Czech-Austrian Winter and Summer School

E-MOBILITY: A COMPARISON OF INFRASTRUCTURE, NUMBER OF VEHICLES AND LESSONS LEARNED FROM MODEL REGIONS AND PILOT PROJECTS

Authors
Tereza Pudová
Vera Ellmeier

Co-operating Universities

Financial support by

Prague and Vienna, 2015

Content

1. Introduction and General Information

To reduce our CO2 levels In Europe, we need to make some general changes in different energy consuming sectors. One of the major player regarding CO2 emissions is the transport sector. 19.7% of GHG is emitted by transportation. In this paper, the focus relies on private vehicles. One option to prevent the CO2 production of vehicles is using electric vehicles (EV) charged by renewable energy sources.

Though the number of EVs is rising with time the growth gradient is smaller as expected. There are couples of reasons which are preventing the faster growth. On the one hand, it is due to technical limitations such as the range, charging time of the battery, price and the life expectation of the battery of the vehicle and the unsatisfactory results of crash tests. On the other hand it is due to missing infrastructure (mainly charging stations) and policy such as subsidizing methods.

The European Union has set many regulations for all the European countries to be able to reach the CO2 targets. One major project is reducing the emissions in the transport sector. Since e-mobility provides zero emission transport when using renewable energy sources to produce the electricity, it is strongly supported from the EU. However, the level of development concerning e-mobility varies strongly throughout the European countries depending on the support of the governments. Some countries which do not invest much into e-mobility may belief in other technical solutions as for example vehicles powered by fuel cells. The argument that speaks very much for e-mobility is that it is the most developed technology compared to other zero emission solutions which therefore may lead to a rapid diffusion. Since the political pressure on the CO2 reduction is very high because of the climate change, time is a very precious and hence e-mobility becomes a very attractive solution.

2. Abstract

This paper describes the actual situation in the field of e-mobility, and it is focused on the situation in the Czech Republic and in Austria, and the comparison between them. Our motivation to the writing was the interest, how different is the e-mobility in two neighbouring countries – our homelands. The core objective of this paper is to analyse the current number of EVs driving on the street and the existing infrastructure (number of charging stations) focusing mainly on Czech Republic and Austria and partly on the EU28. This is followed by giving best practice examples through identifying successful model regions or pilot projects.

After an introduction to the current situation and a description of problem statement, we will describe different types of charging methods – mainly focused on the difference between AC and DC. This description will be followed by a comparison of infrastructure, and about the state of building charging stations in these 2 countries. Then, we will describe the existing models of EVs, and we will compare some EVs made by different car factories. We will see which types you can meet on Czech and on Austrian roads. For the clear view on the situation and on the futures in countries, we will present pilot projects, realised in Czech Republic and in Austria. For the comparison, and lightly also a pattern worth following, we will describe the e-mobility in Norway.

For the conclusion, we will compare the Czech and Austrian situation, and we will turn to the future – which expectations are tied with e-mobility, and what have to be done, for the bigger and more successful expansion of EVs.

3. Problem Statement

The density of EVs driving on the streets varies through the EU depending on how much a country is investing in the development of e-mobility. Each country has different methods to approach this topic. For this paper the Czech Republic and Austria are taken as examples to show how different the level of development in e-mobility can be though they are neighbouring countries which have very similar goals concerning this topic. Though Austria may not be the leading country in e-mobility it is far more developed that the Czech Republic. The reasons for their differences rely mainly on their measurements to enforce e-mobility. In Austria there are a lot of pilot projects concerning this area and the government subsidizes buyers of an Electric Vehicle (EV). In the Czech Republic on the other hand the government is not very interested in supporting such projects or subventions.

However also in Austria the diffusion of e-mobility is going slower than calculated. To get an impression of how this sector developed until now the paper will show the state of the art of e-mobility in each of these countries by analyzing the kind and the current number of EVs driving on the street and the existing infrastructure. To analyse the difficulties which each country has to face in the e-mobility sector it is important to show the strategy which is used. Therefore the paper will reflect the most important projects in each country.

4. CHARGING METHODS

For the charging of E-vehicles exists a different types of chargers – the main difference is in time, that will the charging last. For the technologies, the main difference is, which current the charging uses – AC or DC. As you can see on the picture below, the main difference between them is, the AC charging uses the charger, which is integrated directly in the car, and you can charge it by classical 16 A supply at home – the charging time is about 5-8 hours, so it´s ideal for over-night charging. For the DC charging, the charger is in the charging station, which is typically a part of a commercial charging infrastructure. The electric power supply of DC charging stations is about 50 kW, and to charge approximately 80% of the battery, it suffice 15-30 minutes – it is therefore advantageous for commercial charging – for example at shopping centres.

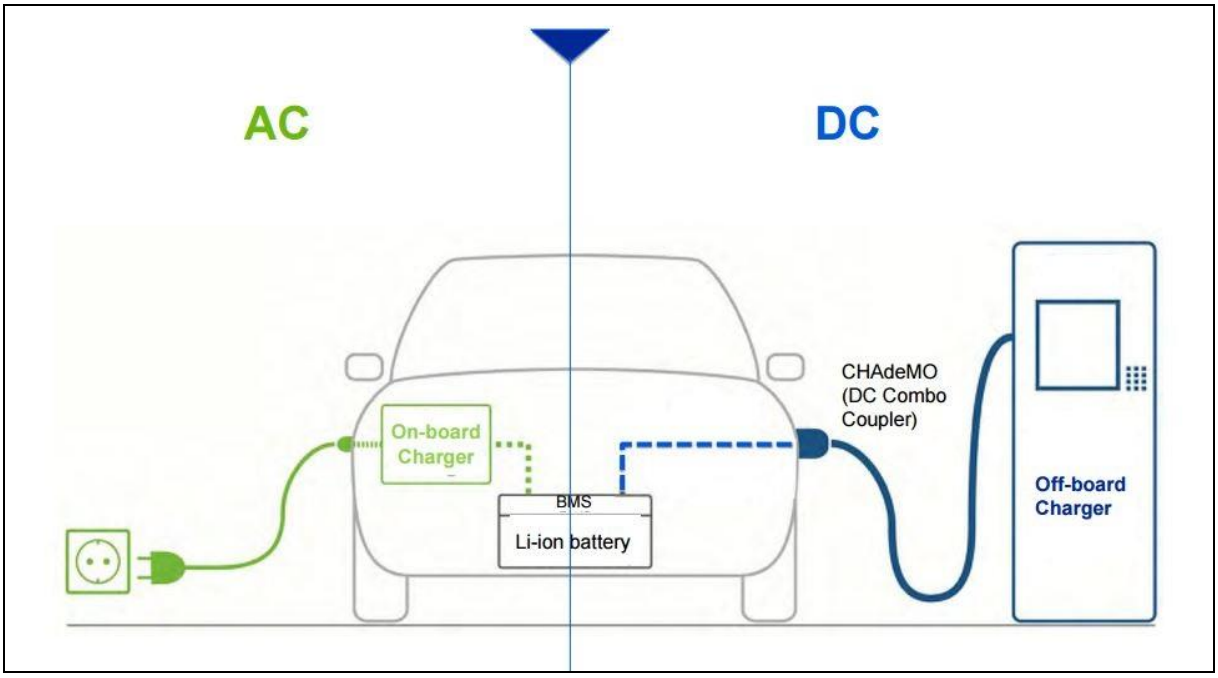

Figure 1 (Top-expo, 2012)

4.1. AC level 1 - Standard electrical outlets

Connecting electrical vehicles to the AC mains (grid) using standard sockets up to 16 A and 250 V single-phase AC or 480 V three-phase AC power supply operation and using the power cables and the protective ground conductor. To complement the additional protection for connection with the existing AC power supply networks can be used in residual current circuit breaker built into the cable. In some countries, for vehicle charging mode one can use RCD type AC connected to existing domestic installations.

