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COMPARATIVE ANALYSIS OF ELECTROMOBILITY DEVELOPMENT LEVEL IN CENTRAL AND EASTERN EUROPE COUNTRIES

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Hubert Igliński

Poznań University of Economics and Business
hubert.iglinski@ue.poznan.pl

ABSTRACT

In the years 2008–2017 the number of battery electric vehicles (BEV) around the world doubled every year. It was mainly due to China, where the growth was even higher (on average by 2.6 times annually) and also due to the USA and Norway. Despite this, BEV still represent a small margin of the market. There were less than 0.2% of BEV among over a billion of internal combustion passenger cars in the world. Many countries, also in Central and Eastern Europe, including Poland, have very ambitious plans for electromobility development. The main purpose of this paper is to conduct a comparative analysis of the level of electromobility development in Poland compared to 10 countries of the Region. The author also attempts to answer the question of the reasons leading to such a state of affairs. The author also recommends further actions necessary to be taken in Poland to make the development of electromobility sustainable. Statistical and logical analysis as well as literature review was used in this paper.

KEYWORDS

electromobility, electric vehicle supply equipment, air pollutant emissions

INTRODUCTION

The number of battery electric vehicles (BEV) registered every year across the world is increasing rapidly. In 2017 nearly 750,000 such vehicles were registered, although only a decade ago there were only 2,500 of them, which means average annual growth dynamics of almost 200 percent within this period. The total number of BEV operating at the end of 2017 was estimated at nearly 2 million. The leading country was China with approximately 950,000 vehicles, followed by the USA with approximately 400,000 and Norway with more than 115,000. France dominated among the European Union countries with 93,000 cars, Germany came second with 59,100 and the United Kingdom was third with 45,000 vehicles (OECD/IEA,[1] 2018a, pp. 112–113). The number of

1 Organization for Economic Co-operation and Development/International Energy Agency.

available models is also increasing – today there are approximately 100 of them and we are still to witness the real eruption of electric vehicles, not only in the sector of passenger cars.

Despite this undeniable success, BEV still make up a small margin of the market. Their share among over a billion of internal combustion engine vehicles is less than 0.2%. The share of BEV in the sales of new passenger cars is slightly better. In 2017 it was just over 0.9% (0.75 million vs. 79.8 million) (ACEA,[2] 2018, p. 10). Norway recorded the highest share of an impressive 20.8%, then there was Holland with only 2.1% and China with of 1.8%. As for the member states of the EU, apart from Holland, a high share of BEV characterised Sweden and France, both countries achieving approximately 1.3% (OECD/IEA, 2018a, p. 115).

When analysing electromobility development plans in different countries, it is clearly visible that Poland has set an ambitious goal – registration of a million of electric vehicles by 2025. A different goal, however equally bold, was set in Slovenia. Like Holland and Ireland, in 2030 the country wants 100% of the newly registered cars to be electric.

The purpose of this article is to conduct a comparative analysis of the level of electromobility development in Poland compared to 10 countries of Central and Eastern Europe.[3] The author also attempts to answer the question of the reasons leading to such a state of affairs. The analysis will only include BEV, as PHEV are, in fact, internal combustion engine vehicles with an additional electric engine and batteries with a capacity of several kWh which allow to cover only several tens of kilometres in the electric mode. Two engines significantly boost the performance (power, acceleration, speed) of PHEV but their weight and energy consumption (fuel and electric energy) increase. Under real life conditions they are approximately twice higher than the manufacturers declare on the basis of widely criticised NEDC tests (Tietge, Mock, German, Bandivadekar, Ligterink, 2017, pp. 15–53) which are, fortunately, becoming a thing of the past. In addition, like all hybrid solutions, PHEV are only a temporary stage leading to complete transport electrification.

ELECTROMOBILITY IN CENTRAL AND EASTERN EUROPE COUNTRIES

At the end of 2017 there were exactly 6,787 BEV registered in the entire Region, most of them in Czechia – 1,327, Estonia – 1,156 and Hungary – 1,148. The greatest acceleration in BEV registrations took place in 2017, when there were over 2,600 more of them in the Region, including 753 in Hungary, 475 in Poland and 389 in Czechia (Table 1). Earlier, between 2014 and 2016 the increases were significantly lower and steady, oscillating around 1,000 units per year (EAFO,[4] 2018).

2 European Automobile Manufacturers Association.

3 The following countries: Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Romania, Slovakia, and Slovenia are defined by the author as Central and Eastern Europe and these are further analysed herein. All the countries together with Poland are also referred to as the Region.

