Economics of E-mobility: costs, fuel, electricity prices & taxes in Austria & Czech Republic

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Abstract: The article provides a review on support measures for electric vehicles which have been currently implemented within the European Union. We analyze different policy instruments including a CO_2 tax aiming to support the introduction of electric vehicles in Austria. Also this paper presents a total cost of ownership (TCO) model for automative offices of Nissan, Peugeot, Renault, Mitsubishi and Think City in Austria and some cars in EU-15. All costs that occur during the expected vehicle's lifespan are included: purchase cost, registration tax, vehicle road tax, maintenance, tires and technical control cost, insurance cost, battery leasing cost, battery replacement cost and fuel or electricity cost. Hence three alternative policy support measures have been assessed to promote EV to ICE.

1. Introduction

Climate change, which accelerates due to greenhouse gases emissions, is the greatest market failure ever. The task is to take a strong action to reduce GHG worldwide, before the climate change irreversibly affects ecosystems, societies and economies. Due to their higher energy efficiency rate, electric vehicles (EV) can play a substantial role in the energy reduction and greenhouse gas emission goals of the European 20-20-20 objective. Currently 98% of the transportation sector in the EU depends on fossil fuels. This sector is responsible for 21% of the greenhouse gases emissions, with more than half of the emissions produced by ICE. The EU Directive (2009/33/EC) promotes clean and energy efficient road transport. Hence it has a goal to decarbonize the transportation sector and to reduce oil dependency. To enable mass roll-out of electromobility in Europe, the first challenge can be qualified as social acceptance, which is crucial, but also highly dependent on technological and logistic development related to wide scale of needs and prerequisites such as charging infrastructure range, costs of batteries and other costs related to electromobility. Therefore, this paper presents total cost of ownership (TCO) analysis and analyze different policy instruments by comparing EV and IC in Austria. Electric vehicles that we are going to look will be hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs).The article is structured as follows. Section 2 provides TCO of different types of EVs, section 3 support scheme for EU-15, section 4 represents methodology and data. Section 5 presents EV market overview in Austria and Czech republic. And last two represent conclusion made by our research in papers.

2. TCOs of different types of EVs

TCO analyses can be divided into two main categories:

1.Consumer oriented studies

2. Society oriented studies

In the first group, the consumer point of view is considered. The costs that are perceived by the consumers are incorporated and different vehicle technologies are compared.

Society oriented TCO studies have a broader scope: next to the consumer costs, externalities (emissions, noise, etc…) and the associated external costs of EVs. TCO reveals that BEVs are still a very expensive alternative, even if they have the most positive impact on the environment. Reason for sure would be limited range, change for this would be if battery prices drops or fuel prices for ICE increases (significantly). HEVs TCO differs little from conventional vehicles, because in this case we have a same driving distance and lower impact on the environment. For FCEVs TCO is still very high, and probably won´t lower for the upcoming years.

3. Implemented support schemes for EV in the EU-15

Many EU member states have introduced national targets for the EU driving stock, the expansion of charging infrastructure, or production targets of electric vehicles [1]. Hence most EU member overcome the cost disadvantage of alternative vehicles by introducing policy instruments, such as an up-front price support in order to increase the affordability of electric vehicles by reducing its cost, which is considered as one of the key barriers for consumers. Policy instruments that are currently implemented in order to stimulate the up-take of alternative propulsion systems consists of [1]:

-Registration of purchase taxes

These taxes are an up-front cost and can have a strong impact on CO2 emissions and the market, if costs are differentiated with regard to the specific CO2 emissions of the vehicles. For instance in France, where vehicles above certain CO2 emission thresholds have to pay a malus and vehicles under the threshold receive a bonus.

-Circulation or motor taxes

These taxes have a limited effect on the purchase, because they are annual or monthly charged. But they are considered politically acceptable, their impact to promote EV is low.

-Fuel taxes

Fuel cahrges have a limited short-time effects, because they do not change the purchasing decision of consumers in the longer term.

Policy instruments, which are going to stimulate the up-take are subsidies, taxation of benefits in kind and treatment of using parking charges. Next table (Table 1) provides some of the implemented support measures in the EU-15.