This method of charging is the simplest one, but also the slowest one. It is profitable, because you don’t need any special equipment, only a simple electric cable. As I already mentioned, this type of charging is good for everyday overnight-charging at home.

4.2. AC level 2 - Charging stations

Connecting electrical vehicles to the AC mains (grid) to 32 A and 250 V single-phase AC or 480 V three-phase alternating current using a standard single-phase or three-phase sockets and power cables and protective ground wires together with wires and controller functions system to protect personnel against electric shock through residual current circuit breakers connected between the electric vehicle and plug or as part of a control cable box. Control cable box must be located within a distance of 0.3 meters from the plug or power facilities or be on the cradle.

This method is used by drivers who want to invest to their car, and they decide to build a private charging station in their garage. The charging time falls to a half, but it requires an investment of approximately 800 €.

4.3. DC level 3 – Fast charging

The fastest charging can be done by a high-current DC charger. The charging time falls to 1/6 in comparison with AC chargers. To fully charge the battery, you need less than one hour. One of the most important disadvantages of this type of charging is doubtless the price – it normally grows up to 20 000 €. Other disadvantage is also the need of special equipment and the access to high-voltage electrical circuit.

Figure 2 (Top-expo, 2012)

5. INFRASTRUCTURE

In this chapter, we the situation about building the charging stations in the Czech Republic and in Austria is described. Many of the EU countries agreed to invest highly into the infrastructure of EVs. In a Memo released by the European commission the charging point numbers of each EU Member for the year 2011 and it's future expectations for 2020 were given. In the Czech Republic there were only 23 charging stations in 2011. The proposed targets for 2020 were put very high with a number of 13.000 charging stations. Austria on the other side had 489 charging stations in 2011 and proposed an augmentation to 12.000 until 2020. (European Commission, 2013)

5.1. Czech Republic

Unfortunately, the E-mobility isn´t much supported by the decisions of the government, so it needs some time to the bigger extension of number of owners of an E-vehicle in the Czech Republic.

For the future, we expect that the distributors will increase the number of charging stations, but it will be still unprofitable for them, until the time, when the number of E-vehicles will be higher. For the distributors, the development of use of E-vehicles will create the new prospective market.

The main part of charging stations in the Czech Republic is AC, with the maximum of 22kW per 1 hour of charging. At the map, you can see the position of charging stations on the map of the Czech Republic.

Figure 3 (Hybrid.cz, June 2015)

In the Czech Republic, there are 3 distributor companies of electricity, each of them has his own location, where he sells electricity, and where he is building charging stations: PRE distribuce, E.ON Distribuce and ČEZ Distribuce. For the gas, the division of the republic is a little bit different. For the gas distribution, Czech Republic has 3 companies: RWE GasNet, PP Distribuce and E.ON Distribuce. On the maps below, you can see the spheres of activities of each distributor.

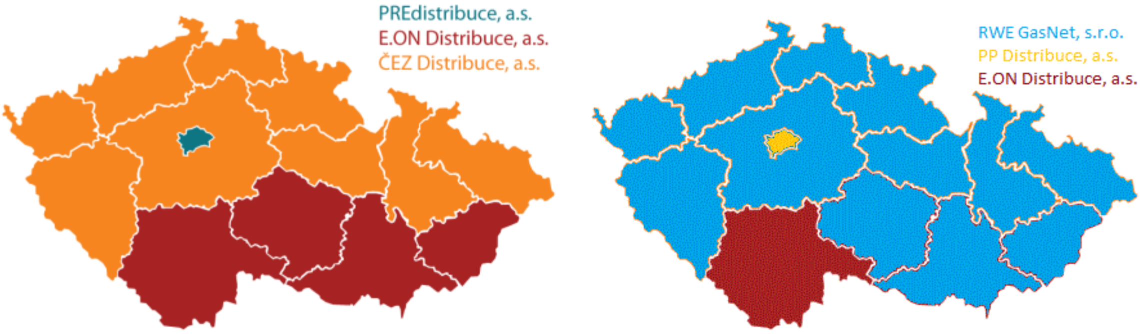

Figure 4 (AMPER, March 2015)

5.2. Austria

The picture below gives an impression of the density of the charging stations for EVs in Austria. One can also see that from the neighbor countries Germany and Switzerland have similar densities to Austria. The Czech Republic shows only very little charging points. However, since this map is Austrian it can be that not all charging stations in other countries are registered.

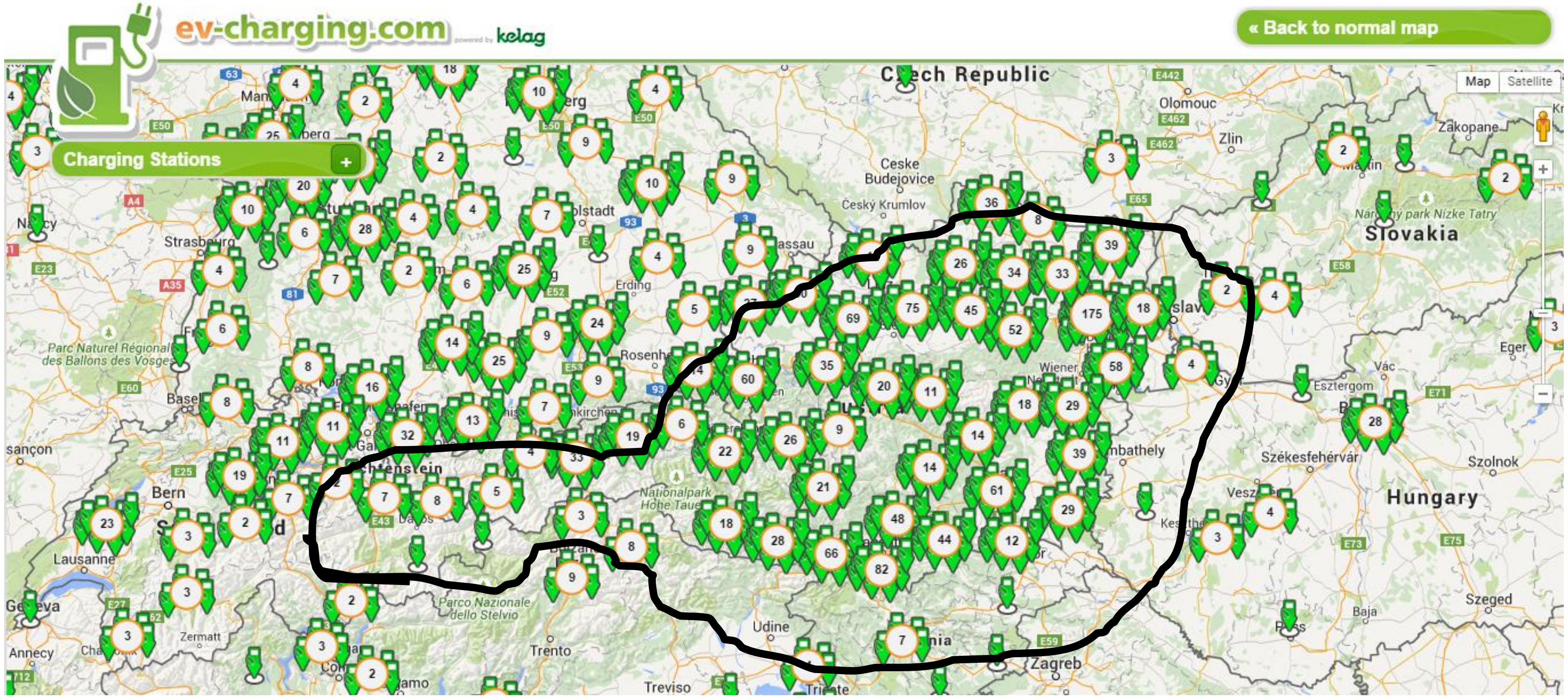

Figure 5 (EV-Charging, June 2015)

