E-Mobility in Urban Areas: A Comparative Analysis of Stock and Policies in Austria and the Czech Republic

Czech-Austrian Winter and Summer School

2024

Authors:	*Id :*
Laura Galarza	st101298
Sebastian Kosir	12122477

Course Coordinator:

Associate Prof. Dipl.-Ing.in Dr.in techn. Amela Ajanovic

16. April 2024

Contents

1 Abstract

Mobility per se was, is and will always be a very important aspect of human lives. Even the first civilizations were highly dependent on the ability to move to different places. Throughout the history, the need for mobility was rising exponentially and the technological advancements such as the railroad, combustion engine and aviation made it possible. With this advanced mobility based mainly on fossil fuels came a different problem, namely the emissions of greenhouse gases into the atmosphere. To get a hold of this problem, there has been an incentive in the recent years to transform the mobility sector once again, resulting in the introduction of e-mobility.
This seminar paper will briefly introduce e-mobility with some background information and describe the different transport modes within this sector. Its core objective is the comparison between Austria and the Czech Republic in the field of existing stock in these countries and their policies regarding e-mobility in urban areas. In the chapter named "Stock" we will conduct a market analysis about trends and growth in the past to the present. Other important topics in this chapter include technological advancements and charging infrastructure. Further in the chapter of "Policies" we discuss government subsidies, urban planning, environmental regulations and each of their impact on the implementation of e-mobility. Lastly, we bring the discussion on the level of the European Union and handle their policies and the implementation of these policies in both of the states. The main focus is not on the countries in general but on their biggest urban areas, namely Vienna, Prague, and their proximal surroundings.

2 Introduction

Electromobility (or e-mobility) represents the concept of using electric technologies, in-vehicle information, communication technologies and interconnected infrastructures to enable the electric propulsion of vehicles and fleets [19].

A brief look into the past of e-mobility, especially electric vehicles (EV), provides a better understanding of their development and their role in the present as well as in the future. The first EV was made possible through the invention of the first electric DC motor by American Thomas Davenport which hit the roads around 120 years ago. By 1900, electric vehicles made up 40 % of the market in the U.S. and the expansion continued. However, poor marketing and some technical challenges eventually flattened the growth and vehicles with combustion engines took over. Due to the clever marketing tactics of large car manufacturers, the EVs could not penetrate the mainstream market and ICE vehicles were on the rise. Even the 1970 oil crisis did not change this fact. The Gulf War in 1991 highlighted the oil dependency and meant the slow reemergence of electric vehicles. Since 2005 there is a steadily growing market for EVs especially due to the rise of Tesla and the continuing improvement of technology (better range, faster charging etc.). Overall, current global trends show further rise and eventual domination of electric vehicles [22].

Not only passenger cars, but also public transportation is an important part of e-mobility. The first metro - the London Underground - has been in operation since 1890 [17], first tram was introduced in Berlin in 1881 [33] etc. Since then, the public transportation evolved massively and now there is 4.36 billion public transport users globally [34]. In the recent years there is also a push for e- and hydrogen-buses to make the public transportation completely carbon neutral.

2.1 Different means of transport

It is important to articulate that e-mobility stands for a whole range of different means of transport using electricity as the main source of energy. It does not mean only different technologies but also different concepts and strategies on mobility with focus on urban areas. Following is a quick summary of different means of electric transport.

2.1.1 Types of electric vehicles

There are different types of electric vehicles on the market. They are divided into categories based on the energy converter used to propel the vehicle, the power source and if it is charged from an internal or external source [25]. A brief overlook on these types can be seen in Figure 1.