Table 1: Policy instruments to supporting EV in the EU-15

Country	Economic instruments for the support of EV
Austria	Exemption from fuel consumption tax Exemption from monthly vehicle tax
Belgium	Purchasers of electric cars receive a personal income tax reduction of 30% of the purchase price (with a maximum of EUR 9,000)
Finland	Exemption of fuel tax
Italy	A tax incentive of EUR800 and a two year exemption from annual circulation tax is granted for the purchase of a new passenger.
Denmark	Exemption from registration tax and annual circulation tax. Further EV qualify for free parking
Germany	EV exempt from the annual road tax for a period of five years from the date of the first registration
Spain	Various regional governments grant tax incentives for the purchase of alternative fuel vehicles including EV – approx. EUR 6,000
France	Bonus-Malus System; New Cars with CO2 emissions below 125 g/km receive a premium. EV receive currently EUR 5,000
Greece	EV exempt from registration tax. If engine capacity below 1929 cc, exemption from road tax. Further EV are even allowed to drive in Athens when parts of the city are restricted to ICE to reduce traffic congestion.
Ireland	EV exempt from registration tax – approx. EUR 2,500.
The Netherlands	approx. EUR 6,400 reduction from the registration tax
Portugal	Exemption from registration tax
Sweden	Exemption from annual road tax for a period of 5 years upon first registration
United Kingdom	Exemption from annual road tax
Ireland	Exemption from registration tax
Luxemburg	Annual circulation taxes based on CO_2 emissions

Source [1]

Also some policy instrument that is active in Austria is parking management.[3] There are free EV parking in several cities: Klagenfurt, Villach, Wolfsberg St. Veit a. d. G., Salzburg *(only while charging)*, Graz, etc. [3]
As for the neighboring country of Austria, Czech republic, since 2016 the government have been granting subsidies for electromobile´s, CNG automobile´s and plug-in hybrid´s purchase. Depending on vehicle this subsidy starts at 50 000 CZK (cca 1 860 EUR) . Another policy instrument is parking management in the capital city Prague. EV also have the right of getting highway stamp free (cca 56 EUR).

4. Methodology, scope and assumptions

The TCO is a function of different parameters, some of which are related to the vehicle technology: purchase cost, registration tax, vehicle road tax, maintance, tires and technical control cost, insurance cost, battery leasing cost, battery replacement cost and fuel or electricity cost. TCO is defined as following:

$$TCO = -I + \sum_{t=1}^{N} c(1+r)^{-t} + R(1+r)^{-N} \quad , \qquad (1)$$

Where I-purchase price, c- maintance and operating costs, r the discount factor and R the resale price. Maintance and operating costs include infrastructure charges, insurance, fuel consumtion tax (NoVA) and the monthly engine related vehicle tax (motorbezogene Versicherungssteuer). TCO that was analysed in this article have been calculated for limited vehicle dealer manufacturers and importers in Austria. As mentioned before survey has been conducted with

Nissan, Peugeot, Renault, Mitsubishi and Think City. The ICE have been chosen of similar size and technical specifications. Table 2 provides and overview of main specifications and costs of EV and ICE for which TCO have been calculated over the period 2011 until 2020.

Table 2: Technical, performance and cost assumptions of analyzed vehicles

	VW Golf Rabbit	VW Golf Rabbit	Nissan Leaf	Peugeot iOn	Mitsubishi i-Miev
Technology					
ICE engine displacement (l)	1.6	1.2	-	-	-
Turbocharger (yes/no)	yes	yes	-	-	-
PT power (kW)	77	77	-	-	-
Electric motor power (kW)	-	-	80	47	49
Battery capacity (kWh)	-	-	24	16	16
Energy source	Diesel	Gasoline	Electricity	Electricity	Electricity
Performance					
Weight (kg)	1,314	1,314	1,545	1,120	1080
Acceleration 0-100 km/h (in s)	11.3	10.6	-	-	-
Top speed (km/h)	190	190	140	130	130
Fuel consumption (l/100km)	4.1	5.2	-	-	-
Electricity consumption (kWh/100km)	-	0	15	15	15
Tailpipe CO_2 emissions (g/km)	107	121	-	-	-
Costs					
Vehicle incl. VAT and NoVA (EUR)	20,350	22,120	39,600	36,000	35,900
NoVA (fuel consumption tax in % of purchase price)	4%	4%	0%	0%	0%
Battery cost (EUR/kWh)	-	-	600	600	600
Battery cost (EUR)	-	-	14,400	9,600	9,600
Loss in value p.a.	17%	16%	32%	32%	32%
Maintenance cost (EUR/100km)	4.6	4.1	2.5	2.5	2.5

Source [1]

Data was provedes such as 15000km are traveled annually over a period of five years, because manufactures expect that the battery of EV needs to be replaced after 75000km. We also assume that the purchase price of ICE will not change over time, because further efficiency gains in ICE are costly. Currently battery costs amount to approx. 600EUR/kWh and will decrease to approx 300EUR/kWh. And for replacing the battery pack, we consider a price of 400EUR/kWh. The battery of HEVs and PHEVs is not expected to be replaced. Some car manufactures sell their electric vehicles without the battery, hence customers are obliged to sign a contract for battery leasing. And the guarantees that manufacturer gives is battery change if a battery capacity would drop under 80% of its original capacity.