The table below provides information about every Austrian charging station provider. Most of them derive from the different energy companies which exist for each state. Smatrics is the only company that installs charging infrastructure in all of Austria. The others only concentrate on their region. For the EV drivers this fact makes it very impractical because for each provider they need an own RFID card to be able to use their charging stations. However the biggest problem is that all of them have their own map to show their mark their charging stations. This means that in addition EV drivers have to look parallel in different maps to find their desired charging station. There exist also apps which apparently show you every charging station in Europe (e.g. https://ev-charging.com/at/en). The problem is that these are usually not updated which is very important to see if a charging station is free or not. Some energy providers give you the opportunity to reserve one charging points for a short time to impede that two people want to charge their car at the same time at the same charging point. Making the reservation and be able to see is only possible on the providers map.

Charging Companies & their infrastructure in AUT

Name	SMATRICS (April 2015)	EVN (TankE)	TankE Wien	Linz AG	Kelag	Electro Drive Salzburg	Electro Drive Burgenland	Electro Drive Tirol	Vlotte	E-Mobility Graz	Post E-Mobility
Source	http://smatrics.com/ (June 2015)	https://www.evn.at/Privatkunden/Energie-optimieren/E-Mobilitat/Unterwegs-laden.aspx (June 2015)	http://www.tanke-wienenergie.at/unsere-tankstellen/ (June 2015)	http://www.linzag.at/portal/portal/linzag/linzag/linzag_1/presse_1/pressemeldungen_4_p_47872;jsessionid=9524BB48AD2BDBFF35C455EEF711B7EC.node2 (July 2015)	http://konzern.kelag.at/content/page_lade-infrastruktur-der-kelag-17846.jsp (July 2015)	http://www.electrodrive-salzburg.at/ladestationen.php (June 2015)	http://www.energieburgenland.at/fileadmin/images_oekocenter/emobilitaet/Liste_E-Ladestationen_Burgenland.pdf (July 2015)	http://www.electrodrive-tirol.at/index.php?id=23 (June 2015)	http://www.vlotte.at/inhalt/at/vlotte_stromstellen.htm (June 2015)	http://www.emobility-graz.at/ladestellen/ladestellenkarte-graz/ (June 2015)	https://www.post.at/co2neutral/e_mobilitaet.php (July 2015)
Region	Austria (in a radius of every 60 km)	Lower Austria	Vienna	Linz & surroundings	Carinthia	Salzburg	Burgenland	Tirol	Vorarlberg	Graz & surroundings	Austria (focus on Vienna and ist surroundings)

Model Region	yes/no	no	in cooperation with Model Region "E-Pendler NÖ"	in cooperation with Model region "E-Mobility on Demand"	No	is part of a model region "E-LOG Klagenfurt"	yes	no	yes	yes	yes	yes
Charging method	Schuko		x	x	x		x	x	x	x	x	
	Type 2	x	x	x	x	x	x			x	x	
	CCS	x					x					
	ChAdeMo	x					x					
Charging power	kW	11-50	≤ 11	≤11	3,7 (only 2 with 22)	22	≤22	3,7	3,7	most 3,7	most <22	n.a.
Numbers of Charging Stations/points	Charging stations	88	15	n.a	26	57	59	32	17	150 Charging Points	227	n.a.
	Charging points	180	33	25	73	120	n.a	n.a	10	150	65 (20 between 22-40 kW)	n.a.
Charging Costs	yes/no	yes	yes	yes	free	free	yes	Yes [1]	yes	yes	n.a.	n.a.
Energy Provider[2]		Verbund AG (Hydropower)	EVN AG	Wien Energy GmbH	Energie AG	Kelag AG	Salzburg AG	Energie Burgenland AG	Innsbrucker Komunalbetriebe AG	Vorarlberg Kraftwerke AG	Energie Graz GmbH & Co KG; Energie Steiermark AG	n.a

Table 1

[1] only possible if person is custumer of Energy Burgendland

[2] Source: (Bundesverband Elektromobilität Österreich)

6. EVs Types & Stock

This chapter provides information about the existing passenger PEVs and EVs throughout the European market in addition informs the reader about the EV stock and its developments in the Czech Republic and in Austria. Tesla has by far the highest electric engine power which on the one hand strongly raises the driving range however on the other hand raises also the charging time of the battery tremendous. Therefore Tesla also developed so called *superchargers* which can load the battery approximately in the same time as other EVs are loaded with level 3 (DC 50kW). Tesla is strongly increasing the number of super chargers, in Europe they are however still rare compared to the numbers in the USA. In Austria there are four locations of super chargers, in the Czech Republic there are none.

Car Brand	Model	Engine[3]	Electric-Engine Power (kW)	CO2-Emission (g/km)	elecrical range (km)	energy conten (kWh)	slow charging time (hr)	accelerated charging (hr)	fast charging time, DC (hr)	AC coupler (EV side)	DC coupler (EV side)	Power Input (kW)	Power Input DC [kW]
BMW	i3	BEV	96	13	160	18,8	6	3 (opt.)	0,5-1	Type 2	Optional: CCS	3,7/7,4	50
Citroën	C-Zero Airdream Attraction	BEV	49	-	150	14,5	6-11		0,5	Type 1	ChAdeMO	3,7	50
Citroen	Berlingo First Electric	BEV	42			23,5	6-7			Type 1		3,7	
Fiat	E500	BEV	82				<24	4		Type 1		6,6	
Ford	Focus	BEV	107	-		23	6-7	4-5		Type 1		3,7/6,6	
Ford	Transit Connect	BEV	105		130	28	8-10			Type 1		3,7	

[3] BEV ... Battery Electric Vehicle
PHEV ... Plug In Hybrid Electric Vehicle
REX ... Range Extender