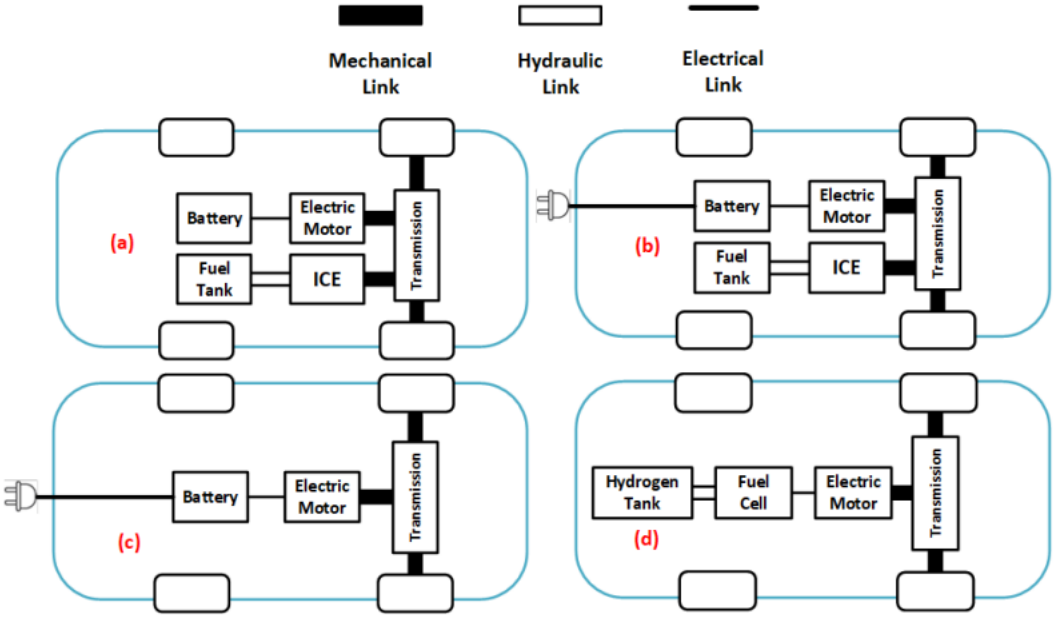

Figure 1: Basic structure of different electric vehicles (EVs) types. (a) Hybrid Electric Vehicle (HEV); (b) Plug-in Hybrid Electric Vehicle (PHEV); (c) Battery Electric Vehicle (BEV); and (d) Fuel Cell Electric Vehicle (FCEV). ([25])

2.1.2 Personal electric vehicles

Personal electric vehicles (PEVs) refer to vehicles that are typically small, lightweight, and designed for personal transportation over short distances such as segways, scooters, bicycles, skateboards, mopeds etc.

2.1.3 Public transport

Probably the most important for urban areas of all these transportation means is the public transport. This includes, but is not limited to: metro systems, trams, e-buses, hydrogen buses, trolleybuses, suburban railways and others. Their importance is not only in the sustainability, but also in their efficiency. They free up space in the cities and can transport much more people than

passenger cars. Other advantages are safety, promotion of social-equity, and cost-effectiveness.

Other means of transport (such as cable cars, drones and electric vessels) either exist, but are not relevant to this paper, or are in the experimental phase and not in usage. The different strategies include for example carsharing or smart cars.

2.2 Importance of e-mobility

The most commonly mentioned importance of e-mobility is its role in the sustainable transition towards the carbon-free future. To prove this statement, it is essential to look at the whole picture. The EVs alone are of course carbon neutral and are much less noisy than conventional cars. However, the source of the electricity that charges the EVs is usually added to the emissions as well. This makes the energy-mix of the country or rather area extremely important, and proves that e-mobility alone is not enough to achieve green future in mobility sector [2].
E-mobility can also reduce the overall energy demand in this sector. In case of Vienna and business-as-usual scenario, energy demand decreases by 35 % in 2030 [3]. The causes for this development are promotion of public transport, but also higher efficiency of EVs. On average, the energy supplied by the power grid to EVs ranges between 49% and 61% of the energy supplied by the fuel to ICE cars for identical trips [24].

The chapters “Stock” and “Policies” try to provide a closer look on the existing stock and policies on e-mobility in Austria and the Czech Republic respectively, complete the existing picture of its importance, and compare these countries in this specific subject.

3 Methodology

The main method of research for the purposes of this paper is a combination of quantitative and qualitative research. In every chapter, there is a qualitative description of the topics relevant to the objective supported by quantitative data from statistics, predictions and relevant figures. The major sources are other scientific papers regarding e-mobility as well as government policies of both countries previously discussed and policies of the European Union, such as *The Green Deal*. Firstly, the different modes of transport and e-mobility as such are presented, since these subjects are very similar both in Austria and the Czech Republic. In the following chapters each of the students provides a closer look into the research regarding stock and policies in their country, and then compares it. In the chapter about the European Union, we work together to find relevant data and discuss them in this paper. All the data used in this paper are listed at the end of it as "References".

4 Stock

4.1 Austria

The biggest urban area in Austria is Vienna and its proximal surroundings, which represents the biggest market for e-mobility as well. Regarding e-mobility in public transport (PT), Vienna has the sixth largest tram network in the world, comprising of approximately 171 km. The whole public transport network encompasses around 880 km of bus lines and 83 km of metro lines. There are more than 1 million of regular public transport users in Vienna, which is more than registered passenger cars (726 000). In one year (2022), the distance driven by mass transport vehicles amounts to 78 million km, i.e. around 213 000 km per day. Although the Covid-19 crisis and the numerous lockdowns associated with this slowed down the growing trends, in 2022 the public transportation in Vienna was used by more than 747 million people [15]. Figure 2 shows the number of PT vehicles in use in peak hours.

