Approaches to the development of EV infrastructure depending on the prediction of the development of electric mobility in the EU

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Abstract

The subject of this article is to better understand the relationship between development of electric vehicle charging infrastructure in connection with development of electric vehicles sales in Europe. Optimal set-up among these two main elements of emerging e-mobility sector has principal effect on currently running policy discussions (targets setting within Revision of Directive on Alternative Fuels Infrastructure Deployment), business models of charging point operator / e-mobility provider as well as further positive perspectives of electric vehicle sales in Europe.
Article summarizes key assumptions of methodology used by ChargeUp Europe (professional association of leading charging point operators) and concludes, that increasing utilization of EV infrastructure assets is not at the centre of methodology assumptions nor conclusions (of main scenario), which might collude with sustainability of charging point / mobility providers business models.

key words

business model of charging point operators, Power / BEV ratio, target setting whithin AFIR revision

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Introduction

The relationship between the quantity and quality of the charging infrastructure and the prediction of the development of electric vehicles will fundamentally affect expenditures from public and private funds for further development of the infrastructure, customer experience of electric vehicles, and its subsequent use. All these factors have a major impact on the business framework of charging infrastructure operators / charging service providers.

The identification of approaches in this area within the EU and their critical evaluation, as well as the naming of previous practical experience in the field of electromobility is the subject of this article in order to provide relevant recommendations for the optimal development of the sector in the future.

1 Work methodology

The main goal of this paper is to assess the currently discussed methodologies for the development of charging infrastructure for electric vehicles in order to identify important assumptions for the development of charging infrastructure in terms of its long-term sustainability.

Based on an research of available literature (including studies, articles, publications), the primary methods of document analysis, interpretation, subsequent synthesis and deduction are applied in this article. As part of the methodological approaches, I will analyse selected data sets, while using description and qualitative evaluation.

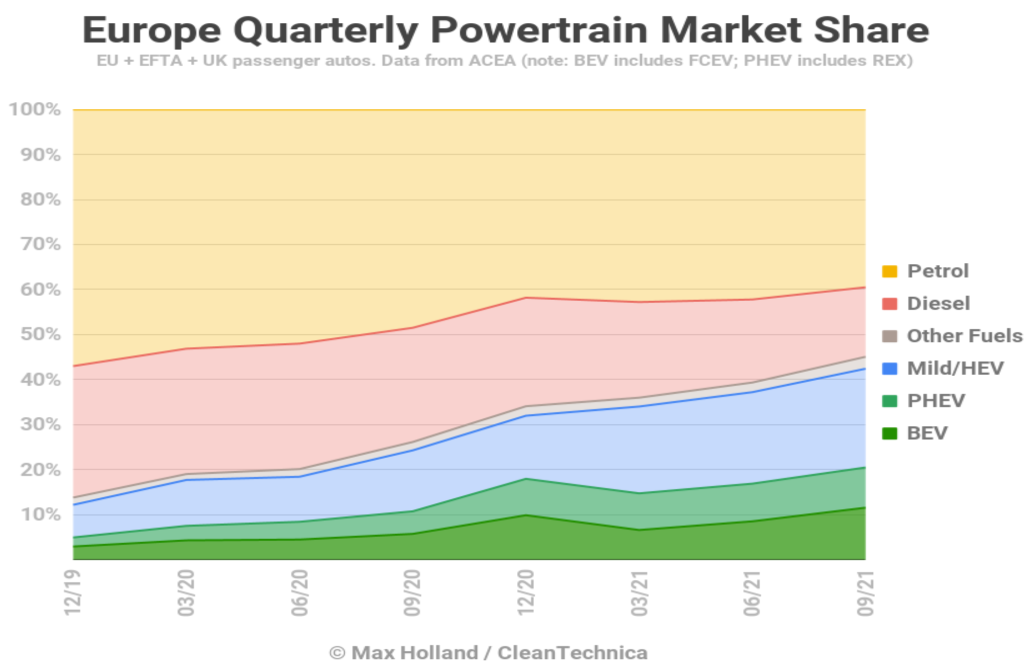
At the same time, quantitative methods have been used in this article, namely a regression model of panel data, which evaluated the relationship between the development of electric vehicle sales (BEV segment) in relation to the development of charging infrastructure (separately assessed against AC and DC) in Central Europe.

2 Results and discussion

2.1 The current state of the electromobility sector

In 2021, the situation in the electromobility sector in Europe was positive, despite the ongoing COVID - 19 pandemic. All relevant car manufacturers are constantly expanding the offer of electrified models, customers started to trust the technology, which is reflected in a decent growth rate of electric vehicle sales. Electromobility in last quarters of 2021 was accelerating significantly on a global scale as well as in the conditions of the European Union. As could be seen in Chart 1 below, different types of electrified drive (BEV - pure electric cars, PHEV - plug-in hybrids, Hybrids and MildHybrids) were gaining trust among customers, while fundamentally replacing traditional types of drives - mostly diesel drive, resp. gasoline powered vehicles.