Mercedes	B-Klasse	BEV	100		200	28	3			Type 1 (USA)		11	
Mia L		BEV	24			8/12	3-5			Schuko		3,7	
Mitsubishi	i-MieV	BEV	49		150	16	8		0,5	Type 1	ChAdeMO	3,7	50
Nissan	Leaf	BEV	80		199	24	8		0,5	Type 1	Optionnal: ChAdeMO	3,3	50
Nissan	e-NV 200	BEV	80			24	8/Optional 4		0,5	Type 1	Optionnal: ChAdeMO	3,3/Optional 6,6	50
Peugeot	i-On	BEV	49			14,5	6		0,5	Type 1	ChAdeMO	3,7	50
Renault	Zoe	BEV	43		160	22	6	0,5		Type 2		43	
Renault	Twizzy	BEV	13		100	6,1	3,5			Type 2		2	
Renault	Kangoo	BEV	44		170	22	6-9			Type 2			
Smart	fortwo electric drive	BEV	55		140	17,6	7	1		Type 2		3,3/optional 22	
Tesla	S 60	BEV	225		370	60		0,6/0,4		Type 2		11/optional 22	
Tesla	S 85	BEV	270		370	85		0,4		Type 2		22	
Tesla	Roadster	BEV	215		340	70	20	1-1,5		Type 2			
Volvo	C30	BEV	89		163	24	8	3		Type 2		22	
VW	e-Up	BEV	60	-		18,7	6		0,5	CCS	CCS	3,6	40
VW	e-Golf 2015	BEV	85		190	24,2	8		0,5	CCS	CCS	3,6	40
BMW	i8	PHEV	75	49	35	5,2 (net)	2			Type 2		3,7	
Chevrolet	Volt	PHEV	111	27	40-80	16	4			Type 1		3,7	
Ford	C-Max Plug in Energie	PHEV			30	7,6	2,5			Type 1		3,7	
Mistubishi	Outlander	PHEV	2*60	44	52	12	5		0,5	Type 1	ChAdeMO		50

Porsche	918 Spyder	PHEV	210	70	25	6,8	1,7		0,4	Type 2	opt.	3,7	20
Porsche	Panamera S	PHEV	70	71	36	9,4	3,8/2 bei 380V			Type 2			
Toyota	Prius	PHEV	60	49	20	4,4	1,5			Type 1			
Toyota	RAV4	PHEV	115		166	41,8	15	6		Type 1		10	
Volvo	V60	PHEV	50	48	50	12	3,5			Type 2		-	
Fisker	Karma	REX	300	83	81	20,1	5,5			Type 1		3,7	
Opel	Ampera	REX	111	27	40–80	16	4			Type 1		3,7	

Table 2[4]

[4] Data of this tablee was taken from the homepage of each vehicle brand and from the Austrian Automobil, Motobike and Touring Club; short ÖAMTC Homepage.

6.1. Czech Republic

In the Czech Republic, there isn´t a big number of EVs registered. For the date 1.1.2014, there were only 1768 E-vehicles, including only 229 cars. In comparison with other states of EU, this is not much. In addition, it must be realized that most of these vehicles are owned by distributors themselves, who use them for their own purposes, for promotion or as a part of projects leased for example municipalities of cities.

In the Czech Republic, you can find different types of e-cars. The ČEZ company in cooperation with the company Škoda auto in 2012 began the testing of electric vehicles Skoda Octavia Green E Line. The basic model of electric car became Škoda Octavia Combi, which chassis is best suited for the assembly of battery packs, electric and electronic control.

Other cars, used by company ČEZ are Nissan Leaf, with maximal speed 144 km/hr, and operating range of 200 km. Other e-car used by ČEZ are BMW i3 (maximal speed 150 km/hod and operating range of 190 km) or Peugeot Partner Electric (Maximal speed is 110 km/hod, and operating range is 170 km). E.ON uses mainly Mercedes Benz Vito E-cell, and RWE uses Citroen C-zero. Other e-car, you can meet in the Czech Republic are: Citroen Berlingo, Peugeot iOn, Smart Elektric Drive, Opel Ampera or Toyota Prius Plug-in Hybrid.

6.2. Austria

Statistic Austria collected data from the EV stock since the year 2000. In the following graphs one can see the most interesting developments of EVs in the past 15 years. The statistics do however not say which kind of EVs they considered. The information given is that these vehicles use an electric motor which actually would also include non full electric vehicles since a hybrid also has an electrical engine inside but still uses fuel as its primary energy source.

Since this seminar paper focuses on passenger EVs the following figure below shows their share out of the whole EV stock in Austria during the years 2000 until April 2015. The whole stock includes every type of one lane and two lane vehicle which needs an energy source apart of the human force to be able to move. 34% out of all EVs are passenger cars from which more than two thirds are new registered EVs.

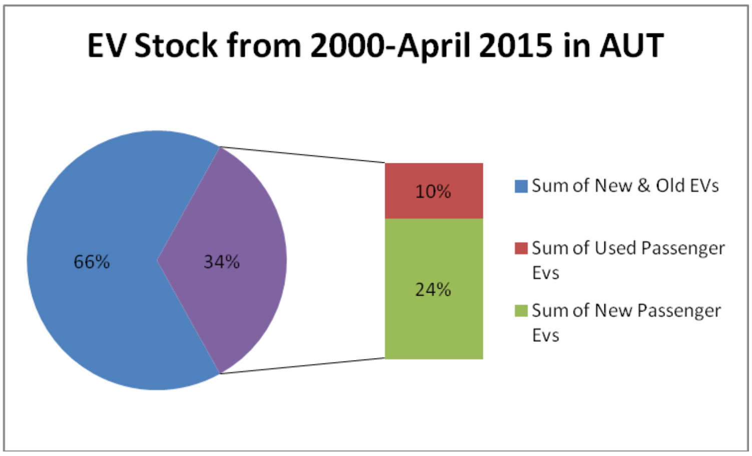

Figure 6 (Statistic Austria, May 2015)

In the figure below one can see the number of new registered EVs in Austria for each year between 200 and April 2015. This graph shows very good that the number of new bought EVs since 2008 is constantly increasing except of the year 2013. Looking only at the numbers of new passenger EVs one can conclude that the growth of these cars is about three to four years behind the entire growth development of the EV stock since a significant number of new bought passenger EVs is not until the year 2011.

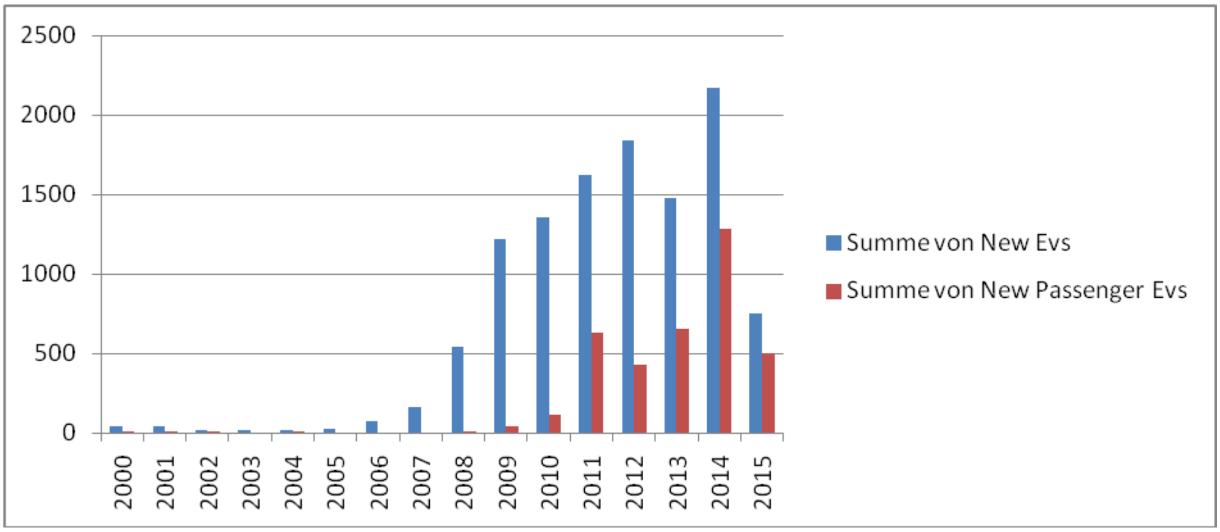

Figure 7 (Statistic Austria, May 2015)

The graph below shows the cumulated stock of passenger EVs in Austria. Comparing the graph from above with this, one can see some correlations. The cumulated stock shows an rapid growth from the year 2011 which makes sense when comparing it with the new bought passenger EVs from the graph above.

