The development of electric transport – its effect on the security of the electrical energy system and forecasting energy demand in chosen 8 BASREC countries (Norway, Denmark, Germany, Sweden, Finland, Estonia, Lithuania and Poland)

Abstract

The analysis is focused on the development of electric transport and how does it affect the security of electrical energy system and forecasting energy demand in eight chosen BASREC countries, which are Norway, Denmark, Germany, Sweden, Finland, Estonia, Lithuania and Poland.

The first two chapters contain general introduction on the e-mobility market and explain main aims and scope of the project. Chapter 3 is constituted with the prognosis part on e-mobility development regarding to the predicted number of cars, buses and development of charging infrastructure. Afterwards each of the countries covered by the analysis were described in terms of: general information, national goals and requirements, developmental barriers in regards of internal conditions; current regulation including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of technical infrastructure and placement of vehicle charging stations. The last part of that chapter is dedicated to the areas of primary electric transport development. Chapter 4 comprises the description of obligations under the Directive 2014/94/EU on the deployment of alternative fuels infrastructure. In the following chapter the effect of electric transport on electrical security was analysed. This chapter is divided into two parts: electric vehicles demand to grid and electric power required by electric vehicles fleet to grid. Chapter 6 presents results from the workshop which was held during the project elaboration and includes information on electric system management and model cooperation between vehicles owner – DSO – energy retailers. Afterwards the regulation proposal for electric transport support by 2020 were presented for each of the countries covered by the analysis. Chapter 8 presents general proposal for support mechanisms of electric transport development. The next chapter comprises the analysis of environmental effects of e-mobility development which differs in each of the countries.

Finally the summary and conclusions are presented and an appendix is attached.

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Acronyms

BASREC	the Baltic Sea Region Energy Cooperation
BEV	battery electric vehicle
CO_2	carbon dioxide
DSO	Distribution System Operator
eq	equivalent
EUR	euro
EV	electric vehicle
GHG	greenhouse gases
GWh	gigawatt hour
HEV	hybrid electric vehicle
ICE	internal combustion engine
kt	kiloton
kW	kilowatt
kWh	Kilowatt hour
LDV	light duty vehicles
LV	low voltage
MWh	megawatt hour
PHEV	plug-in hybrid electric vehicle
R&D	research and development
REEV	range-extended electric vehicle
TCO	total cost of ownership
UK	United Kingdom
V2G	vehicle to grid

1. Introduction

E-mobility, in general, can be understood as a **development of electric-powered drivetrains** that are especially designed to help shift vehicle design from the use of fossil fuels and therefore reduce GHG emissions. Several different types of vehicles are included under this term:

- Bicycle
- Moped/motorbike
- Car
- Truck
- Train
- Agricultural/military machines
- Aeroplane
- Ship

This study is focused on cars, in terms of **passenger cars** and **buses**.

There are several driving forces that substantially stimulate the development of e-mobility. One of the most important is the **reduction of oil dependence**, as the transport sector is responsible for a significant proportion of the total GHG emissions. The introduction and systematic development of electric vehicles will contribute to decarbonising transport. E-mobility is seen as the ultimate solution to transport problems.

While reducing the oil dependence of the transport sector it is necessary to **develop a well-functioning electricity grid**. Such a grid will be beneficial not only for the development of e-mobility, but also for the developing European society. A newly developed grid should be regarded as a **new system** that could be used not only to provide electricity for vehicles, but also as an **energy storage system**.

However, there are **several challenges** that should be taken into account when discussing the development of e-mobility. These include the forecasted number of cars, which determines the need for the development of an e-mobility charging infrastructure, as well as the ecological footprint provoked by the production of electricity.

2. Aim and scope

The **aim of the project** is to develop an analysis and a **set of recommendations** taking into consideration the implementation of obligations under **Directive 2014/94/EU** for eight selected BASREC countries.

The analysis comprises several major parts. One of the most important aspects of the analysis is the prognosis of the amount of e-mobility development for each of the countries. That includes prognosis for the number of cars and buses and their charging infrastructure. The analysis indicates that we can distinguish three types of market development: early, advanced early and moderate market development.

In the analysis the following countries were taken into account:

- Denmark,
- Estonia,
- Finland,
- Germany,
- Lithuania,
- Norway,
- Poland,
- Sweden.

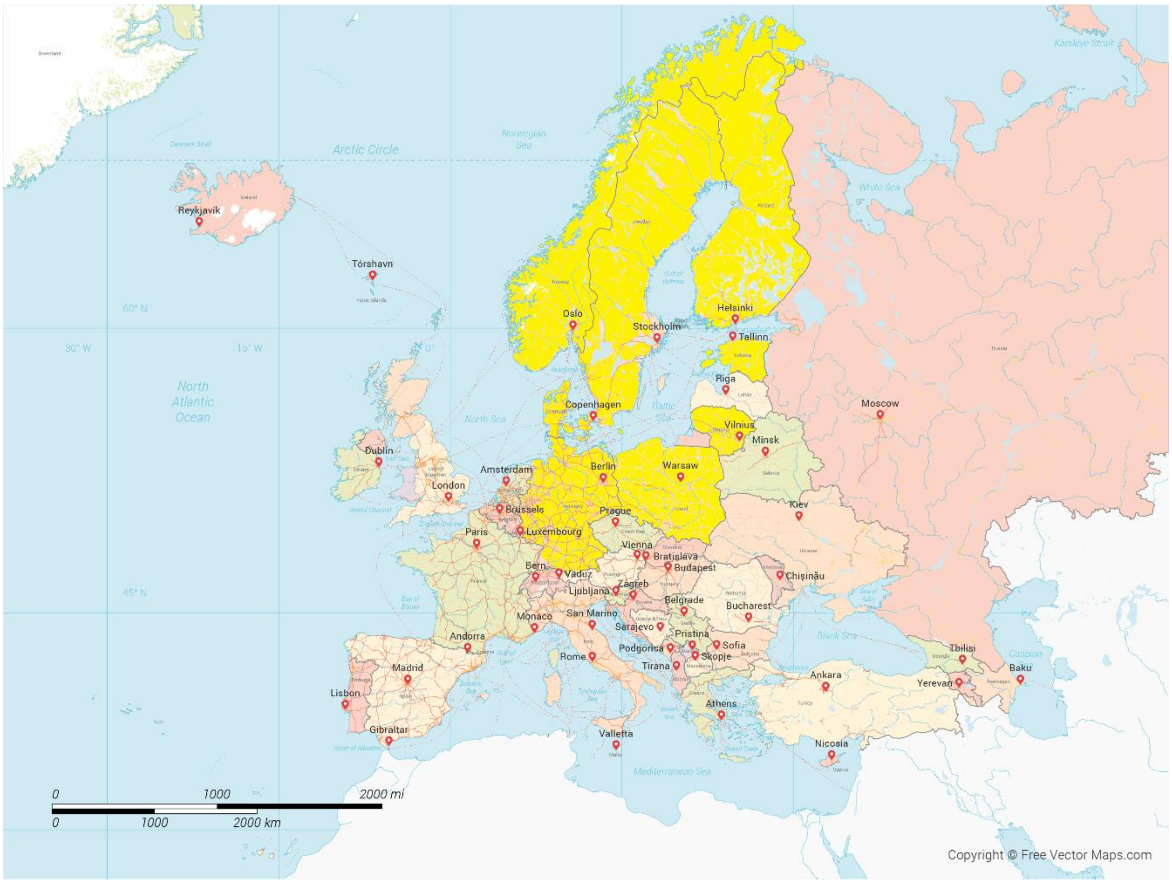

Figure 1. Map of Europe with countries covered by the analysis marked in yellow.

Each of the countries covered by the project has been described in terms of national goals and requirements, developmental barriers with regard to the internal conditions (social, economic), current regulations including rules concerning operating charging stations and support systems, as well as regulations limiting expansion of the technical infrastructure and the placement of vehicle charging stations, and finally evaluation of the existing technical and spatial infrastructures.

Afterwards there is a chapter dedicated to analysis of Directive 2014/94/EU in terms of existing obligations resulting from the EU membership in the context of electric transport. The Directive concerns building up infrastructure for alternative fuels.

The next chapter comprises analysis of the effect of electric transport on the security of the electrical energy system with evaluation of the demand for electrical energy as an alternative fuel for transport until 2030 and evaluating the possibility of satisfying the upcoming demand. The following part is dedicated to the current proposal for regulations concerning supporting the development of electric transport in each of the countries covered by the analysis, with a particular focus on solutions that can be introduced before 2020.

The current proposal for support mechanisms (including financial mechanisms) for electric transport development including the estimated costs required to achieve the directive for the build-up of infrastructure for alternative fuels has been described in the next chapter.

Afterwards the analysis consists of an assessment of the cumulative environmental effects of the development of e-mobility. This includes a comparison of avoided pollutant emissions in the transport sector in relation to the emissions from the increased production of electricity.

Finally, at the end of the analysis, a summary and conclusions have been presented.

3. Analysis of the current state of affairs

3.1. Chapter structure

The following chapter has been divided into two parts. The first one is devoted to a prognosis of the development of electric vehicles by 2020, 2025 and 2030. This includes different prognosis scenarios for:

- cars,
- buses,
- charging infrastructure.

Countries covered by the analysis have been grouped according to the current state of their e-mobility level of advancement.

The other part comprises an analysis of the current state of affairs in the eight chosen BASREC countries. They were analysed in terms of:

- general information on the country,
- national goals and requirements,
- developmental barriers in regard to internal conditions,
- current regulations including rules concerning operating charging stations and support systems, as well as regulations limiting expansion of the technical infrastructure and the placement of vehicle charging stations,
- evaluation of existing technical and spatial infrastructure.

3.2. Prognosis of e-mobility development for 2020, 2025 and 2030

3.2.1. Number of cars

Many studies have forecasted that EVs, HEVs and PHEVs will be a growing component of the world vehicle fleet in the future. These forecasts have served the needs of society, automakers, electric utilities and policymakers in understanding what the impact of EVs, HEVs and PHEVs will be on their sphere of influence. Society seeks to understand the benefits that it will accrue from more efficient vehicles.

Automakers try to understand the market potential of each vehicle technology with the goal of designing saleable products. The utility industry seeks to model and forecast the new electricity infrastructure demand under different transportation technology scenarios. Policymakers seek to be able to understand the impact of present and future regulatory standards, and to understand domestic and foreign energy demand.

Market forecasting is a well-developed field of study with practitioners in the fields of economics, business, finance and systems engineering, but forecasting of the EV, HEV and PHEV market share is complicated by factors that are difficult to model using the classical tools of market forecasting. First, PHEVs and EVs are a new automotive technology that has only just been introduced in recent years. Only sales data since the model year 2011 are available for validation of any PHEV and EV market model. Additionally, in some BASREC countries detailed data on car sales and the segments of EVs is not available. Second, PHEVs and EVs require consumers to shift their behaviour away from fuelling at a petrol station toward plugging in their personal vehicle.

Third, PHEV and EV fuel consumption is measured in terms of either fuel consumption or energy consumption, or both. Consumers' evaluation of PHEV and EV ownership costs will require a weighting of these energy consumptions.

Fourth, the make-up of an automotive industry vehicle fleet is highly regulated within the EU and Norway. Additionally, financial measures implemented in some BASREC countries seriously influence early market development.

Researchers have recently been developing market forecasting models that can include these types of complications, but the methods, scope, fidelity and results that are the outputs of these models differ greatly among studies.[1]

Mainly because of the limited and different scope of data available about BASREC countries at this stage it is not possible to build a separate model to forecast EV market development. For this reason a review of other forecasts was undertaken, especially elaborated in the United Kingdom in 2013 by the Ricardo-AEA consortium for the UK Petroleum Industry Association and the Royal Automobile Club Foundation for Motoring.[2] In this study several future market demand forecasts and backcasting/scenario planning were analysed. Finally, the main output of these analyses is presented in the tabled recommendations on the share of different categories of EVs in total sales of new passenger cars in 2020 and 2030 (Table 1). In this study there is also output on hybrid electric vehicles (without the plug-in component), but in this study this kind of EV is at the centre of the analysis.

Table 1. Share of total sales of new passenger cars in 2020 [Ricardo-AEA]

Mainstream estimates – plug-in hybrid electric vehicles	
2020	1% to 5%
2030	15% to 30%
Mainstream estimates – range-extended electric vehicles	
2020	1% to 2%
2030	5% to 20%
Mainstream estimates – battery electric vehicles	
2020	1% to 5%
2030	5% to 20%

The presented estimates show that in the first stage a substantial share of PHEVs (including REEVs) is visible. However, the share of pure electric vehicles already in 2020 should be noticeable.

[1] Baha M. Al-Alawi and Thomas H. Bradley, *Review of hybrid, plug-in hybrid, and electric vehicle market modeling studies*, Renewable and Sustainable Energy Reviews, 21 (2013) 190–203.
[2] Duncan Kay, Nikolas Hill and Dan Newman, *Powering Ahead. The future of low-carbon cars and fuels,* Ricardo-AEA April 2013.

Although in these recommendations the word "vehicle" was used, it always concerns passenger cars. On this basis, and taking into account the policy climate on EVs in a given BASREC country, a division was made of three groups of countries: early development market, advanced early development and moderate development. For each group of countries, a different share of EVs in car sales was assigned (the share of PHEVs and REEVs was accumulated). Additionally, for a better view on possible EV market development three different scenarios were proposed: basic, moderate and optimistic.

As was explained in the previous section, the proposed division of BASREC countries and the scenarios are based on an expert assessment and is not an output of modelling.

Taking into account that the minimum shares proposed by Ricardo-AEA are rather average for the early development market, 50% of these shares was taken for the basic scenario. For the advanced early development market countries 100% of the proposed minimum share was taken and 200% for Norway. Step by step these shares are increasing in "higher" scenarios and are finally reaching their maximum (maximum proposed in the Ricardo-AEA study) in the case of Norway as the most advanced market for EVs. The data for 2015 and 2025 was calculated by trend line. The final assumptions for market shares of EVs are presented in Table 2.

Table 2. Final assumptions for market shares of EVs [own elaboration]

BASIC SCENARIO				
Proposed shares in Ricardo-AEA study >>>	1–5 %	2–7 %	5–20 %	20–50 %
Early development market	2020		2030	
	BEVs	PHEVs	BEVs	PHEVs
Finland	0.5%	1.0%	2.5%	10.0%
Lithuania	0.5%	1.0%	2.5%	10.0%
Poland	0.5%	1.0%	2.5%	10.0%
Advanced early development market	2020		2030	
Denmark	1.0%	2.0%	5.0%	20.0%
Estonia	1.0%	2.0%	5.0%	20.0%
Germany	1.0%	2.0%	5.0%	20.0%
Sweden	1.0%	2.0%	5.0%	20.0%
Medium development market	2020		2030	
Norway	2%	3%	10%	30%
MEDIUM SCENARIO				
Proposed shares in Ricardo-AEA study >>>	1–5 %	2–7 %	5–20 %	20–50 %
Early development market	2020		2030	
	BEVs	PHEVs	BEVs	PHEVs
Finland	1.0%	2.0%	5.0%	15.0%
Lithuania	1.0%	2.0%	5.0%	15.0%
Poland	1.0%	2.0%	5.0%	15.0%
Advanced early development market	2020		2030	
Denmark	2.0%	3.0%	10.0%	25.0%
Estonia	2.0%	3.0%	10.0%	25.0%
Germany	2.0%	3.0%	10.0%	25.0%

Sweden	2.0%	3.0%	10.0%	25.0%
Medium development market	2020		2030	
Norway	3%	4%	15%	40%
OPTIMISTIC				
Proposed shares in Ricardo-AEA study >>>	1–5 %	2–7 %	5–20 %	20–50 %
Early development market	2020		2030	
	BEVs	PHEVs	BEVs	PHEVs
Finland	2.0%	3.0%	10.0%	20.0%
Lithuania	2.0%	3.0%	10.0%	20.0%
Poland	2.0%	3.0%	10.0%	20.0%
Advanced early development market	2020		2030	
Denmark	3.0%	5.0%	15.0%	30.0%
Estonia	3.0%	5.0%	15.0%	30.0%
Germany	3.0%	5.0%	15.0%	30.0%
Sweden	3.0%	5.0%	15.0%	30.0%
Medium development market	2020		2030	
Norway	5%	7%	20%	50%

On the basis of the annual share of EVs in total sales of new cars, the total number of EVs was calculated for all BASREC countries. It is presented in the following tables: Table 3 – basic scenario; Based on the assumptions and taking into account the current starting point of BASREC countries in EV market development, especially in Germany, the total number of all EVs is not negligible. Taking into account the anxiety about range and less than smooth battery technology development, PHEVs should take over a significant share of the EV market.

Table 4 – moderate scenario; and Table 5 – optimistic scenario.

Table 3. Basic scenario [own elaboration]

Early development market	**2015**		**2020**		**2025**		**2030**	
	BEVs	PHEVs	BEVs	PHEVs	BEVs	PHEVs	BEVs	PHEVs
Finland	655	781	3 800	4 050	8 995	15 882	15 747	40 332
Lithuania	15	30	314	628	1 591	5 109	4 250	15 564
Poland	599	9667	7 450	29 576	36 114	130 130	95 763	364 698
Advanced early development market	**2015**		**2020**		**2025**		**2030**	
Denmark	4 443	789	14 175	15 661	44 038	119 514	105 104	359 319
Estonia	1 557	82	2 960	1 569	5 543	10 346	10 580	30 053
Germany	30 820	121 124	140 421	319 579	435 035	1 297 701	982 178	3 429 036
Sweden	3 847	8 990	16 761	36 401	55 512	168 620	131 723	466 958
Moderate development market	**2015**		**2020**		**2025**		**2030**	
Norway	54 073	4 267	95 745	24 344	142 897	147 654	239 832	433 275

Based on the assumptions and taking into account the current starting point of BASREC countries in EV market development, especially in Germany, the total number of all EVs is not negligible. Taking into account the anxiety about range and less than smooth battery technology development, PHEVs should take over a significant share of the EV market.

Table 4. Moderate scenario [own elaboration]

Early development market	**2015**		**2020**		**2025**		**2030**	
	BEVs	PHEVs	BEVs	PHEVs	BEVs	PHEVs	BEVs	PHEVs
Finland	4 324	1 143	11 671	11 656	24 819	45 806	47 275	111 662
Lithuania	30	60	628	1 256	3 182	8 292	8 500	24 064
Poland	935	10 338	14 501	43 678	71 829	201 561	191 128	555 427
Advanced early development market	**2015**		**2020**		**2025**		**2030**	
Denmark	4 814	1 160	21 974	23 460	81 700	157 176	203 831	458 046
Estonia	1 594	119	3 737	2 345	8 902	13 706	18 978	38 451
Germany	35 589	125 894	240 588	419 747	829 817	1 692 483	1 924 104	4 370 961
Sweden	4 389	9 532	28 153	47 793	105 654	218 762	258 077	593 312
Moderate development market	**2015**		**2020**		**2025**		**2030**	
Norway	54 361	4 555	101 793	30 393	172 522	194 806	317 924	575 634

Table 5. Optimistic scenario [own elaboration]

Early development market	**2015**		**2020**		**2025**		**2030**	
	BEVs	PHEVs	BEVs	PHEVs	BEVs	PHEVs	BEVs	PHEVs
Finland	4 576	1 395	16 965	16 950	43 261	64 248	88 174	152 561
Lithuania[3]	60	90	1 256	1 884	6 365	11 474	16 999	32 564
Poland	1 607	11 010	28 603	57 780	143 260	272 991	381 857	746 156
Advanced early development market	**2015**		**2020**		**2025**		**2030**	
Denmark	5 186	1 903	29 773	39 057	119 362	210 435	302 558	574 599
Estonia	1 631	193	4 513	3 899	12 262	18 619	27 375	48 624
Germany	40 359	135 433	340 756	620 083	1 224 599	2 287 600	2 866 029	5 541 841
Sweden	4 932	10 617	39 544	70 576	155 796	291 687	384 431	745 704
Moderate development market	**2015**		**2020**		**2025**		**2030**	
Norway	54 937	5 419	113 891	48 539	214 244	266 154	409 843	745 645

The moderate and optimistic scenarios show that further potential in EV development still exists. Of course, it depends on many factors that cannot be predicted at this moment. In particular, battery technology development and public incentives have a decisive and vital impact.

[3] Actual information from Lithuania (September, 2015) confirm that EV fleet development is close to our prognosis. Current number of all newly registrated EVs and PHEVs each are equal to 65.