4 European Alternative Fuels Observatory.

Table 1. Cumulated number of BEV registered in selected countries in years 2010–2017

	2010	2011	2012	2013	2014	2015	2016	2017
Bulgaria	0	0	0	0	2	12	23	89
Croatia	0	0	0	0	39	119	176	184
Czechia	0	56	148	187	374	705	938	1327
Estonia	0	56	562	708	1042	1081	1130	1156
Hungary	0	0	0	0	28	194	395	1148
Latvia	0	0	6	0	178	198	226	297
Lithuania	0	0	0	2	6	31	96	144
Poland	**0**	**35**	**54**	**81**	**149**	**235**	**373**	**848**
Romania	0	5	5	42	59	87	156	388
Slovakia	0	25	25	41	110	233	288	497
Slovenia	0	12	29	34	73	195	373	709
Total	0	189	829	1095	2060	3090	4174	6787

Source: EAFO.

Obviously, such data does not reflect, for example, the significant differences in the population of individual countries, the level of the society's motorisation or the tendency to buy new passenger cars (Table 2). A more detailed analysis allows to conclude that the aforementioned countries are not really the leaders of electromobility development in the Region and the relatively large number of registered BEV mainly originated from their large population, especially in Poland. The highest share of BEV in the total number of registered passenger cars (PC) is recorded in Estonia and Slovenia, where they amount to, respectively, 0.164% (1644 BEV/1 million PC) and 0.065% (646 BEV/1 million PC). Poland, with the share at the level of 0.004% (39 BEV/ 1 million PC) ranks penultimate (overtaking only Bulgaria) and significantly below the average of 0.015%.

Poland also fails to impress when it comes to the share of BEV in the sales of new passenger cars.[5] They constitute less than 0.01% (except for Croatia, the least among the analysed countries), whereas in Slovenia and Hungary the share was, respectively, 5 times and over 6 times higher. And 2017 was still the record year in Poland with as many as 475 BEV registered then, compared to 138 in the previous year and only 86 in 2015.

5 The author is fully aware that not all registered BEVs are new vehicles, but he still classifies them as newly sold cars as the age of second-hand BEVs is still only a few years, which is significantly less than the average age of second-hand internal combustion engine cars that are imported to individual countries of the Region.

Table 2. Selected data on BEV in 2017 by country

	Population (m)	GDP per capita ('000 €)	PC* stock (m)**	Motorization rate (PC/1000 people)	New PC registration	BEV share in total PC (%)	Market share of BEV in new PC registration (%)	BEV/ 1 m people
Bulgaria	7.10	7.1	3.14	443	31,244	0.003	0.211	13
Croatia	4.15	11.8	1.55	374	50,412	0.012	0.016	44
Czechia	10.58	18.1	5.31	502	271,595	0.025	0.143	125
Estonia	1.32	17.5	0.70	534	25,020	0.164	0.104	878
Hungary	9.80	12.6	3.31	338	116,265	0.035	0.648	117
Latvia	1.95	13.8	0.66	341	16,692	0.045	0.425	152
Lithuania	2.85	14.7	1.30	456	25,865	0.011	0.186	51
Poland	**37.97**	**12.3**	**21.66**	**570**	**486,352**	**0.004**	**0.098**	**22**
Romania	19.64	9.6	5.47	279	105,083	0.007	0.221	20
Slovakia	5.44	15.6	2.12	390	96,085	0.023	0.218	91
Slovenia	2.07	21.0	1.10	531	70,892	0.065	0.474	343
Total/average	102.87	12.5	46.33	450	1,295,505	0.015	0.202	66

* Personal car.
** Data from 2016.

Source: *EU Transport…* (2018); ACEA (2018); EAFO; Eurostat Database.

It is also worth comparing the saturation level of BEV in specific societies. It turns out that it is the highest in the countries with the smallest populations. In Estonia, with a population of only 1.32 million citizens, it is 878 BEV per one million people, in Slovenia – 343, and in Latvia – 152. Bulgaria is on the other side of the spectrum – 13 BEV/1 million people and the most populated countries in the Region: Romania 20 and Poland 22.

DETERMINING FACTORS OF ELECTROMOBILITY DEVELOPMENT

Although most drivers, e.g. 9 out of 10 inhabitants of Sweden and Norway, charge their electric cars every day using private chargers (OECD/IEA, 2018b, pp. 41–43), access to public charging stations of a power exceeding 22 kW remains one of the most significant factors determining electromobility development. They are of such importance because the range of most electric cars in real life road conditions does not exceed 200 km and therefore each longer journey requires for the batteries to be charged several times (Igliński, 2018, pp. 64–67).

