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The Lack of Charging Infrastructure for Electric Cars: An Impediment to the Sustainable Development of Electromobility

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Abstract
Charging stations for electric vehicles are becoming increasingly important as the world moves towards more sustainable transportation solutions. They are essential to ensure adequate and accessible charging infrastructure for electromobility users. The paper presents the authors' own scientific representation and original point of view on the technical acceptance of the infrastructure for powering electric vehicles. In this way, those interested can learn about the current situation of charging stations in EU countries, the current situation of charging stations in Romania, the types of existing charging stations and charging times. The scientific research also presents a case study carried out by Roland Berger worldwide, which on the basis of a questionnaire shows how often electric car owners charge at public charging stations, how satisfied they are with the charging speed and where they feel the need for more charging points. At the end of the survey, conclusions are drawn on the data collected.

Keywords: Charging Infrastructure, Charging Time, Electric Vehicle, Electric Station, Charging, Charging Time, Case Study

1. Introduction

Every second car sold globally in 2035 will be electric, as set by current energy, climate and industry policies, according to the International Energy Agency's 2024 global outlook [1]. There are more than 3 million electric cars on public roads in the EU, about 50,000 of them in Romania. By 2030, almost one in three cars on the roads in China and almost one in five in the US and the EU are expected to be electric. But the way to achieving these goals is not easy, as potential future electric car owners have some concerns. These include the number of charging stations and their availability. The overall number of installed public charging points increased by 40% in 2023 compared to 2022, with growth in the number of fast chargers outpacing that of slower chargers. In the major electric vehicle markets, the deployment of charging points continues at an accelerated pace due to specific policies. An ACEA report shows that there were 632,000 charging points for electric vehicles in the EU as of December 31, 2023, of which 2,754 in Romania. The Netherlands has the most points, 144,000, Germany and France each have more than 100,000, and Italy and Belgium have more than 40,000 "charging points" [2]. Almost ten times as many charging points for electric cars would need to be opened in the EU each year compared to the current pace. There are extremely few charging stations compared to the number of new electric cars registered. To date, the lack of infrastructure to power electric cars is the main impediment, which has overtaken the lack of range and the high price of buying an electric car.

2. Literature review

The transport sector accounts for almost a quarter of all EU emissions and most of these are caused by road transport, according to a Green Deal report [3]. This is why the transition to electric cars is one of the main priorities of the European environmental agenda for the next decade - *in the context of the EU's climate neutrality target.* European legislation has thus got tougher. From 2035 [4] all new vehicles in member countries must be electrically powered and have charging stations every 60 km [5], under an EU directive. Uniform development is what the European Union wants for the network of electric car charging stations in member states. A law has been passed in Brussels requiring high-powered fast-charging stations to be installed every 60 kilometers on roads forming part of the trans-European transport network from 2025. For a car with a battery capacity of 77.4 kWh, it could be charged from a 150 kW station in less than 20 minutes. Charging from 10% to 80% is the standard. The project under EU discussion covers the all countries of the EU.

In Romania, the Environmental Fund Administration (AFM) has launched a series of funding programs to support the development of charging station infrastructure in 2018. These programs cover on the one hand, the installation of stations in county municipalities and localities, and on the other hand, a program dedicated to the installation of normal power charging stations. Normal power stations run on alternating current (AC), up to 22 kW and are more common in public places. A charging cycle can take several hours [6], compared to fast (DC) stations, usually located on national roads or highways, which charge in tens of minutes.

More European countries, including Denmark, Ireland, the Netherlands, Slovenia, the Netherlands and Sweden, have announced plans to ban the sale of fossil-fuel vehicles from 2030. These initiatives are part of the Fit for 55 [7], a legislative package to implement the European Union's Green Deal, which requires member countries, including Romania, to reduce greenhouse gas emissions by 55% over the next six years. Against this backdrop, the European Union would need to build some 8.8 million charging points by 2030 to meet its climate targets, or more than 22 thousand per week, estimates the latest ACEA Report [8]. Currently, 70% of charging stations in the European Union are concentrated in three Western European countries: the Netherlands (66,665), France (45,751) and Germany (44,538), according to an ACEA Report [9]. Together, they account for just 23% of the EU's total surface area [10].

3. Situation of charging stations in EU countries

Almost 2.9 million public electric vehicle (EV) charging points will need to be installed in EU countries over the next seven years - about 410,000 per year or 7,900 per week - to reach the decarbonization target for road traffic. However, ACEA calculates that the network will need 8.8 million charging points, which would mean installing them at a rate of 1.2 million per year, or 22,438 per week, assuming all the stations already open remain in operation, according to the first report on the subject by the European Automobile Manufacturers Association (ACEA) [11].