3.2.2. Number of buses

In 2014, the electric bus market changed significantly. The price premium and range of pure electric buses over 8 tonnes was no longer significantly worse than for hybrids. Primarily thanks to the Chinese, such pure electric buses were about 60% more expensive to buy than diesel versions but had up to 90% lower costs after purchase, making the total cost of ownership (TCO) almost competitive.[4]

Compared to diesel, for example, the TCO distributed over eight years for an electric bus (with one extra battery and one fast charger) was 20% lower, and an electric bus (with one extra battery and two fast chargers) was 17% lower. The cost for the plug-in hybrid was 17% lower and the hybrid was 7% lower than a diesel bus.[5]

The EU market is also at the point where strong growth can occur. In particular, the new financial perspectives of the EU budget will favour buses powered by alternative sources, especially with low or zero CO_2 and pollutant emissions. For example, the Polish Partnership Agreement, which is a document defining the strategy of interventions of European funds within the framework of three EU policies – the Cohesion Policy, the Common Agricultural Policy and Common Fisheries Policy – clearly states that the fleet for public transport will be financed (including the infrastructure to support it, such as systems for the distribution of energy carriers). The main Polish operational programme for 2014–2020 clearly prioritises the purchase of vehicles with alternative fuel systems (electric, hybrid, biofuel, hydrogen, etc.) for urban passenger transport. In Poland in 2014, the interest in electric buses was overwhelming in many Polish municipalities. Finally, we can expect that in 2015 there will be about 20 electric buses in operation. In the previous year, Polish municipalities gained experience of electric buses through pilot and test projects. Also, in other BASREC countries, the growth in EB interest is really radical. For example, in Dresden a system is being tested in which buses are recharged while they operate routes.

In this investment climate it is expected that electric buses see their fair share of growth in purchases by public authorities for urban transport. In this respect, based on the analogy of the development of diesel cars in Europe and taking into account estimated purchases of new buses for urban mobility, a prognosis was prepared. Because of the very attractive TCO of EBs, the Bass model was proposed to project further growth in this market. It is a diffusion model. Diffusion is defined as the process of acceptance of a new invention or product by the market. Classical theories on diffusion include the concept of classification of adopters, the role of social influence in adoption, and the S-shaped curve associated with the rate of an innovation's adoption. The diffusion of innovation is

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[4] P. Harrop, F. Gonzalez, Electric Buses 2015–2025 Forecasts, Technology Roadmap, Company Assessment, April 2015, IDTechEx.

[5] Lisiana Nurhadia, Sven Boréna, Henrik Ny, *A sensitivity analysis of total cost of ownership for electric public bus transport systems in Swedish medium sized cities,* Transportation Research Procedia 3 (2014) 818–827.

often modelled as a normal distribution over time. Diffusion of innovations theory was invented by Everett M. Rogers in the early 1960s. Rogers proposes that adopters of any new innovation or idea can be categorised as innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%) (Figure 2).

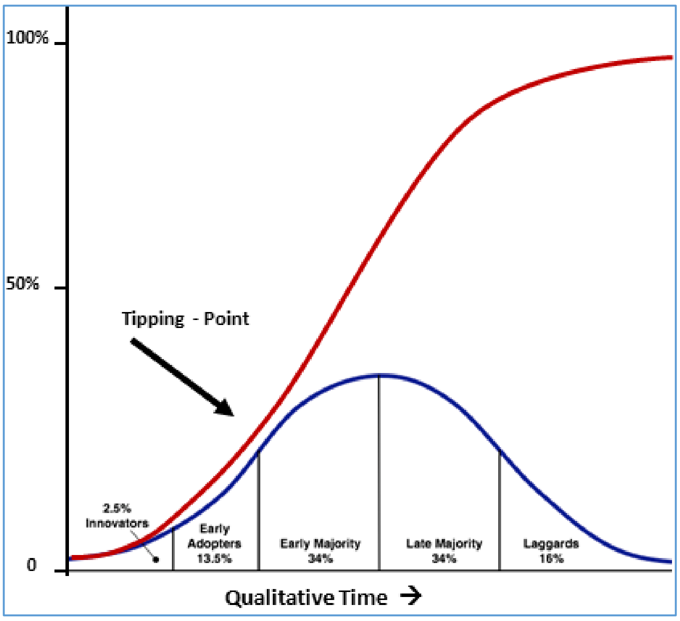

Figure 2. Rogers' innovative curve [source: http://onhealthtech.blogspot.com/2010/09/diffusion-of-ehr-innovation.html].

A tipping point, after which a strong acceleration of market development occurs, comes immediately after the rate of adoption (red line in Figure 2) reaches its largest value, which will be maintained during most of the adoption time.

The Bass model, which is based on Rogers' theory, is used for forecasting the adoption rate of a new technology under the assumption that no competing alternative technology will exist in the marketplace. Bass divided consumers into two groups: innovators and imitators.[6] The final outcome of electric bus market projections is presented in the table and figure below.

Table 6. Electric bus market projections [own elaboration]

Country	Electric buses	Bass modelling		
	2015	2020	2025	2030
Denmark	29	133	323	631
Germany	19	170	491	1 151
Estonia	0	42	123	260
Lithuania	0	21	66	159
Poland	25	121	327	753
Finland	13	98	258	522
Sweden	33	135	267	430

[6] Baha M. Al-Alawi and Thomas H. Bradley, *Review of hybrid, plug-in hybrid, and electric vehicle market modeling studies*, Renewable and Sustainable Energy Reviews 21 (2013) 190–203.

Norway	8	160	436	883

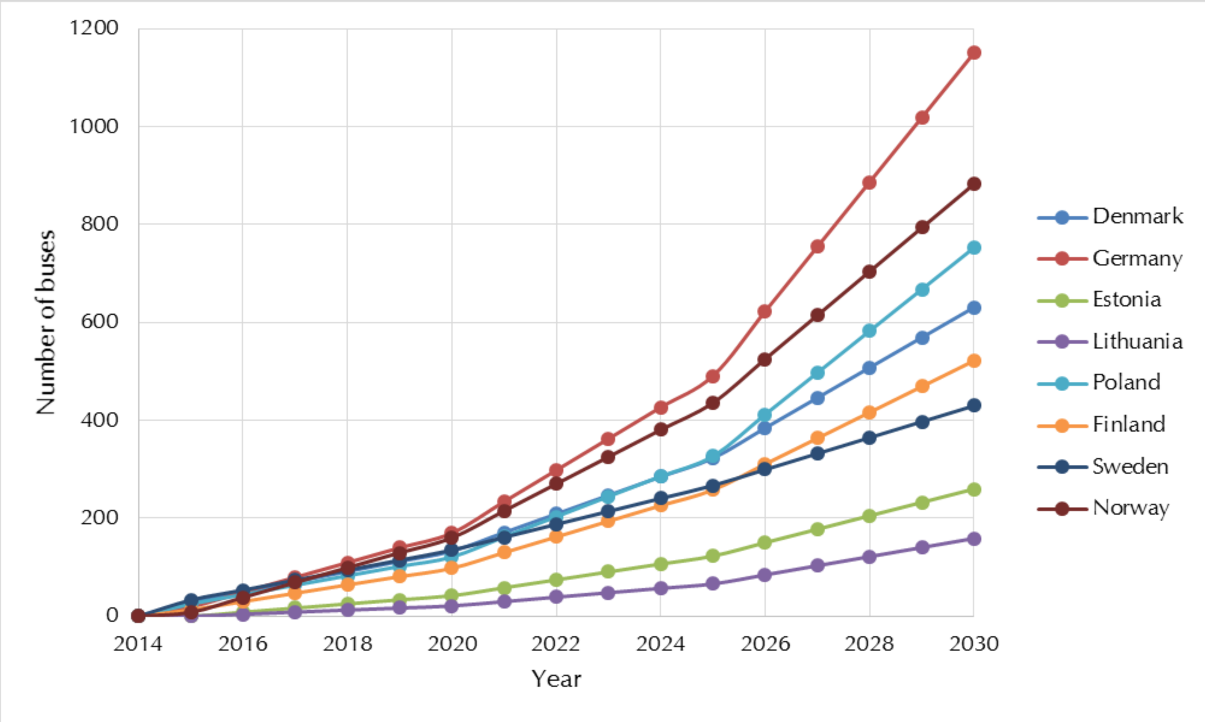

Figure 3. Electric bus market projection [own elaboration].

Taking into account the different potential of BASREC countries, especially the total number of urban buses and available financial stock exchange source, the largest share of electric buses will be in Germany, Poland and Norway. After 2030, the tipping point should be reached and electric buses should dominate, especially in urban public road transport.

3.2.3. Charging infrastructure

Based on the 2nd Report of the Expert Group on Future Transport fuels,[7] the number of charging points needed for servicing electric cars can be estimated to be around two charging points per car with the majority being located at home and at the workplace, and around one charging point per five vehicles at a publicly accessible car park or on the street. On this basis and taking into account the results of different scenarios in the market development of EVs presented in chapters 3.2.1 and 3.2.2, the number of charging points given in Table 7 below can be expected to be deployed (according to an expected scenario development). However, bearing in mind that some experts have some doubts about the assumption that every EV needs two charging points (as a general assumption for the whole system), only figures of BEVs were taken to calculate the number of charging points. This way the final number of charging points was reduced by ca. 40–60 %.

The chapter is divided into two parts. The first part considers publicly accessible charging points in three types of scenario:

- basic (Table 7),
- moderate (Table 8),
- optimistic (Table 9).

The other part comprises the number of privately accessible charging points, also in three types of scenario:

- basic (Table 10),
- moderate (Table 11),
- optimistic (Table 12).

At the end of the chapter the total number of charging points for buses in each of the countries is given (Table 13).

Publicly accessible charging points

Table 7. Basic scenario [own elaboration]

Early development market	2015	2020	2025	2030
Finland	131	760	1 799	3 149
Lithuania	3	63	318	850
Poland	120	1 490	7 223	19 153
Advanced early development market	2015	2020	2025	2030
Denmark	889	2 835	8 808	21 021
Estonia	311	592	1 109	2 116
Germany	6 164	28 084	87 007	196 436

[7]The report results from the work of the experts who have taken part in the European Expert Group on Future Transport Fuels.

Sweden	769	3 352	11 102	26 345
Moderate development market	2015	2020	2025	2030
Norway	10 815	19 149	28 579	47 966

Table 8. Moderate scenario [own elaboration]

Early development market	**2015**	**2020**	**2025**	**2030**
Finland	865	2 334	4 964	9 455
Lithuania	6	126	636	1 700
Poland	187	2 900	14 366	38 226
Advanced early development market	2015	2020	2025	2030
Denmark	963	4 395	16 340	40 766
Estonia	319	747	1 780	3 796
Germany	7 118	48 118	165 963	384 821
Sweden	878	5 631	21 131	51 615
Moderate development market	2015	2020	2025	2030
Norway	10 872	20 359	34 504	63 585

Table 9. Optimistic scenario [own elaboration]

Early development market	**2015**	**2020**	**2025**	**2030**
Finland	915	3 393	8 652	17 635
Lithuania	12	251	1 273	3 400
Poland	321	5 721	28 652	76 371
Advanced early development market	2015	2020	2025	2030
Denmark	1 037	5 955	23 872	60 512
Estonia	326	903	2 452	5 475
Germany	8 072	68 151	244 920	573 206
Sweden	986	7 909	31 159	76 886
Moderate development market	2015	2020	2025	2030
Norway	10 987	22 778	42 849	81 969

Privately accessible charging points

Table 10. Basic scenario [own elaboration]

Early development market	2015	2020	2025	2030
Finland	1 178	6 840	16 191	28 344
Lithuania	27	565	2 864	7 650
Poland	1 079	13 409	65 005	172 373
Advanced early development market	2015	2020	2025	2030
Denmark	7 997	25 516	79 269	189 186
Estonia	2 802	5 328	9 977	19 045
Germany	55 475	252 757	783 063	1 767 921
Sweden	6 925	30 170	99 921	237 102
Moderate development market	2015	2020	2025	2030
Norway	97 332	172 340	257 214	431 698

Table 11. Moderate scenario [own elaboration]

Early development market	2015	2020	2025	2030
Finland	7 782	21 007	44 674	85 095
Lithuania	54	1 130	5 728	15 299
Poland	1 683	26 101	129 292	344 030
Advanced early development market	2015	2020	2025	2030
Denmark	8 666	39 554	147 060	366 895
Estonia	2 869	6 726	16 024	34 160
Germany	64 061	433 059	1 493 670	3 463 387
Sweden	7 901	50 675	190 176	464 539
Moderate development market	2015	2020	2025	2030
Norway	97 850	183 228	310 539	572 264

Table 12. Optimistic scenario [own elaboration]

Early development market	2015	2020	2025	2030
Finland	8 236	30 537	77 870	158 713
Lithuania	108	2 260	11 457	30 599
Poland	2 892	51 486	257 867	687 342
Advanced early development market	2015	2020	2025	2030
Denmark	9 334	53 592	214 851	544 604
Estonia	2 935	8 124	22 071	49 275
Germany	72 647	613 361	2 204 278	5 158 852

Sweden	8 877	71 179	280 432	691 976
Moderate development market	2015	2020	2025	2030
Norway	98 887	205 004	385 640	737 717

Counting the number of charging points for buses should be based on the following assumptions:

- during the night stop at the depot the battery is charged up to 100%,
- when performing daily tasks it must be additionally charged for five hours,
- one charging point on a bus route can handle three buses daily from 5:00 pm to 11:00 pm (18 hours).

In total we need the number of depot charging points to be equal to 95% of the number of buses and 1/3 of 95% of buses on their routes. All the charging points are equipped with standard parameters of low power supply voltage.

Based on the predicted number of vehicles in BASREC countries the total number of charging points for buses should be as follows (Table 13):

Table 13. Total number of charging points [own elaboration]

Country	2015	2020	2025	2030
Denmark	35	160	388	757
Germany	22	204	589	1 381
Estonia	0	51	147	312
Lithuania	0	25	79	191
Poland	30	146	392	904
Finland	16	118	310	627
Sweden	40	162	321	516
Norway	10	192	523	1 059

3.3. Denmark

General information

Denmark (Figure 4) is a relatively small and densely populated country with a large share of the population living in cities.

Figure 4. Map of Denmark.

In urban areas most people have good access to public transport and major investments in better public transport infrastructure are currently taking effect. However, in many rural areas, public transport is less frequent than in the urban areas. In Denmark, many commuters use their bicycle to travel to and from work and for other purposes, particularly during the summer. The cost of car ownership is very high in Denmark compared to neighbouring countries.

Efficient and flexible transportation of goods and people is a vital element of the foundation of the Danish welfare society. At the same time, transport is an important economic sector that contributes to economic growth, employment and foreign trade. Denmark's geography, with most people travelling short distances to and from work and a very high number of inhabited islands, makes it an attractive country in which to use electric cars. The range of an electric car is sufficient to cover most people's daily transport needs.[8] As far as electric cars are concerned, Denmark's strategy is to achieve

[8] Source: Denmark's Sixth National Communication on Climate Change Under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, December 2013, available at:

its target of 200,000 EVs on the road by 2020. Currently there are approximately 2.28 million (2014) registered cars in Denmark.

National goals and requirements

The government's strategy[9] entails ambitious efforts for the period up to 2020, but also points onwards to 2050. With considerable reductions in the use of fossil fuels in the energy sector, stabilisation of oil use in the transport sector and a framework for future efforts, the government's strategy is a huge step towards the target of phasing out fossil fuels completely by 2050 (see Figure 5). However, according to the strategy, realising the goal by 2050 will require a continuation of existing efforts and implementation of new initiatives in the period after 2020.

Today, the Danish transport sector runs almost entirely on fossil fuels. Conversion to renewable energy in transport is a tremendous challenge. In the longer term, electric cars will be important. In the short term, biofuels will play a role. The initiatives to promote the green transition in the transport sector are:

- the establishment of more recharging stations for electric cars and promoting the infrastructure for hydrogen cars, etc.,
- a strategy for the promotion of energy-efficient vehicles,
- fuels must contain 10% of biofuels by 2020.

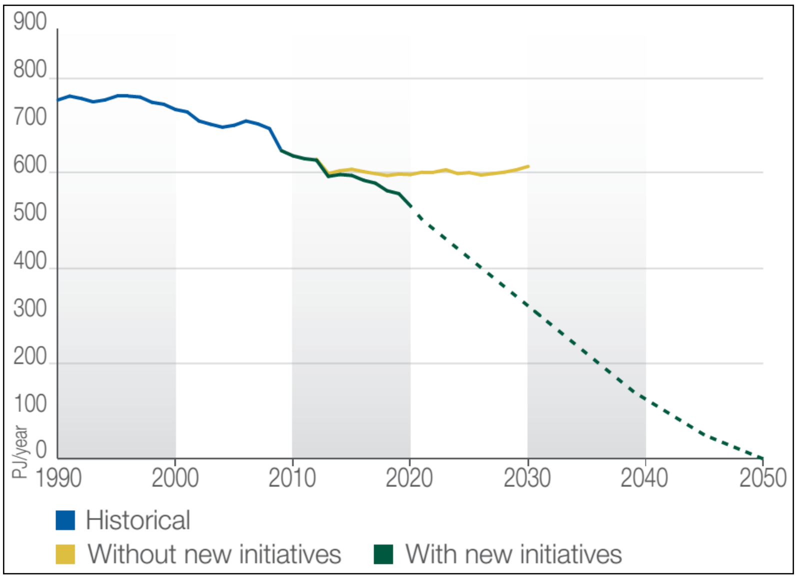

Figure 5. Fossil fuel use by 2050 [Source: The Danish Government, Energy Strategy 2050 – from coal, oil and gas to green energy, February 2011].

http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/nc6andbr1-dnk-2jan2013[1].pdf

[9] The Danish Government, *Energy strategy 2050 – from coal, oil and gas to green energy*, February 2011, http://www.kebmin.dk/sites/kebmin.dk/files/news/from-coal-oil-and-gas-to-green-energy/Energy%20Strategy%202050%20web.pdf, 10.05.2015.

As a result of these and other initiatives, Denmark's total use of oil, coal and gas is expected to be reduced by approximately 25% in 2020 in relation to 2010.[10]

Developmental barriers in regard to internal conditions

As far as Denmark's market penetration by electric vehicles is concerned, there is a basic question about further tax incentives for electric cars beyond 2015. If kept for more than two to three years it can be expected that BEVs can reach about 6,000 to 9,000 in total stock.

In the project *Overcoming the Barriers of Electric Vehicle Uptake in Denmark* sponsored by the Danish Consumer Council (Forbrugerrådet), four top barriers in Denmark for EV industry uptake (ranked highest to lowest) were identified: range, price, consumer knowledge and infrastructure.

A total of 53.4% of survey respondents within the project said that range was an improvement that needed to be made in order for them to consider purchasing an electric vehicle. This places range at the top of the list of consumer concerns and identifies it as a major barrier to electric vehicle uptake. Through our qualitative analysis, we also determined that range is a major obstruction. However, the ability to have more in-depth qualitative rather than quantitative research allowed the group to realise that it is not just range but anxiety about range. Consumers are unaware how far they actually travel and what electric vehicles could fit their needs. Price is the second largest obstruction to the development of the EV industry in Denmark. Current prices for the average EV are still higher than the average internal combustion engine, even with the exemption of the 180% vehicle registration tax. Microcars are taking a high percentage of the EV market because they fit the same needs, yet are priced significantly lower (many under 80,000 DKK). The third barrier, lack of consumer knowledge, could potentially be the best target area for the Danish Consumer Council to focus on. The Taenk survey participants expressed that range was the largest obstruction to uptake, but the team realised that consumers were not aware of which EVs could fit their needs. When inquiring about price, the project group learned that consumers disregard EVs typically due to their initial cost. Most consumers are unaware of cost over time. The lack of infrastructure, in this case the availability of charging stations, is identified as the fourth barrier. The fear of running out of fuel while on the road is a very real factor in potential buyers' minds. Additionally, there is a need for more standardisation of charging stations. Currently, there are two main charging providers in Denmark, Clever and E.On, and crossing over from one to another is not as convenient as refuelling at a petrol station.

[10] Source: Denmark's Sixth National Communication on Climate Change Under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, December 2013, available at: http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/nc6andbr1-dnk-2jan2013[1].pdf

Current regulations including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of the technical infrastructure and the placement of vehicle charging stations

An independent e-mobility market model is currently being implemented in Denmark as regards charging station operations.

Public charging stations are being deployed independently from the "regulated" DSO/grid business. The "provision" of charging stations (building, owning and running them) is a competitive activity that can be carried out by "any market participant" – so actually more than one party might install charging stations in a town or on a single street.[11]

Currently, there are two main charging providers in Denmark, Clever and E.On, and crossing over from one to another is not as convenient as refuelling at a petrol station.