Estonia has the largest network of publicly available fast charging stations in the Region. What is interesting and generally unusual is the fact that their number slightly exceeds the number of slow chargers (Table 3). Estonia is exceptional also because the development of the charging infrastructure began as early as in 2012, when 160 fast charging stations were installed. It was then when the government collected 456 units of Mitsubishi i-Miev it had ordered (a total of 507 units of this model were purchased[6]). Thus, in 2012 the entire country was already criss-crossed by a dense network of charging points and the distances between neighbouring points did not exceed 60 km

6 They were made available for use by social workers employed at the agencies of the Ministry of Social Affairs.

(ELMO, 2018). Numerous fast charging station are also found in Czechia, Slovenia and Poland, and the greatest growth in their number (from 70 to nearly 110 points) in the aforementioned countries was recorded respectively in 2015, 2016 and 2017. On the other hand, most publicly available stations equipped with slow charging devices of a power of up to 22 kW are installed in Czechia (459), Poland (410) and Croatia (381).

Table 3. Selected data on publicly accessible chargers by country in 2017

	Area (1000 km²)	Publicly accessible chargers		Fast chargers/ 1000 km²	Fast chargers/ 1 m population	All chargers/ 1000 km²	BEV/all chargers
		fast > 22 kW	slow				
Bulgaria	111.0	31	63	0.3	4.4	0.8	0.9
Croatia	56.6	55	381	1.0	13.2	7.7	0.4
Czechia	78.9	160	459	2.0	15.1	7.8	2.1
Estonia	45.2	192	191	4.2	145.9	8.5	1.8
Hungary	93.0	66	206	0.7	6.7	2.9	4.2
Latvia	64.6	13	60	0.2	6.7	1.1	4.1
Lithuania	65.3	63	39	1.0	22.1	1.6	1.4
Poland	**312.7**	**142**	**410**	**0.5**	**3.7**	**1.8**	**1.5**
Romania	238.4	19	95	0.1	1.0	0.5	3.4
Slovakia	49.0	96	347	2.0	17.7	9.0	1.1
Slovenia	20.3	145	348	7.1	70.2	24.3	1.4
Total/average	1135	982	2599	0.9	9.5	3.2	1.8

Source: *EU Transport…* (2018); EAFO.

However, the density and location of charging stations is more essential as they determine the accessibility and usability for electric car users. The decision on the location is taken by a private or public investor and it is to be hoped that the best choices are made, whereas the density of networks may be easily measured and compared.

Queues of cars waiting to be charged are not be expected in the countries of the Region as in 2017 there were on average only 1.8 BEV per a publicly available charger. This seems a very good result, especially when compared to Norway, where there are nearly 60 BEV per a fast charger, which is, however, a result of a persistently small number of operating BEV. Therefore, when studying the existing level of electromobility and its potential, it is more reasonable to relate the number of fast chargers to the country's population. In this respect the situation is the best in Estonia – 146 fast chargers per 1 million people and in Slovenia – 70 of them, the worst case being again Romania with only 1 charger, Poland with 3 and Bulgaria with 4.4. On the other hand, there were nearly 400 fast chargers per one million population in Norway.

The network of fast chargers, which are especially desirable by BEV drivers taking longer, at least 200-kilometre journeys, is very poor in the Region. There is not even one such device per 1,000 km². The situation is best in Slovenia where there are more than 7 fast chargers per 1,000 km² and in Estonia with 4.2 chargers. It is the worst in Romania with 0.1 of them and, unfortunately, in Poland with fewer than 0.5 chargers per 1,000 km². For example, there are over 18 fast chargers per 1,000 km² in Holland and 6.3 in Norway.

The above data is based on the arithmetic mean, which inevitably does not reflect two crucial parameters determining the actual accessibility of fast chargers – the settlement pattern of a country and its geographical shape. It is difficult to describe all significant conditions in the Region, but a certain relation may be noted between the share of people inhabiting a country's capital city in its entire population and the level of electromobility development (number of BEV per one million registered passenger cars or one million population). A high concentration of inhabitants makes the chargers easily accessible to the users with relatively low outlays on the development of the charging network. A high effectiveness of the investment is also ensured by a high level of urbanisation with a relatively small number of cities or with a concentrated network of leading urban centres. It turns out that the inhabitants of Riga (793 thousand) make up an impressive 41% of Latvian population, and those of Tallinn (418 thousand) make up 32% of Estonian citizens. As the author concluded above, both countries are the leaders of electromobility development. Poland is on the other end of the spectrum. The population of Warsaw makes up only 4% of the country's population, the level of urbanisation is only 60%, and the settlement pattern is very dispersed. Slovenia, which comes second in the Region in terms of electromobility development, escapes this relation because Ljubljana is inhabited by only 13% of the country's total population (City Mayors, 2018).