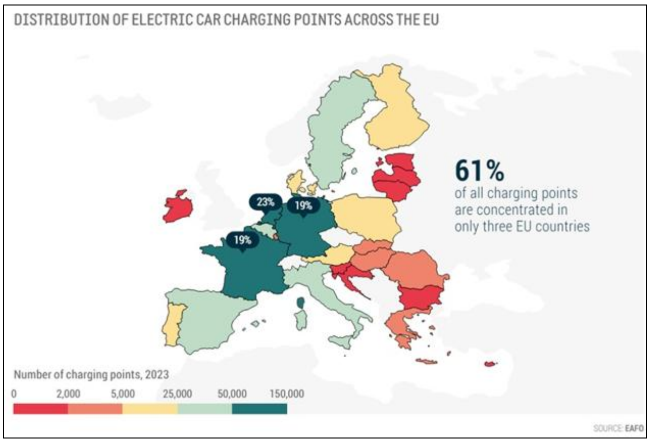

Fig 1: Distribution of electric car charging points across the EU [11]

Fig 1 shows the distribution of electric vehicle charging points in the EU. At this rate in 2023, the public charging network will reach only 1.6 million such points by 2030, far below the need calculated by the European Commission, which says there should be 3.5 million stations in the reference year 2030. Public charging points in Europe are generally equipped with one of two types of connectors, with Type 2 being the predominant connector and the Combined Charging System (CCS) taking most of the remaining market share. The Type 2 connector has a universal plug capable of supplying up to 22 kW for slow and fast charging.

CHARGING POINTS PER COUNTRY, PLUS PERCENTAGE OF EU TOTAL

Country	Chargers	% of EU total	Country	Chargers	% of EU total
Austria	18,637	2.9 %	Italy	41,114	6.5 %
Belgium	44,363	7.0 %	Latvia	535	0.1 %
Bulgaria	1,624	0.3 %	Lithuania	1,313	0.2 %
Croatia	1,074	0.2 %	Luxembourg	2,323	0.4 %
Cyprus	329	0.1 %	Malta	101	0.0 %
Czechia	4,664	0.7 %	Netherlands	144,453	22.8 %
Denmark	23,072	3.6 %	Poland	6,102	1.0 %
Estonia	683	0.1 %	Portugal	7,306	1.2 %
Finland	11,247	1.8 %	Romania	2,754	0.4 %
France	119,255	18.9 %	Slovakia	2,380	0.4 %
Germany	120,625	19.1 %	Slovenia	1,608	0.3 %
Greece	3,166	0.5 %	Spain	30,385	4.8 %
Hungary	3,319	0.5 %	Sweden	37,166	5.9 %
Ireland	2,825	0.4 %	EU	632,423	100 %

Fig 2: Charging point/country, plus percentage of EU total at December 31, 2023 [11]

At the end of 2023, there were 632,423 public charging points available in the EU and around three million battery electric vehicles (BEVs) were in circulation. Fig 2 shows the charging point/country, plus percentage of EU total at December 31, 2023. Analysis of the data in Fig 2 shows that the Netherlands is the region with the most widespread electric vehicle charging infrastructure. They have over 52 times more charging points than Romania (2,754).

The factors that cause the significant difference between the European Commission and ACEA's estimates of the number of charging points across Europe are [11]:

- The European Commission underestimates the number of vehicles on EU roads that will need a charger by 2030: its estimate is 30 million, compared to 65 million according to Strategy & Fraunhofer ISI estimates used in the ACEA calculations;
- ACEA numbers include battery-electric vans, which are mainly charged using the same infrastructure as cars, as well as plug-in hybrid electric vehicles, while the European Commission only counts battery-electric cars;
- The European Commission assumes significantly lower vehicle energy consumption compared to recent real-world monitoring figures (14.8 kWh/100 km for battery electric vehicles (BEVs) and 19.2 kWh/100 km for plug-in hybrid electric vehicles (PHEVs), compared to 20 kWh/100 km for BEVs and PHEVs according to ACEA);
- The European Commission recognizes that the Alternative Fuels Infrastructure Regulation (AFIR) is the minimum necessary coverage and will be insufficient to deliver CO_2 reductions for cars and vans.

4. The situation of charging stations in Romania

In the last six years, Romania has completed only 85 filling stations for electric vehicles through the programs of the Administration of the Environment Fund (AFM). Of these, only five have been completed in the last two years.

One of the main reasons for this is the lack of a dedicated institution to manage the development and monitoring of the charging network in a unified way. Currently, the responsibility for infrastructure expansion is shared between four ministries: the Ministry of Development, Transport, the Ministry of Environment and the Ministry of Energy.

At this date in Romania, the Ministry of Environment has on paper the financing of about 4,100 charging stations, of which it has realized only 2% in the last six years, according to official data [10]. These numbers are insignificant compared to Romania's target of 30,000 [12] of electric vehicle charging stations by the end of 2026. About half of these would be funded through the National Recovery and Resilience Plan (NRRP) [10].

Nationally, however, there are currently 1,700 charging points, out of 45,000 [13] of electric cars registered in the first quarter of 2024.

In Romania, progress in developing the infrastructure for electric vehicles remains far below the needs of the market and the requirements imposed by European legislation, even though range and charging times have improved in recent years.

In the period 2018-2020, a project was launched in Romania for the implementation of the infrastructure of recharging stations for electric vehicles in county municipalities. The main objective of the project was to improve the quality of the environment by reducing greenhouse gas emissions by stimulating the use of electric vehicles. The program could be accessed by the representatives of the administrative-territorial units, who apply online through a competition, and according to the legislation in force, the authority covers 100% of the eligible expenses, by settling the maximum amount at the end of the project.

Of 255 proposed stations, 78 have been completed, six years later. The remaining charging points are still "in progress" and the budget for this first project is 92 million lei. In this sense we can say that things are not looking any better at the level of the program dedicated to localities either. Between 2021-2022, the Environmental Fund Authority has approved the financing of 2,779 stations, of which five have been completed. The budgetary effort is estimated at 500 million lei for this project [10].