The Danish government developed a number of tax incentives designed to promote the purchasing of electric vehicles and reduce carbon emissions. Battery EVs and fuel cell vehicles are exempted from the registration tax and annual tax until the end of 2015. EVs are also exempted from the current Danish registration tax for passenger cars, which is based on the value of the car. Denmark has the highest registration tax for new vehicles in Europe (105% on the price of the vehicle up to 9,500 EUR, and 180% thereafter). EVs are exempt from the registration tax and the green ownership fee (grønejerafgift – max 1200 EUR), making Denmark one of the countries with the highest incentive levels in Europe. This incentive should balance the much higher purchasing cost of electric vehicles and make them price-competitive with conventional vehicles. This is part of Denmark's strategy to achieve its target of 200,000 EVs on the road by 2020. So far, however, sales have been moderate and are still below 0.5% of new sold cars.

Locally, there is free parking for EVs in cities. Currently, there are no special tax rules for PHEVs.[12]

However, there is no agreement on further EV incentives. The main incentives expire in 2015 and there is no decision on how to support EVs beyond 2015.

Denmark has implemented many of the same incentives as Norway, but they have not achieved the same level of success enjoyed by their Scandinavian neighbour Norway. One major barrier is the failure of Better Place, an $850 million investment programme designed to develop electric vehicle infrastructure that went bankrupt in 2012 (Farber, 2013). The programme was primarily focused on Denmark and Israel but after its massive failure the result was a generally negative opinion of electric vehicles in Denmark.[13]

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[11] Deploying publicly accessible charging infrastructure for electric vehicles: how to organise the market?, EURELECTRIC concept paper, July 2013, available at: http://www.eurelectric.org/media/84461/0702_emobility_market_model_final-2013-030-0501-01-e.pdf

[12] http://www.ieahev.org/by-country/denmark-policy-and-legislation/

[13] http://web.cs.wpi.edu/~rek/Projects/ECar_PQP.pdf

Existing technical and spatial infrastructures

According to the European Electro-mobility Observatory there are almost 800 charging posts in Denmark (Table 14).[14]

Table 14. Charging posts and battery swap stations by charging technology in Denmark

Charging type		Unit	Accessibility of charging points		
			Public	Private	Total
Normal & semi-fast charging posts	by wire	Nº	-	-	-
Normal & semi-fast charging posts	wireless	Nº	745	-	745
Fast charging posts	by wire	Nº	30	-	30
Fast charging posts	wireless	Nº	745	-	745
Total normal/semi-fast charging posts		Nº	745	-	745
Total fast charging posts		Nº	30	-	30
Total charging posts		Nº	775	-	775
Battery swap stations		Nº	20	-	20

Taking into account the applied methodology for charging infrastructure determination, Denmark has a satisfactory number of electric points. However, further plans for development in this area have been announced. For example, the Danish electric mobility operator CLEVER will establish this year 263 new charging points in Denmark. This means that, by the end of 2015, CLEVER will operate more than 543 charging points with 22 kW, 43 kW and 50 kW fast charge in Denmark.

[14] http://ev-observatory.eu/denmark-2/#fs_national_targets

3.4. Estonia

General information

Economic aspects and clean technologies are receiving more and more attention for the purposes of planning the development of the transport sector. Estonia's (Figure 6) main requirements in the development of the transport sector include maintaining the condition of main roads and improving the condition of basic and secondary roads; continued reconstruction of the Tallinn-Tartu highway into a four-lane road; decreasing the use of vehicles in towns by improving the conditions for walking, cycling and using public transport and using smart solutions to offer various new services, particularly short-term bicycle and car rent; increasing the number of departures and speed of connection for train traffic for trains to become the preferred means of transport that connects Tallinn and other towns; improving the train connection with Latvia (on the Tartu-Riga line, Rail Baltic) and Russia (the trip to St Petersburg should be shorter by five hours); improving traffic safety by bringing it to a level where the average number of traffic fatalities would not exceed 50 for every three years, and in a long-term perspective, there would be no traffic fatalities at all; and increasing the share of more economic vehicles that run on renewable energy so that biomethane or compressed gas generated from domestic biomass and waste would become the main alternative type of fuel in Estonia.[15]

Figure 6. Map of Estonia.

[15] https://www.mkm.ee/en/objectives-activities/development-plans

National goals and requirements

The policies and measures for transport declared by the government of Estonia in the last national communication within the United Nations Framework Convention on Climate Change (2014) included measures aimed at making transport more environmentally friendly; for example, developing a traffic management and coordination system, enhancing the competitiveness of public transport and promoting light traffic. Recently, a new plan for 2014–2020 was adopted. The key objectives of this new plan are to limit the use of energy in the transport sector and to minimise the impact of this sector on the environment.[16] Moreover, the second Energy Efficiency Action Plan includes 17 general energy efficiency measures, with some measures relating to the transport sector, the key one being the excise duty on transport fuel. This excise has been increased on several occasions in recent years with a view to placing downward pressure on the demand for transport fuel and thereby making it more sustainable. Currently, the excise amounts to 0.42 EUR per litre for unleaded petrol. The National Renewable Energy Action Plan to 2020 includes specific measures for the use of biofuels that are designed to facilitate reaching the 10 per cent RES target as set out in the EU Renewable Energy Sources Directive (2009/28/EC). These include: stipulating a 5–7 per cent mixed biofuel blend for liquid fuels (which is expected to increase the share of biofuels in transport by up to 5 per cent by 2015), transitioning to renewable energy in public transport (which is expected to increase the share of biofuels by 2 per cent by 2020), and increasing the market share of alternatively fuelled vehicles to 1 per cent by 2020.

In March 2011, the government of the Republic of Estonia concluded a contract with the Mitsubishi Corporation for the sale of AAUs in the amount of 10 million AAUs to start the Estonian electrical mobility programme. The programme comprises three parts: 507 Mitsubishi i-MiEV electric cars were commissioned by the Ministry of Social Affairs as an example, the Ministry of Economic Affairs and Communications developed a support system for natural and legal persons for the acquisition of electric cars, and infrastructure for charging electric cars was created to cover the whole country. Distribution of the purchase grant and the administration of the quick charging network are organised by Foundation KredEx.

Since November 2012, the purchase of plug-charged hybrid vehicles has also been supported.

The goal of the programme is to speed up the commissioning of electric cars in Estonia, and facilitate the achievement of the goal undertaken by the state to increase the use of renewable energy by 2020.

It was possible to apply for the grant to purchase electric cars from 18 July 2011 until 17 August 2014. The quick charging network of electric cars was constructed in Estonia by ABB. The programme period was 2011–2014, corresponding to the trade period of AAUs according to the Kyoto Protocol.

[16] http://unfccc.int/resource/docs/2015/idr/est06.pdf

Developmental barriers in regard to internal conditions

Given that the grant to purchase electric cars was suspended last year, further development of the EV market may collapse. Bearing in mind that saturation of EVs has not reached a critical mass, which could allow autonomous growth, and additionally the wealth of Estonian citizens is still far from the EU average, further financial support of end-users has to be considered. Before closure of the financial programme in August last year, a huge discount rally was observed. And after that it can be expected that not many people will be able to buy EVs at full price.

Estonian decision-makers are conscious of that and the latest news from Estonia has proved that Estonia is considering further action in this area. As Toomas Haidak – Head of the Transport Development Department at the Ministry of the Economy – said to *The Baltic Course* last January, it has not been excluded that the payment of subsidies will continue on a smaller scale than before, but not yet this year. "It will be discussed in the context of the preparation of next year's state budget. We actually have the means till 2017 in the framework of the electric mobility programme," said Haidak. However, only moderate incentives are also considered. In July 2015, Prime Minister Taavi Rõivas emphasised that another important step in encouraging the purchasing of electric vehicles will be the decision to allow electric vehicles to be driven on public transport lanes.

After finalisation of its electrical mobility programme, which was financed from the sale of AAUs within the Kyoto Protocol, Estonia is now faced with the difficult decision of how to stimulate further e-mobility growth. With limited financial incentives, the programme is in question.

Current regulation including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of the technical infrastructure and the placement of vehicle charging stations

In order to establish this nationwide charging infrastructure, the government asked financing and programme management agency KredEx to procure a turnkey technical solution with a five-year operational agreement from private providers. In addition, KredEx was responsible for finding and securing locations for chargers and ensuring that electricity-grid companies built sufficient power connections to these locations. All subtasks within the programme were procured from private companies.[17]

Existing technical and spatial infrastructures

[17] www.eltis.org

The purpose of the charging infrastructure project is to create an all-Estonian network of quick chargers. Quick chargers of electric cars are everywhere all over Estonia to ensure sufficient freedom of movement for all users of electric cars.

Charging points are distributed as follows:

- all roads with dense traffic are covered,
- the distance between quick charging points is 40–60 km. Suitable and frequently visited places are considered as locations for quick charging stations, e.g. petrol stations, cafes, shops, etc.,
- ports servicing international private transport and local travel ports,
- all settlements with over 5,000 inhabitants,
- in towns, charging points are built-in locations where people move anyway – for example, next to shopping centres, petrol stations, post offices, bank buildings, car parks, etc.,
- there are 165[18] quick chargers in Estonia. A hundred quick chargers are situated in towns and 65 by roads. Of the larger towns, 27 quick chargers will be in Tallinn, 10 in Tartu, five in Pärnu and two in Narva,
- according to the European Electro-mobility Observatory, there are about 1,000 charging posts in Estonia (Table 15).

Table 15. Charging posts and battery swap stations by charging technology in Estonia

Charging type		**Unit**	**Accessibility of charging points**		
			Public	**Private**	**Total**
Normal & semi-fast charging posts	by wire	N°	-	-	865
Normal & semi-fast charging posts	wireless	N°	-	-	
Fast charging posts	by wire	N°	164	-	164
Fast charging posts	wireless	N°	-	-	
Total normal/semi-fast charging posts		N°	-	865	865
Total fast charging posts		N°	164	-	164
Total charging posts		N°	164	865	1029
Battery swap stations		N°	-	-	-

Estonia has proved that only publicly planned and deployed e-mobility development can deliver full and reliable charging infrastructure. However, when analysing further development of the electric vehicle market in Estonia it is obvious that other strong public incentives will be needed, including restoring direct grants for the purchase of EVs.

[18] According to EEO data there are 164 fast charging posts. Differences may result from the current maintenance work on the charging infrastructure.

3.5. Finland

General information

The aim of the new Finnish transport policy is to further improve productivity and effectiveness and thereby promote sustainable growth, competitiveness and well-being. The main motivation for introducing a new approach to transport is the need to meet the increasingly diverse needs of society and all transport users, individuals and businesses alike. Transport is a service that can be improved by using the resources available in a sensible and responsible way. For the well-being of people and the competitiveness of businesses, it is important to ensure smooth travel and transport for everyone and everywhere.[19]

Figure 7. Map of Finland.

National goals and requirements

The policies and measures for transport declared by the government of Finland in the last national communication within the United Nations Framework Convention on Climate Change (2014)[20] include promoting the use of biofuels, renewing the vehicle fleet, improving energy efficiency and developing more environmentally friendly transport

[19] http://www.lvm.fi/web/en/transport_policy#report
[20] http://unfccc.int/resource/docs/2014/idr/fin06.pdf

modes. All these measures were included in the Finnish Climate Policy Programme. According to the National Act on the Use of Biofuels that came into force in 2011, biofuels will replace 12.5 per cent of the fossil fuels in transport, resulting in GHG emission reductions of 2,000 kt CO2 eq by 2020. The Climate Policy Programme for the Transport Sector aims at a rate of vehicle fleet renewal of 7 per cent per year by 2020. This is supported by the new car taxation, which is differentiated according to vehicle-specific emissions. The estimated GHG emission reduction from the Climate Policy Programme for the Transport Sector will be 2,100 kt CO2 eq in 2020. Another measure included in the Climate Policy Programme for the Transport Sector to achieve the planned targets by 2020 is the improvement of energy efficiency in the transport sector. This can be achieved through energy efficiency agreements in freight and public transport and eco-driving. Finland reported that in 2009 the Public Transport Act was reformed to be in compliance with the European Union public service obligations. The objective of this reform was to create a uniform and user-friendly service package and enhance the number of beneficiaries of public transport. A national strategy and an implementation plan were adopted in 2011 to encourage walking and cycling during the period 2011–2020.

Electric vehicles are still a niche market in Finland, with 360 registered (2014). However, the growth of first registrations from 50 in 2013 to 183 in 2014 shows that Finland can join countries with a modest share of EVs in new registrations. According to the existing policy provisions, there will be no direct government incentives for electric cars in the future. All low-emission technologies are supported by taxation according to vehicle-specific emissions. EVs belong to the lowest tax class in all three tax groups: car tax, motor vehicle tax and tax on driving power.

However, through a new programme, EVE – Electric Vehicle Systems, funded by Tekes – the Finnish Funding Agency for Innovation can change this situation a little bit. Tekes is the most important publicly funded expert organisation for financing research, development and innovation in Finland. They boost wide-ranging innovation activities in research communities, and the industry and service sectors. The main goal of EVE is focused on companies and research institutes that work with electric vehicles and machinery and the components and systems used in them. The long-term goal is to increase the amount of business related to electric vehicles and machinery from the 2010 figure of 200 million EUR to approximately 2 billion EUR by 2020.[21]

Additionally, the Ministry of Employment and the Economy has invested in electric vehicles to support companies. The support is only available for companies leasing an electric car or building a charging station on their premises. The support period of 36 months is expected to end in 2017, and companies that want to benefit from the 35% funding for cars and 30% for charging stations had to apply at the latest by April 2015.[22]

[21] http://www.tekes.fi/en/programmes-and-services/tekes-programmes/eve/

[22] http://castrenblog.com/2015/03/02/is-an-electric-vehicle-boom-about-to-take-off-in-finland/

Developmental barriers in regard to internal conditions

According to the Association of Finnish Automobile Importers, the price of an electric vehicle is the main barrier to boosting electric mobility in Finland. An electric car costs 10,000 EUR more than a petrol car of similar size and power.[23]

Current regulation including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of the technical infrastructure and the placement of vehicle charging stations

Even though there is political will to encourage electric transportation in Finland, some legal obstacles still need to be removed. For example, in housing companies, parking and charging electric vehicles clashes with the general principle of equality among residents when it comes to sharing parking spots and investing in additional electricity services. In addition, the Limited Liability Housing Companies Act provides no clear opinion in cases where residents wish to install charging facilities on their own in parking spots they are using.

Residents with electric cars do not, in general, have priority on plug-in parking spots. On the contrary, general resident meetings may even decide to forbid charging electric vehicles in parking spots altogether. In addition, the charging costs may require payment either according to consumption or by monthly instalments.[24]

[23] http://www.helsinkitimes.fi/finland/finland-news/domestic/8918-electric-cars-not-popular-with-finns.html
[24] http://castrenblog.com/2015/03/02/is-an-electric-vehicle-boom-about-to-take-off-in-finland/

Existing technical and spatial infrastructures

Finland currently has some 250 EV charging stations, 35 of which are located in Helsinki. According to the European Electro-mobility Observatory, there are about 50 publicly available charging posts. The stations are built and operated mainly by private operators, since the government does not actively participate in the construction of charging networks, but focuses instead on coordination and support. The charging station network is expected to expand in 2015 when the first Tesla Supercharger stations are opened in southern Finland.[25]

The European Electro-mobility Observatory data on the charging posts in Finland is presented in Table 16.

Table 16. Charging posts and battery swap stations by charging technology in Finland

Charging type		Unit	Accessibility of charging points		
			Public	Private	Total
Normal & semi-fast charging posts	by wire	Nº	50	-	50
Normal & semi-fast charging posts	wireless	Nº	-	-	-
Fast charging posts	by wire	Nº	10	-	10
Fast charging posts	wireless	Nº	-	-	-
Total normal/semi-fast charging posts		Nº	50	-	50
Total fast charging posts		Nº	10	-	10
Total charging posts		Nº	60	-	60
Battery swap stations		Nº	-	-	-

[25] http://castrenblog.com/2015/03/02/is-an-electric-vehicle-boom-about-to-take-off-in-finland/

3.6. Germany

General information

Germany (Figure 8) is a federal republic comprising 16 states (lands). With its location in the centre of Europe it has been surrounded by nine neighbouring states since the reunification of Germany in 1990. Germany covers an area of 357,000 square kilometres. The longest distance from north to south amounts to 876 km, while from west to east it is 640 km. With about 83 million inhabitants in total, Germany has one of the largest populations in Europe. Its capital is Berlin.

Figure 8. Map of Germany.

Germany has a large fleet of vehicles, including:

- 43,851,230 passenger cars,[26]
- 4,054,946 motorcycles,
- 76,794 buses,
- 2,629,209 heavy goods vehicles,
- 2,081,763 tractors,
- 272,877 others.

[26] As for their propulsion/fuel: 68.3% are petrol cars, 30.1% diesel cars, 1.14% LPG cars, 0.18% CNG cars, 0.19% HEVs and 0.028% EVs.

Germany, as mainly an export-oriented nation, has been influenced by the worldwide economic crisis. This phenomenon is reflected, among other things, in the declining demand for transport. The German stimulus packages are aimed at providing targeted incentives for innovation and a long-term boost to economic growth. Germany, as a traditional transit country in the middle of Europe, faces further rising freight traffic volumes, which are attributable to globalisation. According to forecasts, in Germany a growth of 71% in freight traffic is to be expected by 2025 (compared with 2004) while passenger transport will only rise moderately until then. With regard to transit traffic, an increase of 136% in freight transport is expected by 2025.

In developing transport policy, it is essential to combine the desire for individual mobility with the demand for sustainable development. Therefore, the basis of any action is a long-term vision of the sustainable mobility of people and goods that covers the entire transport system, taking into account all aspects of sustainability (not only environmental aspects such as GHG emissions or biodiversity and security, but also, for example, social and economic aspects). This way of balancing various factors and aspects constitutes the basis for political and planning activities in Germany. Furthermore, this country committed itself back in December 2007 to reducing its CO_2 emissions by 30% by 2020 compared to 1990 as part of the German Integrated Energy and Climate Programme. This document includes, among other things, market incentive programmes on renewable energy and measures to support sustainable transport. It should be added that in 2009 the G8 Countries (Germany is part of this group) agreed to limit global warming to 2 °C. The German transport sector is expected to make its contribution towards achieving this goal.

National goals and requirements

The following national-level documents are relevant for electric mobility issues in Germany:

- The National Sustainability Strategy 2002 and Progress reports (2004, 2005, 2008): The German government strives for sustainable development in terms of the economy, ecology and social issues. Its policy is based on a long-term global perspective that spans the generations. For more information: http://www.bundesregierung.de,
- The Freight Transport and Logistics Master Plan: In July 2008, the German government approved a systematic and intermodal transport policy approach. One of the predominant objectives of this integrated approach is to cope with the drastic rise in freight traffic due to increasing globalisation and therefore make the transport system as a whole more efficient and further reduce CO_2 emissions. For more information: http://www.bmvbs.de,

- The Federal Government Fuel Strategy: As part of the National Sustainable Development Strategy, in 2004 the German government elaborated a strategy with a time horizon of 2020 on the basis of a matrix process conducted by experts and in the light of international developments. For more information: http://www.bmvbs.de. Within the German government's fuel strategy, the National Innovation Programme on Hydrogen and Fuel Cell Technology (NIP) and the National Development Plan for Electric Mobility (NEE) focus on the electrification of transport,
- National High-Tech Strategy and Environmental Technology Master Plan: The German government launched the National High-Tech Strategy in 2006 to support the development of innovative environmental technologies and products and to develop lead markets. It was set up as an overall strategy on innovation policy to promote systematic research in Germany in various fields, such as climate change, use of natural resources and energy, mobility and cross-cutting technology (such as nanotechnology and biotechnology). To further stimulate eco-innovations, an Environmental Technologies Master Plan was adopted at the end of 2008 to consolidate different policy instruments in the field of R&D and environmental policy, such as eco-design, technology procurement and market diffusion programmes for eco-innovations. For more information: http://www.hightech-strategie.de, http://www.bmu.de/wirtschaft_und_umwelt/downloads/doc/42558.php.

In Germany, the promotion of e-mobility constitutes a clear political target. In the framework of the National Development Plan for e-mobility, the German government defined the target that Germany will be the forerunner region in the case of e-mobility and that until 2020 at least one million e-cars will be in use in Germany. It should be added that e-mobility in this country is not limited to passenger cars: electric propulsion is developing also in the categories of buses, trucks, vans, electric motorcycles, scooters and pedelecs.