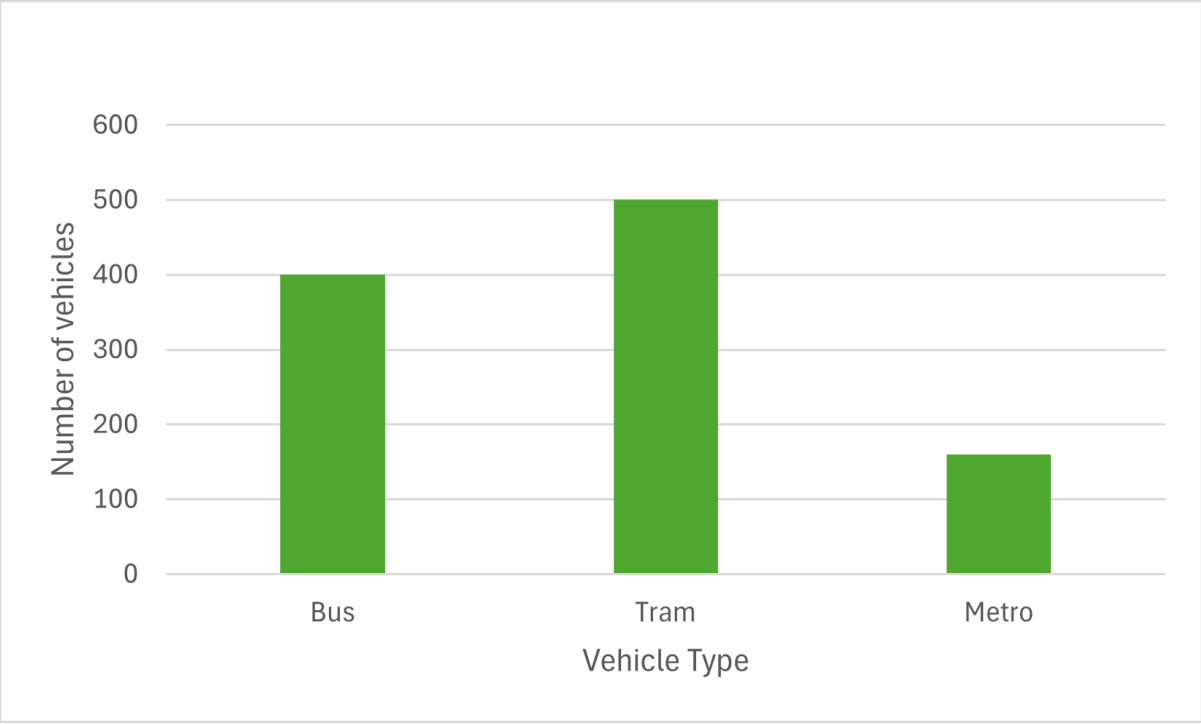

Figure 2: Public transport vehicles in Vienna in peak hours ([15])

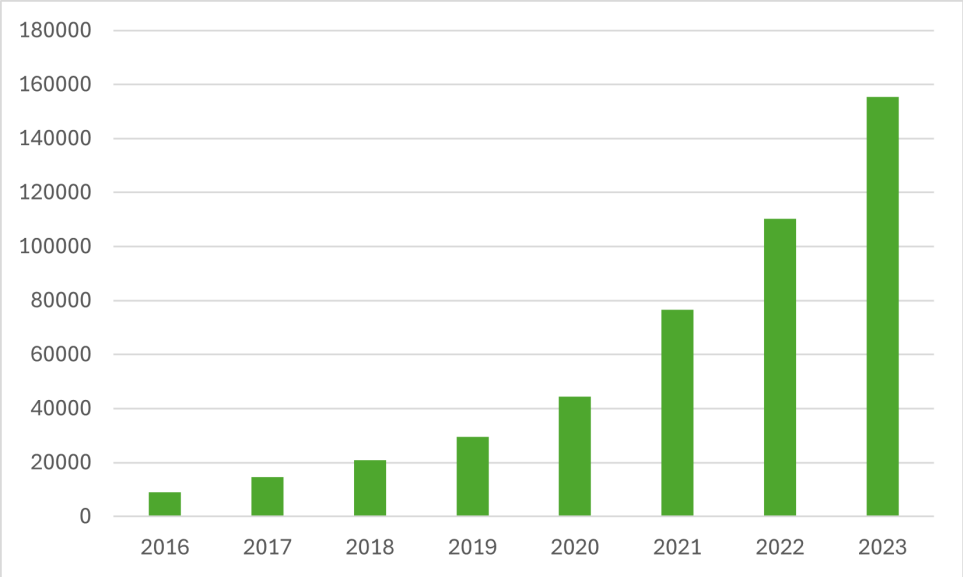

Figure 3: Cumulative number of PEV (without hybrid) in Austria since 2016 ([4])

The number of new registered personal electric vehicles (PEV) and the cumulated number of PEV in Austria respectively show a growing trend as well; see Figure 3. The number of PEV has risen sharply since 2013 with 155 490 vehicles as of the end of 2023, of which 27 745 are in Vienna. Number of plug-in hybrid vehicles amounts to around 250 000 pcs. and there are only 67 H2-vehicles registered in Austria [4].

Although the number of PT passengers and electric vehicles is constantly rising, efficient, sustainable and sufficient charging infrastructure is especially for PEV equally important. As of December 2023, there was a total of 17 425 normal charging points (NCP), 3055 fast charging points (FCP) and 982 ultra-fast charging points (HPC) in Austria. Around 12 % of all charging points with 2271 of NCP, 200 of FCP and 42 of HCP are located in Vienna [5]. The main difference between the types of charging points is the charging capacity. NCP has a charging capacity of max. 23 kW, FCP between 23 and 150 kW and HCP more than 150 kW. Ultra-fast charging stations can charge an EV to 80 % in under 20 minutes assuming that the EV is capable of accepting more than 150 kW [35].

4.2 The Czech Republic

The biggest urban area in the Czech Republic is the capital city Prague. Prague has an extensive public transport network, which is rated as one of the best and most reliable in Europe. However, the adoption of electric vehicles in the Czech Republic lags significantly behind other European countries.