In addition to the insufficient number of charging stations for electric cars, Romania also faces an uneven distribution of the existing ones. At present, charging points are mainly concentrated in big cities and are poorly covered in small towns or along national roads. So electric cars risk remaining an affordable solution only in big cities and only for those who can afford to install a station at home, and not depend on the tens of thousands of electric cars on the market. According to a study by the Intelligent Energy Association, quoted by Free Europe [14], Romania has four times less stations per 100 km than the European average. The draft EU law also stipulates that charging stations, especially on national roads, must be located every 60 km, starting next year.

The latest Environment Fund Agency program to build normal power recharging stations ran from 2022-2023. The project's stated aim is to build 1,213 electric vehicle charging stations. To date, no electric charging stations have been completed under this program. All the stations are in different stages of execution with an allocated budget of 500 thousand lei [10].

In Romania the current status of projects under national funding programs continues to lag behind. Some are still in the analysis phase. Thus, for the program dedicated to recharging stations for electric vehicles in county municipalities, running from 2018 to 2020, 36 applications were submitted for settlement, of which 31 were settled. The last five applications for settlement of investments made in electric stations remained at the point of analysis even four years later. The project for substations in localities, organized in the period 2021-2022, received 65 applications for settlement, of which 20 remained to be assessed and are under analysis with the project officer or on the internal endorsement circuit.

5. Types of existing charging stations and charging times

Charging stations are classified according to the time required to charge a traction battery for electric vehicles:

- Station level 1 - slow station;
- Station level 2 - fast station;
- Station level 3 - very fast station.

Level 1 station or slow charger is usually the station that is recommended for overnight charging, or rather the station that charges the car in about 6-12 hours. It is commonly used in residential areas. It can be plugged into an outlet in your building or may require a dedicated circuit in the general electrical panel, depending on its characteristics. It uses alternating current. Please note that the power of these charging stations does not exceed 6kW. So, if you have a car with a 40kW battery, it will take about 6.6 hours to charge it. The connection between the vehicle and the charging station is made via a cable with a connector adapted to the type of electric current used and the car. The cost of this type of station is low compared with the others.

Level 2 station or fast charger is the station that cannot be plugged into a standard socket. It can also use electricity produced by photovoltaic panels. Charging a car with electricity takes 4-6 hours. It is compatible with most electric and hybrid cars. But the duration can vary depending on the temperature. At low temperatures it can increase. The stations have a cable length of 5.5, 6 or 7.6 meters. Their power does not exceed 22 kW. Please note that if you own a Tesla, it must be powered from a Tesla station.

Level 3 station or DC fast charger are chargers that provide 80% battery charging in 30-40 minutes. They work using direct current and have 2 main types of connectors: CCS (Combined charging system) or CHAdeMO. They cannot be used by all electric or hybrid cars and are found in industrial and commercial areas. They have a power of over 50kW regardless of the type of connector. The CCS station also works on alternating current, with 2 types of connectors: type 1 and type 2 depending on the geographical area in which you are located. The standard CHAdeMO (CHArge de MOve) does not use AC current and can provide a power of 6kW up to 150kW at the moment. The CHAdeMO 3.0 version will be able to provide up to 500kW. The operating voltage is 400V and the operating temperature with maximum efficiency is -20 and 50º C.

However, at this date, due to the evolution of technology, the charging time of a battery for electric vehicles has further decreased. Based on the researched data, we have determined the approximate charging time for a 24 kW electric battery as well as the relevant energy requirement (Table 1):

Table 1: Approximate charging time for a 24 kW electric storage battery and energy requirements [15, p. 46].

Charging time (hours)	Power supplied (kW)	Voltage (V)	Current (A)	Module*	Charging speed
10,4	2,3	230 AC	10	2-3	Slow
8,3	3	230 AC	13	2-3	Slow
6,5	3,7	230 AC	16	2-3	Slow
3,2	7,4	230 AC	32	3	Accelerate
1,6	14,5	230 AC	63	3	Accelerate
1,04	23	230 AC	100	3	Accelerate
0,29	50	400-500 DC	100-400	4	Fast
0,15	100	400-500 DC	100-400	4	Fast

* According to IEC 61851-1, four charging modes are approved for electric cars [15]:
Module 1 – standard power supply via a connection to a single-phase or three-phase socket (not recommended for use, as it damages the electric accumulators);
Module 2 – standard power supply via a connection to a single-phase or three-phase socket, through a dedicated protective equipment for powering electric vehicles;
Module 3 – standard or fast power supply via a connection to a dedicated multi-input electric vehicle socket with control and protection functions on a separate circuit;
Module 4 – fast power supply with specific CHAdeMo-type electrical charging technology (protection and control functions embedded in the supply infrastructure).
An analysis of the data presented in Table 1 shows how much the technology for charging electric batteries has evolved recently. The charging time for an electric car battery has been reduced from 10.4 hours to 15 minutes.
It is very important that the time it takes to charge a battery for an electric vehicle is reduced to the time it takes to fill a fuel tank for a conventional car. Otherwise electric vehicles tend to remain unattractive for the end user [16, pp. 47-52].
The charging time (in hours) for an electric vehicle can be calculated based on the relationship: battery capacity (in kWh) / vehicle charging power (in kW)