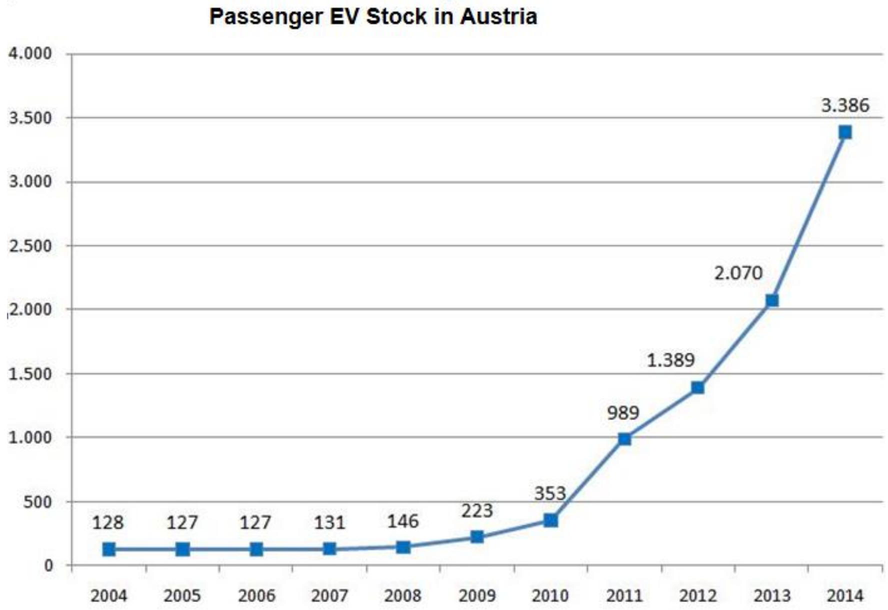

Figure 8 (Statistic Austria, February 2015)

The graph below shows the share of EVs inside the whole vehicle market, which in 2014 where bought new. It shows very good how small the EV market still is compared to the rest of the vehicle market. However the share of passenger EVs inside the pool of new bought passenger cars is even smaller with 0,4% for the year 2014. A positive development regarding the diffusion of EVs is that the share has is at least getting bigger when regarding the course of last seven years.

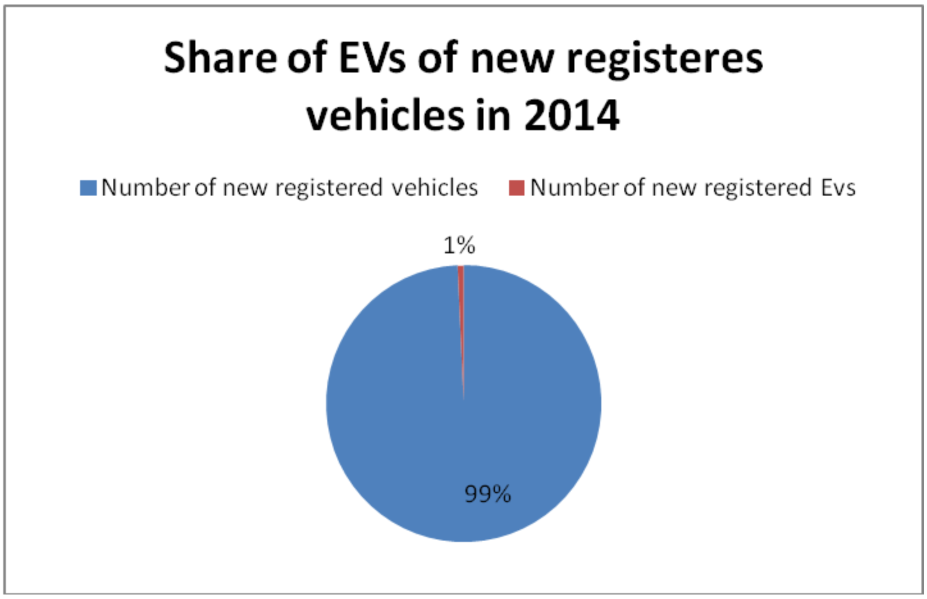

Figure 9 (Statistic Austria, 2015)

7. Ongoing projects

7.1. Czech Republic

The different projects, taking place in the Czech Republic will be presented in groups by the distributors

ČEZ

The pilot project called /E/MOBILITA started in 2009, and the main goal was to check his business strategy. At the beginning of the project, the company build 10 charging stations in Prague, and concluded a partnership with the car factory Peugeot. In the further years, the project was joined by BMW, Nissan, Opel, VW, KIA and Mitsubishi.

At the beginning, the charging stations were built in shopping centres and near to restaurants, than the company agreed the construction with municipalities… During 6 years, the ČEZ company built 43 charging stations in the Czech Republic – the majority is in Prague. 8 stations are built for fast charging. The most part of stations are in surroundings of big cities. The cars in the ownership of the company are used mainly for representative reasons or like a company car for driving in the city.

If you want to use the charging stations, you need to sign a contract with the society – the price you have to pay is 450 Kč (environ 16,2 Euro) for 3 months.

PRE

The pilot project of PRE has a name PREmobilita, and begun in 2010. The main part of the project is the landing of e-bicycles in Prague, but PRE has also 7 personal cars and one pickup for the needs of the company. Until 31.12.2013, the charging was free of charge, and since 2014, it is 2 Kč (without VAT) for 1 minute of DC charging and 0,25 Kč (also without VAT) for 1 minute of AC charging.

E.ON

The pilot project of the company E.ON id called Smart Mobility. It is focused mainly on CNG vehicles, like buses etc, but it also includes E-vehicles. Vehicles are tested by institutions (like ZOO, ADRA, Brno airport…). In the Czech Republic, there are 15 charging stations, mostly in shopping centres, and the charging is free of charge.

RWE

RWE has a pilot project called E-mobility. It is developed mainly in Germany, in the Czech Republic, it is just on its beginning – RWE is analysing the market, and built 1 charging station in Prague.

7.2. Austria[5]

In Austria there are 7 different model regions which are mainly split by the federal states of Austria. In the picture below one can see the location and size of the model regions coloured in blue. The letter signs refer to the model regions of the Austrian mailing company Post AG. All of the model regions are supported by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. All of these model regions are focusing mainly on installing charging stations, the acquisition of new EVs and the distribution of renewable energy. The type of charging stations and EVs can differ slightly between the model regions. Also the investment amount between the model regions varies strongly. Finally also the motivation techniques for the habitants inside the model regions are slightly different between the different projects. In the following table the most important facts of the 7 model regions are summarised.