Prague's public transport consists of metro, trams and buses. First electric tram in the Czechia's capital city was in operation since as early as 1886 [23]. While the metro and tram systems run on electricity, only a small number of trolleybuses, specifically 14, have been electrified on three bus routes. Nevertheless, by 2030, around one quarter to one half of buses in Prague should be electrified [29]. According to the Prague City Transport Company, it is technically and operationally most feasible to operate a combination of traditional and modern battery trolleybuses [30].

Prague has approved a plan on how the Prague Integrated Transport (PID) lines are to be expanded and modified between 2022 and 2032 [26]. However, there is no mention of any electrification in the plan.

Due to the increasing number of electric cars, it is necessary to widely expand the electrical distribution network in order to connect and operate charging points in the capital city of Prague. This is the aim of the General Concept, which seeks to implement 750 parking charging stations by 2025. In total, Prague has 1290 charging points and 663 charging stations, with a total input power exceeding 133 MW. By 2030, the total number of charging stations should be increased to 4 500 stations [28].

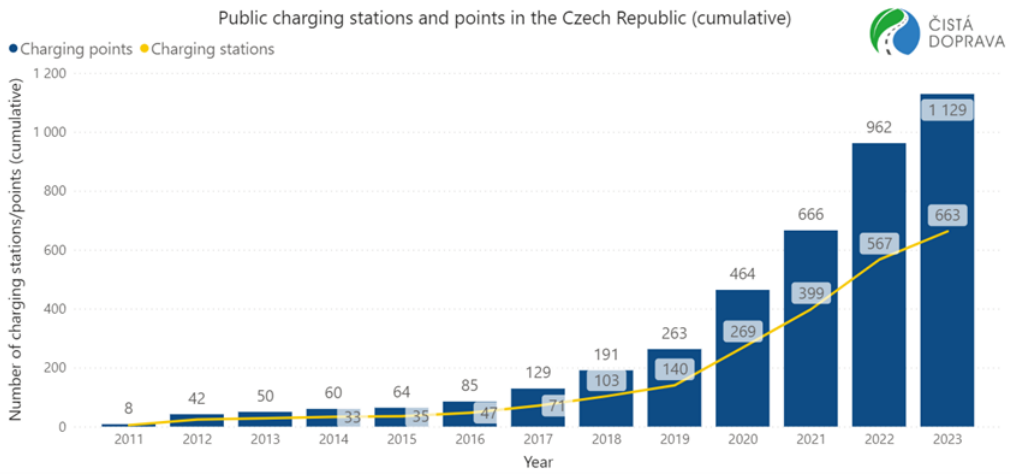

Figure 4: Public charging stations in Czech Republic (Source: [36])

In the Czech Republic, approximately six thousand electric vehicles were registered in 2023. Electric car sales in the Czech Republic have increased by more than a half. Nevertheless, in comparison to other countries, Czechia is still falling short. For instance, petrol cars outsell pure EVs by a factor of twenty and diesel cars outsell them by a factor of nine. According to Josef Pokorný, secretary of the Association Automobile Importers, the interest in electric cars is very low in the Czech Republic.

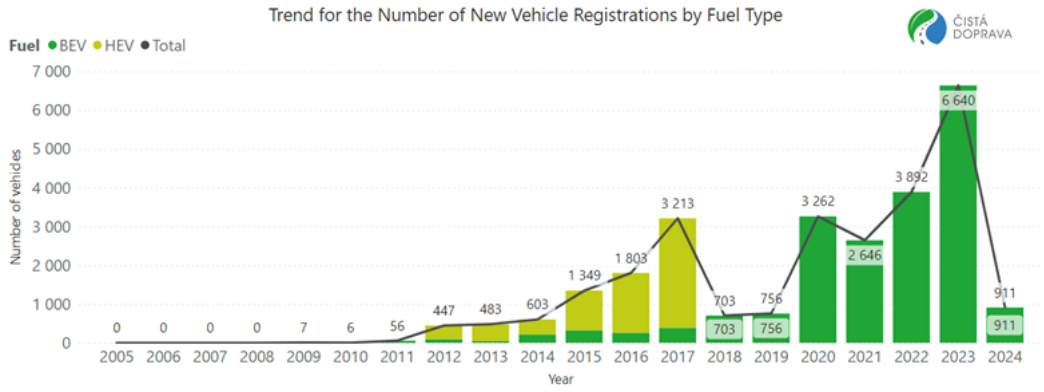

Figure 5: Trend for the number of new EVs in Czech Republic (Source: [36])

4.3 Comparison

It is complicated to compare these two capital cities, mainly because of their differences regarding geographical and political conditions. Nevertheless, both cities have an extensive public transport network. Prague is falling slightly short behind Vienna with only three metro lines in comparison to five in the capital city of Austria and one more being in the construction phase. Both cities are in a similar position regarding buses and trams, however in Vienna there are no trolleybuses except for a few minibuses in the city center. In Prague there is, in contrast to Vienna, no mention of electric buses or hydrogen buses at all.

The amount of sold EVs in both countries is different as well. In Austria, there is approximately eight times more electric vehicles on the roads than in the Czech Republic. The number of charging stations in Austria exceeds the numbers in Czechia by a factor of ten.