Germany has also set itself other very ambitious policy goals to be attained by 2020, as follows:

- to make German industry the leading global supplier,
- to establish Germany as the leading global market.

The results achieved up to the end of the pre-market phase have been somewhat mixed. German industry is well on the way to becoming the leading global supplier. By the end of 2014, German manufacturers already had 17 electric vehicle models on the market and they will continue to expand their product ranges over the next few years. A further 12 new models have been announced for 2015. Germany's focus on promoting research and development (R&D), regulation and standardisation, and education and training has delivered global success. The key industries are now cooperating successfully with researchers throughout the electric mobility value chain.

The next step is to convert German industry's potential into higher market shares, enabling it to become the world's leading supplier. Electric vehicles must be able to compete with other power-train technologies, particularly in terms of price and range. This still requires a significant level of pre-competitive research and development. The German National Platform e-mobility (NPE) estimates that a total of 2.2 billion euros of R&D project funding will be required in order to drive forward the innovations necessary until the conclusion of the market ramp-up phase at the end of 2017. Assuming an average funding share of 50 per cent, this means that Germany's federal government will need to spend 360 million euros per annum on research and development.

To achieve this goal the National e-mobility Platform was started in 2010 as a consulting board of the German federal government in order to hasten the market expansion of innovative electric vehicles. Proposals were made by the NPE on the basis of analyses and inventory and were regularly published as intermediate reports. Members of the NPE are top representatives from industry, politics, research institutes, associations and trade unions.

The basis of the e-mobility strategy of the German federal government was defined in the Integrated Energy and Climate Programme of the German federal government (IEKP), which was adopted in 2007. Here e-mobility was defined as one of the priority targets and concrete measures such as the establishment of cooperation with the industry on a national level and support of the development of efficient motor technologies were decided.

In 2011, the German Government e-mobility Programme was published, which defines a common research and development programme for an efficient market launch, measures for training and qualification in the field of e-mobility, enhancement of charging infrastructure, incentives and international cooperation.

In order to support the market expansion and research about e-mobility the German federal government funded projects between 2009 and 2011 with a total of 500 million euros from the second stimulus package. In the following years funding initiatives on a federal level were going to be implemented with a total funding amount of up to 1 billion euro.

The general financial support for e-mobility may be summarised as follows:

- the annual circulation tax for cars registered as from 1 July 2009 is based on CO_2 emissions. It consists of a base tax and a CO_2 tax. The rates of the base tax are € 2 per 100 cc (petrol) and € 9.50 per 100 cc (diesel), respectively,
- the CO_2 tax is linear at € 2 per g/km. Cars with CO_2 emissions below 95 g/km are exempt currently, which includes all electric vehicles (the previous thresholds: 120 g/km before 2012, 110 g/km in 2012–13). These vehicles are exempt for 10 years when purchasing until the end of 2015 and for five years when purchasing from 2016 until the end of 2020,
- the reduction of the gross list price in the case of using a staff EV for private purposes, which is income tax-relevant (it is a compensation for the disadvantage caused by higher purchase prices). A flat rate of 450 € per kWh battery power is

used, with a maximum reduction of 9.500 €. The flat rate will decrease by 50 € per year until 2023.

Electromobility Model Regions

Within the framework of the financial programme "Electromobility Model Regions" of the Federal Ministry of Transport and Digital Infrastructure, eight model regions were funded with 130 million euro. The programme was started in 2009. Experts from science, industry and municipalities cooperated with the aim of building up the necessary infrastructure and supporting the availability of e-mobility in public space.

Competition Showcase e-mobility

In April 2012, the German government selected four regions in the country (Berlin-Brandenburg, Baden-Wuerttemberg, Bavaria/Saxonia and Lower Saxonia) to act as "Showcase Regions for Electromobility". Based on a decision by the German Bundestag, research and development into alternative drive systems is to take place across each of these regions. The federal government is providing a total of 180 million euro in funding for these large-scale demonstrations and pilot projects. Furthermore, the six federal states included in the showcase e-mobility programme are providing additional funding totalling up to 80 million euro. Until the middle of 2016 altogether about 130 projects will be running in the showcase regions.

Berlin-Brandenburg

This showcase project – which includes electric vehicles, commercial vehicles and pedelecs from many manufacturers – is in a state of advanced progress. The project covers about 30 projects, involves more than 100 partners (from science, business, politics and administration) and includes project funding of around 90 million euro (including 35 million euro from companies, 37 million euro from the federal government and 18 million euro from the states of Berlin and Brandenburg. The showcase project is coordinated by the Berlin Agency for Electromobility eMO. The project targets four focal areas of application: driving, charging and parking, storage and integration.

With regard to data on the project's progress from 2014: in total, 1,800 electric vehicles have been operational on the road. The e-car-sharing fleet alone has included more than 400 electric cars.

In terms of the goals to achieve in 2015, as many as 4,000 electric vehicles (including both passenger cars and commercial vehicles) and 1,600 publicly accessible charging points are envisaged.

Couriers and parcel services are using electric vans and delivery bikes for deliveries. Battery-powered vehicles are being used for waste collection. In turn, welfare services are testing electric cars for daily use.

Meanwhile, the largest 100% electric truck approved for use on public highways anywhere in the world is delivering goods around the city. An electric bus service featuring inductive charging runs between Berlin's Zoo and Südkreuz railway stations, the latter being converted into a multimodal "station of the future" using renewable energy. A “micro smart grid” and wind power load management system are being tested. Significant numbers of both AC and DC charging points are being added to the public charging infrastructure. The appropriate education and training is being provided through a “mobility driving school”, together with training and CPD measures in the automotive and electrical trades.

Baden-Württemberg

More than 100 partners from industry, the research community and the public sector are involved in Baden-Württemberg’s showcase region LivingLab BWe mobil. The 37 individual projects in the Stuttgart region and the city of Karlsruhe have a total budget of around 110 million euros. They are financed by the German federal government, the government of the state of Baden-Württemberg and the regional government in Stuttgart. To date, the various projects have succeeded in putting more than 1,000 electric vehicles on the road and constructing around 800 charging points.

The nine selected thematic areas are: intermodality, urban and transport planning, fleets and commercial transport, energy, infrastructure and ICT, vehicle technology, electric mobility at home, communication and participation, and education and training. Together with research at the overarching project level, these thematic areas provide targeted coverage of the entire electric mobility system. In tandem with the leading-edge cluster Elektromobilität Süd-West, LivingLab BWe mobil has created a dynamic process of stimulating innovations in the area of Baden-Württemberg.

As well as providing the public with a visible demonstration of how electric mobility can be successfully implemented in everyday scenarios, the LivingLab BWe mobil projects have also highlighted areas where further research and development is required both in terms of technology and the underlying conditions in which it is deployed.

Bavaria/Saxonia

In the areas of Bavaria and Saxony, the issues of long-distance mobility, urban mobility, rural mobility, international mobility networks and training and continuous professional development (CPD) were covered by about 40 projects involving more than 100 partners. Thanks to funding from the federal government and the state governments of Bavaria and Saxony, the first results of these projects can already be seen on the streets. For instance, in 2014 a network of CCS fast charging stations was installed and opened along the A9 motorway, while work also began on the construction of an “Energie-Speicher-Plus-Haus” (energy storage plus house). Around 3,000 electric vehicles are on the road in Bavaria and Saxony. In addition to the use of electric vehicles by local waste disposal, delivery and bus services (from 2015), several hundred electric cars have been acquired by car-sharing schemes, company vehicle fleets and other commercial and private multipliers.

Future technologies such as batteries, power electronics, renewable energy and smart grid control are crucial parts of a synergetic system. A car dealership, for instance, is testing a solar system combined with a puffer storage to charge around 30 rental cars.

The project's findings are being communicated to schools, companies and higher education institutions through training and CPD provision.

Lower Saxonia

The Hannover-Braunschweig-Göttingen-Wolfsburg metropolitan region is promoting electric mobility as a part of a sustainable transport and energy policy. A number of companies located in the region are involved in the development and manufacture of vehicles and components for the global market. A significant increase is also being targeted in the number of electric vehicles in everyday use on the region's roads.

By the beginning of September 2014, around 1,700 fully electric vehicles had been registered in the metropolitan region, which has a total population of 3.8 million. Some 80 municipal and district authorities and local government enterprises are currently adding electric cars to their fleets as part of the electric mobility showcase project. Buses fitted with inductive charging technology, electric motorcycles in tourist regions and a fast cycle lane for electric bicycles are good examples of the range of different electric mobility initiatives that exist within the metropolitan region. Germany's most northern showcase region is also placing particular emphasis on the production and storage of renewable energy for charging electric vehicles. In addition, the impact of electric mobility on the labour market is being investigated and the relevant training and CPD provision are being developed.

Developmental barriers in regard to internal conditions

The main barriers to the deployment of e-mobility in Germany are considered to be:

- cost of batteries and their cost-effectiveness,
- range of EVs,
- missing infrastructure for EVs.

Despite significant support from the public sector and the political consensus about supporting e-mobility, according to present estimates, only additional measures can ensure that Germany achieve the goal of one million electric vehicles. There is currently sufficient experience and data with regard to user behaviour to allow for the creation of a targeted framework for promoting electric mobility in Germany. In order to establish Germany as the leading global market with one million electric vehicles on the road by 2020, the NPE recommends the rapid implementation of the set of measures outlined below as a matter of priority. On the governmental side, the NPE considers the introduction of a special depreciation allowance for business users and the co-financing of the public charging infrastructure as the next important steps. It will also be necessary to ensure that the successful cross-sectoral engagement of industry in the field of electric mobility is continued.

In order to become the international lead market, it will be necessary to create an electric mobility system that incorporates vehicles, energy supply and transport infrastructure and is both attractive and visible to users. Thanks to its Systemic Roadmap, Germany is well on the way to meeting its objective. Nevertheless, the most realistic current market evolution scenario indicates that – despite the existence of technologically attractive products, services and solutions – additional measures are still required if the goal of one million electric vehicles is to be achieved. If existing hurdles are swiftly removed, effective monetary and non-monetary incentives are introduced and the charging infrastructure is expanded in a functional, need-based manner, it should still prove possible to meet the original target of getting one million electric vehicles on the road in Germany by 2020. There is now a great wealth of experience and data with regard to user behaviour that can be used to make targeted changes to the underlying conditions. The next step is therefore to roll out this targeted set of measures. Failure to meet the target of 500,000 vehicles by the end of 2017 would result in the need for extremely costly measures in order to deliver the goal of one million vehicles by 2020. The 2013 coalition agreement announced a number of incentives for EV users.

Current regulation including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of the technical infrastructure and the placement of vehicle charging stations

The crucial document concerning these issues is the German Standardisation Roadmap for Electromobility (with Version 1 published in 2010 and Version 2 in 2012[27]). It both summarises the progress to date and contains suggestions as to future actions. The document describes the "Electromobility" system approaches that, according to experts from German industry, the research sector and politics, will make a major contribution towards achieving the goal of 1 million electric vehicles on Germany's roads by 2020.

The German progress towards e-mobility is highlighted, in addition to actions described in other paragraphs, by the introduction of the Combined Charging System (CCS) and efforts on behalf of making the CCS the standard international system for both normal and fast charging. The CCS is based on open, universal standards for electric vehicles. It combines AC charging up to a maximum of 43 kilowatts with fast DC charging up to a maximum of 200 kilowatts.

In addition to the connectors and sockets, the CCS also incorporates all the control functions, as well as handling communication between electric vehicles and infrastructure. As such, it is intended to provide solutions for all the relevant charging scenarios.

The key elements of the Combined Charging System are as follows:

[27] Version 3 is under preparation.

• for AC charging:

- using an AC charging electrical interface for power transmission – including safety signalling – that complies with international standard IEC 61851-1,
- using Type 2 connectors that comply with international standard IEC 62196-2;

• for DC charging:

- using a DC charging electrical interface for power transmission – including safety signalling – that complies with international standard IEC 61851-23,
- using Combo 2 connectors that comply with international standard IEC 62196-3

• the communication interface between the electric vehicle and the charging station, which is based on international standard ISO 15118.

The large-scale adoption of the CCS in Europe will occur thanks to Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of an alternative fuels infrastructure. The Directive contains a binding requirement to use the Combined Charging System CCS for public charging points. The CCS, in conjunction with Type 1 connectors for AC charging and Combo 1 connectors for DC charging, is also set to be adopted as the standard in the US. Negotiations are currently ongoing with China, Japan and other partners in the hope of convincing them to adopt the CCS in order to establish a global standard. The CCS is already an established standard in Europe and the US. In Germany it is already legally binding for all public-access charging points to conform to this standard.

In addition to the charging infrastructure, the standardisation activities in Germany regulate the following crucial aspects of e-mobility systems:

- smart grid-related issues: an efficient, optimised utilisation of electricity supply grid resources and sustainably generated electric energy, which give rise to a number of special requirements, particularly on the technology used and on standardisation of the interface between electric vehicles and the grid,
- new energy flow and communications interfaces and protocols, adaptation of existing interfaces,
- data security: e-mobility (especially with V2G functionalities) results in a large amount of information that will be collected and stored at various points and exchanged via various communications interfaces between the involved parties. Therefore, ensuring adequate security of these data and of the data processing systems is of great importance,
- different categories of road vehicles that are fully or partially propelled by an electric motor. This point is very broad and as such includes issues such as:

- different degrees of electrification of road vehicles,

- different drive configurations for purely electric vehicles,
- safety (electrical, functional, safety in case of accidents),
- standardisation of components,
- fuel cells and the related hydrogen supply infrastructure,
- capacitors: modern double-layer called "supercaps" or "ultracaps" can be used as energy storage devices for electric vehicles (at present, these are of relevance particularly for HEV applications).

What is interesting is that the construction of batteries is not included in this list. The reason for this is that only lithium-ion batteries are considered to be relevant on the market in the coming decade.

Existing technical and spatial infrastructures

Germany has approximately 650,000 km of roads, of which 231,000 km are non-local roads. The road network is extensively used with nearly 2 trillion kilometres travelled by car in 2005, in comparison to just 70 billion km travelled by rail and 35 billion km travelled by plane.

According to the National e-mobility Platform: currently, in the international ranking of leading e-mobility markets, Germany occupies an average position. At present, approximately 24,000 electric vehicles are registered in Germany, while there are around 4,800 AC charging points at some 2,400 different locations, as well as about 100 fast charging points[28] (Table 17). This provides a solid platform for the market ramp-up phase in Germany. The charging points are mostly installed in large urban agglomerations, including Berlin, Munich and Hamburg. The current charging infrastructure provides a solid platform for the market ramp-up phase in Germany.

Table 17. Charging posts and battery swap stations by charging technology in Germany

Charging type		Unit	Accessibility of charging points		
			Public	Private	Total
Normal & semi-fast charging posts	by wire	Nº	4800	-	4800
Normal & semi-fast charging posts	wireless	Nº	-	-	-
Fast charging posts	by wire	Nº	-	-	-
Fast charging posts	wireless	Nº	-	-	-
Total normal/semi-fast charging posts		Nº	-	-	-
Total fast charging posts		Nº	100	-	100
Total charging posts		Nº	4900	-	4900
Battery swap stations		Nº	-	-	-

[28] According to the European Electro-mobility Observatory there are 4,720 charging points in Germany in total (without division into categories) as of January 2014.

With regard to charging infrastructure, in Germany there are around 4,800 AC charging points at some 2,400 different locations, as well as about 100 fast charging points.[29] These numbers certainly provide a solid platform for the next phase of the market development in Germany, especially compared to its Eastern neighbours such as Poland or the Czech Republic. However, there are also some disadvantages connected with this situation, namely the existence of a relatively well-developed charging infrastructure based on the results of previous standards in addition to the significant cost of transforming the infrastructure into one based on the Combined Charging System (CCS).

[29] According to the European Electro-mobility Observatory there are 4,720 charging points in Germany in total (without division into categories) as of January 2014.

3.7. Lithuania

General information

Lithuania is the southernmost, largest (with an area of 65,300 km^2) and most populous (with a population of 2.9 million) state of the three Baltic States, located in north-central Europe (Figure 9).

Figure 9. Map of Lithuania.

Like the other two Baltic States – Estonia and Latvia – Lithuania is a member of both the European Union and NATO. Lithuania, as an EU member state, is willing to contribute to the long-term sustainable development strategy aimed at the preservation of a clean and healthy environment and higher quality of life for the present and future generations.

In Lithuania, 88.6% of all motorised road transport vehicles are domestic or commercial vehicles, 7.1% are freight vehicles, 1.6% are motorcycles, 0.8% are buses and 2% are others (supporting and auxiliary means of transport).

The total consumption of electricity by transport in 2013 amounted to 2.5 thousand TOE of electricity (cars, trolleys and trains combined).

There are a number of factors highlighting the potential for electric car use in Lithuania:

- the extensive electricity market development in the Baltic region and the neighbouring countries (including nuclear power plants),
- Lithuania is too dependent on fossil fuels,
- 80% of trips made by city citizens amount to around 60 km, so a single charge run of an EV with a range of 150 km would suffice for their needs,
- the qualified and competitive workforce in Lithuania – which is a prerequisite for an industry of electric cars or its parts,
- removed barriers for electric cars – streamlined registration procedures for remanufactured electric vehicles.

An expert view (according to sources from the Lithuanian Electric Vehicles Association) on the development of electric cars in Lithuania envisages:

- serial electric car production by 2020,
- complete charging station network in biggest cities by 2016,
- electrified urban public transport by 2030,
- increase of electric car fleet to 50 per cent share by 2050.

National goals and requirements

There is currently no integrated electric mobility strategy for Lithuania, but the following national-level documents are relevant for electric mobility issues:

- The long-term (until 2025) development strategy of the Lithuanian transport system,
- Ordinance of Minister of Transport and Communications on recommendations concerning development of public-access charging points for electric vehicles and on approving plan of establishing charging points for electric vehicles next to roads of national significance,
- Lithuanian Innovation Strategy (LIS) for the years 2010–2020,
- LIS Action Plan for 2010–2013,
- National Energy Strategy,
- Energy Efficiency Action Plan,
- Law on Renewable Energy Sources,

- The National Strategy for the Development of Renewable Energy Sources,
- National Strategy for the Implementation of the United Nations Framework Convention on Climate Change until 2012,
- Operational Programme for Promotion of Cohesion for the years 2007–2013.

According to the government's vision, until the year 2025 10% of all new vehicles registered in Lithuania should be electric (it should be mentioned that the whole country's car fleet, according to researchers, may reach 2 million in 2020). In order to facilitate reaching this goal, an adequate charging infrastructure for EVs should be developed.

Developmental barriers in regard to internal conditions

EVs are not widely used in Lithuania due to underdeveloped infrastructure and high EV prices. The adoption of electric vehicles, similarly to other countries, is slowed by the fact that initially it is necessary to create a specific infrastructure (specialised service stations, battery replacement stations, etc.). For the above-mentioned reasons, most electric cars are not available on the Lithuanian market.

Lithuania does not apply any financial measures to promote the purchase of electric vehicles. Only "soft" measures to promote electric vehicles are in place, i.e. measures connected with authorisation to operate public transport lanes, free parking (introduced by Vilnius, Kaunas and Klaipeda) and free charging. Electric car prices are higher than mid-range passenger car prices, so without financial incentives, the number of EVs is increasing slowly. To highlight the salary disparity between Lithuania and the western/northern EU member states, it needs to be mentioned that, according to 2010 data, a German citizen was able to purchase a Toyota Prius for 7.5 times his/her average salary, while in the case of a Lithuanian citizen the required number of salaries amounted to as many as 58.

The popularisation of electric vehicles is additionally hampered by the fact that, although the overall number of cars registered in Lithuania is growing significantly, most of them are second-hand cars imported from abroad, which mostly have petrol engines. In 2010, the number of vehicles amounted to 2.1 million, compared to 1.5 million in 2007. In Vilnius, more than 70% of all cars are petrol powered, 23% are diesel powered and about 4% are gas powered. In 2009, about 80% of all cars in Vilnius were over 10 years old and the average car age was about 16 years. The main driver here is price, so it is even more challenging for new, relatively expensive EVs to compete against cheap, used cars working on fossil fuels.

One way of tackling this issue is the conversion of conventional cars to EVs. The Lithuanian State Road Transport Inspectorate approved the technical specifications, and the first converted electric car 3E (former Honda HR-V) manufactured in Lithuania was registered on October 9, 2010, and, according to the data from the Lithuanian Electric

Vehicle Association, at the beginning of 2012 there were already 25 converted electric vehicles. There are a number of Lithuanian companies dealing with conversions and other services connected with EVs, including JSC Autoelinta, JSC Elinta and JSC Arginta.