[5] if not differently stated the source of this chapter is (E-Connected)

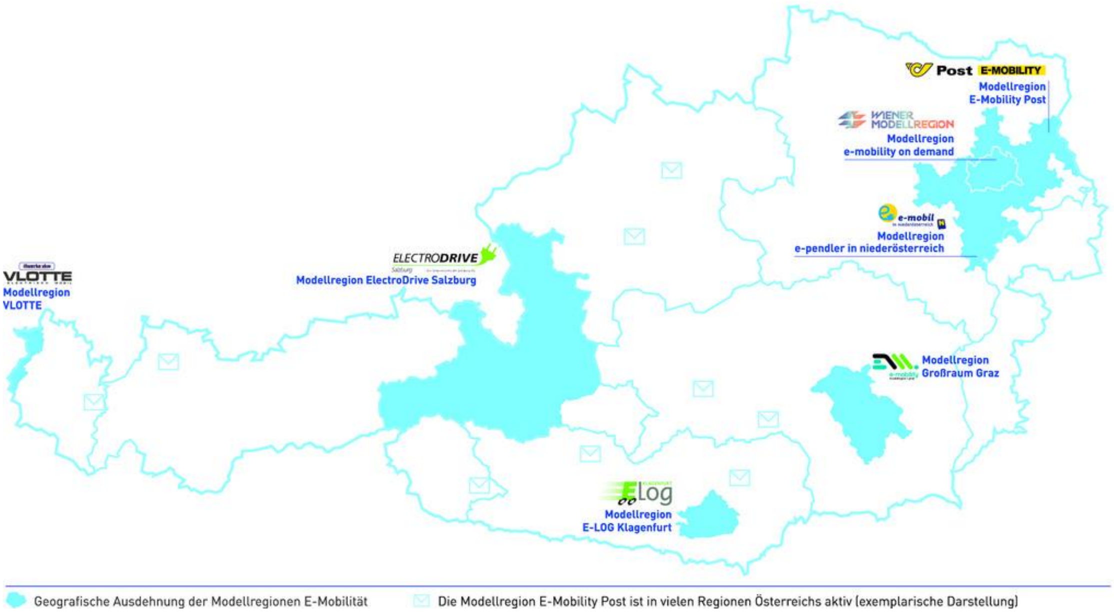

Figure 10 (© Klima- und Energiefonds, October 2014)

VLOTTE

- Start: 2008, in the EU one of the biggest and most successful model regions.
- Investment amount: 5,2 million
- Area: 260 km²+ surroundings
- Population: 366.000
- Project includes 360 EVs
- Business model: 500€/month includes EV leasing, charging for free on public stations, maintenance costs for electric; free public Transport for whole of Vorarlberg.
- Energy aspect: In addition to the charging stations they constructed a 757m² PV Area with an energy amount of 106.300 kWh. In cooperation with other companies VLOTTE invested in a small Hydro Power plant in Brunnenfeld where they own 648.300kWh of it.

ElectroDrive Salzburg

- Start: 2010
- Investment amount: 1,9 million€
- Area: 6.100km²
- Population: 510.000
- Amount of driving EVs :324 EVs (703 single lane EVs)
- Business model: Since 2012 they concentrate on the installation of semi public charging stations. The second generation is made for electric cars which can charge with level 2 (compare chapter 4.2.). For this project the most important fact is that the charging stations run with renewable energy resources. Using the RFID “Drive Card” costumers are able to charge their EVs.

- Energy aspect: Every Charging station uses renewable energy. ElectroDrive Salzburg in addition also invested in two PV and in one biomass plant.

E.Mobility on Demand (Vienna)

- Start: 2011
- Investment amount: 1,3 million €
- Area: 2000 km²
- Population: 1,2 Households
- Amount of driving EVs: 42 E-Passenger Car; 30 light duty commercial vehicles; 12 E-buses; 32 E-special –purpose vehicles.
- Business model: The focus relies on a smart introduction of EVs and car-sharing EVs into the public transport system. The goal is to introduce multifunctional mobility card which includes public transport and semi- public transport" such as car sharing, E-taxis and cooperate fleets. These semi-public transport vehicles would meet on so called hotspots which are easy to reach by public transport too.

Großraum Graz (Graz and its surroundings)

- Start: 2011
- Investment amount: 1,6 million€
- Area: 1.600km²
- Population: 476.311 → 265.000 in Graz
- Amount of driving EVs : 298 E-Passenger Cars; 1.051 E-bikes
- Business model: Leasing models for all kind of EVs (e.g. car, scooter, segway, etc.). Possibility of testing and renting EVs. A parallel development of an intelligent commutation system to provide in the future intermodal transport routes.
- Energy aspect: Several PV- panels have been installed inside the region; in total it is an area of 2.638 m².

E-Mobility POST

- Start: 2012
- Investment amount: 3,3 million €
- Area: all of Austria, however focusing on Vienna and its surroundings.
- Population: 8 million. → 1,8 million. in Vienna
- Amount of driving EVs : 653 EVs → 581 single lane EVs; 58 double lane EVs; 14 light duty commercial vehicles and 70 natural gas vehicles
- Business model: The Austrian mail company "Post AG" is integrating step by step more EVs into their vehicle fleet. Therewith also the driving routes and charging infrastructure has to be adapted including PV panels to provide energy from a renewable source.
- Energy aspect: In 2013 the Post AG installed a PV facility on the roof of the central letter office (Briefzentrum Wien) which provides Energy of about 917.000 kWh.

E-LOG Klagenfurt

- Start: 2012
- Investment amount: 1,6 million€
- Area: Klagenfurt and its surroundings; 700km²

- Population: 150.000 → 95.000 in Klagenfurt
- Amount of driving EVs : 200 EVs (
- Business model: E-LOG Klagenfurt wants to build a logistics centre for EVs on the peripheral of Klagenfurt. The centre will count 200 EVs which are provided to service and logistic companies. For each EV also a charging box is included. To reach the car pool centre fom the city 3 City Trains are installed which have hydrogen fuel cells as there power source.
- Energy aspect: To compensate the additional energy consumed by the EV-pool an area of 6.300 m² of PV panels is going to be installed

E-Pendler Niederösterreich

- Start: 2012
- Investment amount: 1,3 million €
- Area: 740 km² around Vienna
- Population: 296.000
- Amount of driving EVs: Until June 2014 there were 88 EVs and 8 E-bikes. The goal is to have 102 passenger EVs, 3 E-buses and 86 E-bikes until the end of the project lifetime.
- Business model: The project focuses especially on the commuting traffic which should become more energy efficient by better combining the public with the individual transport and more environmentally friendly by introducing EVs to the habitants. The introduction of a new mobility package that include a general guidance on the topic, the possibility to buy an EV including a charging box which provides energy from renewable sources.
- Energy aspect: On the one hand it s planned to install PV facilities with an energy output of 440 MWh/a which should directly feed the private and semi private charging stations. On the other hand additional PV facilities for public charging stations are going to be installed.