Austria is with these numbers more than five years ahead of Czech Republic. These contrasts can in fact serve as a good example for Czechia to follow in the footsteps of its southern neighbor.

5 Policies

5.1 Austria

The first policies regarding e-mobility in Vienna or rather enhancing public transport and therefore reducing car use in the city came in 1968 with the city council's unanimous vote to build a metro system [7]. More measures followed as for example to leave a car at home once a week. The first Traffic Concept for Vienna was published in 1969, with its updates on a 10-year basis [3]. The most recent and relevant plans with focus on e-mobility and urban development are: Urban Mobility Plan Vienna (2015, [14]), The Vienna Smart City Strategy (2022, [32]) on the municipal level and Austria's 2030 Mobility Master Plan (2021, [8]) on the national level. All these documents are based on the EU policies, which are discussed more in detail in the chapter "The European Union".
The Urban Mobility Plan Vienna (2015) has defined 6 main objectives regarding mobility in the city with each of them setting a target or determining a positive impact by being:

1. FAIR: The street space should be allocated fairly to a variety of users and sustainable mobility must be affordable for all. The goal of this objective is to rebuild the streets of the city to better accommodate walkers and cyclists, and at the same time keeping the cost of public transport affordable, such as the annual pass or climate ticket. These measures will make the city more walkable or increase the use of PT respectively.

2. HEALTHY: Promoting active mobility and reducing number of motorized vehicles will improve the health of people as well as decrease the number of traffic casualties and persons injured in traffic accidents.

3. COMPACT: Distances covered between work, home and errands should be minimized. Thanks to the concept of compact city the share of trips done by foot or bike will increase to 45 % in 2025.

4. ECO-FRIENDLY: Modal split of mobility will rise to 80 % of eco-mobility and 20 % of car traffic by 2025.

5. ROBUST: Urban mobility should be possible without owning a means of transport. Thanks to this objective the CO2 emissions from mobility in Vienna should decline to 1.7 million t per year by 2025.

6. EFFICIENT: As already mentioned, e-mobility is more efficient in terms of energy consumption. The final energy consumption of the Vienna transport system will decline to around 7.3 TWh by 2025.

In addition to plans regarding urban mobility, government subsidies play a key role in the transformation to e-mobility in Austria. The Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology divides the incentives into three categories: subsidies for the purchase of private vehicles, e-mobility subsidies for companies, local authorities and associations and tax advantages. In 2023, citizens who purchased e-vehicles, hydrogen-vehicles, e-mopeds and e-motorcycles could receive subsidies. The general requirements were the minimal range of 60km, maximal gross list price of EUR 60 000 and the use of electricity from renewable sources. E-vehicles and hydrogen-vehicles were subsidized with EUR 2 000, e-motorcycles with EUR 500 and e-mopeds with EUR 350. The purchase of new charging infrastructure was also subsidized. The e-mobility subsidies for companies etc. were more complicated, but with more possibilities to receive the subsidy. Companies that purchased e-vehicles including e-busses, e-mopeds and e-motorcycles could receive subsidies up to EUR 20 000 per vehicle depending on the type of the vehicle. New charging infrastructure was subsidized up to EUR 40 000 depending on the charging capacity and their availability to public [9].

Government subsidies and plans together with education schemes to raise the awareness of the public regarding e-mobility and its benefits will play a vital role in the transition process of the mobility sector [3].

5.2 The Czech Republic

The Smart Prague concept focuses on developing a strategic plan for advancing electromobility in the city. The implementation of projects is decided by the city authorities, who consider the recommendations of the IT Concept and the Smart Prague Concept.

A key aspect of building a new EV charging network is the use of European funds and other subsidies, as outlined in the General Concept. The total cost of the new charging stations and accessories is expected to be up to CZK 500 million before VAT with a potential subsidy rate from European funds of up to 85 % of the planned investment costs [16]. Prague aims to build EV charging infrastructure close to residences and workplaces. The estimations are that by 2030 there will be around 180 000 electric cars. The capital would provide charging for 200

000 electric cars. [28].

Compared to owners of a car with an internal combustion engine, owners of electric cars can enjoy a number of benefits in the Czech Republic. An electric car, a plug-in hybrid vehicle or hydrogen vehicle that has a CO2 emission value in combined operation of no more than 50 g/km can receive "EL" vehicle registration plate. This provides free driving on highways in the Czech Republic and if a car is used for business, an exemption from road tax is applied. Another perk is free parking in Prague and Liberec. One of the best advantages is the possibility to use a preferential electricity tariff during off-peak hours [6].

5.3 Comparison

In the matter of policies the Czech Republic is falling short of Austria as well. For instance, in Prague's plans to expand its public transport network, there is no mention of electrification. However, the capital city of Prague has the Sustainable Urban Mobility Plan (SUMP), which states its aims to improve transport and transportation policies in the city. In Vienna, one new metro line is under construction and another is being prolonged. There is also an incentive to substitute some of the bus lines for e-buses or hydrogen-buses respectively. The City of Vienna aims to reshape its streets to support active mobility and e-mobility. Regarding subsidies for EVs, there is currently no financial subsidy for purchasing an EV by natural persons in the Czech Republic in contrast to Austria with a new subsidy scheme for citizens as well as for companies every year. There are, however, numerous advantages for owners of electric vehicles in Czechia, such as tax exemptions, highway toll exemptions etc. The government of the Czech Republic can be inspired by Austria in order to increase the public interest in e-mobility by for instance implementing some of the subsidies of the Austrian government. Financial subsidies and uncomplicated conditions are one of the best incentives for citizens to purchase an EV.