6. What electric car owners think about charging infrastructure. Case study

A new study by Roland Berger, shows how often electric car owners charge at public charging stations, how satisfied they are with the charging speed and where they feel they need more charging points to charge the electric traction batteries in their cars.
Consultancy Roland Berger conducts annual studies of the global electric car market, including a survey of electric car owners. Now in its fifth year, the 2024 study was conducted with 16,000 electric car owners in 32 countries in Europe, North America, South America, the Middle East and Africa, including Romania. In this way, the study provides a realistic picture of how the charging infrastructure has developed to date, beyond the figures reported on charging network expansions.
In the initial phase of the survey, Roland Berger focused on identifying electric car users' perceptions of electric car prices, charging costs or range compared to cars with internal combustion engines.
Based on this survey of almost 16,000 participants worldwide, as well as official data on sales of electric cars and the number of charging stations, Roland Berger calculates an index for each country. The higher the index, the better developed the country is in terms of infrastructure for charging electric cars [17].
The questions asked to respondents in this case study are as follows:

A. What is the acceptable price for an electric car compared to a heat engine car?

Normally, one of the main complaints drivers have about electric cars is their price compared to similar models in the same segment equipped with combustion engines [17].

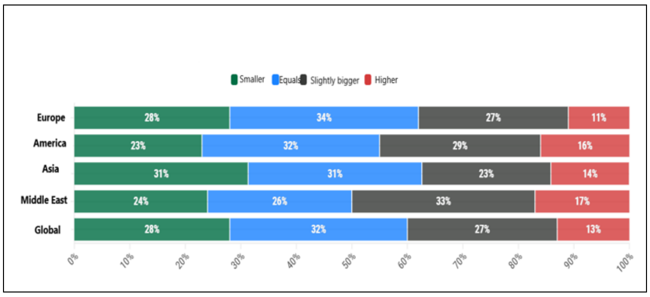

Fig 3: The answer to the question: what is the acceptable price for an electric car compared to a heat engine car [17]?

Fig 3 shows the respondents' answers, in percentages, to the question: *what is the acceptable price for an electric car compared to a car with a combustion engine?*
Analyzing the data in Fig 3, it emerges from the Roland Berger survey that 34% of Europeans find it acceptable for an electric car to be the same price as a combustion-engined car, while 28% expect lower prices and a similar percentage expect slightly higher prices. 62% of respondents find it acceptable for electric cars to be more affordable or as affordable as combustion-engined cars, while only 11% of respondents said it is acceptable to pay a relatively high price for an electric car. With small percentage differences for the four response options, they are largely the same for the other regions, with the exception of the Middle East, where 50% of respondents expect electric cars to be more expensive.

B. What are the costs associated with electricity to power electric vehicles?

While in Romania there is a perception that energy for electric cars is more expensive compared to the associated costs for gasoline or diesel for a car with a thermal engine (cost for a full tank of gas compared to range), in Western Europe, 43% of owners say they have lower costs in this respect, while 35% pay about the same amount of money. Virtually only 22% of respondents say electricity is more expensive [17].

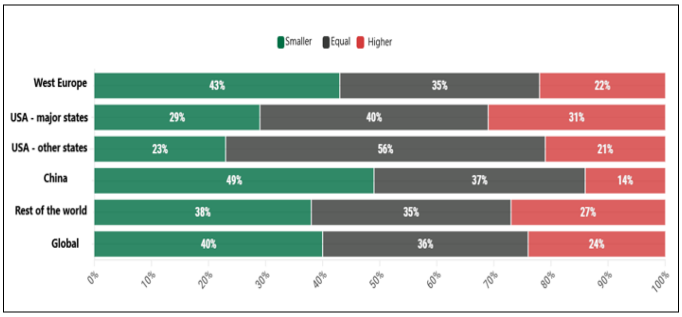

Fig 4: The answer to the question: what are the costs associated with powering electric vehicles [17]?

Fig 4 shows the respondents' answers, in percentages, to the question: *how are the costs associated with powering electric vehicles?*

Analysis of the data presented in Fig 4 shows that the percentage values are also close at the global level, but this average is due to discrepancies between China and the main US states. Thus, 86% of electric owners in China pay less money on electricity than they would have paid on fossil fuels, while 69% of residents in the main markets for electricity in the United States agree with this statement. California, Florida, New York and Texas are the largest US states with the most developed electric car manufacturing industries.

C. What range do you expect from an electric car?

On this question, the survey shows that Europeans are among the most pessimistic electric car owners when it comes to the range they expect. Thus, 41% of Eastern Europeans and 42% of Western Europeans expect a range of 300-500 kilometers, while 35% of Eastern Europeans and 34% of Western Europeans expect 500-700 kilometers. In other words, 76% of Europeans expect ranges between 300 and 700 kilometers. In an analysis of the data presented, China and South Korea are at the opposite pole, with only 22% and 19% of respondents respectively expecting ranges of 300-500 kilometers. Thus, 73% of Chinese and 71% of South Koreans want a range of more than 500 kilometers.

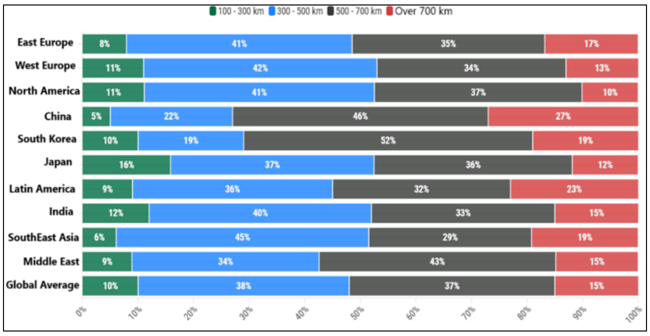

Fig 5: The answer to the question: what range do you expect from an electric car [17]?