Tires are expected to be changed every 40 000 km [2]. Here we include 32EUR to replace the tires and 24 EUR for balancing.

Also there are maintenance costs that are depend on the vehicle type and annual mileage. They include oil replacements, brake replacements etc. Maintenance cost for BEVs is 65%

of a similar conventional vehicle [2]. Maintenance costs of hybrid cars, they are considered to be the same as ICE cars.

The current gasoline price in Austria amounts to 1.3 EUR/l and for diesel to 1.1 EUR/l including taxes and charges. The electricity price for Austrian households is currently to 0.15 EUR/kWh with taxes and charges. The average increase in the electricity price from 2000 until now has been circa 2.8%. Similar price developments are assumed to 2020.

While assuming TCO, many countries in Europe already accepted this assessment, however in the case of Czech republic and other middle and eastern Europe countries lack this approach. Its absence within EV market in these countries is alarming.

The current market price of Nissan Leaf in Czech republic is 730 000 CZK (27 177,96 EUR incl. VAT), Mitsubishi i-Miev costs 726 000 CZK (27 029 EUR incl. VAT) and Peugeot iOn costs 592 800 CZK (22 070 EUR incl. VAT).

As for the tires, the cost of replacing and balancing in the Czech republic is very different from one supplier to other. The cost therefore usually ranges from 200-400 CZK (7, 44 EUR to 14, 88 EUR) in usual autoservice to replace tires, while in Prague the price can amount around 1000 CZK (37 EUR). As for the balancing, it uses to be up to 350 CZK (13 EUR).

The current gasoline price in Czech republic is about 1.15 EUR/l, but for diesel 1,11 EUR/ l including taxes and charges. We can see, that diesel costs the very same in Austria and the Czech republic, but gasoline is cheaper in the Czech republic. The electricity price for Czech households is currently about 0,14 EUR/kWh.

As the costs in the Czech republic are very sporadic and range widely, with EV market so niche and is in early adaptor stage, with low market share and also low number of EV itself, therefore many data is missing, we decided to compare some cars with their TCO in EU-15, for better understanding, but also to make a brief comparison of the EV markets in the Czech republic and Austria, to make the differences more clear. Afterthat we made a conclusion of the results.

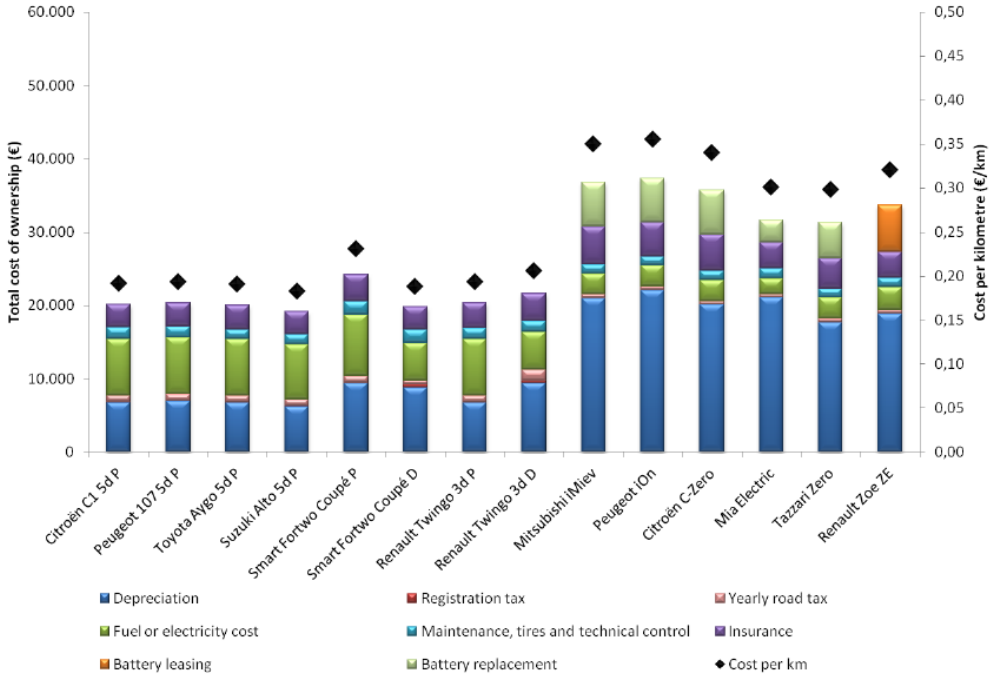


Figure 1: TCO results for small city cars

Source[2]