Graph 1 Quarterly sales of passenger cars in Europe by type of drive



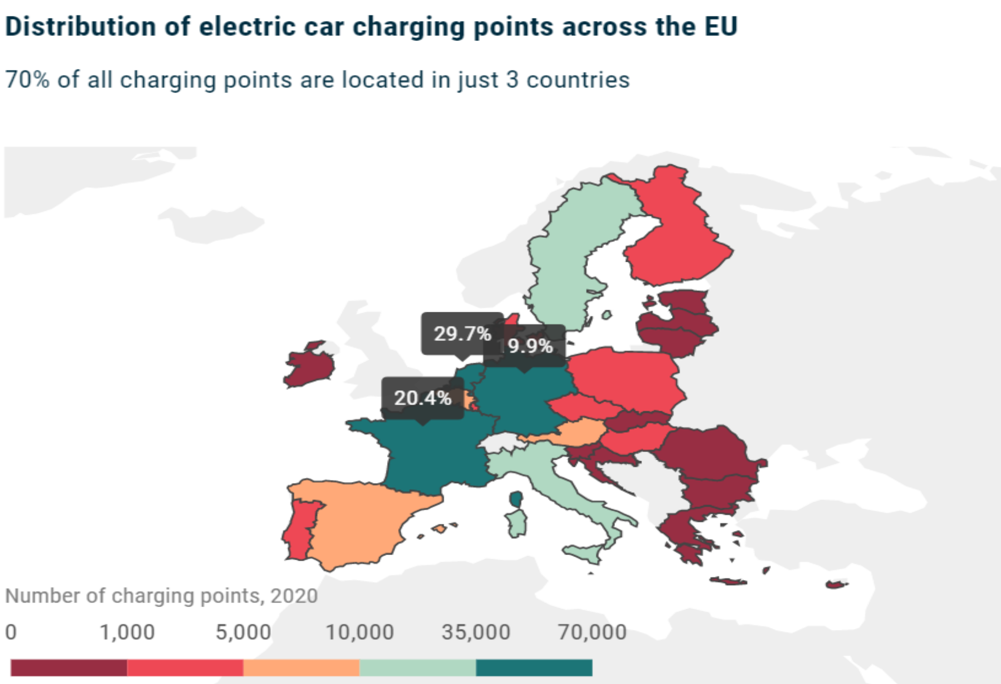
Undoubtedly, there are several reasons for the positive development of electric car sales. It is not the purpose of this article to analyse them in detail. The expanding offer from manufacturers is largely a response to the regulations previously adopted in the area of tightening emission standards.

At the same time, customers' awareness of the impact of passenger transport on environment is increasing. In addition, the price level of electric cars as well as technological progress (for example related to extended range or charging speed) are clearly positively reflected in customer´s purchasing decisions.

Developments in the sale of electric cars are not homogeneous within the European Union. Electromobility is advancing more strongly in Member States with relatively high GDP compared to Member States with relatively lower GDP. In these Member States, electromobility is still in its infancy. (measured in terms of the share of electric cars in total vehicle sales in a given year).

Among the factors that create the preconditions for the sale of electric cars undoubtedly belong the number and quality (we can understand the term quality from different angles, but above all in relation to the location, availability, price of services, reliability, charging speed, etc.) of the charging points which form the infrastructure for charging electric vehicles. The current numbers of electric cars sold in Europe alone suggest that the infrastructure is built to an extent and quality that does not create barriers to the normal use of electric cars.

Fig. 1 Distribution of charging points within the European Union

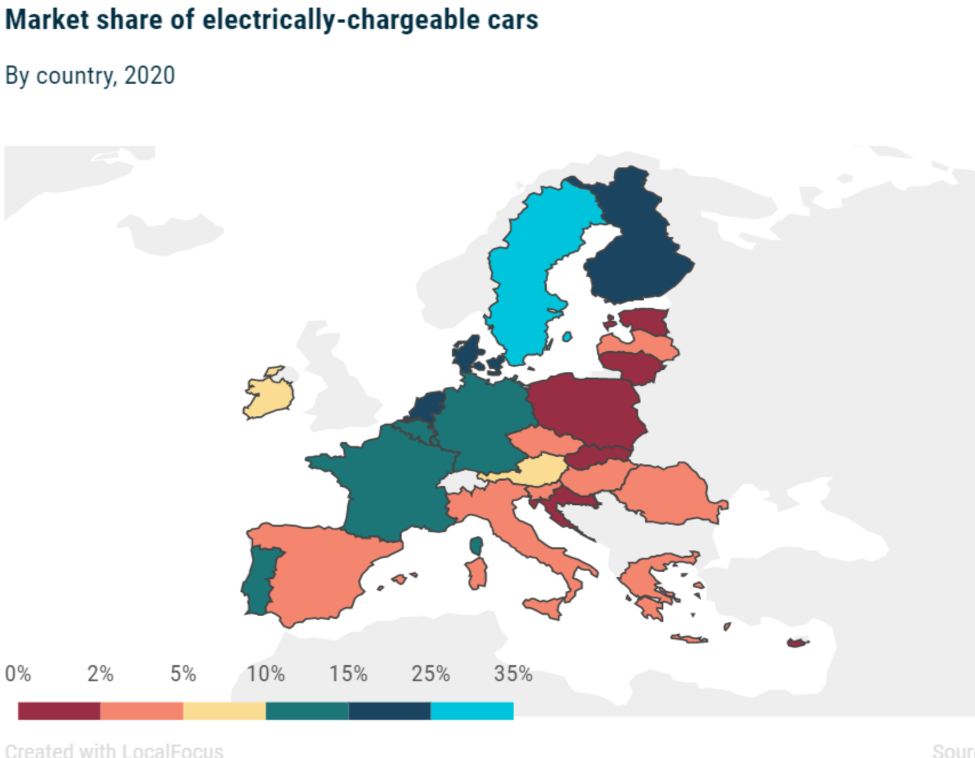


Source: ACEA

ACEA, the European Automobile Manufacturers Association, has published a study on the relationship between electric vehicle share in individual Member States and the number of charging infrastructures and the uneven location within countries. The main outputs are as follows.

ACEA evaluates that from approx. 250,000 charging points in the European Union, more than 70% are located in only 3 Member States, namely 30% of the total in the Netherlands, a further 20.4% in France and 19.9% in Germany, these 3 Member States occupy only 23% of the territory of the European Union. Romania, which is about six times larger than the Netherlands, has only 493 charging points, which is about 0.2% of the total number of charging points in Europe.