Fig 5 shows the respondents' answers, in percentages, to the question: *what range do you expect from an electric car?*

One possible explanation is that the countries with the most developed battery technologies through manufacturers such as CATL, LG Chem or Samsung SDI, have closer technical links with local manufacturers such as BYD, Hyundai and Kia. In this case, the perception of the range of an electric vehicle might also be influenced by different standards for determining it (e.g. (e.g. the Chinese CLTC standard gives a range 15%-20% higher than the European WLTP standard for the same models).

After analyzing the perception of the electric vehicle market, the study focused on the state of the infrastructure for electric charging of electric vehicle traction batteries. The following questions were asked for this sector:

D. How much distance do you travel with stored electricity from the power stations?

Regards of the total distance traveled by electric car, respondents' answers to this question show that 67% of Eastern Europeans rely on public charging stations to cover at least 40% of the total distance traveled by an electric car. This drops to only 47% in Western European countries, while at the other end of the scale are China and South Korea with 75% and 85% respectively..

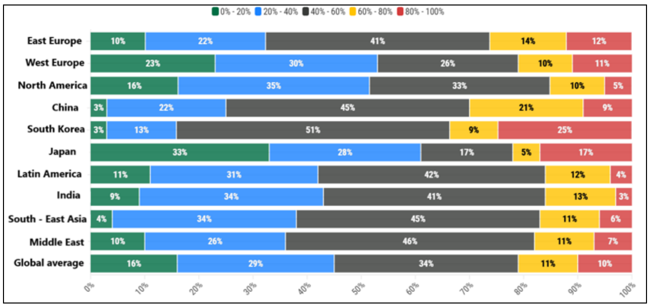

Fig 6: The answer to the question: how far do you drive with stored electricity from filling stations? Relative to total distance traveled by electric car [17]

Fig 6 shows the respondents' answer, in percentages, to the question: *how far do you travel with stored electricity from filling stations?*

Relative to total distance traveled by electric car. Analysis of the data presented in Fig 6 shows that one of the explanations for the reliance on public charging stations is the low number of owners who have the possibility to charge electric vehicles at home.

Japan ranks high in this survey, as 33% of owners drive no more than 20% of their distances on charged energy at public stations. This drops to 23% in Western Europe and only 10% in Eastern Europe.

E. How many times a week do you charge your electric vehicle at a public charging station?

Data collected by Roland Berger shows that 58% of electric car owners in Eastern Europe charge their electric car once or at most twice a week at a public charging station, while 32% need at least 3 charges per wek. The percentage of those who charge once or twice a week at a public charging station is slightly lower in Western Europe, mainly due to the greater availability of home charging stations. Fig 7 shows respondents' answers, in percent, to the question: *how many times a week do you charge your electric car at a public charging station?*

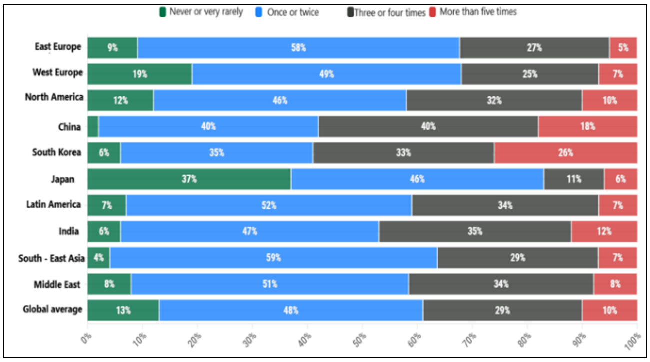

Fig 7: The answer to the question: how many times a week do you charge your electric vehicle at a public charging station [17]?

The data presented in Fig 7 show the following:

- with the notable exception of Japan, electric car owners in Europe are most dissatisfied with the charging speed offered by public charging stations. Only 54% of eastern Europeans and 47% of western Europeans are satisfied with the charging speed, and the figures are slightly surprising given that fast charging stations are more common in the western half of the continent. Across Europe, 20% of charging points in Europe offer fast charging (DC), compared to 25% in the Americas and a record 44% reported by China;

- globally, 55% of owners are satisfied with charging speeds, with 62% in China and 63% in North America;
- Japan's only 27%, which may be one reason why only 3.6% of cars sold in 2023 in that country were electric.

F. Are you satisfied with the charging speed of public charging stations?

With the notable exception of Japan, electric car owners in Europe are most dissatisfied with the charging speed offered by public charging stations. Fig 8 shows the respondents' answers, in percentages, to the question: *are you satisfied with the charging speed of public stations?*

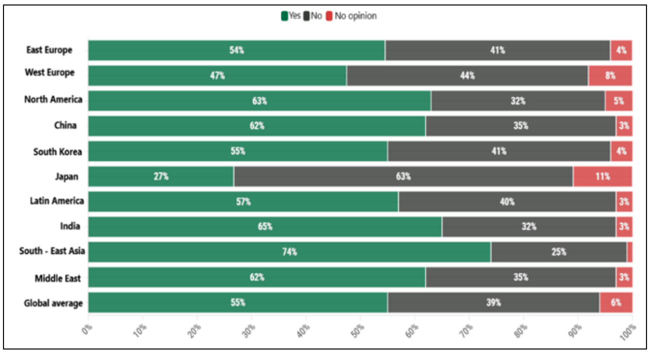

Fig 8: The answer to the question: you satisfied with the charging speed of public charging stations [17]?