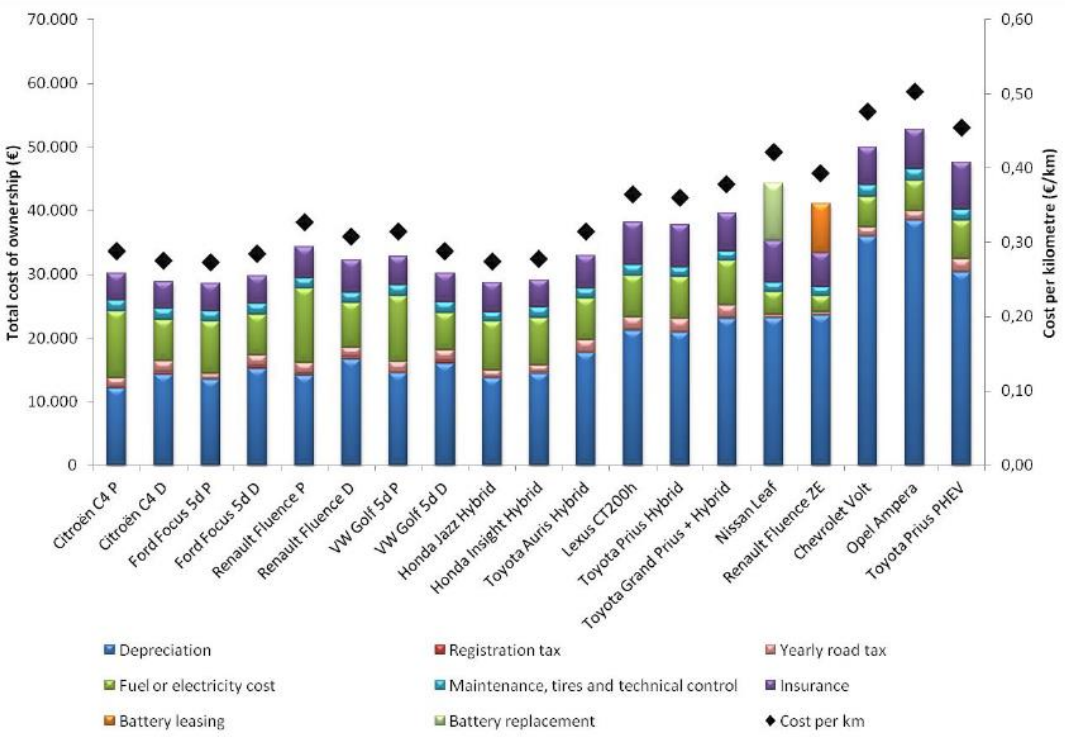


Figure 2: TCO results for medium cars

Source [2]