Current regulation including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of the technical infrastructure and the placement of vehicle charging stations

In 2015, the Ministry of Transport adopted recommendations concerning the development of public-access charging points for electric vehicles, according to which it is recommended to install at least another 17 public electric vehicle high-voltage (fast) charging points up to 2020 in the Lithuanian parts of the European significance highways E85 – 10 points (**Klaipeda–Kaunas–Vilnius**–Lida–Cernovcy–Bucharest–Alexandroupoli) and E67 – 7 points (Via Baltica: Helsinki–Tallinn–Riga–**Panevezys–Kaunas**–Warsaw–Wroclaw–Prague).

There are no special separate rules concerning operating charging stations and support systems or expansion of the technical infrastructure and the placement of vehicle charging stations, with the exception of those included in the above-mentioned recommendations. According to the recommendations, the charging infrastructure should be developed:

- along the motorways E85 and E67,
- in the five largest cities of Lithuania,
- in other territorial self-government units, where: the number of citizens exceeds 25,000/total length of roads of local significance exceeds 1,000 km/more than 10,000 passenger cars are registered.

Existing technical and spatial infrastructures

The Lithuanian public road network, including state and local roads and urban streets, amounts to about 82,131 km, including 21,313 km of state roads, which are under the responsibility of the Lithuanian Road Administration.

Therefore, Lithuania, when compared with economically stronger states, has a fairly well-developed road network. One of the main reasons behind developing the road network is that Lithuania is a transit country with a number of roads crossing it from west to east and from north to south. There are six European motorways crossing the country.

In 2015, 65 fully electric vehicles were registered in Lithuania. Currently, Lithuania has 19 electric vehicle charging points, but the communication is only ensured between Vilnius and Kaunas, and travel to other cities is still limited. In addition to the above-mentioned project on 19 fast charging points (Table 18), according to the government up to 150 slow charging stations will be additionally installed. However, this expansion is expected to be delivered by a private initiative rather than the public sector. Currently the government is not willing to invest in the development of the required charging network for electric vehicles, which undoubtedly limits the development potential of the EV market.

Table 18. Charging posts and battery swap stations by charging technology in Lithuania

Charging type		**Unit**	**Accessibility of charging points**		
			Public	**Private**	**Total**
Normal & semi-fast charging posts	by wire	Nº	19[30]	-	19
Normal & semi-fast charging posts	wireless	Nº	-	-	-
Fast charging posts	by wire	Nº	-	-	-
Fast charging posts	wireless	Nº	-	-	-
Total normal/semi-fast charging posts		Nº	-	-	-
Total fast charging posts		Nº	-	-	-
Total charging posts		Nº	19	-	19
Battery swap stations		Nº	-	-	-

In addition to the above-mentioned project on 19 fast charging points, according to the government up to 150 slow charging stations will be additionally installed. However, this expansion is expected to be delivered by a private initiative rather than the public sector. Currently the government is not willing to invest in the development of the required charging network for electric vehicles, which undoubtedly limits the development potential of the EV market. In the meantime, the current number of charging points cited in the table is not sufficient for popularisation of e-mobility in Lithuania, even taking into account the relatively small territory of this country. Nevertheless, the situation should be remedied to some extent thanks to the aforementioned programme on installing charging points along the main highways.

[30] Actual information from Lithuania confirms 11 charging points (September, 2015) and the other 19 will be constructed

3.8. Norway

General information

2

Norway's (Figure 10) decentralised settlement pattern causes a relatively high demand for transport.[31] Norway has old water transport traditions. Nowadays car ferries play a strong role in the system. Also modern modes of transport play an important role, i.e. road, rail and air. Public transport is well developed only in agglomerations. Especially in rural areas, individual road transport plays a key role. For this reason, the low population density and the general wealth of Norwegian society mean that electric cars are an attractive way for people to move around.

Figure 10. Map of Norway.

National goals and requirements

There is a general political agreement regarding electric vehicles and vehicle taxation policy in Norway. The Climate Policy Settlement signed in the Parliament in June 2012 includes all political parties except the Progress Party. The settlement includes the preservation of the tax benefits of electric cars, until the end of 2017 (the next

[31] Source: Denmark's Sixth National Communication on Climate Change Under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, December 2013, available at: http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/nc6andbr1-dnk-2jan2013[1].pdf

parliamentary term), unless the total number of electric vehicles in the fleet exceeds 50,000 before then. The local incentives (free parking, access to bus lanes, free passage through road tolls) may, according to the settlement, only be altered in close consultation with affected local authorities. The Climate Policy Settlement cannot be interpreted as implying that after 2017 electric vehicles should lose all of their benefits: the agreement merely states what will apply until the end of 2017. In terms of the number of EVs, Norway has a target of 200,000 electric vehicles on the road by 2020, which is really feasible when the last figures on registrations are taken into consideration. However, the overall goal for 2025 is that 100% of new cars sold will be emission-free. This will be achieved through a step-by-step approach:

- all municipal vehicles will be electric by 2015,
- all public transit will be fossil fuel-free by 2020,
- all taxis will be zero-emission by 2022.[32]

Developmental barriers in regard to internal conditions

In an annual survey conducted by Norsk Elbilforening its members were asked about what they consider to be crucial in order to increase the Norwegian EV fleet in the future:

- 30 per cent think increased range is the most important thing,
- 23 per cent emphasise an improved political EV framework.

This means the automotive industry has to play its part, in relation to increased range and battery capacity. In Norway, range can be a particular challenge during cold winters, as a consequence of decreased battery capacity and higher consumption.

These are the other all-important factors in increasing the EV fleet, according to the survey (all numbers in per cent):

- more fast charging stations (16),
- more parking spaces with charging opportunity (11),
- more EV models to choose from (9),
- lower EV prices (7),
- better information about EVs (4).[33]

Current regulation including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of the technical infrastructure and the placement of vehicle charging stations

[32] http://ecomento.com/2015/08/06/norway-all-new-cars-electric-by-2025/

[33] *The Norwegian EV success story*, Norsk Elbilforening, available at: http://elbil.no/index.php?option=com_jdownloads&Itemid=148&view=finish&cid=28&catid=8

Norway has what is probably the world's best incentives for zero-emission vehicles, and correspondingly the world's highest number of electric cars per capita by a wide margin. However, there was never a grand design or strategy behind this outcome. Rather, it is the result of many small measures adopted over the years to support a growing Norwegian EV industry and to reduce emissions from road transportation. As early as 1990, a temporary abolishment of import tax was introduced (finally made permanent in 1996). Also, in 1996 the annual registration tax was reduced. In 1997, exemption from road tax was introduced. In 2000, free parking was deployed for EVs. In 2000, company tax was reduced. In 2001, 0% VAT was applied. Apart from financial incentives, soft measures were introduced such as access to bus lanes (Oslo, 2003) and to road ferries (2009).

In sum, these incentives created the world's best EV marketplace, but the road here was never straightforward.

As regards the infrastructure, the Transnova support programme for charge points was established with a limit of NOK 50 million in 2009, as part of a larger crisis package to counteract the financial crisis. The funds were to go to normal charge points, and there were no guidelines related to where these charge points could be established in the country. The first-come-first-served principle applied, and all documented costs up to NOK 30,000 per charge point were covered. The programme resulted in a total of 1,800 charge points. By far the most charge points cost less than the maximum amount. In 2011 and 2012, Transnova gave support to around 50 fast charge stations, and additional support was provided in 2013. The fast charge stations are supported by up to NOK 200,000, while the total incurred costs are typically from NOK 500,000 to 1,000,000 excluding VAT.

A new development is the establishment of semi-fast charge stations (20 kW). When it comes to the costs for this, some are more reasonable than for fast charging.

Oslo Municipality has its own charge station programme, where, in addition to providing support for establishing charge stations, 404 charge points were established and were operated under municipal management up to 2013.[34]

Existing technical and spatial infrastructures

From 2009, with the simultaneous launch of Transnova's national EV infrastructure programme and Oslo's local programme, charging points quickly became commonplace across Norway. The vast majority of Norway's current charging points are regular schuko outlets. Like the rest of Europe, Norway will gradually adopt the Mode 3 Type 2 standard for new charging points going forward.[35]

The first CHAdeMO fast charging points became operational in 2011. Today, there are 79 operational CHAdeMO chargers in Norway. Future fast charging points are

34 https://www.toi.no/getfile.php?mmfileid=33828
35 http://www.evnorway.no/

expected to be a mixture of CHAdeMO and CCS, as well as AC 22kW. Where do Norwegians charge their EVs?

- 80 per cent answer that they charge their car at home,
- 60 per cent charge at work,
- 50 per cent are able to use public charging points,
- only 10 per cent say they are able to charge their EV if living in shared apartment buildings or flats.[36]

Norway had EVs on the road, and while the national charging infrastructure was being built in 2009–2010, questions arose on how to maximise the benefit from it. The answer was to collect all the information in a central database, and distribute it with the goal of increasing knowledge about the availability of a charging infrastructure for electric vehicles. This makes it easier to be an EV user. And the result will be more EV users.

Cooperation between the governmental entity Enova and the Norwegian Electric Vehicle Association resulted in the development of an open, publicly owned database that allows everyone to build services using standardised data free of charge.[37]

According to the European Electro-mobility Observatory there are about 5,500 charging posts in Norway (Table 19).

Table 19. Charging posts and battery swap stations by charging technology in Norway

Charging type		Unit	Accessibility of charging points		
			Public	Private	Total
Normal & semi-fast charging posts	by wire	Nº	-	-	-
Normal & semi-fast charging posts	wireless	Nº	-	-	5193
Fast charging posts	by wire	Nº	-	-	227
Fast charging posts	wireless	Nº	-	-	-
Total normal/semi-fast charging posts		Nº	-	-	-
Total fast charging posts		Nº	-	-	227
Total charging posts		Nº	4629	-	5420
Battery swap stations		Nº	-	-	-

Norway started building charging stations early not only for normal charging but also fast charging. Transnova has had several programmes for supporting the development of fast charge stations and a large programme for developing normal charging stations. At the moment there are about 227 fast charging posts in Norway.

[36] *The Norwegian EV success story*, Norsk Elbilforening, available at: http://elbil.no/index.php?option=com_jdownloads&Itemid=148&view=finish&cid=28&catid=8
[37] http://info.nobil.no/index.php/english

3.9. Poland

General information

The Republic of Poland (Figure 11) is located in central-eastern Europe. The area of Poland amounts to 312,679 km^2, while the country's population is around 38.5 million. Poland is a member of both the European Union and NATO. Its capital city is Warsaw.

Figure 11. Map of Poland.

With the eastern and part of its north-eastern border constituting the longest land border of the Schengen area, Poland remains a key country for both imports to the European Union and exports from the EU. This results in a well-developed road transportation system, which in recent decades has been significantly modernised with assistance from EU funds. Poland joined the European Union in 2004 and the Polish transport system is being integrated into the European transport system.

As of 31 December 2013, the total number of cars and tractors registered in Poland amounted to 25.7 million (compared to 24.9 million in 2012).

National goals and requirements

In Poland there are legal documents that are potentially of use in promoting and enabling more integrated sustainable transport, mobility management and land use planning.

Transport plans are included in the documents: a transport policy, development strategy, spatial development policy and integrated public transport development plan. These documents exist at the national, regional and local level, although they are not always available at all levels due to time lags in their preparation.

The main policy document and basis for promoting a sustainable mobility policy is the National Transport Policy for 2006–2025 – developed by the Ministry of Infrastructure and adapted by the Polish government in June 2005. It focuses on urban quality improvements, including through an increase of the competitiveness of public transport versus individual transport, and an improvement of pedestrian and cycling conditions with special attention to disabled people. Another key legislative document approved by the Polish government is the National Transport Development Strategy 2020 with the perspective to year 2030. The main goals are to increase access to transport, and to improve the safety and efficiency of the road transport sector by creating a coherent, sustainable and user-friendly transport system on the national level.

For a significant period of time Poland was relatively delayed compared to its Western neighbours in terms of the development of e-mobility. However, as a result of European directives and worldwide trends, Polish authorities and the competent bodies and institutions also started to consider this issue. Poland, among others countries, participated in work on a document on environmentally friendly vehicles adopted by the Competitiveness Council (COMPET) in May 2010 and was represented in the High-Level Group CARS 21 (Competitive Automotive Regulatory System for the 21st Century). The next step constituted work on the national level, undertaken by the Interministerial Team on Improving the Competitiveness of the Car Industry (Międzynarodowy Zespół ds. Konkurencyjności Przemysłu Motoryzacyjnego). The Polish Ministry of the Economy – a participant of the Interministerial Team – established the informal working group in order to deliver the proposed strategy on supporting e-mobility in Poland. The group – supervised by the Ministry – consisted of representatives of three sectors: energy companies, the car industry and territorial self-government (represented by one unit – the city of Warsaw). The work of the group was conducted in 2011 and from the formal standpoint it was finalised when the document based on this work was adopted by the Interministerial Team on 25th June 2012.

The document was titled "Issues of implementation of an integrated e-mobility system in Poland" ("Uwarunkowania wdrożenia zintegrowanego systemu e-mobilności w Polsce"). This document contained, among other things, a summary of European e-mobility trends (including incentives being used or planned) and analysis of different variants of the development of a charging infrastructure in the Republic of Poland. The recommendations presented in the document are cited in Chapter 7.

However, the recommendations envisaged in the "Issues of implementation of an integrated e-mobility system in Poland" were not subsequently implemented on the national level. Also, the rules on the implementation of Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of an alternative fuel infrastructure are not ready yet: the related discussion is ongoing. There is also no other national-level binding document, strategy or act of law focusing on promoting e-mobility. Therefore, for now, Poland does not have any national e-mobility goals for the future.

Developmental barriers in regard to internal conditions

Similarly to other EU member states from central-eastern Europe (with the exception of Estonia), the main barriers to e-mobility development in Poland are:

- the high prices of electric vehicles compared to conventional vehicles, combined with the lower income of citizens compared to the countries of western and northern Europe,
- no semblance of an integrated infrastructure for EVs, including charging infrastructure,
- a dominant share of second-hand vehicles among cars being purchased on the market – since second-hand vehicles are almost exclusively fossil-fuelled, this makes an increasing share of EVs exponentially more difficult,
- a lack of a sufficient range of EVs present on the market,
- resulting from the lack of range and undeveloped infrastructure: a lack of trust among potential EV owners in regard to purchasing EVs, especially in the role of first car in the family,
- a lack of central regulations defining the position of electric vehicles in many important aspects, including their cooperation with the energy grid,
- a lack of financial and legal assistance for e-mobility on the national level;
- actions of lobbyists supporting conventional vehicles powered by fossil fuels.

Another obstacle is the obsolete state of the majority of the energy grid and often electricity deficits in Poland. This is not a problem for now, given the tiny quantity of electric vehicles operational in this country, but it has been highlighted by many experts as a potential problem for the future, when these quantities will increase – together with a corresponding energy demand.

As a result of the lack of concrete e-mobility actions on the central level, such actions are mainly undertaken on the city level (Szczecin, Katowice, Tarnów, Wrocław, Warsaw). The main player in this field is the city of Warsaw, as it is both the capital city of Poland and its largest innovation centre.

Summary of the e-mobility status in the Warsaw agglomeration at the end of 2014:

- tests of various electric vehicles and hybrids conducted in various city units and municipal companies (such as a long-term test of two electric cars in the city fleet),
- around 20 charging points for electric vehicles/plug-in hybrids in Warsaw,
- 197 electric vehicles and 532 hybrid vehicles registered in Warsaw in total,
- 52 unregistered and six registered (i.e. with access to public roads) electric vehicles in use in the municipal MPWiK water and wastewater company,
- 4 hybrid buses operational since 2011 in the Warsaw MZA municipal bus company,
- tender for 10 electric buses completed by MZA in 2014 (the buses became operational in June 2015),
- introduction of road signs marking the areas for charging e-cars,
- implementation of a lower rate of transport tax for EVs/HEVs,
- allowing access of EVs to the restricted zone of the Royal Route in the Warsaw Old Town.

In turn, in 2012 the city of Cracow, the foundation “Partnership for the Environment” and Toyota Motor Poland signed an agreement on the “Mobile Cracow” (“Kraków Mobilny”) programme on behalf of popularisation of electric and hybrid vehicles. Certain other cities have been introducing measures on behalf of e-mobility as well. Among others, Szczecin in 2012 adopted reduced parking fees for EVs and hybrids not exceeding 100 g CO_2/km, while in 2013 Katowice abolished any parking fees for electric and hybrid vehicles.

Current regulation including rules concerning operating charging stations and support systems, as well as regulation limiting expansion of the technical infrastructure and the placement of vehicle charging stations

The above-mentioned issues are currently not regulated by any specific national-level legal provisions, strategies or documents. However, regulations in this field will be necessary in the near future due to the obligatory implementation of Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of an alternative fuel infrastructure.

Existing technical and spatial infrastructures

As of 2013, the Polish public road network amounts to 383,313 km, including 1,482 km of motorways and 1,244 km of expressways.

As previously mentioned, in 2014 197 fully electric vehicles and 532 hybrids in total were registered in Warsaw – compared to, respectively, 124 and 100 in 2012. With regard to the whole country, the available data covers only brand-new passenger cars and light trucks (up to 3.5 t maximum weight), which were registered in the consecutive years since 2010. Therefore, unlike in the case of Warsaw, the data does not include buses, pedelecs or converted electric vehicles.

- 2010: 7 EVs,
- 2011: 36 EVs,
- 2012: 36 EVs,
- 2013: 28 EVs,
- 2014: 84 EVs,
- in total: 191 EVs.

Currently, there are 12 public-access fast charging posts in the city of Warsaw (plus an undefined, small number of individual charging points, dedicated, for example, to research purposes – which makes the total number around 20). In turn, according to the European Electro-mobility (Table 20) Observatory there are 30 slow charging posts in the whole of Poland (as of November 2013). Nevertheless, the real number for 2015 is most likely higher; however, there is no evidence of charging points allowing for a verified update of this data.

Table 20. Charging posts and battery swap stations by charging technology in Poland

Charging type		**Unit**	**Accessibility of charging points**		
			Public	**Private**	**Total**
Normal & semi-fast charging posts	by wire	Nº	30	-	30
Normal & semi-fast charging posts	wireless	Nº	-	-	-
Fast charging posts	by wire	Nº	-	-	-
Fast charging posts	wireless	Nº	-	-	-
Total normal/semi-fast charging posts		Nº	-	-	-
Total fast charging posts		Nº	12	-	12
Total charging posts		Nº	42	-	42
Battery swap stations		Nº	-	-	-

As shown in the table, the total number of public-access charging points in Poland is very low, especially for such a relatively large European country. This situation is remedied only to a minor extent by charging points constructed by selected companies; these are usually single stations serving, for example, marketing purposes and located on the land of these companies, so access to them is limited. In addition, there are also a number of charging points that used to be functional, but are no longer operational: e.g. stations constructed within the EU Green Stream project or stations constructed by the E+ company (Polenergia group), which were supposed to operate on a commercial basis.

However, commercial operations on the Polish e-mobility market are hardly feasible until national-level e-mobility support schemes are introduced.

3.10. Sweden

General information

While the country (Figure 12) has a relatively small population (9.5m – 2013), it has several attributes that attract it to electric-drive vehicles. It has a wealthy population, a societal commitment to environmental protection, limited hydrocarbon resources, abundant hydroelectric power, a strong and globally integrated industry and a long-lasting history of international leadership.

Figure 12. Map of Sweden.