Analyzing the data presented in Fig 8 shows that only 54% of Eastern European and 47% of Western European respondents are satisfied with the speed of charging, which is slightly surprising given that fast charging stations are more common in the western half of the continent. Europe-wide, 20% of charging points in Europe offer fast charging (DC), compared with 25% in the Americas and a record 44% reported by China. Globally, 55% of owners are satisfied with charging speeds, with 62% in China and 63% in North America. Japan is the dissenting note with only 27%, and this may be one reason why only 3.6% of cars sold in 2023 in that country were electric.

G. How easy is it to charge your electric car at a public charging station?

Based on hard data on the infrastructure of stations and the charging speeds they offer, 80% of Eastern Europeans and 75% of Western Europeans now believe that charging at public stations has become easier, while only 2% of respondents said it has become more difficult.

Fig 9 shows respondents' answers, in percentages, to the question: *how easy is it to charge your electric car at a public charging station?*

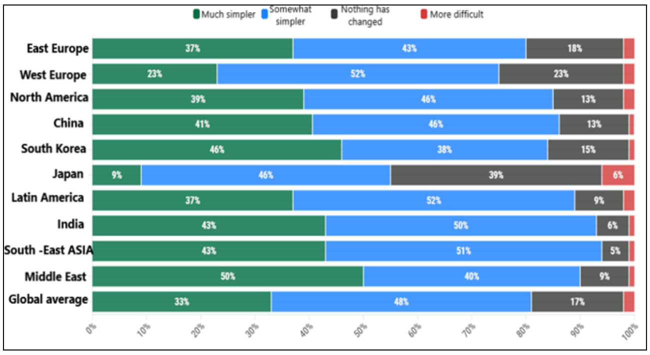

Fig 9: The answer to the question: how easy is it to charge your electric car at a public charging station [17]?

Analysis of the data presented in Fig 9 shows that the percentages are slightly lower than the global average of 81%, driven up in particular by electric car owners in China, who responded that it is easier to charge at public charging stations at 87%.

H. Where are more charging stations needed?

This was a multiple choice question and was related to where charging stations are needed for the most efficient electric car experience.

In this case, Western Europeans mainly chose shopping mall and supermarket parking lots (58%), parking lots at work (55%) and close to highways (46%). Fig 10 shows the respondents' answers, in percentages, to the question: *where is there a need for more charging stations?*

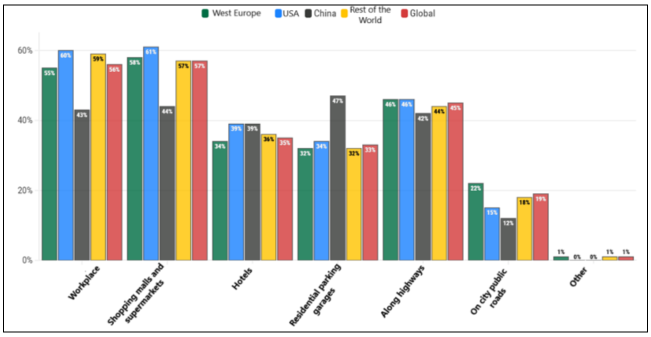

Fig 10: The answer to the question: *where more charging stations are needed* [17]?

These were the top three options preferred by homeowners around the world, rather than stations at hotels or those installed on the street by local governments.

I. How do you find out about the network of charging stations?

Respondents around the world were asked how they find out where electric car charging stations are located, and here they were given a choice of answers. Surprisingly, more than half of Western Europeans use a charging network's mobile app (52%) or the app provided by the car manufacturer (51%), significantly more than the 25% who use apps that integrate charging stations from multiple providers, such as PlugShare. Fig 11 shows respondents' answers, in percentages, to the question: *where do you get your information about the network of charging stations?*

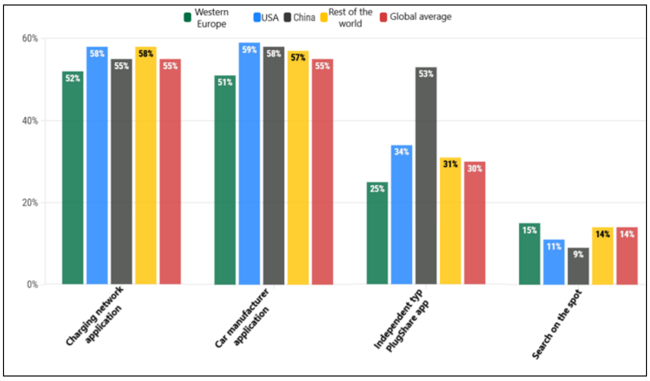

Fig 11: The answer to the question: how do you informed out about the network of charging stations [17]?

Only 15% of respondents said they prefer to look for a station while driving, without a dedicated mobile app.

J. How important is it that the manufacturer of the electric car you own has its own charging network?

Globally, Tesla is the only electric vehicle manufacturer to have developed and owns the largest network of charging stations. This has been an effective strategy in driving sales growth even during periods when electric cars were less popular than they are today.