Fig. 2 Market share of electric cars in individual countries



Source: ACEA

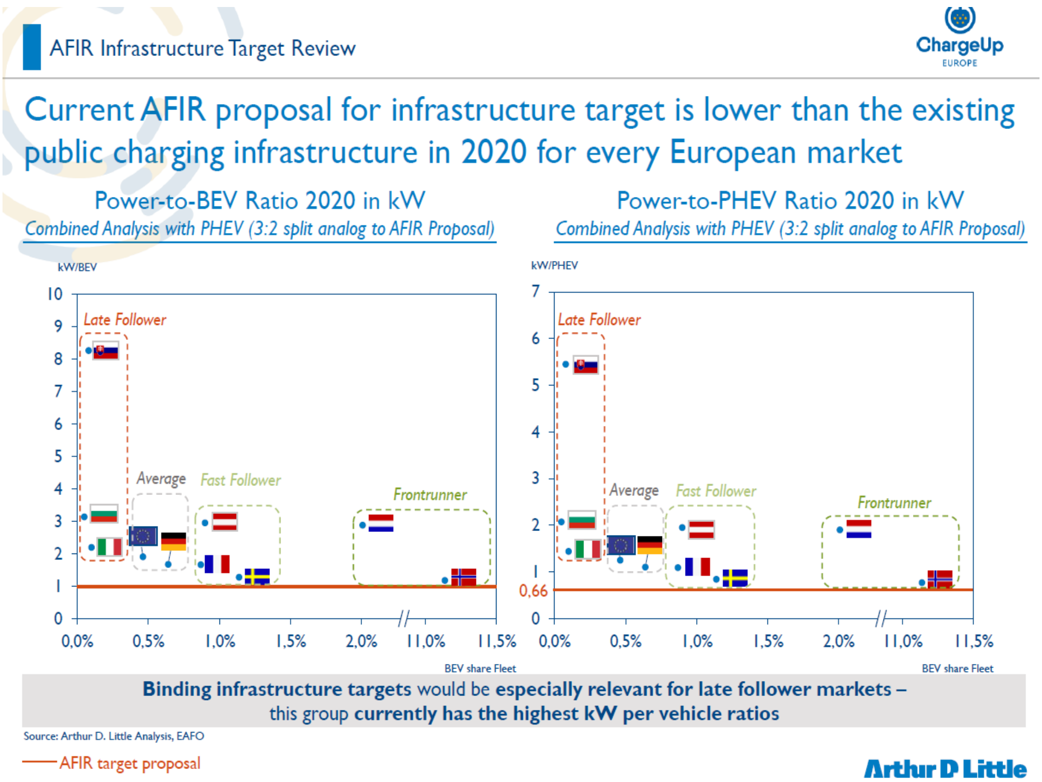
Although the presented comparison represents a significant simplification of the relationship between electric vehicle sales and related charging infrastructure, it is quite clear from the above map figures (Figure 1 and Figure 2) that in Member States where electric vehicles have higher market share, there is also significantly more developed infrastructure.

The simplification of ACEA's output is that, for example, the number of charging infrastructures is not evaluated for the size of the country, there is no distinction between different types of charging infrastructure and the output in question equalises AC chargers with HPC (ultra-fast) chargers, which is in terms of their use (number of charging sessions per day) contrary to their purpose for which they were built.

The fact that this simplified view is more complicated in the real world is also indicated by the examples of Portugal and Finland (see Figure 1 and Figure 2), which have a relatively high market share of electric cars in relation to the European average, as well as a relatively small number of chargers (compared to countries that are European leaders in terms of number of charging points).

As can be seen from Figure 3, an interesting example is Slovakia, which has a very favourable ratio of installed power in the charging infrastructure to the market share of electric cars. In Slovakia, the number of charging stations (moreover, with a high ratio of fast charging stations) is disproportionate (high) to the low number of electric cars and their share in the total fleet taking into account also rather small area of Slovakian territory.

Fig. 3 The ratio of charging infrastructure installed power to the number of electric cars



Source: ChargeUp Europe

2.2 Perspectives for electromobility within the EU

The current positive trend in the development of electromobility in the EU and ambitious goals based on the Green Deal, respectively. Fit for 55 and related legislative proposals (primarily the Alternative Fuel Infrastructure Directive (AFIR)) lead to a review of public policies and the setting of new targets for the development of charging infrastructure.

Understanding and correctly estimating the number of charging points divided into public and private chargers, further broken down by charging speed in specific markets in relation to the prediction of electric vehicle sales and plug-in hybrid vehicles is a key prerequisite for the development of electromobility.

The relationship between the quantity and quality of the charging infrastructure and the prediction of the development of electric vehicles will fundamentally affect the investment in the construction of charging stations, the customer experience of electric vehicles users, the use of this charging infrastructure. All these factors have a major impact on the business framework of charging infrastructure operators / charging services providers.

The ratio of: Installed capacity / number of BEVs (pure electric cars), alternatively Installed capacity / number of PHEVs (plug-in hybrids), primarily set for measuring the status of individual markets (national), is used extensively in public discussions on the development of charging infrastructure. comparison, or for the purpose of setting targets.

The ratio of the installed power in the charging infrastructure to the number of electric cars or pug-in hybrids expresses the intensity and at the same time the quality (speed) of the built and operated public charging infrastructure that individual drivers of electrified vehicles can use. The higher the ratio, the more likely it is that drivers can use (charge) their electric vehicle, as they will have sufficient power in the operating charging infrastructure needed to extend the range. The indicator at the same time integrates different charging speeds, which are directly dependent on the installed power and thus takes into account the quality of the charging infrastructure in terms of charging speed. In simplicity, for the purposes of this indicator, it is equivalent to have one 100 kW fast charger or 5 (five) 20 kW slow chargers in a given area.