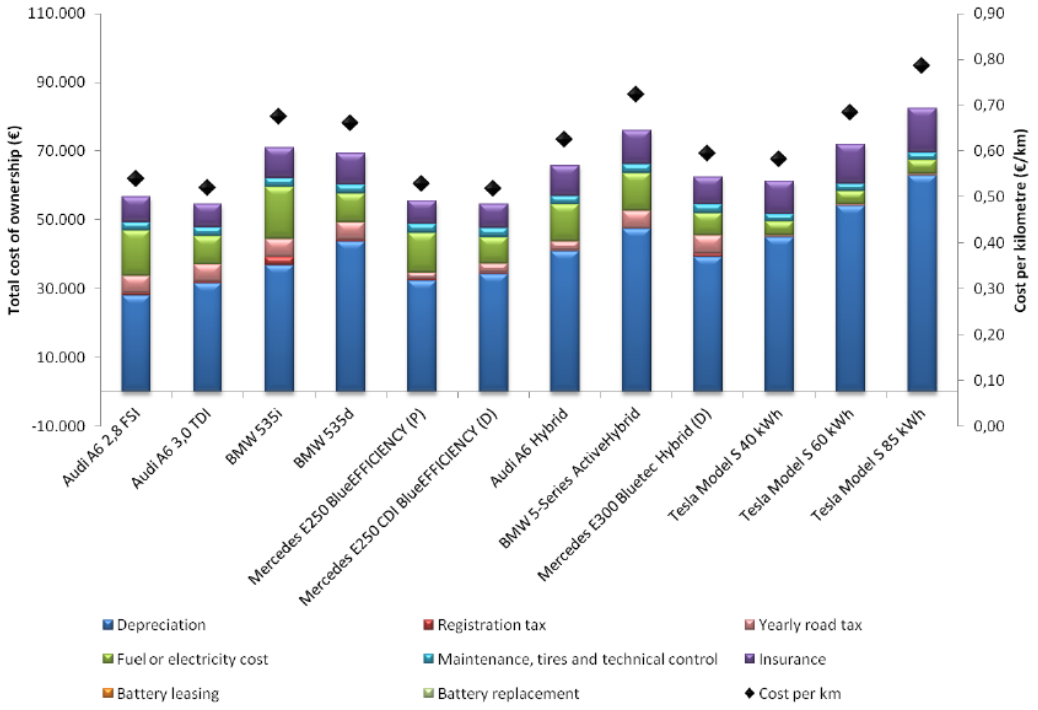


Figure 3: TCO results for premium cars

As it was analysed in paper that we used we can see that for small cars in EU-15 difference between ICEVs and BEVs is: for small petrol cars range 0.18-0.23EUR/km and small diesel cars range from 0.19-0.21EUR/km and BEVs range from 0.3-0.36EUR/km. BEVs TCO is higher compared to petrol and diesel cars in this case, but pro for BEV is that fuel and electricity costs are lower for selected cars.[2] Ranges for medium cars are 0.27-0.33EUR/km for petrol cars, 0.28-0.31EUR/km for diesel cars, 0.27-0.38EUR/km for hybrids, 0.39-0.42EUR/km for BEVs and 0.45-0.5EUR/km for PHEVs. This figure shows that this BEVs are closing ICE. And if a consumers wants to combine the eco-efficiency of BEVs with the driving range of conventional vehicles, PHEVs are still a costly option.[2]

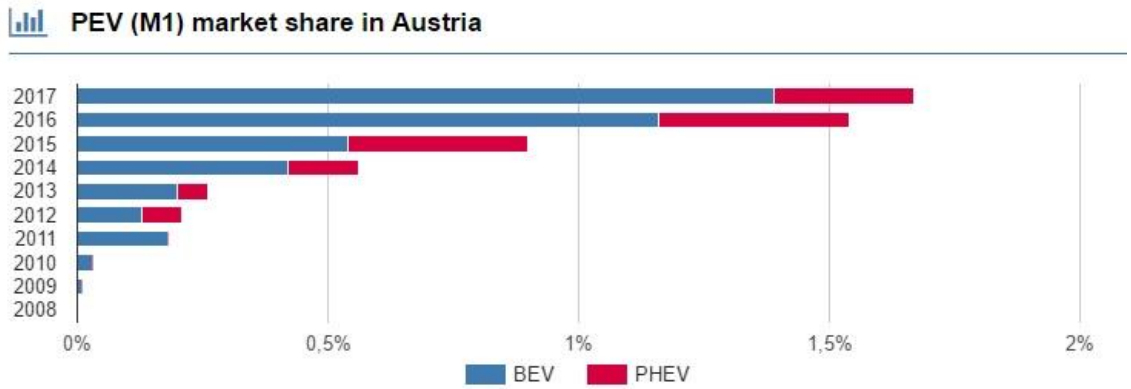
For the premium car segments we have: 0.53-0.67EUR/km for petrol cars, 0.52-0.72EUR/km for hybrids and 0.58-0.79EUR/km for BEVs. Model with the largest battery pack is cost comparable with HEVs. And it is very important to mention that Tesla warranty gives battery replacement after 7 years or 160000kms.[2]

5. EV market overview

Although electromobility still remains a very niche market, it propose a huge potential for the future. It can be supposed, that the number of EV will increase worldwide and this trend already started. New registrations of EV increased by 70% between 2014 and 2015. Over 550 000 EV was sold in 2015. More than half of these registrations was made in China and US. Other countries that drive the shift are Norway, the Netherlands, Sweden, Denmark, France, Japan, Germany and United Kingdom. As we can see, Austria and Czech republic is not on the list. So how the situation looks like on markets of these two countries?