National goals and requirements

Sweden has chosen not to be explicit on the choice of vehicle technology. The goal of the government is to have a vehicle stock that is "independent" of fossil fuels by 2030. The government of Sweden set an ambitious goal of making the country's vehicle fleet free of fossil fuel use by 2030 and has, therefore, adopted a programme to further tighten policy instruments. This programme includes: a) increased levels of energy and carbon taxation, which provide incentives for a more climate-efficient transport sector; b) a strategy to encourage the increased use of vehicle biofuels; c) a carbon-differentiated vehicle tax; d) ever more stringent EU requirements regarding the CO_2 emissions of new cars; and e) requirements regarding long-term community and infrastructure planning, which will enable the implementation of a more climate-efficient transport system.[38]

Developmental barriers in regard to internal conditions

Sweden is routinely listed as one of the most innovative countries in the world, with a proud automotive manufacturing legacy, a history of support for alternative vehicles and fuels, and a national policy framework with high CO_2 taxes to support the adoption of low carbon technologies. However, despite these seemingly good conditions, progress in battery electric vehicles (BEVs), currently the most researched and argued for low carbon option for personal road-based transport, has been very slow. The national policy and car actors in Sweden are therefore now significantly more reluctant and ambivalent towards the technology uncertainties with BEVs, resulting in a lack of signal. Also, at the Stockholm city level, even in the "green sector", there is ambivalence in relation to BEVs. Do we really want to promote an expansion of BEVs through, for instance, building up a charging infrastructure, or should local transport policy be more geared towards shifting from private to public transport? The regime response to this weak signal is to focus on developing PHEVs rather than BEVs. PHEVs are seen as the natural development of earlier hybridisations, as easier to implement, circumventing the (real and perceived) lack of charging infrastructure, and less challenging from a consumer acceptance perspective. If more BEVs is viewed as a desirable way to hasten progress towards the set policy objective of a fossil fuel-free vehicle fleet by 2030, both locally in Stockholm and nationally in Sweden, an acceleration of the penetration of BEVs needs to be induced through appropriate policy measures. Several measures are linked and build upon each other. First, there is reason to investigate a further enhancement of economic incentives – with a long-time horizon but also with a clear plan for phasing out as technology costs come down. Second, local and national government can give a more coherent signal that they see this as an important infrastructure development priority. Such a signal probably requires overcoming the current aversion against technology-specific support measures. Third, the promotion of demonstrations and pilots, using both fleets of professional vehicles and public procurement, could help to familiarise drivers with the experience of BEVs.[39]

Existing technical and spatial infrastructures

According to the charging station database NOBIL there are about 1,302 charging posts in Sweden.

Table 21. Charging posts and battery swap stations by charging technology in Sweden [source: http://info.nobil.no]

Charging type		Unit	Accessibility of charging points		
			Public	Private	Total
Normal & semi-fast charging posts	by wire	Nº	30	-	30

[38] http://unfccc.int/resource/docs/2014/idr/swe06.pdf

[39] Björn Nykvis, Måns Nilsson, *The EV paradox – A multilevel study of why Stockholm is not a leader in electric vehicles*, Environmental Innovation and Societal Transitions 14 (2015) 26–44.

Normal & semi-fast charging posts	wireless	Nº	-	-	-
Fast charging posts	by wire	Nº	-	-	-
Fast charging posts	wireless	Nº	-	-	-
Total normal/semi-fast charging posts		Nº	-	-	-
Total fast charging posts		Nº	12	-	12
Total charging posts		Nº	120	1182	1302
Battery swap stations		Nº	-	-	-

3.11. Areas of primary electric transport development

The concentration of economic activities in urban areas has made these places of easier access to jobs and social opportunities and led to consequent strong urbanisation. In the case of EU-27 more than 74%[40] of the population live in urban areas.

Taking into account the range of electric vehicles, especially purely electric without an additional energy source for car propulsion, and that most of the people around the world live in cities, urban areas have proved that they are ideal spaces for e-mobility market development.

Moreover, nowhere is the need for cleaner air and reduced noise and carbon dioxide emissions more pressing, and nowhere else can you expect to find as many green-minded early adopters who will welcome a clean vehicle that takes them the short distances they need to go on one charge.[41]

Innovators and early adopters with their green-minded thinking can only constitute a critical mass in a limited area where travel distances are shorter and the charging infrastructure is densely located.

These theses can be proved when we look at the most advanced BASREC country in the project, Norway.

At the beginning of the mass market development of EVs in Norway the main cities had the biggest share of EV users – see Table 22.

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[40] EU transport in figure, Statistical pocketbook 2013.
[41] http://www.mckinsey.com/insights/manufacturing/the_fast_lane_to_the_adoption_of_electric_cars

Table 22. Vehicle fleet in Norway distributed according to counties from 2010 to 2012, total number of vehicles and share of EV fleet [source: www.elbil.no]

	2012	Share	2011	Share	2010	Share
Akershus	2 822	29,5%	1 742	32,2%	1 137	33,8%
Oslo	2 169	22,6%	1 366	25,2%	946	28,1%
Hordaland	1 029	10,7%	471	8,7%	275	8,2%
Rogaland	789	8,2%	393	7,3%	191	5,7%
Sør Trøndelag	732	7,6%	341	6,3%	207	6,1%
Buskerud	508	5,3%	298	5,5%	183	5,4%
Møre og Romsdal	300	3,1%	118	2,2%	56	1,7%
Vest-Agder	257	2,7%	153	2,8%	101	3,0%
Vestfold	227	2,4%	115	2,1%	60	1,8%
Østfold	165	1,7%	97	1,8%	40	1,2%
Nordland	114	1,2%	56	1,0%	15	0,4%
Aust-Agder	100	1,0%	47	0,9%	28	0,8%
Troms	98	1,0%	80	1,5%	57	1,7%
Nord Trøndelag	78	0,8%	31	0,6%	14	0,4%
Telemark	51	0,5%	34	0,6%	20	0,6%
Hedmark	49	0,5%	27	0,5%	12	0,4%
Oppland	45	0,5%	23	0,4%	13	0,4%
Sogn og Fjordane	29	0,3%	11	0,2%	8	0,2%
Finnmark	18	0,2%	8	0,1%	3	0,1%
Totalt	**9 580**	**100%**	**5 411**	**100%**	**3 366**	**100%**

But the share of the major cities is dropping, implying that EV sales are spreading to smaller cities and the rest of the country.[42] This shows that after the first stage of market development and battery technology improvements, rural areas can also join the EV market.

In the survey conducted within this project all respondents chose the biggest cities and other urban areas as the primary areas for EV market development. However, some respondents indicated that inter-urban transport also has some potential for early market development. Table 23 shows specific areas of selected BASREC countries indicated by the respondents.

Table 23. Specific areas indicated in the survey

BASREC country	Areas indicated in the survey
Denmark	Copenhagen and the eastern part of Jutland
Germany	Berlin and surrounding region (Brandenburg)
Lithuania	Neringa municipality and national park; Vilnius/ Kaunas/Klaipėda/Šiauliai/Panevėžys
Poland	Silesian, Warsaw and Gdańsk agglomerations

[42] Erik Figenbaum, Marika Kolbenstvedt, Electromobility in Norway – experiences and opportunities with electric vehicles, Institute of Transport Economics 2013.

Nowadays, electric vehicles are ideal for urban environments, where shorter journeys are experienced in stop-start conditions, and drivers have convenient access to charging infrastructure. However, in the future it is expected that manufacturers will introduce BEVs with a greater driving range that will enable a wider range of applications.[43]

Some experts argue that EVs will be important for improving air quality and reducing noise pollution in these cities. However, EVs are no more space-efficient than conventional vehicles. They also require the availability of dedicated recharging facilities, usually for several hours at a time – often a particular problem for those living in apartments. Public transport, walking and cycling are all substantially more space-efficient, and can also deliver air quality improvements, GHG emission reductions, and reduced noise pollution.[44]

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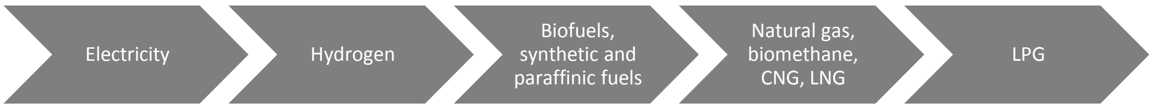
[43] Duncan Kay, Nikolas Hill and Dan Newman, Powering Ahead. The future of low-carbon cars and fuels, Ricardo-AEA April 2013.
[44] Ibidem.

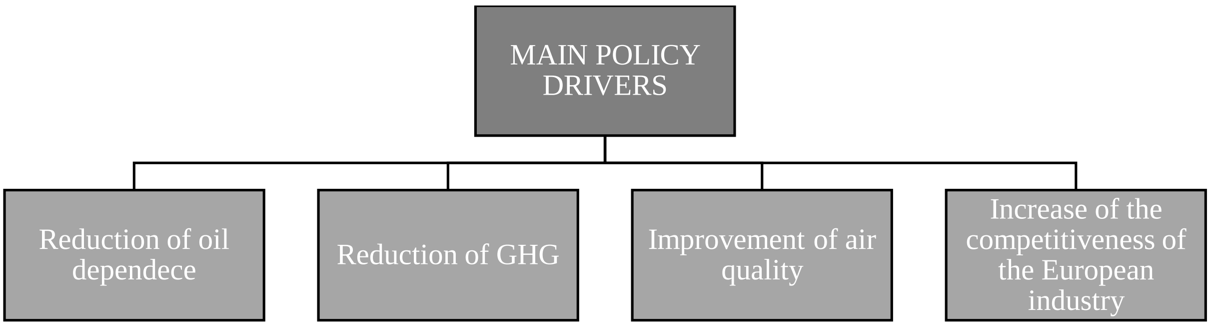
4. Obligations under Directive 2014/94/EU

On 28 October 2014, **Directive 2014/94/EU** of the European Parliament and of the Council of 22 October 2014 **on the deployment of an alternative fuel infrastructure** was published in the Official Journal of the European Union. The Directive focuses on **alternative fuels,** which, according to the Directive, are:



The analysis is focused only on **electricity** and the associated electric vehicle transportation sector.

Nowadays the transport sector is highly dependent on oil, which makes it environmentally unfriendly. In order to slow down or stop global warming it is necessary to minimise the oil dependence and mitigate the environmental impact of the transportation sector. That is why a common framework of measures for the deployment of alternative fuels in the EU countries has been established. The Directive comprises four main policy drivers:



As presented above, there are four main driver factors that shape the EU policy. The reduction of oil dependence and its substitution with low- or zero-carbon fuels is a way to reduce the greenhouse gas (GHG) emissions that are responsible for global warming. The main GHG responsible for this phenomenon is carbon dioxide (CO_2); however, during oil combustion there are more gases emitted (such as NOx and particulate matters) and their excessive concentration in the air provokes negative health effects on human beings. From mankind's point of view, improvement of air quality, especially over urban areas, is essential.

When reducing the oil dependence and meanwhile transforming to more efficient and cheaper sources of energy it will be possible to increase the competitiveness of the European industry. Production and exploitation costs could therefore be reduced.

The means for achieving the goals presented above are seen in alternative fuels. "**Alternative fuel**", which is mentioned in the Directive title, is understood as a fuel or power source that can be used as a substitute for fossil oil sources in the energy supply.

It has to have the potential to contribute to the decarbonisation of this sector and also make it more environmentally friendly. Electricity is one of the types of alternative fuels.

The electricity supply for transport is described in Article 4 of the Directive. There are several points regarding the development of infrastructure, which EU members are obligated to introduce. The most important one is to **ensure an appropriate number of recharging points accessible to the public by 31 December 2020**. In the recital of the Directive there is an indication that at least one recharging point should be provided for every 10 cars. A '**recharging point**' is an interface capable of charging one electric vehicle at a time or exchanging a battery of one electric vehicle at a time. When estimating the number of recharging points by the end of 2020 the number of electric vehicles to be registered by that time should be taken into account. The network of recharging points should at least allow electric vehicles to circulate in urban/suburban or other densely populated areas.

The policy frameworks at the national level should **encourage** and also **facilitate** the **deployment** of **recharging points** that are **not accessible to the public**.

In terms of **normal** and **high-power recharging points** (excluding wireless or inductive units), which will be deployed or renewed from 18 November 2017, it is very important that they **meet** at least the **technical specifications** mentioned in Annex II of the Directive (points 1.1 and 1.2) and the **safety requirements** at the national level.

While developing a **network** of **recharging points** accessible to the **public intelligent metering** systems should be taken into account if considered feasible and economically reasonable. Publicly accessible charging points should enable electric vehicle users to **recharge on an ad hoc basis** without being obligated to enter into a contract with an electricity supplier or operator. The **prices** charged by the operator should be kept at a **reasonable level**, be **non-discriminatory** and also **easily** and **clearly comparable**. The recharging point operators should be allowed to purchase electricity from any Union electricity supplier. Each country should create kind of permission that contract with energy supplier for recharging points operator might be other than entity supplying electricity to households or premises where the recharging points are located.

The development of the recharging point network should be done with an **appropriate level** of European **standardisation** taking into consideration detailed technical specifications for wireless recharging points and battery swapping for motor vehicles, and also recharging points for L-category motor vehicles and electric buses.

5. Effect of electric transport on electrical security

Analysis of the expected impact of electric vehicles on the electrical grid and electricity consumption covers the following aspects:

- identification of the main technical features for the available fleet of vehicles,
- estimation of the electric vehicle demand on the grid,
- impact of electric vehicle demand on the electric energy supply system.

Currently few vehicles use the full electric technology. The data available to analyse the effect of electric transport on electrical security is limited, so a lot of estimations and assumptions have to be made. A very dynamic development of electric vehicle technologies (e.g. increasing battery performance) can substantially modify the forecasted trends in unexpected ways.

5.1. Electric vehicles demand to grid

This part of the study, which considers a calculation model of electricity consumption, is based on the estimated potential market evolution of electric vehicles (point 3.2.1)nup to 2030.

The first element to be estimated is the **average daily distance** covered by the vehicles. This was estimated taking into account the **market share of different EV fleets in relation to their size** (Table 24) and **typical distances covered by vehicles** during working days (250 days a year) and during weekends and holidays (around115 days a year) (Table 25). In addition, the assumption determines the number of driving days – 80% on weekdays and 10% during holidays. Finally, the **average daily** and **yearly distance** for standard EVs were estimated (Table 25).

The next element of the estimation is the electric energy demand required to run EVs. The assumption is based on the representative EV demand according to the EV size. That includes battery capacity, vehicle range and electricity consumption (Table 24). Each PHEV is taking as 0.5 of standard EV according to the fleet size.

The results of the estimation of electric vehicle demand on the grid are presented in Table 28 (daily demand) and Table 29 (yearly demand).

A very important aspect that was taken into account was the EV fleet structure, as different fleets vary within the electricity demand (Table 24). When analysing vehicle features (a list of the EV cars can be found in **Appendix 1**) it was possible to distinguish three main fleet categories based on battery capacity and distance range. The analysis also includes the expected recharging times for each type of fleet. An average time of five hours has been considered in this study to also take into account future technological developments. A period of 10 minutes was assumed as a fast charging time – such systems are already available in some of the car models listed in **Appendix 1**. The following data is in line with what is declared by both the manufacturer and also in open-source literature.

The analysis also takes into consideration that a part of a Light Duty Vehicles (LDVs) fleet could probably be converted to electric technology. The available data were not enough to give a reliable estimation of this amount. According to the literature, the total number of LDVs is assumed to be at the level of 10% of the total number of electric vehicles (the percentage usually accepted for this kind of study).

For the calculation, an efficiency of 90% has been considered for the recharging phase (see Clement, K., Van Reusel, K., Driesen, K., 2007. The consumption of electrical energy of plug-in hybrid electric vehicles in Belgium. In: Proceedings of the European Ele-Drive Conference. Brussels, Belgium). In fact, the discharging phase is also characterised by a certain efficiency. Other sources of efficiency losses (e.g. due to the electricity transport) are also included in the analysis. Finally, efficiency losses at the level of 15% have been taken into account in calculating energy consumption and energy demand on the grid in Table 28 and Table 29.

Table 24. Electric vehicle structure and features – private vehicles [source: "Potential Impact of Electric Vehicles on the Electric Supply System. A case study for the Province of Milano, Italy", A. Perujo, B. Ciuffo, JRC-IES European Commission, EUR 23795 EN 2009]

EV size	Structure [%]	Capacity [kWh]	Range [km]	Consumption [kWh/100 km]	Recharging time		Power required to the grid	
					Standard [h]	Fast [min]	Standard [kW]	Fast [kW]
Small	30%	10	100	10.00	5	10	2.2	66.7
Medium	63%	20	130	15.38	5	10	4.4	133.3
Large	7%	35	180	19.44	5	10	7.8	233.3
Standard EV	-	18.05	124.5	14.05	5	10	-	-
Light Duty Vehicles are % of total EV								
Light Duty Vehicles	10%	20	100	20	5	10	4.4	133.3

Table 25. Distance of standard trip in a typical day [source: NISSAN, May 2009, Customer survey conducted online in five countries]

Typical week day 250 days in year. Trips cover 80% of days				Typical weekend and holidays 115 days in year. Trips cover 10% of days			
Average [km]	Distance [km]	% of trip	col.1*col.3	Average [km]	Distance [km]	% of trip	Col.5*col.7
1	2	3	4	5	6	7	8
40	< 50	58%	2 320	50	< 100	31%	1 550
75	100 < 50	24%	1 800	125	150 < 100	14%	1 750
125	150 < 100	10%	1 250	175	200 < 150	8%	1 400
200	> 150	8%	1 600	300	> 200	49%	14 700
Average distance of one trip			69.7	**Average distance of one trip**			194
Yearly average distance			13 940	**Yearly average distance**			2 231
Daily distance for one standard EV			44.3	**Yearly distance for one standard EV**			16 171

The results presented in Table 25 are in line with the statistics presented in Table 26. The higher average yearly distance in Table 25 is rational because of the lower cost of exploitation of EVs compared with traditional engine cars.

Table 26. Average yearly distance of passenger cars for the BASREC countries

Period 2001–2012			
COUNTRY	**Yearly average distance [km]**	**Tendency**	
Finland	18 326	Decrease	↓
Lithuania	8 547	Increase	↑
Poland	10 741	Decrease	↓
Denmark	No data	No data	-
Estonia	15 985	Increase	↑
Germany	13 017	No data	-
Sweden	14 423	Decrease	↓
Norway	14 045	Decrease	↓

Table 27. EV electric energy consumption and demand

Category of cars	Daily distance [km]	Daily consumption [kWh/100 km]	Daily demand [kWh/100 km]	Yearly distance [km]	Yearly consumption [kWh/100 km]	Yearly demand [kWh/100 km]	Share
Passenger cars (365 days)	44.30	6.22	7.16	16 170	2 271.85	2 612.62	90.91%
LDV (365 days)	60.00	12.00	13.80	21 900	4 380.00	5 037.00	9.09%
Standard EV = Car+LDV	**45.73**	**6.75**	**7.76**	**16 690**	**1 126.48**	**1 295.45**	X
Bus							100%

Note:

1) *The number of LDVs is 10% of the passenger car fleet,*
2) *The electricity demand includes losses of energy at the level of 15% (transmit ion and conversions).*

Data for PHEVs are evaluated simply as 50% of BEVs. The number of EVs used for calculation consists of the number of BEV vehicles and 50% of the number of PHEV vehicles.

The above tables comprise all data needed to evaluate the demand for electrical energy by the EV fleet showed in Table 28 and Table 29.

