national economy can afford the shift. Most probably, the future will take us there, but

actual market trends, both for cars as well as for electricity, do not support the assumption for the next several decades.

However, zero emissions targets could be reached if all sorts of energy sources are to be taken into consideration: hydrogen for terrestrial passenger and/or goods transportation; nuclear for ships and big carriers; and, of course, electrical for urban private transportation.

The challenge is to find solutions that strikes a balance between the benefits of EVs adoption and the current energy market.

Following the barriers to EVs acceptance identified in this article, future research will focus on buyers' perspective and reasons to shift from a traditional internal combustion engine to electric or hydrogen ones. A comparison between different battery types and hydrogen engines will be also provided.

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