However, this indicator also has its inherent shortcomings in assessing the adequacy of the charging infrastructure to the number of electrified vehicles. One of the shortcomings is the concurrent charging. Imagine a situation where five electrified vehicles arrive at one charging point with a charging power of 100 kW and at the same time the driver's preference is to start charging their vehicle as quickly as possible, while a charging speed of 20 kW is sufficient for them. As a result, a que of four vehicles will be created. Naturally, in this situation, drivers would prefer the existence of 5 charging points with an output of 20 kW / each charging point, which would result in the simultaneous charging of 5 electric cars.

Another shortcoming of this indicator is the fact, it does not take into account the location of charging points in relation to the needs of electric car users. Similarly, it does not take into account important aspects that determine the use of the charging infrastructure, such as price, charging authorization, operational reliability of the charging infrastructure, and the like.

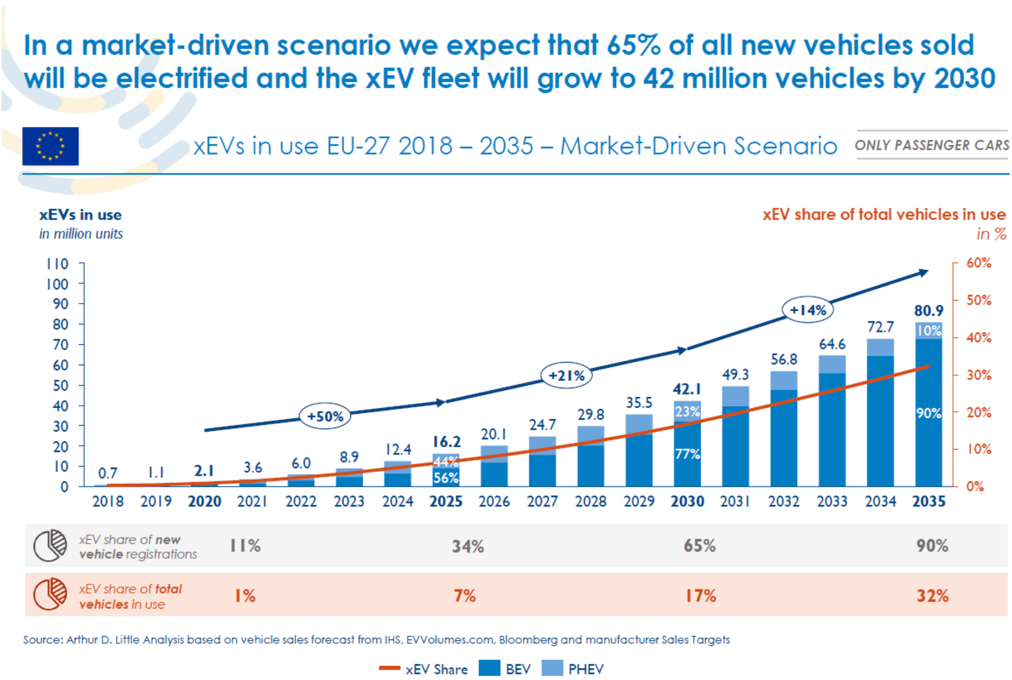
Charge up Europe, which brings together major charging infrastructure operators and charging service providers in collaboration with the consulting company Arthur D Little, has developed a methodology to set new targets for the update of the Alternative Fuels Infrastructure Directive (AFIR). whereas this methodology sets minimum capacity targets for charging infrastructure in Europe by 2030.

The basic logic of this methodology is the assumption that the charging infrastructure for electric vehicles and its future development should be derived from the goals related to the plans for the sale of electric cars on the European market. At the same time, the different charging usecases of electric vehicle users need to be taken into account, with different technologies to be used for these different needs. (AC charging, DC charging (50-150 kW), HPC charging- over 150 kW)

.In line with the already proven solution of the "egg-chicken" dilemma, in which the development of electromobility in general (especially in Europe) recognizes that the construction of infrastructure should be ahead in time, and thus create the preconditions for growth in electric vehicle sales in the period from the present to 2030, the methodology envisages the rapid development of the charging infrastructure by 2025, which will enable the optimal sett-up of the electromobility market in Europe in 2030.

The methodology assumes the following increase in sales of electric cars and their share in the total fleet of passenger cars in Europe, as shown in Figure 4.