This apparent paradox may be explained by other factors. New electric cars are expensive, they cost approximately twice as much as their combustion engine counterparts and therefore, in addition to the high accessibility of public chargers, gross domestic product per capita in the society is of key importance. The inhabitants of Slovenia achieved the highest income in the Region amounting to EUR 21 thousand in 2017, followed by the citizens of Czechia with EUR 18.1 thousand and Estonia with EUR 17.5 thousand. The lowest income was recorded in Bulgaria – EUR 7.1 thousand, Romania – EUR 9.6 thousand, Croatia – EUR 11.8 thousand and Poland – EUR 12.3 thousand. Obviously, the average income does not illustrate the real distribution of income and wealth within a society. Nevertheless, it should be noted that the amounts are predominantly so low that an absolute majority of the population of the Region has no possibility of purchasing even the least expensive BEV, e.g. a VW e-up for approximately EUR 25 thousand or a slightly larger e-Golf for as much as EUR 40 thousand.

The success of BEV sales greatly depends on an incentive scheme, especially on financial incentives that significantly decrease the cost of purchasing a car. As a rule, they do not completely offset the difference in the purchase price of an electric car and a corresponding internal combustion engine model but are frequently enough for the Total Cost of Mobility (TCM) to be compensated over e.g. a 4-year horizon.

The government of Estonia offered and exceptional package of financial incentives at the initial stage of electromobility development. Subsidies for purchase of BEVs amounted to a record EUR 18 thousand plus EUR 1,000 for the purchase and installation of home-use charging equipment. The programme was ceased in 2014, which resulted in a significant decrease (by nearly 90%) in the interest in purchase of electric cars. Nowadays Estonians cannot rely on any significant preferences when purchasing BEV. However, it turns out that income has grown so much that by mid-2018 another 75 BEV were registered, i.e. 3 times as many as throughout 2017 (EAFO, 2018).

Compensation of up to EUR 7,500 is available in Slovenia for purchasing an electric passenger car, both to private persons and business entities. BEV owners also pay the lowest registration fee,

amounting to only 0.5% of vehicle value.[7] They are also exempt from fees for infrastructure use (EAFO, 2018).

On the other hand, in Latvia BEV owners are fully exempt from registration tax and ownership tax. Electric cars may also use bus lanes and in certain cities they are exempt from parking fees.

Such or similar encouragement is still not used either in Bulgaria or in Poland. The Act on Electromobility and Alternative Fuels of 11 January 2018 only defines the framework, yet still modest, of such support. However, the required legal regulations have not been introduced yet. Therefore, it should not be surprising that with the lack of encouragement, a poor network of publicly available charging points and a still small per capita income, the level of electromobility in Poland remains so low.

CONCLUSIONS AND RECOMMENDATIONS

It is impossible to avoid the question of the purpose of electromobility development. It is certainly not only a matter of competition between the countries and of increasing the number of BEV and their market share. The obvious answer is that the purpose is to reduce emission of pollutant to the atmosphere and the noise level. For particulate matters (PM), nitrogen oxides (NO_x) or aromatic hydrocarbons, especially in cities and in relation to Diesel engine cars, an increase in the number of BEV in traffic may lead to improvement. But how to address the real civilisation challenge which is reduction of the emissions of greenhouse gases, especially CO_2? This is where significant controversy appears.

The relation between the increase in GHG concentration in the atmosphere and the key role of humankind in this process and between the increase of average temperatures and the vehemence of other weather and climate phenomena is commonly recognised and perfectly proven scientifically (IPCC,[8] 2013). Therefore, attempting to reduce GHG emissions, when energy is produced emissions must not exceed approximately 550 g CO_2/kWh (OECD/IEA, 2014, p. 226). Otherwise, electromobility development is counter-productive and BEV[9] (in the Well-to-Wheel cycle) emit more GHG than internal combustion engine vehicles.

In the Region this threshold is exceeded by Estonia, where the average GHG emission in 2015 was as high as 1026 g CO_2/kWh and in Poland – 730 g CO_2/kWh (Table 4). This is a paradoxical and reprehensible situation when the leader of electromobility development in the Region is at the same time the largest emitter of GHG per an energy unit. The only consolation may be the small population of Estonia and its insignificant share in global emissions. Fortunately, the emissions in Slovenia and Latvia are low.

If electromobility in Poland is to develop in a responsible and reasonable manner, the national electricity system should be completely reconstructed. Due to the dominance of hard coal and

7 The highest rate is applied to passenger cars with a Diesel engine with emissions exceeding 250 g CO_2/km and amounts to 31% of vehicle value (*Zakon o davku na motorna vozila*, retrieved from: http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO1276).