Table 28. EV daily demand on the grid [own elaboration]

		Basic scenario (MWh)				Medium scenario (MWh)				Optimistic scenario (MWh)			
COUNTRY		**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
Early development market													
Finland	Number of standard EV cars	1 046	5 825	16 936	35 913	4 896	17 499	47 722	103 106	5 274	25 440	75 385	164 455
	Consumption	7.06	39.31	114.31	242.39	33.04	118.11	322.09	695.89	35.59	171.70	508.79	1 109.95
	Demand	8.11	45.21	131.45	278.74	38.00	135.82	370.40	800.27	40.93	197.46	585.11	1 276.44
Lithuania	Number of standard EV cars	30	628	4 146	12 032	60	1 256	7328	20 532	105	2 198	12 102	33 281
	Consumption	0.20	4.24	27.98	81.21	0.40	8.48	49.46	138.58	0.71	14.83	81.68	224.62
	Demand	0.23	4.87	32.18	93.39	0.47	9.75	56.88	159.36	0.81	17.06	93.93	258.32
Poland	Number of standard EV cars	5 433	22 238	101 179	278 112	6 104	36 340	172 610	468 842	7 112	57 493	279 756	754 935
	Consumption	36.67	150.09	682.88	1 877.05	41.20	245.27	1 164.99	3 164.33	48.00	388.03	1 888.14	5 095.25
	Demand	42.17	172.60	785.32	2 158.61	47.38	282.06	1 339.73	3 638.98	55.20	446.24	2 171.36	5 859.54
Advanced early development market													
Denmark	Number of standard EV cars	4 838	22 006	103 795	284 764	5 394	33 704	160 288	432 854	6 138	49 302	224 580	589 858
	Consumption	32.65	148.52	700.54	1 921.94	36.41	227.48	1 081.82	2 921.44	41.42	332.75	1 515.74	3 981.10
	Demand	37.55	170.80	805.62	2 210.23	41.87	261.60	1 244.10	3 359.66	47.64	382.66	1 743.11	4578.26
Estonia	Number of standard EV cars	1 598	3745	10 716	25 607	1654	4910	15 755	38 204	1728	6463	21 572	51687
	Consumption	10.79	25.27	72.33	172.82	11.16	33.14	106.33	257.85	11.66	43.62	145.59	348.85
	Demand	12.40	29.06	83.17	198.75	12.83	38.11	122.28	296.52	13.41	50.16	167.43	401.18
Germany	Number of standard EV cars	91 382	300 211	1 083 886	2 696 696	98 536	450 462	1 676 059	4 109 585	108 076	650 798	2 368 399	5 636 950
	Consumption	616.76	2 026.20	7 315.42	18 200.69	665.04	3 040.28	11 312.15	27 736.64	729.43	4 392.40	15 984.93	38 045.21
	Demand	709.27	2 330.13	8 412.73	20 930.79	764.80	3 496.32	13 008.97	31 897.13	838.84	5 051.26	18 382.67	43 751.99
Sweden	Number of standard EV cars	8342	34 962	139 822	365 202	9 155	52 050	215 035	554 733	10 241	74 832	301 640	757 283
	Consumption	56.30	235.96	943.69	2 464.84	61.79	351.30	1 451.33	3 744.03	69.12	505.06	2 035.84	5 111.10
	Demand	64.75	271.36	1 085.25	2 834.57	71.06	403.99	1 669.03	4 305.64	79.48	580.82	2 341.22	5 877.76
Medium development market													
Norway	Number of standard EV cars	56 207	107 917	216 724	456 470	56 639	116 990	269 925	605 741	57 647	138 161	347 321	782 666
	Consumption	379.35	728.36	1 462.73	3 080.83	382.27	789.59	1 821.79	4 088.30	389.07	932.48	2 344.16	5 282.41
	Demand	436.25	837.61	1 682.13	3 542.95	439.61	908.03	2 095.06	4 701.55	447.43	1 072.35	2 695.78	6 074.77

Table 29. EV yearly demand on the grid [own elaboration]

		Basic scenario (GWh)				Medium scenario (GWh)				Optimistic scenario (GWh)			
COUNTRY		**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
Early development market													
Finland	Number of standard EV cars	1 046	5 825	16 936	35 913	4 896	17 499	47 722	103 106	5 274	25 440	75 385	164 455
	EV Consumption	1.18	6.56	19.08	40.46	5.52	19.71	53.76	116.15	5.94	28.66	84.92	185.25
	EV Demand	1.35	7.55	21.94	46.52	6.34	22.67	61.82	133.57	6.83	32.96	97.66	213.04
	Yearly energy supply	79 739	79 517	79 295	79 072	79 739	79 517	79 295	79 072	79 739	79 517	79 295	79 072
	EV share %	0.00	0.01	0.03	0.06	0.01	0.03	0.08	0.17	0.01	0.04	0.12	0.27
Lithuania	Number of standard EV cars	30	628	4 146	12 032	60	1 256	7 328	20 532	105	2 198	12 102	33 281
	EV Consumption	0.03	0.71	4.67	13.55	0.07	1.42	8.26	23.13	0.12	2.48	13.63	37.49
	EV Demand	0.04	0.81	5.37	15.59	0.08	1.63	9.49	26.60	0.14	2.85	15.68	43.11
	Yearly energy supply	9 133	9 577	10 022	10 466	9 133	9 577	10 022	10 466	9 133	9 577	10 022	10 466
	EV share %	0.00	0.01	0.05	0.15	0.00	0.02	0.09	0.25	0.00	0.03	0.16	0.41
Poland	Number of standard EV cars	5 433	22 238	101 179	278 112	6 104	36 340	172 610	468 842	7 112	57 493	279 756	754 935
	EV Consumption	6.12	25.05	113.98	313.29	6.88	40.94	194.44	528.14	8.01	64.77	315.14	850.42
	EV Demand	7.04	28.81	131.07	360.28	7.91	47.08	223.61	607.36	9.21	74.48	362.41	977.98
	Yearly energy supply	128 503	139 615	150 726	161 837	128 503	139 615	150 726	161 837	128 503	139 615	150 726	161 837
	EV share %	0.01	0.02	0.09	0.22	0.01	0.03	0.15	0.38	0.01	0.05	0.24	0.60
Advanced early development market													
Denmark	Number of standard EV cars	4 838	22 006	103 795	284 764	5 394	33 704	160 288	432 854	6 138	49 302	224 580	589 858
	EV Consumption	5.45	24.79	116.92	320.78	6.08	37.97	180.56	487.60	6.91	55.54	252.98	664.46
	EV Demand	6.27	28.51	134.46	368.90	6.99	43.66	207.65	560.74	7.95	63.87	290.93	764.13
	Yearly energy supply	30 834	29 834	28 834	27 834	30 834	29 834	28 834	27 834	30 834	29 834	28 834	27 834
	EV share %	0.02	0.10	0.47	1.33	0.02	0.15	0.72	2.01	0.03	0.21	1.01	2.75
Estonia	Number of standard EV cars	1 598	3 745	10 716	25 607	1 654	4 910	15 755	38 204	1 728	6 463	21 572	51 687
	EV Consumption	1.80	4.22	12.07	28.85	1.86	5.53	17.75	43.04	1.95	7.28	24.30	58.22
	EV Demand	2.07	4.85	13.88	33.17	2.14	6.36	20.41	49.49	2.24	8.37	27.95	66.96
	Yearly energy supply	6 998	7 442	7 887	8 331	6 998	7 442	7 887	8 331	6 998	7 442	7 887	8 331
	EV share %	0.03	0.07	0.18	0.40	0.03	0.09	0.26	0.59	0.03	0.11	0.35	0.80
Germany	Number of standard EV cars	91 382	300 211	1 083 886	2 696 696	98 536	450 462	676 059	109 585	108 076	650 798	368 399	636 950
	EV Consumption	102.94	338.18	1 220.97	3 037.77	111.00	507.44	1 888.04	4 629.36	121.75	733.11	2 667.95	6 349.90

		Basic scenario (GWh)				Medium scenario (GWh)				Optimistic scenario (GWh)			
COUNTRY		**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
	EV Demand	118.38	388.91	1 404.12	3 493.43	127.65	583.55	2 171.25	5 323.76	140.01	843.08	3 068.14	7 302.38
	Yearly energy supply	517 645	516 533	515 422	514 311	517 645	516 533	515 422	514 311	517 645	516 533	515 422	514 311
	EV share %	0.02	0.08	0.27	0.68	0.02	0.11	0.42	1.04	0.03	0.16	0.60	1.42
Sweden	Number of standard EV cars	8 342	34 962	139 822	365 202	9 155	52 050	215 035	554 733	10 241	74 832	301 640	757 283
	EV Consumption	9.40	39.38	157.51	411.39	10.31	58.63	242.23	624.89	11.54	84.30	339.79	853.06
	EV Demand	10.81	45.29	181.13	473.10	11.86	67.43	278.57	718.63	13.27	96.94	390.76	981.02
	Yearly energy supply	123 794	120 738	117 683	114 627	123 794	120 738	117 683	114 627	123 794	120 738	117 683	114 627
	EV share %	0.01	0.04	0.15	0.41	0.01	0.06	0.24	0.63	0.01	0.08	0.33	0.86
Medium development market													
Norway	Number of standard EV cars	56 207	107 917	216 724	456 470	56 639	116 990	269 925	605 741	57 647	138 161	347 321	782 666
	EV Consumption	63.32	121.57	244.14	514.20	63.80	131.79	304.07	682.35	64.94	155.64	391.25	881.66
	EV Demand	72.81	139.80	280.76	591.33	73.37	151.55	349.67	784.71	74.68	178.98	449.94	1 013.90
	Yearly energy supply	109 492	110 048	110 603	111 159	109492	110 048	110 603	111 159	109 492	110 048	110 603	111 159
	EV share %	0.07	0.13	0.25	0.53	0.0670	0.14	0.32	0.71	0.07	0.16	0.41	0.91

Table 30. Fleet and share of EVs

Basic scenario																	
Early development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Finland	Number	3 189 786	655	781	1 046	3 229 658	3 800	4 050	5825	3 270 029	8 995	15 882	16 936	3 310 905	15 747	40 332	35 913
	% of fleet	100.00%	0.02%	0.02%	0.03%	100.00%	0.12%	0.13%	0.18%	100.00%	0.28%	0.49%	0.52%	100.00%	0.48%	1.22%	1.08%
Lithuania	Number	1 837 399	15	30	30	1 860 367	314	628	628	1 883 621	1 591	5 109	4146	1 907 167	4 250	15 564	12 032
	% of fleet	100.00%	0.00%	0.00%	0.00%	100.00%	0.02%	0.03%	0.03%	100.00%	0.08%	0.27%	0.22%	100.00%	0.22%	0.82%	0.63%
Poland	Number	21 369 631	599	9667	5 433	21 636 752	7 450	29 576	22238	21 907 211	36 114	130 130	101 179	22 181 051	95 763	364 698	278 112
	% of fleet	100.00%	0.00%	0.05%	0.03%	100.00%	0.03%	0.14%	0.10%	100.00%	0.16%	0.59%	0.46%	100.00%	0.43%	1.64%	1.25%
Advanced early development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after re calculation	FLEET	BEVs	PHEVs	EV after recalculation
Denmark	Number	2 852 713	4 443	789	4 838	2 924 031	14 175	15 661	22 006	2 997 131	44 038	119 514	103 795	3 072 060	105 104	359 319	284 764
	% of fleet	100.00%	0.16%	0.03%	0.17%	100.00%	0.48%	0.54%	0.75%	100.00%	1.47%	3.99%	3.46%	100.00%	3.42%	11.70%	9.27%
Estonia	Number	600 005	1 557	82	1 598	645 005	2 960	1 569	3745	693 381	5 543	10 346	10716	702 048	10 580	30 053	25607
	% of fleet	100.00%	0.26%	0.01%	0.27%	100.00%	0.46%	0.24%	0.58%	100.00%	0.80%	1.49%	1.55%	100.00%	1.51%	4.28%	3.65%
Germany	Number	44 785 396	30 820	121 124	91 382	45 345 213	140 421	319 579	300 211	45 912 028	435 035	1 297 701	1 083 886	46 485 929	982 178	3 429 036	2 696 696
	% of fleet	100.00%	0.07%	0.27%	0.20%	100.00%	0.31%	0.70%	0.66%	100.00%	0.95%	2.83%	2.36%	100.00%	2.11%	7.38%	5.80%
Sweden	Number	4 552 476	3 847	8 990	8342	4 893 911	16 761	36 401	34 962	5 016 259	55 512	168 620	139 822	5 141 665	131 723	466 958	365 202
	% of fleet	100.00%	0.08%	0.20%	0.18%	100.00%	0.34%	0.74%	0.71%	100.00%	1.11%	3.36%	2.79%	100.00%	2.56%	9.08%	7.10%
Medium development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalculation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Norway	Number	2 472 275	54 073	4 267	56 207	2 657 695	95 745	24 344	107 917	2 724 138	142 897	147 654	216 724	2 792 241	239 832	433 275	456 470
	% of fleet	100.00%	2.19%	0.17%	2.27%	100.00%	3.60%	0.92%	4.06%	100.00%	5.25%	5.42%	7.96%	100.00%	8.59%	15.52%	16.35%
Medium scenario																	
		2015				2020				2025				2030			

Early development market		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Finland	Number	3 189 786	4 324	1 143	4 896	3 229 658	11 671	11 656	17 499	3 270 029	24 819	45 806	47 722	3 310 905	47 275	111 662	103 106
	% of fleet	100.00%	0.14%	0.04%	0.15%	100.00%	0.36%	0.36%	0.54%	100.00%	0.76%	1.40%	1.46%	100.00%	1.43%	3.37%	3.11%
Lithuania	Number	1 837 399	30	60	60	18 60 367	628	1 256	1256	1 883 621	3 182	8 292	7328	1 907 167	8 500	24 064	20 532
	% of fleet	100.00%	0.00%	0.00%	0.00%	100.00%	0.03%	0.07%	0.07%	100.00%	0.17%	0.44%	0.39%	100.00%	0.45%	1.26%	1.08%
Poland	Number	21 369 631	935	10 338	6 104	21 636 752	14 501	43 678	36 340	21 907 211	71 829	201 561	172 610	22 181 051	95 763	364 698	278 112
	% of fleet	100.00%	0.00%	0.05%	0.03%	100.00%	0.07%	0.20%	0.17%	100.00%	0.33%	0.92%	0.79%	100.00%	0.43%	1.64%	1.25%

Advanced early development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalculation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Denmark	Number	2 852 713	4 814	1 160	5 394	2 924 031	21 974	23 460	33 704	2 997 131	81 700	157 176	160 288	3 072 060	203 831	458 046	432 854
	% of fleet	100.00%	0.17%	0.04%	0.19%	100.00%	0.75%	0.80%	1.15%	100.00%	2.73%	5.24%	5.35%	100.00%	6.63%	14.91%	14.09%
Estonia	Number	600 005	1 594	119	1 654	645 005	3 737	2 345	4910	693 381	8 902	13 706	15 755	702 048	18 978	38 451	38 204
	% of fleet	100.00%	0.27%	0.02%	0.28%	100.00%	0.58%	0.36%	0.76%	100.00%	1.28%	1.98%	2.27%	100.00%	2.70%	5.48%	5.44%
Germany	Number	44 785 396	35 589	125 894	98 536	45 345 213	240 588	419 747	450 462	45 912 028	829 817	1 692 483	1 676 059	46 485 929	1 924 104	4 370 961	4 109 585
	% of fleet	100.00%	0.08%	0.28%	0.22%	100.00%	0.53%	0.93%	0.99%	100.00%	1.81%	3.69%	3.65%	100.00%	4.14%	9.40%	8.84%
Sweden	Number	4 552 476	4 389	9 532	9 155	4 893 911	28 153	47 793	52 050	5 016 259	105 654	218 762	215 035	5 141 665	258 077	593 312	554 733
	% of fleet	100.00%	0.10%	0.21%	0.20%	100.00%	0.58%	0.98%	1.06%	100.00%	2.11%	4.36%	4.29%	100.00%	5.02%	11.54%	10.79%

Medium development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalculation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Norway	Number	2 472 275	54 361	4 555	56 639	2 657 695	101 793	30 393	116 990	2 724 138	172 522	194 806	269 925	2 792 241	317 924	575 634	605 741
	% of fleet	100.00%	2.20%	0.18%	2.29%	100.00%	3.83%	1.14%	4.40%	100.00%	6.33%	7.15%	9.91%	100.00%	11.39%	20.62%	21.69%

Optimistic scenario

Early development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Finland	Number	3 189 786	4 576	1 395	5 274	3 229 658	16 965	16 950	25 440	3 270 029	43 261	64 248	75 385	3 310 905	88 174	152 561	164 455
	% of fleet	100.00%	0.14%	0.04%	0.17%	100.00%	0.53%	0.52%	0.79%	100.00%	1.32%	1.96%	2.31%	100.00%	2.66%	4.61%	4.97%
Lithuania	Number	1 837 399	60	90	105	1 860 367	1 256	1 884	2 198	1 883 621	6 365	11 474	12102	1 907 167	16 999	32 564	33 281
	% of fleet	100.00%	0.00%	0.00%	0.01%	100.00%	0.07%	0.10%	0.12%	100.00%	0.34%	0.61%	0.64%	100.00%	0.89%	1.71%	1.75%
Poland	Number	21 369 631	1 607	11 010	7 112	21 636 752	28 603	57 780	57 493	21 907 211	143 260	272 991	279 756	2 2181 051	381 857	746 156	754 935
	% of fleet	100.00%	0.01%	0.05%	0.03%	100.00%	0.13%	0.27%	0.27%	100.00%	0.65%	1.25%	1.28%	100.00%	1.72%	3.36%	3.40%
Advanced early development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Denmark	Number	2 852 713	5 186	1 903	6 138	292 4031	29 773	39 057	49 302	2 997 131	119 362	210 435	224 580	3 072 060	302 558	574 599	589 858
	% of fleet	100.00%	0.18%	0.07%	0.22%	100.00%	1.02%	1.34%	1.69%	100.00%	3.98%	7.02%	7.49%	100.00%	9.85%	18.70%	19.20%
Estonia	Number	600 005	1 631	193	1 728	645 005	4 513	3 899	6 463	693 381	12 262	18 619	21 572	702 048	27 375	48 624	51 687
	% of fleet	100.00%	0.27%	0.03%	0.29%	100.00%	0.70%	0.60%	1.00%	100.00%	1.77%	2.69%	3.11%	100.00%	3.90%	6.93%	7.36%
Germany	Number	44 785 396	40 359	135 433	10 8076	45 345 213	340 756	620 083	650 798	45 912 028	1 224 599	2 287 600	2 368 399	46 485 929	2 866 029	5 541 841	5 636 950
	% of fleet	100.00%	0.09%	0.30%	0.24%	100.00%	0.75%	1.37%	1.44%	100.00%	2.67%	4.98%	5.16%	100.00%	6.17%	11.92%	12.13%
Sweden	Number	4 552 476	4 932	10 617	10 241	4 893 911	39 544	70 576	74 832	5 016 259	155 796	291 687	301 640	5 141 665	384 431	745 704	757 283
	% of fleet	100.00%	0.11%	0.23%	0.22%	100.00%	0.81%	1.44%	1.53%	100.00%	3.11%	5.81%	6.01%	100.00%	7.48%	14.50%	14.73%
Medium development market		2015				2020				2025				2030			
		FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation	FLEET	BEVs	PHEVs	EV after recalcu-lation
Norway	Number	2 472 275	54 937	5 419	57 647	2 657 695	113 891	48 539	138 161	2 724 138	214 244	266 154	347 321	2 792 241	409 843	745 645	782 666
	% of fleet	100.00%	2.22%	0.22%	2.33%	100.00%	4.29%	1.83%	5.20%	100.00%	7.86%	9.77%	12.75%	100.00%	14.68%	26.70%	28.03%

In Table 29 and Table 30 the main results regarding the impact of electric vehicles on the total electric energy consumption are summarised for all the scenarios at the time horizon of 2030. From Table 29 it can be inferred that 7,302 GWh is the total annual electric energy required by electric vehicles in Germany in 2030 in the optimistic scenario of the electric vehicle fleet development. This is less than 1.5% of the electric energy consumption in this country. The next interesting result can be seen in Denmark. Using the same scenario as for 2030, EVs will require 764 GWh of energy, which is 2.7% of the electric energy consumption in this country. Even using the same electric vehicle fleet evolution until 2050 the situation does not change significantly and never exceeds the value of 5% of the total energy consumption. For this reason, despite all of the approximations made, we are confident about the reliability of the magnitude of the results presented so far. Taking this into account, the impact of electric vehicles on the total electric energy consumption can be considered quite ineligible. The problem that will be examined in the next section will be related to "when" this energy is needed, i.e. the electric power demand that is required to the grid. It can be seen that even in the extreme event of electric vehicles accounting for almost 30% of the vehicle fleet (28.03% for Norway, year 2030, optimistic scenario) the energy consumption will not represent more than 2.7% of the total amount, thereby confirming what was previously stated.

At this point it is necessary to define **the power needed by each single vehicle** to be recharged and to hypothesise the way all the vehicles overlap the requirement for electricity. The estimated electric power required is reported in Table 31. The data presented above shows that a normal house grid, with power of about 8 kW, will be sufficient for an EV recharging system. The supply of electrical energy with power of less than 3 kW will not be sufficient anymore, requiring the owner of a car to change the agreement made with the electric energy supplier. This will in turn cause an increase in the energy cost and this should be taken into consideration in a more detailed analysis.

Table 31. Estimated electric power required by each vehicle category to be recharged

Size	Power required to the grid	
	Standard (kW)	Fast (kW)
BEV		
Small	2.2	66.7
Mid-size	4.4	133.3
Large	7.8	233.3
Light duty vehicles	4.4	133.3
PIHV	2.2	66.7

Demand for electricity and its evolution in the BASREC countries

In order to assess the impact of electric vehicles on the energy supply system it is necessary to include aspects such as:

- geographical location,
- detailed information about the electric grid capacity,
- the yearly energy consumption,
- the demand (also variable with time) for electric power.

Data regarding the total electric energy consumption for the last few years and the power required to the grid is available at a national level for each BASREC country.

Starting from the available data it was possible to estimate the future trend (see Figure 13 – Figure 22) for the yearly electric energy consumption. The peak power required to the grid has also been estimated.