Fig. 4 Forecast of electric car sales within the EU until 2035



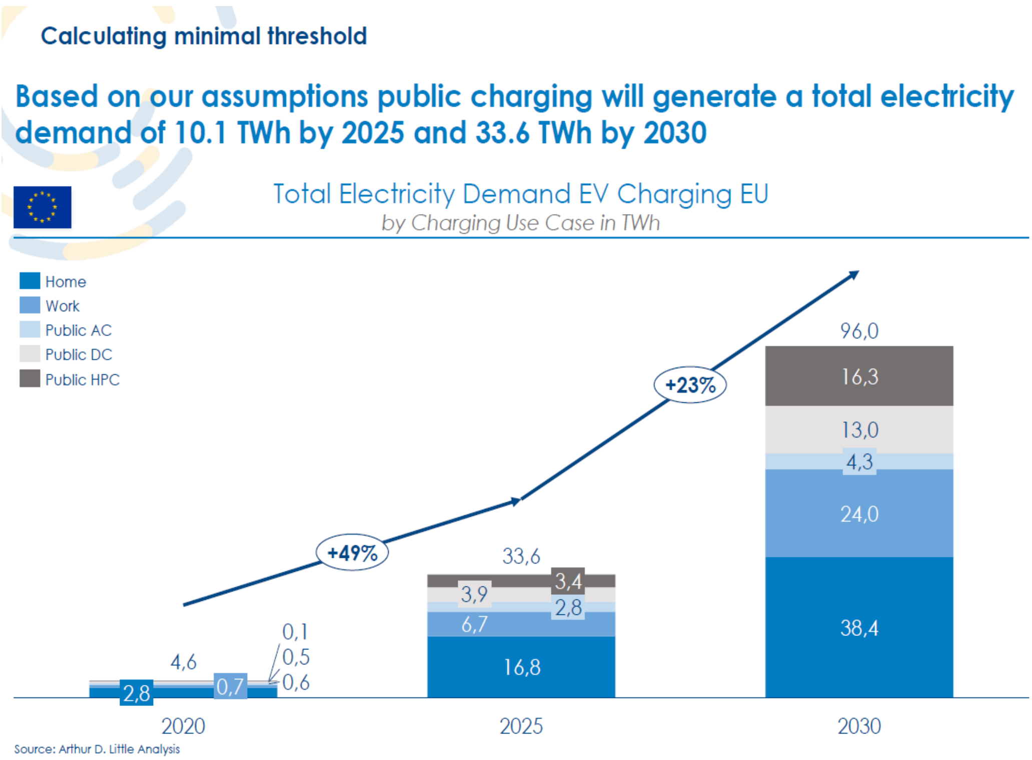
Source: ChargeUp Europe

At the same time, the methodology assumes that with the growing share of electric cars in the total population of passenger cars, the number of users living in urban environments will increase and thus their charging will be more dependent on the use of public charging infrastructure, primarily in the fast charging segment (in contrast with users who have access to home charging in their garages or reserved parking spaces in parking garages). Similarly, charging requirements will be increasing in places where electric car users are working.

Another prerequisite for this methodology for calculating the required installed capacity of the charging infrastructure as well as the total amount of electricity used to power electric vehicles is the annual average mileage (15,000 km for BEV and 5,000 km for PHEV), average electricity consumption per 100 km (a declining trend is expected due to the development of technology and more significant use of smaller cars).

The above-mentioned assumptions result in a significant increase of the required installed capacity in the charging infrastructure, which will allow the transmission of the calculated amount of electricity (See figure below)

Fig. 5 Prediction of electricity consumption for charging electric cars within the EU until 2030



Source: ChargeUp Europe

The methodology used by the Charge up Europe association, uses the following assumptions to calculate the need for the number of charging stations.

In the first place, it is based on the assumption of the ratio of charging stations to the number of electric cars (according to different charging speeds), which reflect the current situation (reference to EAFO). At the same time, this methodology models the individual "usecases" of home charging, work charging, public slow charging (AC), public fast charging (DC), and public ultra-fast charging (HPC). In connection with forecasted level of EV sales and resulting need of electric energy needed for their charging this methodology concludes in the main scenario to the required number of charging stations (according to the charging speed). The assumptions regarding the ratios of the number of charging stations to the number of electric vehicles are of an arbitrary nature, the subsequent usability of individual types of charging stations is the result of the calculation.

In this approach, it is important to be aware of the following aspects. The business model of charging infrastructure operators as well as charging service providers is significantly dependent on the use (utilization) of individual charging points. The sustainability of business in this sector is based on the assumption of a growing number of users, which will result in an increase in the use of existing infrastructure with a consistent increase in revenues from already implemented infrastructure investments which enables these subjects to cover fixed expenditures (in terms of financing costs and related operating costs).

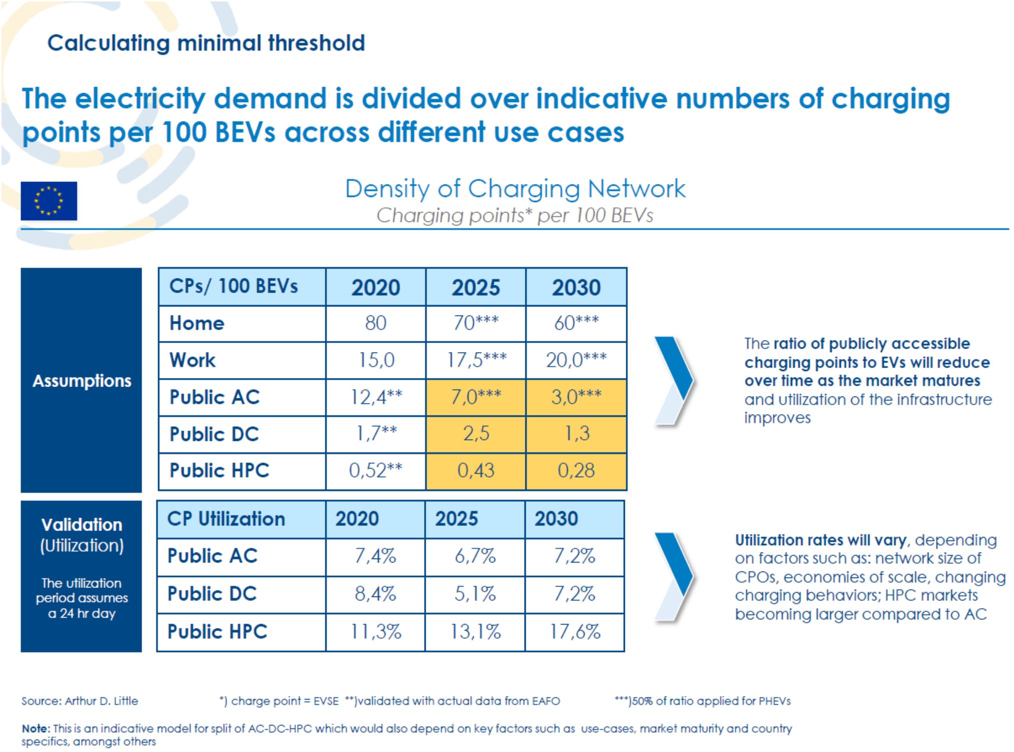
The purpose of this article is not to analyse in detail the economic nature of the charging infrastructure operator's business model, but the key revenue generating factors are evident. Charging infrastructure operators who have "outpaced" the growth of the customer base through their investments in network development (many of them with the participation of European Union funds) sometimes might have the difficulty to cover the operating costs themselves (which are significantly affected by the capacity component of energy distribution tariffs), not to mention the generation of resources for further network development.