8 Intergovernmental Panel on Climate Change.

9 It should be remembered that the production of batteries itself as well as their disposal significantly burden the natural environment.

lignite in the energetic mix (approx. 85% of the share) and a very low share of truly low-emission sources of electricity, i.e. wind and solar energy as well as due to a lack of willingness to change the situation,[10] the production of each kWh of electric energy in 2016 caused emissions of not only 781 g CO_2 but also of 0.818 g SO_2, 0.824 g NO_x and 0.053 g PM (*Wskaźniki emisyjności…*, 2017, p. 6). It should also be remembered that coal and lignite combustion generates significant emissions of heavy metals, in particular of dangerous mercury. Consequently, if it is necessary to use a car, under present conditions it is best to choose a small petrol-driven car that meets the requirements of EURO 6 standard as it does not emit any SO_2, the emission of NO_X is at least 20 times less, and even PM and CO_2 emissions are lower than in the case of BEV.

Table 4. CO_2 emissions from electricity generation (g CO_2/kWh) in years 1990–2015

	1990	1995	2000	2005	2010	2013	2014	2015	1990–2015 (1990 = 100)	2010–2015 (2010 = 100)
Bulgaria	773	589	487	517	553	506	493	498	64.4	90.1
Croatia	369	254	301	317	227	221	193	233	63.1	102.6
Czechia	760	811	731	625	585	505	509	521	68.6	89.1
Estonia	962	1094	1082	1067	1031	1014	1081	1026	106.7	99.5
Hungary	503	519	473	374	320	292	277	274	54.5	85.6
Latvia	115	132	134	86	118	131	128	145	126.1	122.9
Lithuania	159	65	99	101	340	204	184	186	117.0	54.7
Poland	**1009**	**923**	**884**	**838**	**800**	**771**	**755**	**730**	**72.3**	**91.3**
Romania	865	753	588	501	417	355	319	340	39.3	81.5
Slovakia	397	371	250	225	201	176	162	169	42.6	84.1
Slovenia	438	390	350	356	331	319	226	265	60.5	80.1

Source: OECD/IEA (2017).

Summing up, it is worth developing electromobility in Poland but the process should begin with public transport as, regardless of the type of drive, it is much more energy efficient than individual transport, especially in cities (Igliński 2015, pp. 163–169). Similarly, for longer routes it will be more effective to invest in railways while rapidly reducing the share of coal in the energetic mix and replacing coal with energy from renewable sources.

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10 The dreams of building nuclear power stations within a short time, given the lack experience in this matter, high construction costs and problems acquiring and disposing of fuel as well as the general tendency to abandon this energy source, may as well be shelved alongside fairy tales.

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Wskaźniki emisyjności CO_2, SO_2, NO_x, CO i pyły całkowitego dla energii elektrycznej na podstawie informacji zawartych w krajowej bazie o emisjach gazów cieplarnianych i innych substancji za 2016 rok (2017). Warszawa: Instytut Ochrony Środowiska – Państwowy Instytut Badawczy.

ANALIZA PORÓWNAWCZA POZIOMU ROZWOJU ELEKTROMOBILNOŚCI W KRAJACH EUROPY ŚRODKOWEJ I WSCHODNIEJ

STRESZCZENIE

W latach 2008–2017 liczba samochodów elektrycznych na świecie ulegała podwojeniu każdego roku. Działo się tak głównie za sprawą Chin, gdzie wzrost był jeszcze szybszy (średniorocznie o 2,6 razy), oraz USA i Norwegii. Mimo tego samochody elektryczne wciąż stanowią niewielki margines rynku. Jest ich mniej niż 2 promile wśród ponad miliarda spalinowych samochodów osobowych. Wiele krajów, także w Europie Środkowej i Wschodniej, w tym Polska, ma bardzo ambitne plany rozwoju elektromobilności. Celem artykułu jest dokonanie analizy porównawczej poziomu rozwoju elektromobilności w Polsce na tle 10 krajów regionu. Autor podejmie również próbę odpowiedzi na pytanie o przyczyny, które legły u podstaw takiego stanu rzeczy. Rekomenduje także dalsze działania konieczne do podjęcia w Polsce w celu zrównoważenia rozwoju elektromobilności. W artykule zastosowano analizę statystyczną i logiczną oraz analizę literatury przedmiotu.

SŁOWA KLUCZOWE

elektromobilność, ładowarki do samochodów elektrycznych, emisja zanieczyszczeń