6 The European Union

6.1 Policies

Faced with a growing transport demand and the associated environmental impacts, the European Parliament has approved a regulation that will make new cars and vans emission-free from 2035. This means that the production and the import of petrol and diesel cars will end. And since light commercial vehicles are responsible for around 14.5 % of total EU emissions of carbon dioxide, this change could make a significant contribution to *The Green Deal* plan.

The EU aims to encourage the purchase of electric cars by making them more affordable and attractive to consumers. To achieve this, the EU has proposed various measures in order to support sales. One key approach is providing financial support to buyers. Most EU member states offer some incentive to buy electric vehicles. Additionally, governments can offer other advantages, such as tax reliefs, parking discounts or complete exemption from paying parking fees in certain cities [1]. The interest in EVs can also increase with introduction of free or preferential parking, free charging at public stations and access to low emission zones [20].

The uptake of EVs will rely on public investments in charging infrastructure and subsidies for home chargers as well. Ensuring easy travel for electric vehicles across Europe is important, but the EU faces challenges due to fragmented road networks and limited integration between countries. Although the charging network in the EU is growing, the EU is still far from the Green deal target - 1 million charging stations by 2025, with uneven distribution across transport sectors and no comprehensive plan for electromobility [18]. Therefore, on February 29th 2024, the European Commission proposed to allocate EUR 1 billion for charging and refueling stations through the Connecting Europe Facility (CEF). This funding aims to support infrastructure development along the Trans-European Transport Network (TEN-T) for alternative fuels. Commissioner for Transport Adina Vălean highlighted the importance of this investment in creating a sustainable and affordable electric vehicle infrastructure [10].

Efficiency plays a pivotal role in generating interest in EVs. Electric motors are much more efficient in converting energy into motion, with around 90 % of the energy powering the car. And when braking energy is used to recharge the batteries, the efficiency is close to 100 % [13].

The European Commission is actively backing numerous initiatives aimed at advancing the electrification of transportation, with a primary focus on curbing carbon emissions and promoting sustainable mobility throughout the EU. Furthermore, the European Commission introduced

the Sustainable and Smart Mobility Strategy (2021) which serves as a foundational document guiding the development of national policies. This strategy provides a framework outlining the policies to be adopted and the approaches to be taken in pursuit of sustainable and smart mobility solutions.

6.2 Future

Electric transformation is part of *The Green Deal* - a policy initiative with the ultimate goal of achieving climate neutrality by 2050. European countries have pledged to reduce their emissions by at least 55 % by 2030. However, there will be a reassessment in 2026 to discuss whether the automotive industry is adequately prepared for electrification by 2035.
To help reduce emissions in cities, it is important to invest in accessible, fast, modern and clean public transport such as:

- building a network of commuter trains, express buses and subways
- electrifying buses, taxis and delivery vans
- creating infrastructure for charging electric cars
- regulating the entry of cars with internal combustion engines
- building cycle paths and pedestrian zones

Looking to the future, it's worth considering the potential of autonomous transport, as suggested by the US think tank RethinkX. They propose a system akin to Uber, where autonomous vehicles optimize car usage. Currently, cars are only in use 4 % of the time, remaining idle for the remaining 96 %. This service, expected to utilize electric cars, could offer a more cost-effective alternative to car ownership. McKinsey & Company predicts this shift to occur between 2026 and 2029 [31].
Cities must be designed to support a high quality of life without reliance on cars. In the future, they should promote an efficient and reliable public transportation, as well as safe and convenient walking and cycling options. The ongoing challenge lies in constructing new infrastructure to support public and alternative modes of transport [13].

6.2.1 Batteries

The rapid growth of e-mobility is expected to increase demand for batteries by more than a tenfold by 2030. One problematic battery component is lithium, with global supplies estimated at 89 million tons. If all the cars worldwide were electric, it could consume 85 % of this supply [21]. In response, the EU has proposed a regulation regarding the entire battery life cycle. The regulation aims to reuse up to 80 % of lithium from waste batteries by 2031 and mandates portable batteries to be removable and replaceable by the end user by 2027 [11]. In summary, the regulation ensures that batteries will be safe, sustainable and competitive [12].

6.2.2 Challenges

The European green cars initiative highlights a lot of new challenges. The EU must prioritize reducing the charging time, expanding the charging network and lowering the costs through mass production. Additionally, efforts are needed to cooperate with rare earth mining countries beyond China, such as Chile. Exploring alternatives to lithium, such as sodium, is vital as well. Diversification is the key, involving various systems for vehicle-grid interaction, charging stations and maintenance facilities. While promising, this transformation requires significant support and education [27].