The strategy has also been adopted on a smaller scale by other manufacturers, particularly in the US market. Fig 12 shows respondents' answers, in percentages, to the question: *how important is it that the manufacturer of the electric car you own has its own charging network?*

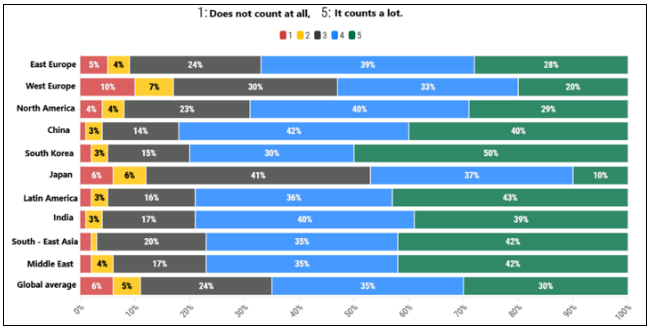

Fig 12: The answer to the question: how important is it that the manufacturer of the electric vehicle you own has its own charging network [17]?

Roland Berger's study shows that for 28% of Eastern Europeans such a network of charging stations has a significant effect on their decision to buy a brand. The percentage is only slightly higher in North America (29%) and slightly lower in Western Europe (20%), with a global average of 30%.

K. Where does Romania rank compared to other countries and regions?

Romania is included in this index for the third consecutive year and, after having an index below 40 in 2022 and 2023, for 2024 it has an index of 46. Of the European countries included in the study, Romania has a better index than Hungary (42). Countries in Western and Northern Europe had an index between 53 (Portugal) and 70 (Germany), with values very close to this maximum in France and the UK (both 69%) [17].

Globally, the highest score is in China (82), which has stagnated compared to the previous edition of the survey, while the US has an index of 70. The global average index is 54.

7. Conclusions

A key determinant for the transition to alternative fuels and a fleet of mostly zero-emission vehicles by 2050 is the installation of charging infrastructure in pace with the level of uptake of electric vehicles. The ultimate objective of the policy is to make charging electric vehicles as easy as filling the tank of a conventional car, so that electric vehicles can be driven smoothly throughout the EU. To achieve this objective, the EU needs to address the following interrelated problem: on the one hand, the level of electric vehicle uptake will be limited as long as charging infrastructure is not available, while on the other hand, infrastructure investment needs more certainty about the levels of electric vehicle uptake.

According to a new ACEA report, sales of electric cars in the European Union have increased 17-fold in the last 6 years.

Despite successes, such as the promotion of a common EU standard on power outlets for charging electric vehicles and improved access to different charging networks, there continue to be barriers affecting the movement of electric vehicles across the EU.

With the adoption of the European Green Deal announced in December 2019, the EU is now aiming to reduce greenhouse gas emissions from transport by 90% by 2050 compared to 1990 levels, as part of a wider effort to become a climate neutral economy. A key element of the effort to reduce road transport emissions is the shift to alternative, lower-carbon fuels. Of these fuels, electricity is the most commonly used new source, especially for cars.

69% of all charging stations in the EU are located in just three countries, Germany, France and the Netherlands, and only 16% are fast-charging stations with a power above 22 kW.

In addition to the particular technical characteristics of electric means of transport, such as the autonomy of electric batteries, long charging time, high cost price, higher vehicle weight due to additional electrical equipment, there are also the insufficient number or power of charging stations at the end of the line or on the route. All these impediments make the electric vehicle unattractive at the present time and lead to a decline in the quality of road transport services.

At European level, the lack of infrastructure for powering electric vehicles has become the main impediment, over and above the problem of autonomy and the high cost of running them. This is a major impediment to the sustainable development of the modern road system.

In Romania the infrastructure for supplying electricity to vehicles is deficient. It is completely lacking on motorways, express and national roads, being very well organized in urban areas, especially in supermarket parking lots. In terms of geographical spread, at the end of 2022 in Romania there are currently only 9 counties with more than 40 charging places: Cluj, Timiș, Bihor, Sibiu, Suceava, Iași, Brașov, Prahova and Constanța, of which the first four counties also reported the highest growth rates compared to 2021. In addition, Cluj is also the county with the highest proportion of places with at least one fast charging station: 60%. In other words, the network of charging stations has developed mainly in Transylvania and in the most popular counties in terms of tourism, i.e. Prahova and Constanța. By contrast, in many counties in south-eastern Romania, such as Teleorman, Giurgiu, Călărași, Ialomița or Brăila, there are fewer than 10 charging stations. The explanation is simple: the charging stations were mainly located where most electric cars are sold and where people's purchasing power is higher. In Bucharest there are currently around 300 places with charging stations, most of them in Sector 1 and the fewest in Sector 5.

The existence of several different payment and information systems complicates the user experience. For example, there is little coordinated information between the different networks on real-time availability, charging data and payment details.

Currently, the most powerful charging stations in Romania offer a charging speed of 300 kW.

Traditional gas stations are adapting quickly to the transition to electric cars, and the report by Roland Berger highlights this best. Gas stations reported the highest percentage increase in the number of sites offering charging stations for electric cars. The first gas station network to develop charging stations for electric cars was MOL through the MOL Plugee brand, and today you can also find charging stations in 22 OMV and 16 Petrom gas stations across the country. A similar number of stations already have Rompetrol, a company that has recently started a new project based on a contract won in 2021 following a tender organized by CNAIR. Thus, Rompetrol has already started the use of 12 service spaces on the A1 highway (6 in each direction), and each gas station will have two 150 kW fast-charging stations. Thus, in total, Rompetrol will have another 24 fast-charging stations.