If the ratio of charging stations to the number of electric vehicles currently forms the starting position for the next 10 years, it is appropriate / necessary to verify the extent to which these ratios form the basis for an economically sustainable business model.

There is a significant risk that the right decision regarding the "egg chicken" dilemma (infrastructure vs. electric car) will now be evaluated without taking into consideration the sustainability of the economic nature of the business model and only afterwards, when confirming the business model (and knowing an economically justifiable minimum utilisation rates in given conditions) without the impact of subsidies, to use the current ratio of charging infrastructure to electricity as a starting point for the future.

The methodology itself (as shown in Figure 6) predicts an even lower utilization rate of some segments of the charging infrastructure. This is in contrast to the generally accepted expectations of higher assets utilisation rates. It is, of course, possible to achieve higher yields (through increasing unit prices for charging services) even with lower utilization, but this approach would reduce the competitive advantage of the electric car over traditional internal combustion vehicles.

Fig. 6 Prediction of the ratio of the number of charging points to the number of electric cars within the EU by 2030



Calculating minimal threshold

The electricity demand is divided over indicative numbers of charging points per 100 BEVs across different use cases

Density of Charging Network

Charging points per 100 BEVs*

Assumptions

CPs/ 100 BEVs	2020	2025	2030
Home	80	70***	60***
Work	15,0	17,5***	20,0***
Public AC	12,4**	7,0***	3,0***
Public DC	1,7**	2,5	1,3
Public HPC	0,52**	0,43	0,28

The **ratio of publicly accessible charging points to EVs will reduce over time as the market matures** and utilization of the infrastructure improves

Validation (Utilization)

The utilization period assumes a 24 hr day

CP Utilization	2020	2025	2030
Public AC	7,4%	6,7%	7,2%
Public DC	8,4%	5,1%	7,2%
Public HPC	11,3%	13,1%	17,6%

Utilization rates will vary, depending on factors such as: network size of CPOs, economies of scale, changing charging behaviors; HPC markets becoming larger compared to AC

Source: Arthur D. Little *) charge point = EVSE **)validated with actual data from EAFO ***)50% of ratio applied for PHEVs

Note: This is an indicative model for split of AC-DC-HPC which would also depend on key factors such as use-cases, market maturity and country specifics, amongst others

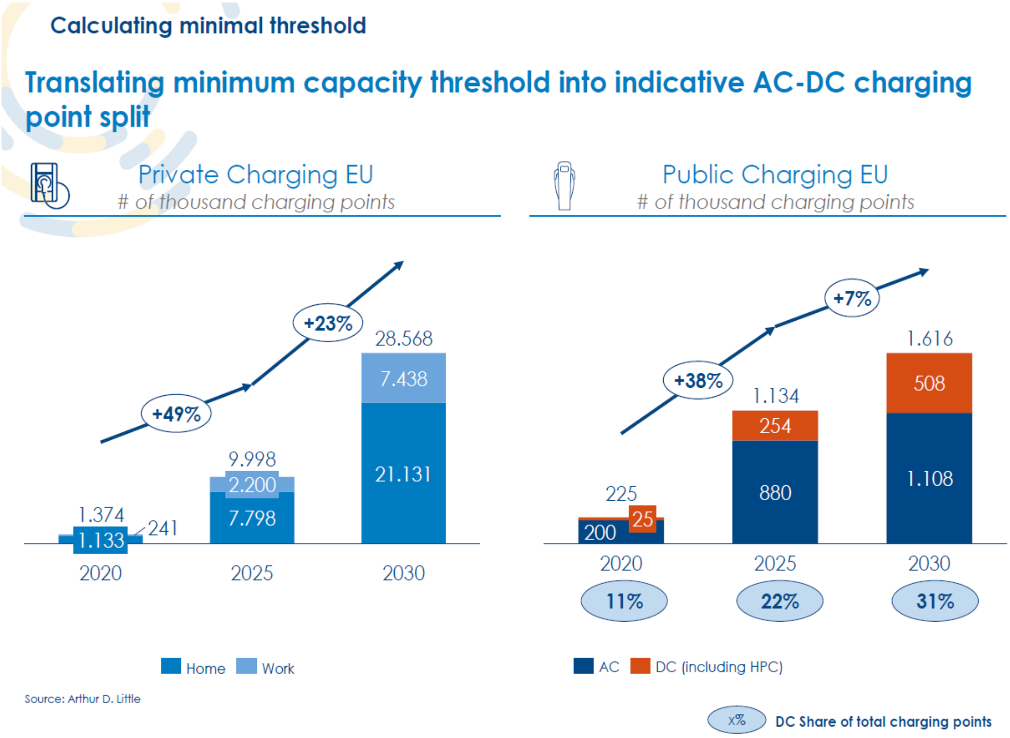
Source: ChargeUp Europe

The result is, in the sense of the assumptions described above, an increase in the number of charging points as pointed out by Figure 7 below.

Understanding and correctly estimating the number of charging points broken down by charging speed in specific markets in relation to the prediction of the development of sales of electric vehicles and plug-in hybrid vehicles is a key prerequisite for the development of electromobility itself.