7 Conclusion

Through this detailed analysis of urban e-mobility in Vienna and Prague, their stock and policies as well as policies on the EU level, several key insights have emerged. Both cities and the whole countries respectively show massive efforts in promoting a sustainable transportation solutions, namely through their strategic development plans, financial subsidies and incentives encouraging e-mobility. Nevertheless, in some sectors there are big disparities between Austria and the Czech Republic, because of their different government and socioeconomic structures. Austria began its transformation towards emission-free transport much sooner than the Czech Republic and through this, it is ahead of its neighbor with its stock as well as policies. Vienna, in its strategic plans and through the city's actions, sets a strong emphasis on public transport and extensive infrastructure for active mobility and e-mobility too. Meanwhile, Prague shows a strong initiative and innovation in navigating the challenges, although there are opportunities to strengthen its infrastructure plans and policies.

This comparative analysis shed a light on the need for much more ambitious incentives in the mobility sector. The importance of specific and interdisciplinary solutions modified to the needs of each city and country as a whole is made clear through this paper. This provides a room for collaboration between cities and countries within the EU to achieve our shared sustainable goals. Vienna's strong foundation in promoting e-mobility can, for instance, show a possible way on how to undergo the transformation of mobility sector.

Furthermore, the policies and incentives on the level of the European Union are equally as important. They provide a framework as well as funding mechanisms and subsidies for the countries. The EU plays a key role in coordinating efforts and underlining the interconnectedness of the countries regarding the fight against climate change.

In the future, continued collaboration and innovation will be vital to fully realizing e-mobility. Lessons learned in Austria, the Czech Republic and the EU serve as a valuable guideline for global efforts in advancing sustainable transportation agendas and creating a healthy and green city environments for future generations.

References

[1] ACEA. *Overview – Electric vehicles: tax benefits and purchase incentives in the European Union*. 2022. URL: https://www.acea.auto/fact/overview-electric-vehicles-tax-benefits-purchase-incentives-in-the-european-union-2022/. (accessed: 27.03. 2024).

[2] European Enivronment Agency. *Electric vehicles*. URL: https://www.eea.europa.eu/en/topics/in-depth/electric-vehicles. (accessed: 03.03. 2024).

[3] A. Ajanovic, M. Siebenhofer and R. Haas. 'Electric Mobility in Cities: The Case of Vienna'. In: *Energies* 14.1 (2021). DOI: https://doi.org/10.3390/en14010217.

[4] Statistics Austria. *Kfz-Bestand*. URL: https://www.statistik.at/statistiken/tourismus-und-verkehr/fahrzeuge/kfz-bestand. (accessed: 09.03. 2024).

[5] austriatech. *Electromobility in Austria: Facts Figures, January 2024*. (accessed: 09.03. 2024).

[6] Zdeněk Buček. *Znáte opravdu všechny největší výhody vlastnictví elektromobilu v Česku.* 2022. URL: https://elektrickevozy.cz/clanky/nejvetsi-vyhody-elektromobilu-cesko. (accessed: 17.03. 2024).

[7] R. Buehler, J. Pucher and A. Altshuler. 'Vienna's path to sustainable transport'. In: *International Journal of Sustainable Transportation* 11.4 (2017), pp. 257–271. DOI: 10.1080/15568318.2016.1251997.

[8] Federal Ministry for Climate Action Environment Energy Mobility Innovation and Technology (BMK). *Austria's 2030 Mobility Master Plan*. 2021. URL: https://www.bmk.gv.at/en/topics/mobility/mobilitymasterplan2030.html. (accessed: 16.03. 2024).

[9] Federal Ministry for Climate Action etc. (BMK). *Elektroautos und E-Mobilität – Förderungen und weiterführende Links*. 2023. URL: https://www.oesterreich.gv.at/themen/mobilitaet/elektroautos_und_e_mobilitaet/Seite.4320020.html. (accessed: 16.03. 2024).

[10] European Commission, Directorate-General for Energy and Transport. *A sustainable future for transport – Towards an integrated, technology-led and user-friendly system*. Publications Office, 2009. DOI: doi/10.2768/13118.

[11] European Council. *Rada přijala nové nařízení o bateriích a odpadních bateriích*. 2023. URL: https://www.consilium.europa.eu/cs/press/press-releases/2023/07/10/council-adopts-new-regulation-on-batteries-and-waste-batteries/. (accessed: 12.03. 2024).

[12] European Council. *Zelená dohoda pro Evropu*. 2023. URL: https://www.consilium.europa.eu/cs/policies/green-deal/. (accessed: 12.03. 2024).

[13] Petr Daniš. *Klima je příležitost: opravdová řešení pro naši budoucnost na Zemi*. Tereza, vzdělávácí centrum, z.ú., 2023. ISBN: 978-80-87905-39-5.

[14] Vienna City Administration: Municipal Department 18 (MA 18): Urban Development and Planning. *Urban Mobility Plan Vienna - STEP 2025*. 2015. URL: https://www.wien.gv.at/stadtentwicklung/studien/pdf/b008379b.pdf. (accessed: 16.03. 2024).

[15] *Die Wiener Öffis in Zahlen*. URL: https://www.wienerlinien.at/die-wiener-oeffis-in-zahlen. (accessed: 09.03. 2024).