Charging station compatibility is a key issue for electric vehicle users as it influences the accessibility and efficiency of the charging process. Firstly, it is important to note that there are several standards and types of connectors used globally, each with their own specifications and compatibilities. Some of the most common connector types include CHAdeMO, CCS (Combined Charging System), Type 1 and Type 2, as well as the Tesla-specific connector. These are developed to ensure compatibility with different electric vehicle models and charging infrastructures.

The time it takes to charge an electric vehicle varies significantly depending on several factors, including the type of charging station, the vehicle's battery capacity and the level of charge desired. Level 1 charging stations, which use a standard 120 V outlet, are the slowest, requiring 8 to 12 hours to fully charge an electric vehicle battery. These stations are ideal for overnight charging at home, providing a convenient solution for users who don't need a quick recharge. Level 2 charging stations, which use a 240 V socket, offer a much faster charging speed. They can fully charge an electric vehicle in 4-6 hours, making them suitable for residential and commercial use. Level 2 stations are commonly found in public parking lots, shopping centers and workplaces, where users can leave their vehicle to charge throughout the day.

DC fast charging is the fastest option available, using high-voltage direct current to charge a battery up to 80% in about 30 minutes. This is an ideal solution for long trips, where users need a quick recharge to continue their journey. DC fast charging stations are strategically located on highways and in congested urban areas to provide fast and convenient access to charging.

Another factor influencing charging time is the battery capacity of the electric vehicle. Vehicles with larger batteries will take longer to fully charge, even at fast charging stations. The initial state of the battery (how discharged it is) and environmental conditions can also affect charging time. Extreme temperatures can slow down the charging process, and thermal management of the battery becomes crucial to ensure efficient and safe charging. Thus, users need to take these factors into account when planning electric vehicle charging.

On highways and national roads (DN), charging stations are located to facilitate long-distance travel. These stations, often equipped with DC fast-chargers, allow drivers to recharge vehicles during short breaks, reducing overall travel time. Locating them in highway service areas and near major intersections helps ensure a continuous flow of electric vehicles on major routes, eliminating vehicle range anxiety. However, in Romania, on these categories of roads, to date, they are lacking or insufficient in number, which shows the dissatisfaction of electric vehicle users. This is one of the aspects which make this environmentally friendly means of transport unattractive.

In rural and semi-urban areas, the distribution of charging stations is increasing, although at a slower pace compared to urban areas. Government initiatives and subsidies are key to expanding the charging infrastructure in these regions, ensuring that more remote communities also have access to charging stations. Pilot projects and public-private partnerships are helping to increase the network of charging stations, thus promoting the uptake of electric vehicles in these areas as well.

In addition, many private companies are investing in charging station networks to attract customers and promote an image of environmental responsibility. Supermarkets, restaurants and hotels are just a few examples of locations that are installing charging stations to offer an additional service to their customers. This trend is beneficial both for users, who have access to more charging points, and for companies, which can attract a growing customer segment - electric vehicle owners.

Charging station management software plays a crucial role in efficiently managing and optimizing the use of electric vehicle charging infrastructure. This software enables real-time monitoring of charging stations, providing essential information about each station's status, utilization levels, and overall performance. Through management platforms, operators can quickly identify and resolve technical issues, ensuring maximum availability and a seamless user experience for electric vehicle owners.

The differences between public and private stations reflect the varying needs of electric vehicle users. While public stations are essential to support mobility and eliminate range anxiety during long journeys, private stations offer a convenient and efficient solution for daily recharging. The expansion of both types of charging infrastructure is crucial to support the transition to electric vehicles and to ensure their widespread adoption.

While the growth in the number of electric vehicles brings challenges for the electricity grid, the deployment of smart solutions and innovative technologies can turn these challenges into opportunities. Efficient charging management and the use of V2G technologies can contribute to a more stable and resilient electricity grid, while promoting the use of renewable energy and reducing carbon emissions. This is essential to ensure a sustainable transition to electric mobility and to integrate electric vehicles into a smart and flexible energy system.

Integration of charging stations with smart grids is another key aspect of the future of charging infrastructure. Smart grids enable more efficient energy management, adapting vehicle charging according to the demand and supply of energy on the grid. This not only helps stabilize the electricity grid, but also promotes the use of renewable energy sources. For example, vehicles could be charged predominantly during periods when solar and wind power are abundantly available, reducing reliance on fossil fuel energy sources.

Electric vehicles as mobile power sources (Vehicle-to-Grid, V2G) are an innovation that could revolutionize both the transport and energy sectors. V2G technology allows electric vehicles to return energy to the grid when not in use, thus acting as temporary storage units. This can help to balance energy demand, especially during peak periods, and provide an additional source of income for vehicle owners. As these technologies become more accessible and widespread, charging stations will play a crucial role in making electricity grids a more resilient and sustainable energy system.

Tesla cars are designed to charge both fast and slow. They can be charged with their own charging stations or with a connector that has a special plug at one end for plugging into the car and a plug at the other end for general types of charging stations. Dedicated Supercharger stations allow charging within an hour and are located near restaurants and hotels.

Electric vehicle charging stations are an essential element in the transition to sustainable mobility. With expanding infrastructure and continued technological innovation, they will become increasingly accessible and efficient for all users.

At European level, the lack of infrastructure to power electric vehicles, especially in Eastern European countries, has become the main impediment, which has overtaken the problem of autonomy and the high cost of purchasing them. This is a major impediment to the sustainable development of the modern road system.

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