On the one hand, building public charging points in the AC slow charging segment is significantly easier in terms of the existence of free capacities in the affected part of the distribution systems and ultimately significantly cheaper (in terms of hardware - charging station prices, capacity charges), compared to the public DC and HPC fast charge segment (for the above reasons). This also applies if we compare the equivalent charging power (eg. 7 x AC charging station with power every 22kW versus 1 X 150 kW DC charging station). It is clear that AC charging and DC / HPC fast charging have specific "usecases"

Fig. 7 Prediction of the number of charging points within the EU until 2030



Source: ChargeUpe Europe

I have created two models for further research. The first has the ambition to assess the relationship between the historical development of the AC charging infrastructure and the sale of electric cars on the selected market. The second model has the ambition to evaluate the dependence between the historical development of DC charging infrastructure and the sale of electric cars on the selected market in the same time horizon. The selected market is the region of Central Europe, specifically the member States Slovakia, Poland, Hungary and Austria (Table 1).

For the purposes of model creation, I used a regression model of panel data with random effects (REM). Using this model, I have examined, on the basis of historical data (period 2012 - 2021), the dependence between the number of new registered electric vehicles in a given year in a given country and the number of charging infrastructure (broken down into AC chargers- stations with an output of up to 22 kW and a DC charging station with an output of more than 22 kW), which was available to the owners of electric cars on the relevant market in the given period. GRETL software was used for model creation and subsequent quantitative analyses. The dependent variable is BEV - the number of "clean" electric cars, the independent variables are AC and DC charging stations.

The selection of the most suitable model of panel data was realized through panel diagnostics. The random effects model (REM) appears to be a more suitable model in terms of the results of the Hausman test (Chi-square (2) = 1.39823, statistical value = 0.497026).

The resulting estimate of the regression model is as follows:

Model 1: A random effects model using 40 observations

Comprising 4 cross-sectional units (4 countries)

Time series length = 10

Dependent variable: BEV

	Coefficient	Standard deviation	z	p-value	
const	714,777	651,187	1,098	0,2724	
DC	−0,971081	0,292861	−3,316	0,0009	***
AC	10,0331	1,35229	7,419	1,18e-013	***

Based on the results of Durbin Watson (DW) statistics, which is a residue autocorrelation test from statistical regression analysis, as well as on the Woolridge test, I have evaluated partial autocorrelation (positive). At the same time, I have confirmed the occurrence of heteroskedasciticity at the level of significance of 5%, as the result of the statistics expressed by the p value in the Bresus-Pagan test is 6.43163e-10

In order to modify the model, I have omitted AC as an independent variable in accordance with original intention, and the modified model demonstrates the following results:

Model 2: A random effects model using 40 observations

Comprising 4 cross-sectional units (4 countries)

Time series length = 10

Dependent variable: BEV

	Coefficient	Standard deviation	z	p-value	
const	775,741	845,596	0,9174	0,3589	
DC	1,08215	0,144537	7,487	7,05e-014	***

This model passed the autocorrelation test, while checking the homoskedasticity of the linear model at a significance level of 0.05.

Similarly, I have adjusted the model so that I have used only the AC variable as the independent variable, the resulting statistics are shown below.

Model 3: A random effects model using 40 observations

Comprising 4 cross-sectional units (4 countries)

Time series length = 10

Dependent variable: BEV

	Coefficient	**Standard deviation**	**z**	**p-value**
const	622,829	718,214	0,8672	0,3858
AC	5,77957	0,481243	12,01	3,16e-033 ***

Presented results of Model no. 2 and Model No. 3 show at a level of significance of 5% for independent variables significantly lower values than 0.05, and therefore based on the above I can conclude that for the variables AC and DC in the coefficient β1 of the linear regression models (in Model 2 and Models 3) are statistically significant.

One simple but principled conclusion follows from the above. The development of sales of electric cars (category BEV) based on the assessment of historical data in the countries of Central Europe is significantly more sensitive to the growth of charging infrastructure in the AC segment (normal charging with alternating current up to 22kW) compared to the increase in charging points in Central European countries in the DC segment (fast DC charging with power greater than 22kW).

Comparing the future needs with the current state of the charging infrastructure is a necessary prerequisite for determining the right number of charging points divided into public and private chargers, further broken down by charging speed in specific markets in relation to the prediction of electric vehicle sales and plug-in hybrid vehicles

The aim of the examination of dependencies within the mentioned models was to verify the assumptions of the development of the charging infrastructure, which has been methodologically used by the Charge-Up Europe association in its recommendations and subsequent possible adjustments of the initial assumptions.

Based on a quantitative assessment and analysis of the current development of the electromobility sector in selected Central European countries, it appears that the Charge - Up for Europe association insufficiently evaluated in its methodological approach the historical dependence between electric vehicle sales and infrastructure development by individual segments (AC) versus DC).

Tab. 1 Number of AC and DC charging infrastructure and number of electric cars in the period 2011 - 2021 in Slovakia, Austria, Poland and Hungary

source https://www.eafo.eu/alternative-fuels/electricity/charging-infra-stats

Slovensko

ROK	verejné rýchlonabíjacie stanice (> 22 kW)	verejné normálne nabíjacie stanice (=< 22 kW)	Spolu
2012			0
2013			0
2014	18	32	50
2015	37	62	99
2016	57	255	312
2017	74	347	421
2018	115	347	462
2019	233	350	583
2020	268	656	924
2021	424	922	1346

[illegible]

Rok	PHEV	BEV	Spolu
2011	17		17
2012			0
2013		13	13
2014	49	69	118
2015	68	123	191
2016		55	55
2017	185	209	394
2018	288	302	590
2019	219	156	375
2020	852	867	1719
2021	784	692	1476