Lessons learned

The first model region started with VLOTTE in 2008. Until now it is the only model region that has written a report about their experience during the project lifetime which ended in 2014. It is very hard to find actual information about the other ongoing model regions. The newest information is already one year old. However there are some challenges which are common for all of them:

- Passenger EVs are mostly used for short routes between work and home. This is no surprise since this is the case for all of the passenger cars. However the difference is that the EV is usually charged during the working time and again at home. By having charging possibilities at home and at work these drivers don’t need an additional infrastructure. This fact makes the change from a combustion motor driven car to an EV very simple and could be the reason for its success.
- Introducing EVs for a city however is more complicated since most of the population live in flats and park their car on the streets. However installing charging stations

throughout all of the streets would lead to huge space reductions and a cable chaos and could be a security risk since the charging stations use high voltage for charging. That is also the reason why people always talk about hot spots when introducing EVs into cities. On these hot spots public transport is available so that EV drivers can park and charge their car their and continue their journey into the city by public transport. So on these hot spots the individual transport meets the semi public and public transport. Ideally in the future there should be no need for individual transport inside the cities anymore. People would be using share taxis and public transport.

- The charging behaviour of EV drivers affects the grid negatively because they mostly it is in the mornings when getting to the office and in the evenings when getting home when people charge their batteries. One study of VLOTTE says that the average energy needed for one route is 20kWh. This means that with each EV more the grid in the mornings and evenings is has to cope with 20kWh additionally which will lead to immense load peeks. This is the reason why it is not just enough to install some box for charging EVs but to parallel develop a whole charging management which considers the above mentioned and the driver's needs.
- In general the energy aspect in the matter of e- mobility is very important which is why it has to be considered in every project for the model regions. On the one hand EVs only make sense if their energy comes from a renewable source which nowadays is not always the case because people just install their wall box without considering from where they get the electricity. Also the public charging stations installed through the model region projects not always take their energy from a renewable source. To "clean" their footprint they put up some solar panels which feed their energy to the grid. This is however holds some problems because this additionally stress the grid. The more gentle way which is also done by some model regions is to transmit the energy from the solar panels directly the batteries of the EVs.

Other interesting Projects (Klima und Energy Fonds, 2011)

The following projects are the results of future challenges, especially concerning the technology which come within the diffusion of e-mobility. Only the combination of model regions and these "technical" projects make a sustainable and efficient development of e-mobility possible.

Empora

When the number of EVs rises the energy amount to charge the car rises too. The problem which rises within is that in the peek ours for example when people arrive at work in the mornings everybody will connect the car to charge it. This additional amount of electricity needed however stresses the grid extremely and could lead to a breakdown because of overload. Therefore and integrated system is developed which can regulate the amount of energy taken to charge the cars. Empora develops a system which can control the amount and flow direction of electricity.

Smile

Towards a more efficient and cleaner mobility concept, it is important that people are able to combine different means of transportation to reach their desired goal in shortest time possible with less complication possible. Therefore Smile is working on an app which will manage all transportation systems. This app offers people options to reach their destination including the duration, costs and CO_2 emissions. Within this app one should be able to pay for every transport system.

Crossing Boarders

The development of e-mobility should not stop at the Austrian boarders since EVs should be able to cross countries without troubles. Therefore the project has as aim build up an infrastructure for EVs which connects Munich, Salzburg, Vienna and Bratislava so that EV drivers can drive from one end to the other without problems.

7.3. Europe - Norway

For the comparison with other country from Europe, we chose Norway – the main reason is, that in Norway, there are 5% of all electric cars in the world, and the total number of cars on electricity and plug-in hybrids exceeded 1% of all vehicles registered. They are currently the indigenous traffic drives over 30-thousand. At the end of 2015, their number could be increased to 50 thousand, which would be managed to meet the government's target two years in advance.

Electric mobility is one of the ways the government to achieve government targets on climate policy. Average CO_2 emissions from new passenger cars in Norway must reach by 2020 to the level of 85 g / km. For comparison, the objectives of the European Union are slightly less ambitious, 2020 Brussels calls for meeting the emission limits 95 g / km. Approximately 98% of the country's electricity is produced from carbon-free sources, hydropower is absolutely dominant.

The Norwegian Government in 2009 established the organization Transnova. It covers the dissemination of new technologies aimed at reducing CO_2 emissions in the transport sector. Within its competence also it includes the construction of charging stations for electric cars charging stations can be crucial especially for taxi services that are considering converting corporate fleets to electric vehicles. The beginning of the Norwegian support when buying a car on electricity dates back to the early 90s of last century. Support mechanisms dosed Cabinet process until the market responded by growing interest in electric cars.

One of the most motivating incentives that persuaded Norwegians buy the electric car has become an exemption from the payment of VAT. Effect also has the option driving lane that is reserved for buses. Another motivation for buying a car with electric traction in Norway is exemption from tolls. The Nordic country is definitely not a cheap thing, only in the region of Oslo stand tolls 1 thousand per year. In other parts can climb up to 2 thousand euros per year. If you have an electric car, you do not pay the toll.

New owner of the car on electricity in Norway may not pay a registration fee. Oslo is for vehicles with alternative propulsion allocated free parking spaces. Most of electric cars in Norway belong to private persons. In households normally fulfil the function of the other car. In January 2015, the number of newly registered electric cars in Norway reached 18% of all passenger cars registered for the month. From a total of 10,532 cars were powered by 1895 clean electricity. To the number of electric vehicles registered in the same period last year (January 2014) is a more than 70% percent increase. If we add to this amount and plug-in hybrids, the ratio exceeds the limit of 20%.

A certain obstacle to the further development of , e-mobility in Norway could become a 50 000 registered electric cars, which are expected later this year. After exceeding this limit could be lifted favourable conditions for the purchase and operation of electric vehicles, but on the next steps solutions to this situation has not yet been decided.

7.4. Comparison of the Czech and Austrian E-Mobility Development

Czech Republic and Austria both belongs to the region of Central Europe. In this region, Austria is the leader in the field of e-mobility. However the development of e-mobility in the Czech Republic is really small, comparing to Austria (as you can read upper in our paper), in the region, it belongs with Poland to the group of “fast followers”. The main difference between the Czech Republic and Austria in the field of e-mobility is the support from the government. In Austria, e-mobility has a strong support – from the Federal Ministry of transportation, innovation and technology. In the Czech Republic, the support is very limited, and there are only few incentives to buy. In Austria, there are many pilot project regarding e-mobility – 5 utility providers are very active, and support large-scale pilot projects. In Czech Republic, there is not a lot of pilot projects, and the existing ones are mainly regional, and in a small-scale.

At the figure 10, you can see a comparison of the number of newly registered e-vehicles in Czech Republic and Austria between years 2011 and 2014 – you can see, that in Austria, the number is much bigger than in the Czech Republic.