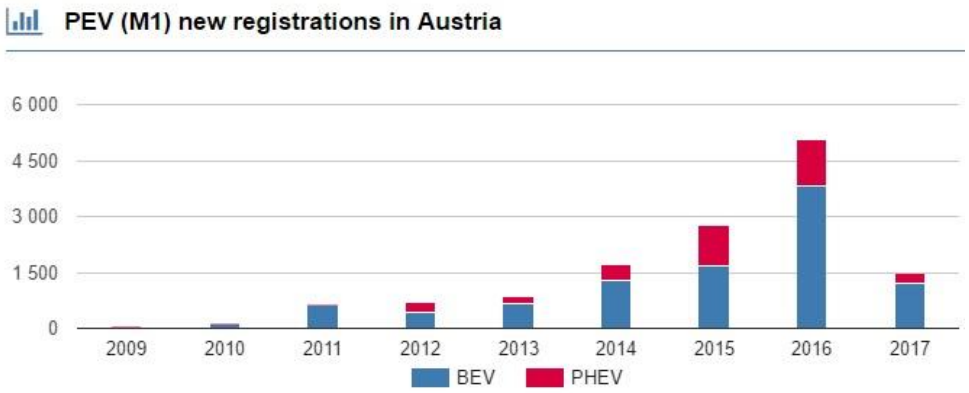
MARKET OVERVIEW AUSTRIA

Although Austria was not higlighted as one of the leader countries of electromobility, as on the table below, it is clear, that there is strongly increasing market share of EV in Austria from year to year. By the year 2016 the market share exceed 1,5 %, which is relatively high performance. As the trend of increasing market share is quite stable, year 2017 should be the year with even higher market share.



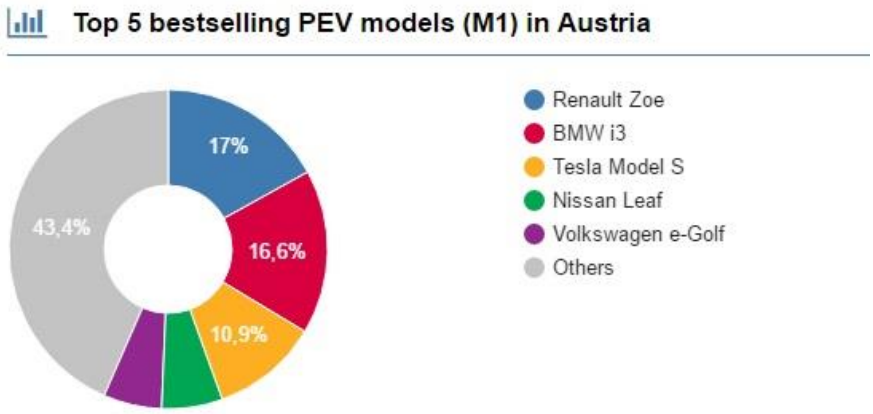
Source: AEFO

As for the amount of new registrations in Austria, the year 2014 was the year, when there was more than 1500 EV registrations per year. Since there the amount increases each year by nearly 1 500.



Source. EAFO

Bestselling EV as for the models are Renault Zoe, BMW i3, which both have nearly same market share, followed by Tesla Model S and the others like on the table below.

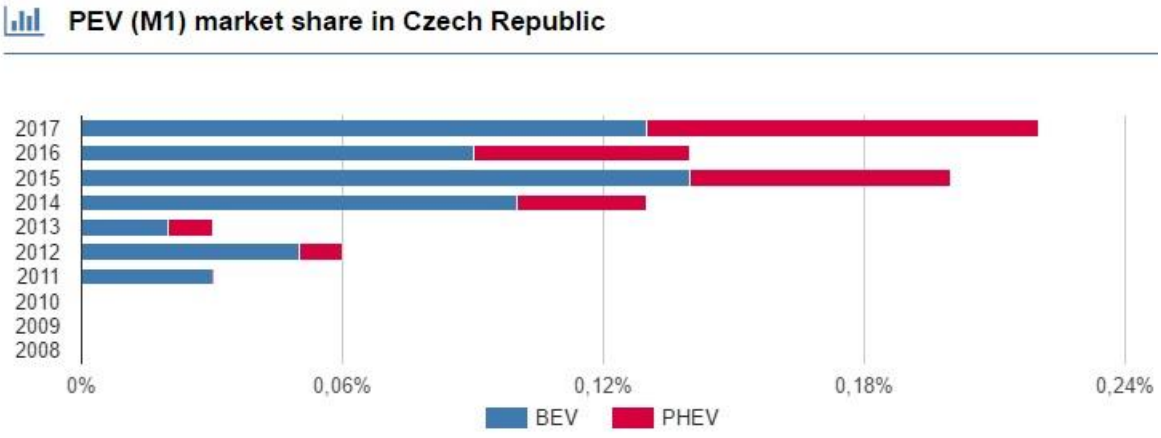


Source: EAFO

It can be stated, that the expansion of EV demand on both markets in Austria and the Czech republic, started in 2014. However, while the situation looks quite predictable with good performance of the EV market in the case of Austria, the situation in the Czech republic remains at the early stage of adopting and shifting demand towards electromobility. While assessing the market overview and the totally different performance of the EV market in Czech republic, considering also other circumstances like consumer behaviour and also the government policy, maybe the core difference lies in the fact of Austria getting much more attention and efforts in the field of green, or let´s say environmentally friendly goods, technologies and energy.