Rakúsko

ROK	verejné rýchlonabíjacie stanice (> 22 kW)	verejné pomalé nabíjacie stanice (=< 22 kW)	Spolu
2012		1060	1060
2013	13	1160	1173
2014	66	1327	1393
2015	208	1327	1535
2016	263	1644	1907
2017	504	3234	3738
2018	546	3429	3975
2019	594	3742	4336
2020	1347	6885	8232
2021	1957	10930	12887

Rok	PHEV	BEV	Spolu
2011		631	631
2012	267	427	694
2013	184	654	838
2014	434	1271	1705
2015	1101	1677	2778
2016	1237	3826	5063
2017	1826	5433	7259
2018	1937	6760	8697
2019	2108	9231	11339
2020	8037	15528	23565
2021	12843	25705	38548

Poľsko

ROK	verejné rýchlonabíjacie stanice (> 22 kW)	verejné pomalé nabíjacie stanice (=< 22 kW)	Spolu
2012			0
2013		70	70
2014	3	115	118
2015	8	290	298
2016	32	290	322
2017	113	410	523
2018	281	488	769
2019	308	529	837
2020	652	1039	1691
2021			

Rok	PHEV	BEV	Spolu
2011			0
2012	12		12
2013	34	12	46
2014	105	43	148
2015	176	86	262
2016	132	138	270
2017	514	475	989
2018	667	639	1306
2019	1184	1446	2630
2020	4553	3449	8002
2021	7429	4601	12030

Maďarsko

ROK	verejné rýchlonabíjacie stanice (> 22 kW)	verejné pomalé nabíjacie stanice (=< 22 kW)	Spolu
2012			0
2013	2	60	62
2014	3	120	123
2015	22	158	180
2016	37	163	200
2017	54	206	260
2018	74	508	582
2019	124	592	716
2020	287	1008	1295
2021	451	2038	2489

Rok	PHEV	BEV	Spolu
2011			0
2012			0
2013		8	8
2014	24	28	52
2015	59	166	225
2016	109	201	310
2017	389	753	1142
2018	689	1267	1956
2019	1046	1821	2867
2020	3043	2854	5897
2021	3364	2649	6013

Source: own research

Conclusion

Despite the positive development of electric car sales in the last quarters of 2021 within the EU, there are fundamental regional differences in individual Member States. The current debate on the reassessment of binding targets under the motion of modification of the Directive on the Deployment of Alternative Fuels Infrastructure is the best time to take into account regional differences. It is very necessary that economic preconditions for the sustainability of the business models of the key players concerned (e.g. charging infrastructure operators) must also be taken into account. As further subsidies for charging infrastructure development through public funds are expected, it is appropriate to assess whether the current setting of charging stations to electric vehicle ratios (including the setting of the charging station's structure itself) is sustainable in the long run.

The article mentions the weaker points of the methodology that is articulated in the public debate, especially in the area of indicators and assumptions, while the aim is not to identify these points and make them subject to self-serving criticism, but rather to point out possible consequences that would ultimately affect the entire electromobility sector in a long run.

List of bibliographic references

ACEA (2021, July 27), *Progres report 2021, Making the transition to zero based mobility*, Available at: https://www.acea.auto/files/ACEA_progress_report_2021.pdf

AustriaTech (2020, January), *Electromobility in Austria, Facts and Figures, January 2020*, Availabe at: https://www.austriatech.at/assets/Uploads/Publikationen/PDF-Dateien/68e9ddd74d/Facts_Figures_2020_01_E.pdf

Hildermeier J.,(2020 September 14) *The expansion of Europe's EV charging infrastructure: new rules and incentives needed*, *energypost.eu: The expansion of Europe's EV charging infrastructure: new rules and incentives needed,* Available at: https://energypost.eu/the-expansion-of-europes-ev-charging-infrastructure-new-rules-and-incentives-needed/

ChargeUp Europe (2021, November), *For Conumers and Climate, ChargeUp Europe´s position on AFIR proposal*, Available at: https://static1.squarespace.com/static/5e4f9d80c0af800afd6a8048/t/6183a691e794dc2c37309d63/1636017810621/For+Consumers+and+Climate+-ChargeUp+Europe+position+on+AFIR+proposal+%281%29.pdf

ChargeUp Europe (2021, June 24), *A methodology for minimum capacity targets for EV Charging Infrastructure*, Available at: https://static1.squarespace.com/static/5e4f9d80c0af800afd6a8048/t/60d420220d01b22d4c24ca42/1624514595669/ChargeUp+Europe+-+methodology+for+minimum+capacity+targets+for+EV+Charging+Infrastructure.pdf

ChargeUp Europe (2021, June), *Through binding capacity targets for publicly accessible charging infrastructure and Member state action plans*, Available at: https://static1.squarespace.com/static/5e4f9d80c0af800afd6a8048/t/60d426dda0462c583a9d0353/1624516320310/Charging+up+Europe+through+binding+capacity+targets+for+publicly+accessible+charging+infrastructure+and+Member+State+action+plans+.pdf

European Court of Auditors (2021 April 13), *Infrastructure for charging electric vehicles*, Available at:https://www.eca.europa.eu/Lists/ECADocuments/SR21_05/SR_Electrical_charging_infrastructure_EN.pdf

Výrost T., Baumöhl E., Lyócsa Š.,(2013) *Quantitative Methods in Economics* III. ,Košice,Slovensko: ELFA

LUKÁČIKOVÁ, A.,LUKÁČIK, M (2008) .: *Econometric modeling with applications*. Bratislava, Slovensko: ECONOMIST

Falchetta G., Noussan M.(2021): *Electric vehicle charging network in Europe: An accessibility and deployment trends analysis,* Transportation Research Part D: Transport and Environment, Volume 94, May 2021, 102813, https://doi.org/10.1016/j.trd.2021.102813