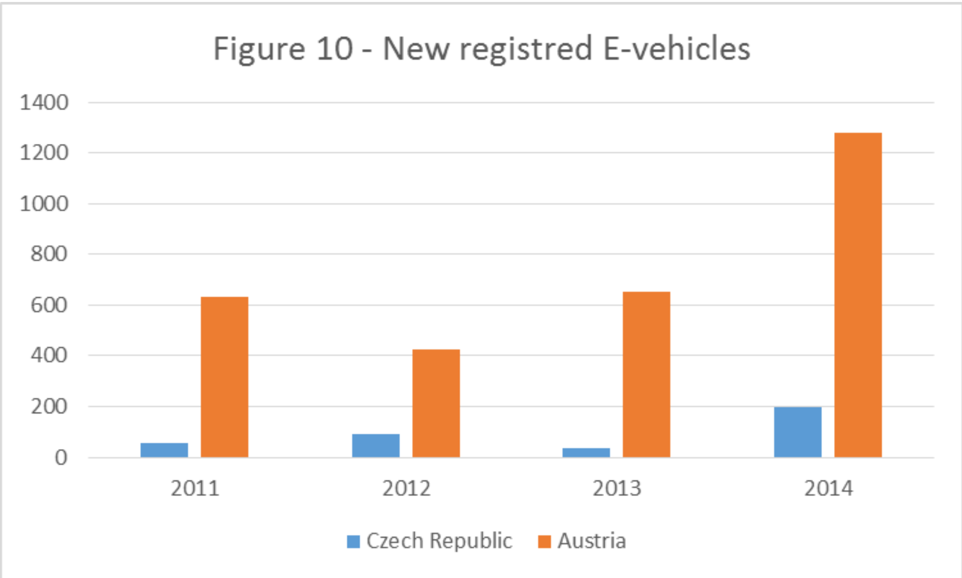

Figure 11 (Source: Statistik Austria, Czech Statistical Office, Mai 2015)

8. Conclusion

8.1. Expectations for future development- What needs to be done to enforce the efficient diffusion of E-mobility

In many countries the motivation for supporting e-mobility has different targets. While priority targets are also crucial for the chosen means of incentives – e.g. Norway is mainly about shopping premiums when buying an electric car for end users. In Germany however, where initially there were no German electric vehicles, financial assistance was channelled mainly into research and innovation for e-mobility, which should bring the effects of all German carmakers and their suppliers. The federal government supports program for e-mobility outside these sub-goals also sets out the main strategic objective to create in Germany until 2020 the most important centre of EV production and the biggest producer for electric vehicles in the world. This goal is extremely ambitious, but not impossible, as the example of renewable energies, which in some fields Germany became a true pioneer and world leader.

Though the strategy for supporting e-mobility may be different in each country there are some common challenges which need to be solved for a successful diffusion of e-mobility. One of these challenges is the installation of fast charging DC stations. In Europe there are only very few DC charging stations compared to the rest. These however are indispensable since people do not want to wait 2 hours until the battery is charged. In addition technology is moving towards batteries with a lot more energy capacity which on the same time means longer charging time.

Another challenge which comes within the rising numbers of EVs the grid overload especially during peak hours. As mentioned in the paper before there are already people working on this topic. However there are still some questions raised concerning the charging time of a car. If the electricity which is used to charge the EV is throttled to avoid an overload, the charging time of the battery is prolonged without the driver’s knowledge. And what if the driver needs the car to be charged in a certain time but it is impeded because of the power reduction? To be able to give the people the same flexibility as they have now with combustions engine driven cars some kind of communication system that allows people to survey and give limited control of the charging process. If a person really needs to charge the EV in a short time they may have to pay more for the electricity but the communication system would make it possible.

As one see throughout the paper there are a lot of different directions taken to enforce a faster diffusion of E-vehicles. However, all these directions have common goals – the main ones are the reduction of selling price of E-vehicles and the minimization or elimination of the biggest possible number of disadvantages.

The electrical engine is simpler than combustion motor, it doesn´t need the demanding maintenance, so there isn´t the possibility to improve it. Essentially, it all turns about battery, because the most of disadvantages rely on the battery.

8.2. Advantages and disadvantages

ADVANTAGES

- Zero emissions if charged with renewable energy sources
- One litre equivalent of electricity is much cheaper that gasoline.
- Fast technological improvement so that nowadays already feasible
- Compared to other zero emission vehicles, EVs are the most common on the market
- Noise reduction
- Simplicity of electromotor – no maintenance, long lifetime
- the possibility of charging from any outlet (in the future – possibility of charging from any outlet)

DISADVANTAGES

- Battery need to be improved concerning: Driving range, charging time, safety (impede explosions when there is a crash, especially Lithium batteries are very delicate in this aspect)
- Batteries are made from rare earth materials which are limited (lithium)→ recycling system of batteries need to go hand in hand with development.
- Still very high battery costs (Which will shrink with the number of EVs produced)
- “Transport Problem” not solved by exchanging combustion engines with electrical ones→ Number of vehicles driving on streets will be still rising.
- The idea that the EV batteries could work on the same time as storage of power is not realistic since the capacity is far too small.
- Purchase price – very high (approx. 2*the price of vehicle with combustion engine,
- The necessity of construction of the network of charging stations – very costly
- Conductive charging may lead to a cable chaos in parking houses since every EV would be charged while working. However the biggest question is how the EVs are going to be charged inside the City. Nowadays cars are everywhere parked. It would not be possible to install for every parking spot a charging station. Also if there is only one charging station per street, how does it work with the cables?

8.3. Policy measurement - European strategy on development of EVs

The European Union in recent years intensively promote projects and activities grouped under the theme of e-mobility, in the context of the overarching goals of the Europe 2020 targets a concrete expression of the climate and energy commitment is known as the "20-20-20", which aims by 2020, reduce greenhouse gas emissions by 20% below 1990 levels, increasing the share of renewable energies in overall EU consumption to 20% and increase energy efficiency in Europe by 20%.

EU has ambitious targets for transport: for example the White Paper on transport plans that already in 2050 in the cities will not run any cars powered by conventional manner and overall emissions in the transport sector compared to currently reduced by up to 60%.

Financial support for activities aimed at achieving these goals is huge, for example to increase the budget of the program Horizon 2020 to support pan-European research and development, by 46% to € 80 billion, while the share of science and research, and had risen to 8.5% across the EU budget .

Essential to promote e-mobility and modern technology is also an initiative Smart Cities and Communities, which aims to promote modern technologies in European cities. To achieve this objective, the three commissioners, transport, energy and ICT, together with industry leaders defined the theme of Smart City on the pillars of sustainable transport, sustainable neighbourhoods and integrated infrastructure.

References

BEÖ [Online] / Verf. Bundesverband Elektromobilität Österreich. - 21. June 2015. - http://beoe.at/.

Clean power for transport – Frequently asked questions [Bericht] / Verf. European Commission. - Brussels : [s.n.], 2013.

E-Connected [Online] / Verf. E-Connected. - 21. June 2015. - http://www.e-connected.at/content/modellregionen-0.

Klimafonds [Online] / Verf. Klima und Energy Fonds. - 2011. - 22. June 2015. - https://www.klimafonds.gv.at/unsere-themen/e-mobilitaet/leuchttuerme/.

Stat Cube [Online] / Verf. Statistik Austria. - Statistik Austria, June 2015. - 21. June 2015. - http://statcube.at/superweb/timeout.jsp.

Elektromobilita -ČEZ [online]. [cit. 2015-06-23]. - http://www.odbornecasopisy.cz/data-ftp-user/konference/2015/Perspektivy_emobility_AMPER_2015/04-Chmelik_ELEKTROMOBILITA_SKUPINY_CEZ.pdf

Nabíjecí infrastruktura pro elektromobily [online]. [cit. 2015-06-23]. - http://www.top-expo.cz/domain/top-expo/files/8.cdf-2012/prednasky/kuzelka_miroslav.pdf

Charging system [online]. [cit. 2015-06-23]. - https://www.clponline.com.hk/ev/Pages/ChargingSystem_ChargingMethods.aspx

E-mobility in Central and Eastern Europe [online]. [cit. 2015-06-23]. - http://www.rolandberger.cz/media/pdf/Roland_Berger_CEE_emobility_study_20111020.pdf

Figures

Tables