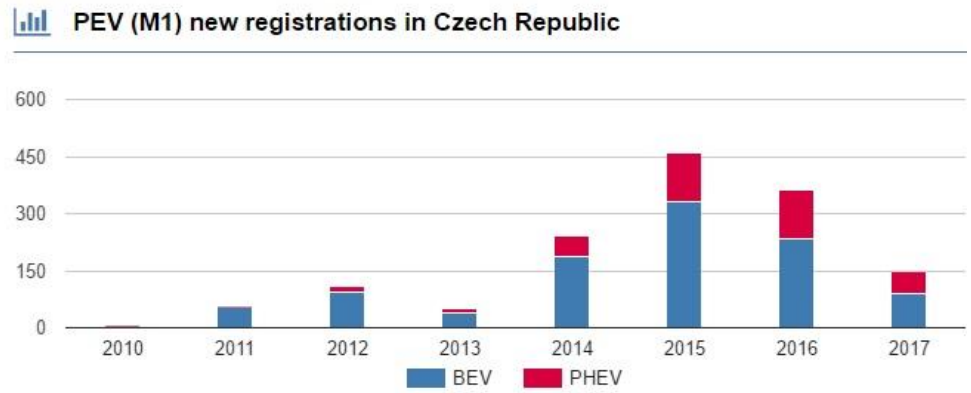
MARKET OVERVIEW CZECH REPUBLIC

The situation in the Czech republic is much worse in comparison with Austria. PEV market share in the Czech is still very niche, but since 2014 the situation has been improving, although there was some tiny fall in 2016, as on the table below. Also it is harder to analyse and predict future, as the trends aren´t so stable as in case of Austria. The market share of EV in Czech republic is still very low under 1 %.



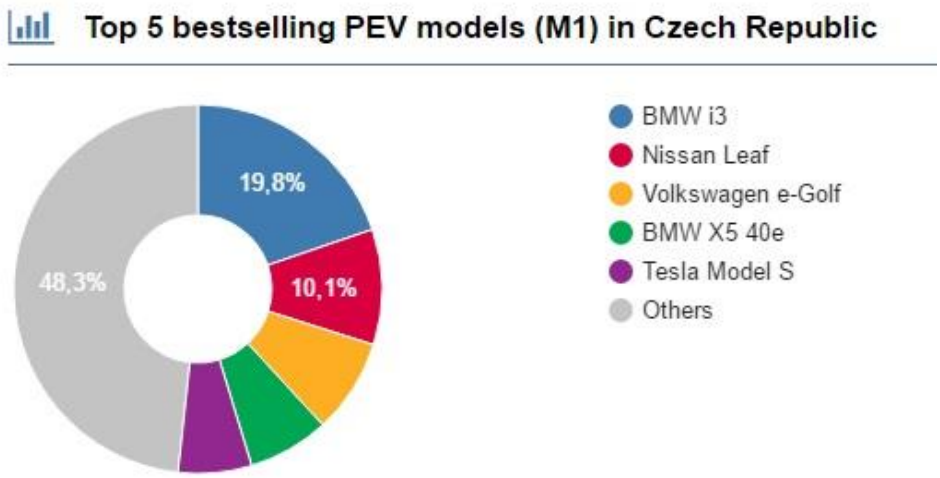
Source: EAFO

As for the EV registrations in the Czech Republic, the amount of new EV per year is still far below 500 and the trend is highly fluky, but the increase between 2013 and 2014 made a change and the era of higher demand started. While Austria had more than 4 500 registrations in 2016, Czech republic haven´t achieved even 10% of this amount.