[16] *Dobíjecí infrastruktura pro elektromobily by mohla být z podstatné části financována z evropských peněz*. 2023. URL: https://www.praha.eu/jnp/cz/o_meste/magistrat/tiskovy_servis/tiskove_zpravy/dobijeci_infrastruktura_pro.html. (accessed: 17.03. 2024).

[17] Magdalena Dugdale. *World's oldest metro systems*. 2019. URL: https://www.railway-technology.com/features/worlds-oldest-metro-systems/?cf-view&cf-closed. (accessed: 02.03. 2024).

[18] Evropský účetní dvůr. *Infrastruktura pro dobíjení elektrických vozidel*. 2021. URL: https://www.eca.europa.eu/Lists/ECADocuments/SR21_05/SR_Electrical_charging_infrastructure_CS.pdf. (accessed: 02.03. 2024).

[19] *Electro Mobility (e-Mobility)*. URL: https://www.gartner.com/en/information-technology/glossary/electro-mobility-e-mobility. (accessed: 02.03. 2024).

[20] Ferenc Erdélyi. *Electric vehicles*. 2024. URL: https://www.eea.europa.eu/en/topics/in-depth/electric-vehicles. (accessed: 03.03. 2024).

[21] UNITED STATES GOVERNMENT. *USGS science for changing world*. 2022. URL: https://www.usgs.gov/. (accessed: 16.03. 2024).

[22] A. Kilischekow and W. Million. *THE HISTORY OF ELECTRIC VEHICLES AND E-MOBILITY: HUMBLE BEGINNINGS TO MODERN HIGH-TECH MARVELS*. URL: https://lionsmart.com/en/history-of-electric-vehicles/. (accessed: 02.03. 2024).

[23] František Křižík. *František Křižík u zrodu elektrické dráhy v Praze – ta letos slaví 120 let*. 2006. URL: https://www.technickytydenik.cz/rubriky/archiv/frantisek-krizik-u-zrodu-elektricke-drahy-v-praze-ta-letos-slavi-120-let_17693.html. (accessed: 17.03. 2024).

[24] J. Martins et al. *Real-Life Comparison Between Diesel and Electric Car Energy Consumption, In Grid Electrified Vehicles: Performance, Design and Environmental Impacts*. 2013. Chap. 10. ISBN: 978-1-62808-839-7.

[25] M. Nour et al. 'Review of Positive and Negative Impacts of Electric Vehicles Charging on Electric Power Systems'. In: *Energies* (2020). DOI: 10.3390/en13184675.

[26] Adéla Očenášková. *Lanovka do Bohnic i trolejbusy. Plán Prahy odhaluje, jak se změní doprava v metropoli*. 2022. URL: https://zpravy.aktualne.cz/ekonomika/doprava/jak-se-rozsiri-prazska-integrovana%20doprava/r~3655156cf39d11ec8c6f0cc (accessed: 16.03. 2024).

[27] Office for Official Publications of the European Communities. *European green cars initiative: towards an electric future? Research policy*. 2010. ISBN: 978-92-7912614-7.

[28] SMART PRAGUE. *GENEREL ROZVOJE DOBÍJECÍ INFRASTRUKTURY V HLAVNÍM MĚSTĚ PRAZE DO ROKU 2030*. URL: https://smartprague.eu/projekty/generel-rozvoje-dobijeci-infrastruktury-v-hlavnim-%20meste-praze-do-roku-2030. (accessed: 18.02.2024).

[29] *Praha: až polovina autobusů na elektrický pohon do roku 2030*. 2020. URL: https://www.hybrid.cz/praha-az-polovina-autobusu-na-elektricky-pohon-do-roku-2030/. (accessed: 17.03. 2024).

[30] Dopravní podnik hlavního města Prahy. *Tolejbusové tratě*. URL: https://www.dpp.cz/spolecnost/nove%20stavby/trolejbusove-trate. (accessed: 17.03. 2024).

[31] *Rethinking Transportation 2020-2030*. 2020. URL: https://www.rethinkx.com/energy. (accessed: 15.03. 2024).

[32] City of Vienna: Municipal Department for Urban Development and Planning. *Smart City Strategy Vienna*. 2022. URL: https://smartcity.wien.gv.at/wp-content/uploads/sites/3/2022/05/scwr_klima_2022_web-EN.pdf. (accessed: 16.03. 2024).

[33] *Who designed the concept of the first electric tram*. URL: https://engre.co/about/achievements/the-first-electric-tram-in-the-world/. (accessed: 02.03. 2024).

[34] *Worldwide number of public transport users from 2017 to 2022 with a forecast through 2027*. URL: https://www.statista.com/statistics/1413707/global-public-transport-users-forecast/. (accessed: 02.03. 2024).

[35] Zapmap. *EV charging connector types*. URL: https://www.zap-map.com/ev-guides/connector-types. (accessed: 09.03. 2024).

[36] ČEZ: Čistá elektrina zítřka. *FUTUREGO: Mapa dobíjecích stanic*. URL: https://www.elektromobilita.cz/cs/mapa-dobijecich-stanic. (accessed: 18.02.2024).