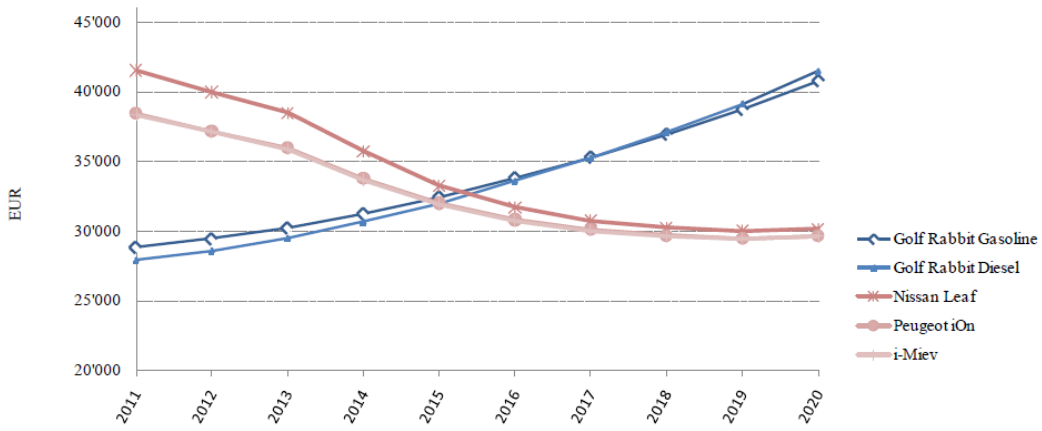
Source: EAFO

As for the bestselling models in Czech republic, BMW i3 holds nearly one quarter of the market, followed by Nissan Leaf. It means that BW i3 has a strong position in the market in both of these countries.



5.Conclusion

The BAU-scenario shows that EV shall be competitive with ICE in upcoming years.



TCO-BAU-scenario[1]

Major problem is CO2 and NoVA taxes, which increase the costs of ICE, have to be prohibitive to make electric cars competitive. A CO2 tax can be levied by directly taxing gasoline and diesl, that iplies that a CO2 tax would result in increase of fuel price. In next table are presented gasoline and diesel prices until 2015 for analysed cars in Austria.[1].

	2011	2012	2013	2014	2015
Golf Rabbit Gasoline					
CO_2 emission g/km	121	121	121	121	121
Fuel consumption l/ km	0.052	0.052	0.052	0.052	0.052
CO_2 emission g/l	2'327	2'327	2'327	2'327	2'327
CO_2 tax ct/g	0.250	0.230	0.225	0.100	0.050
ct/l	581.7	535.2	523.6	232.7	116.3
Golf Rabbit Diesel					
CO_2 emission g/km	107	107	107	107	107
Fuel consumption l/ km	0.041	0.041	0.041	0.041	0.041
CO_2 emission g/l	2'610	2'610	2'610	2'610	2'610
CO_2 tax ct/g	0.250	0.230	0.225	0.100	0.050
ct/l	652.4	600.2	587.2	261.0	130.5

From the analysed papers, the implementation of CO2 tax becomes effective, if the CO2 price is circa 2000EUR/t. Currently, the CO2 price on the EU Emission Allowances spot market trades at 15EUR/t. Therefore to achieve a certain price differential and market penetration of EV is not considered viable in this way. Also NoVA needs to be increased by up to 45% in order to support EVs (currently 4%). As CO2 tax, increase of NoVA would be considered politically infeasible and it may cause adverse effects on the total automative market.

General maintenance costs for BEVs are assumed to be 65% of the costs of ICE. Next scenarios need to be investigated and take major impact in upcoming years: an increas in fuel prices, a decrease in battery prices and an up-front subsidy for BEVs. These scenarios are realistic changes in economic parameters that could occur in the near future. For instance if fuel prices increase for 4%, the TCO for ICE would increased.

However BEVs are still not cost competitve to ICE, but the cost difference between BEVs has lowered. And also many countries stimulate the purchase of electric vehicles by offering governmental finincial subsidies. But still BEVs without leasing contract and PHEVs are still cost inefficient. If the consumer opts for a BEV with battery leasing, TCO values are within the range of current HEVs. And when equipped with 40kWh battery pack, BEVs are competitive with modern petrol and diesel cars. In general battery prices has the largest impact, and the increased fuel prices do not render BEVs cost competive.

References

[1] G.Viktoria, S.Johannes, S.Erwin, Analysis of alternative policy intruments to promote electric vehicles in Austria 2011

[2] L.Kenneth, L.Philippe,M.Cathy, M.V.Joeri, How expensive are electric vehicles? A total cost of ownership analysis 2013

[3] Pushing the deployment of electric vehicles Options for policy makers, april 2015

[4] EAFO (2017). Austria: Sumary. Retrieved from: http://www.eafo.eu/content/austria

[5] EAFO (2017). Czech Republic: Summary. Retrieved from:
http://www.eafo.eu/content/czech-republic