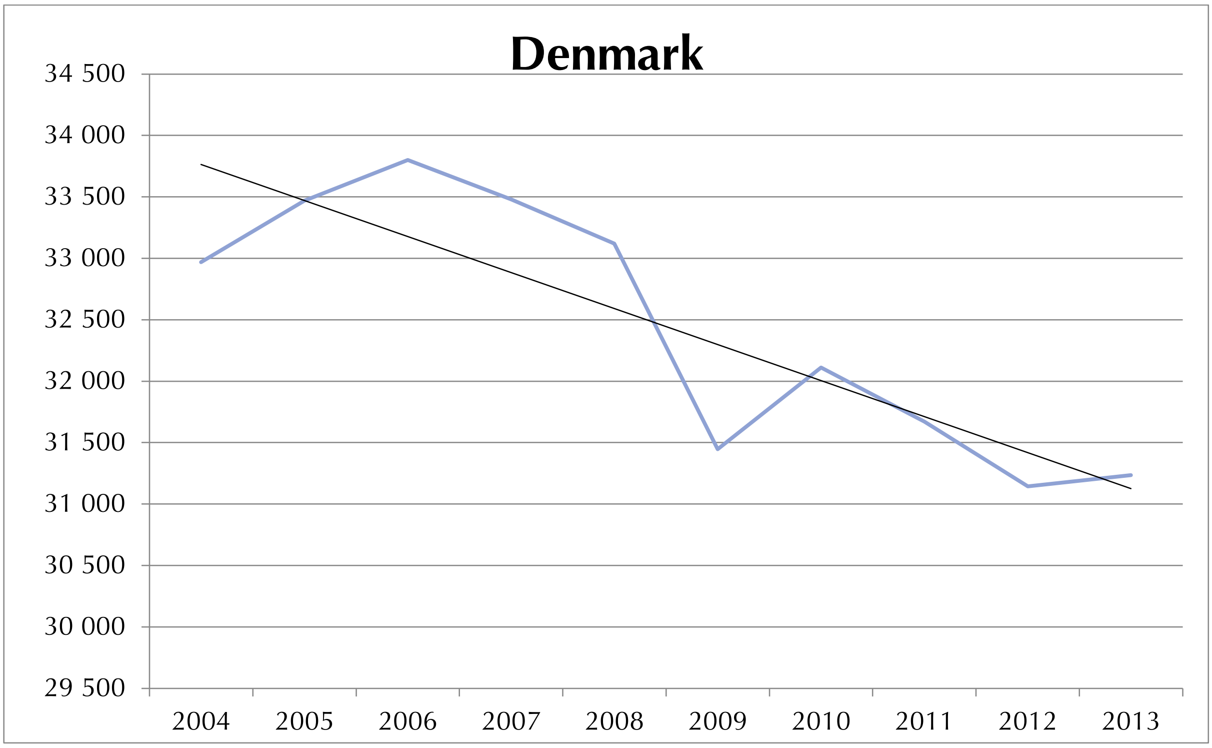


Figure 13. Annual electricity consumption in Denmark [GWh] [own elaboration].

Figure 14. Annual electricity consumption in Germany [GWh] [own elaboration].

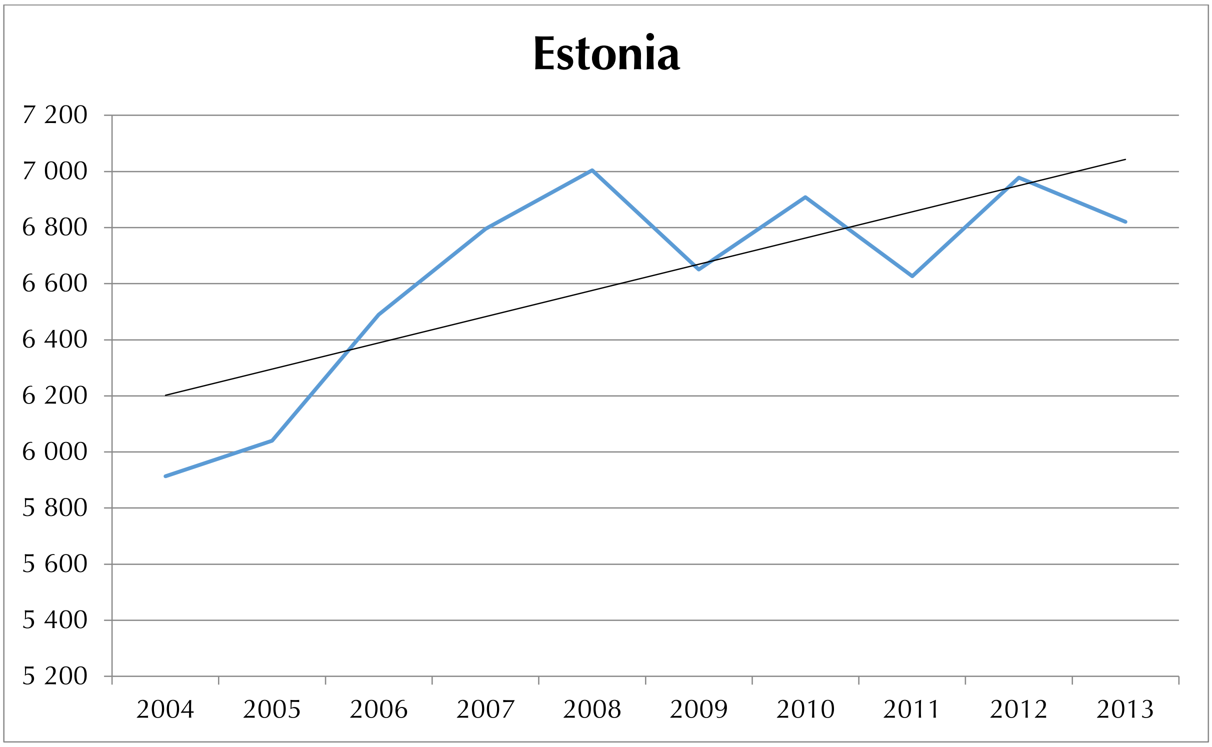


Figure 15. Annual electricity consumption in Estonia [GWh] [own elaboration].

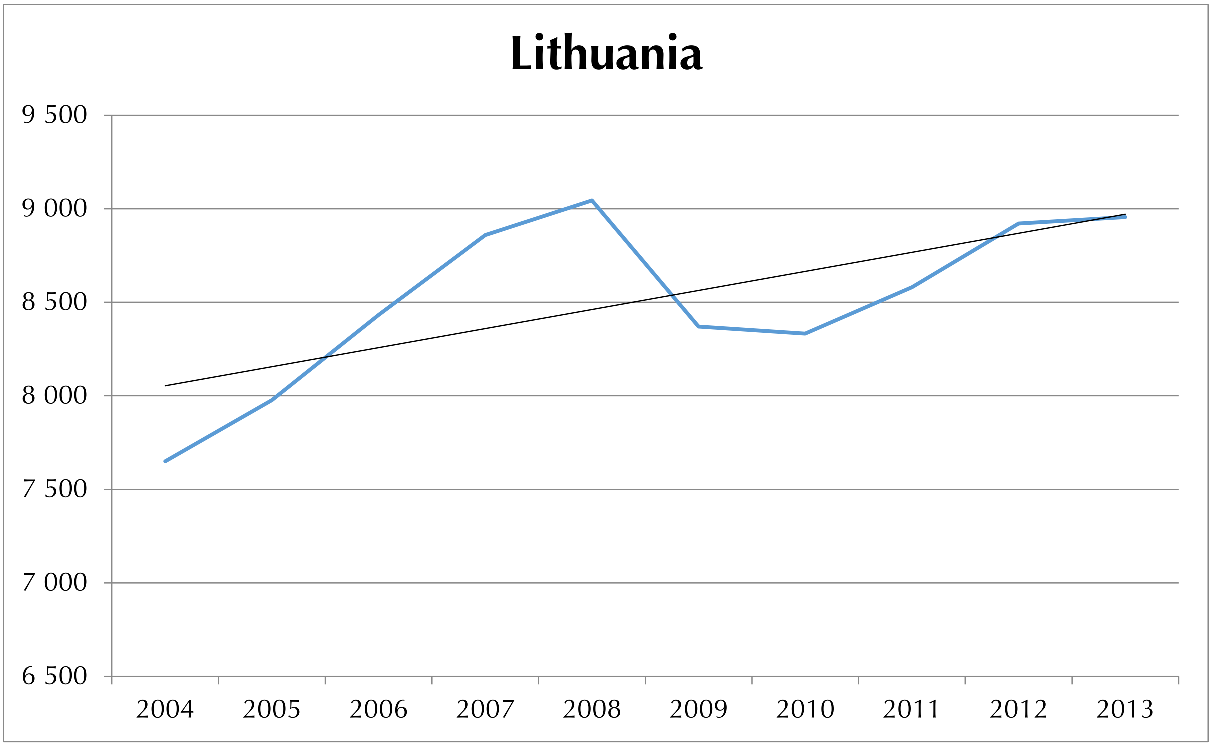


Figure 16. Annual electricity consumption in Lithuania [GWh] [own elaboration].

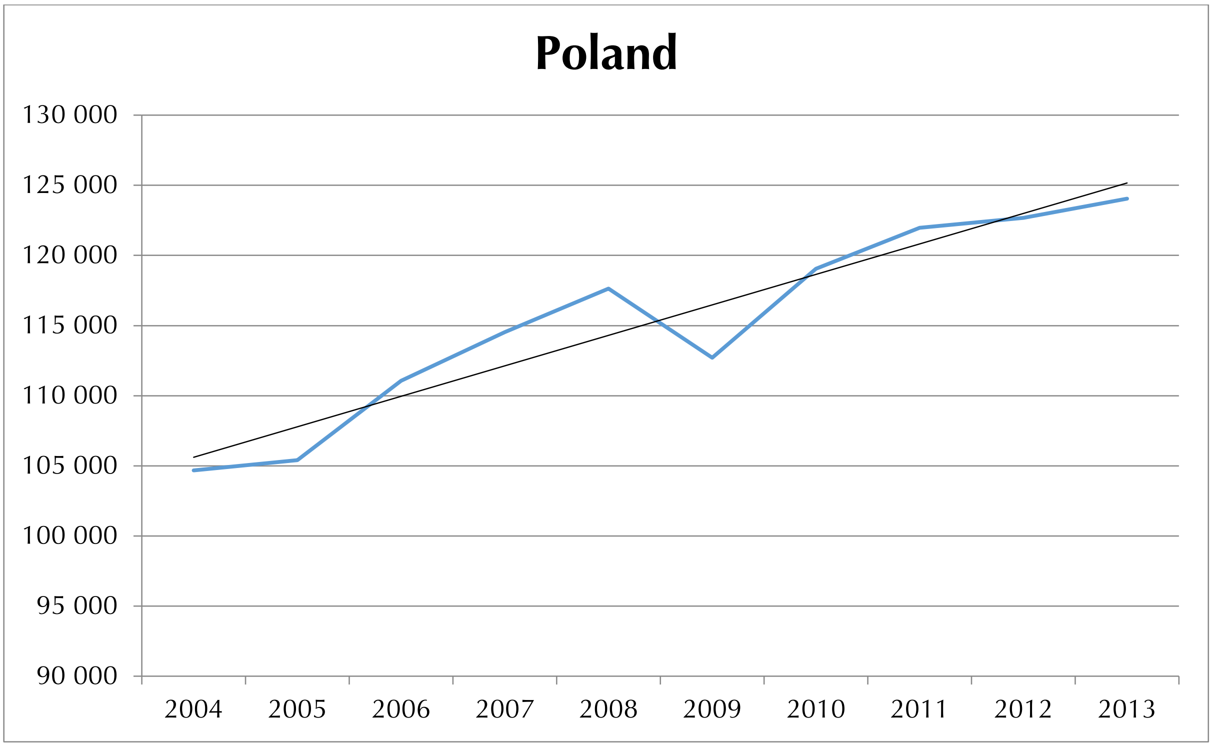


Figure 17. Annual electricity consumption in Poland [GWh] [own elaboration].

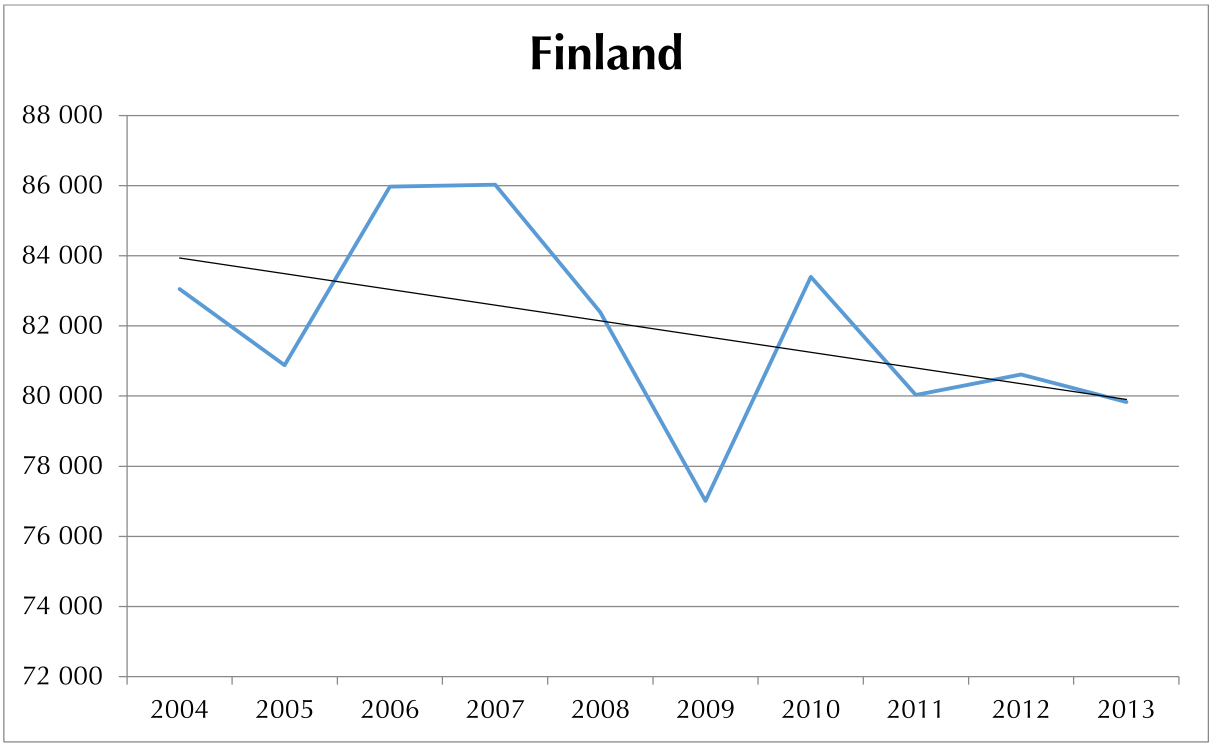


Figure 18. Annual electricity consumption in Finland [GWh] [own elaboration].

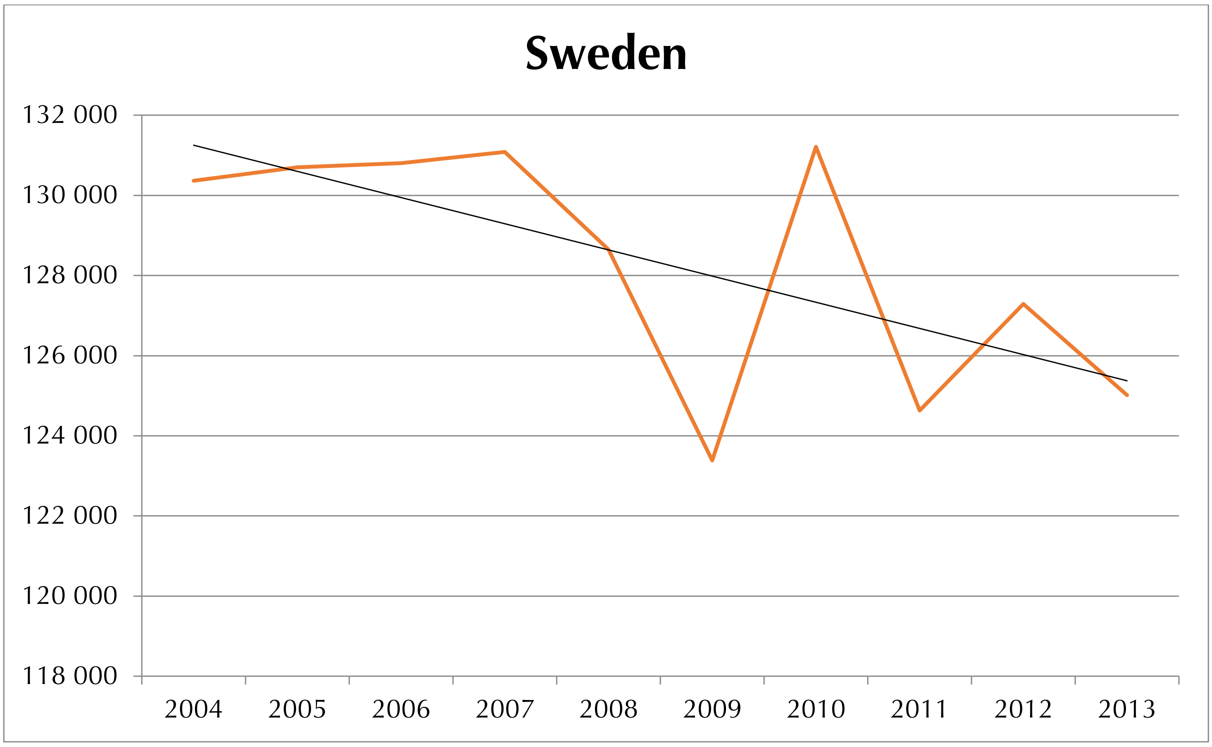


Figure 19. Annual electricity consumption in Sweden [GWh] [own elaboration].

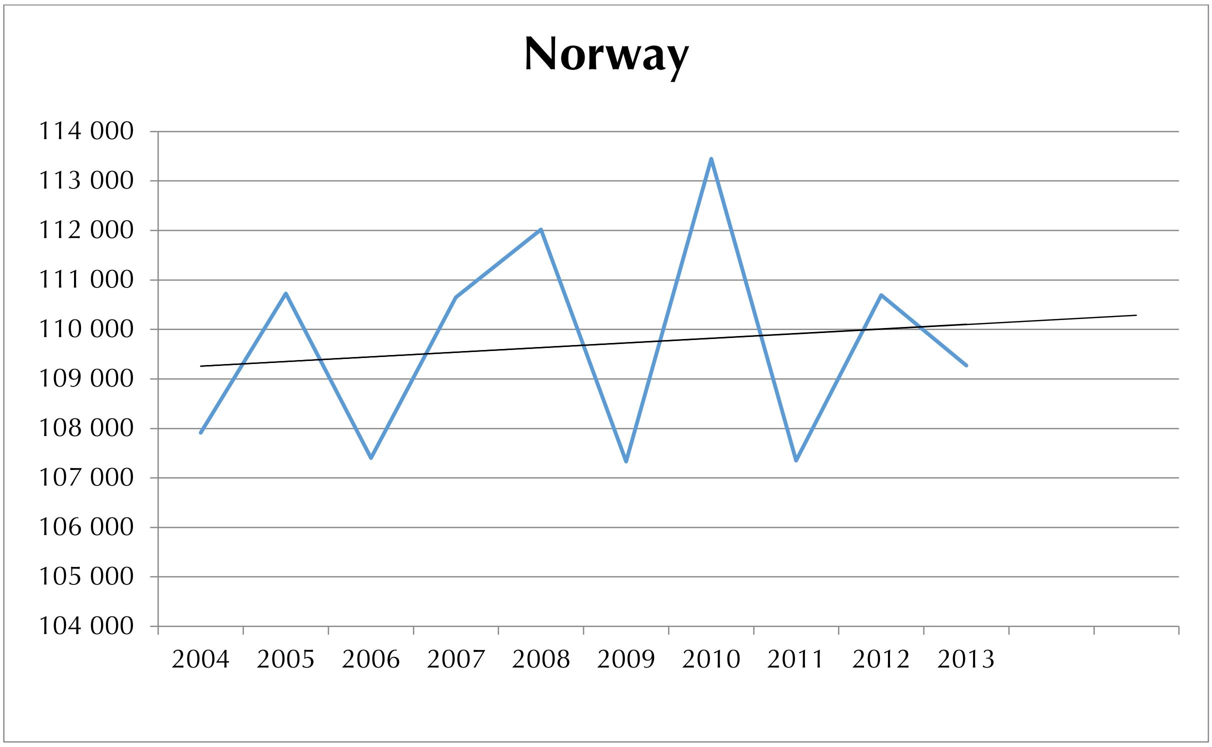


Figure 20. Annual electricity consumption in Norway [GWh] [own elaboration].

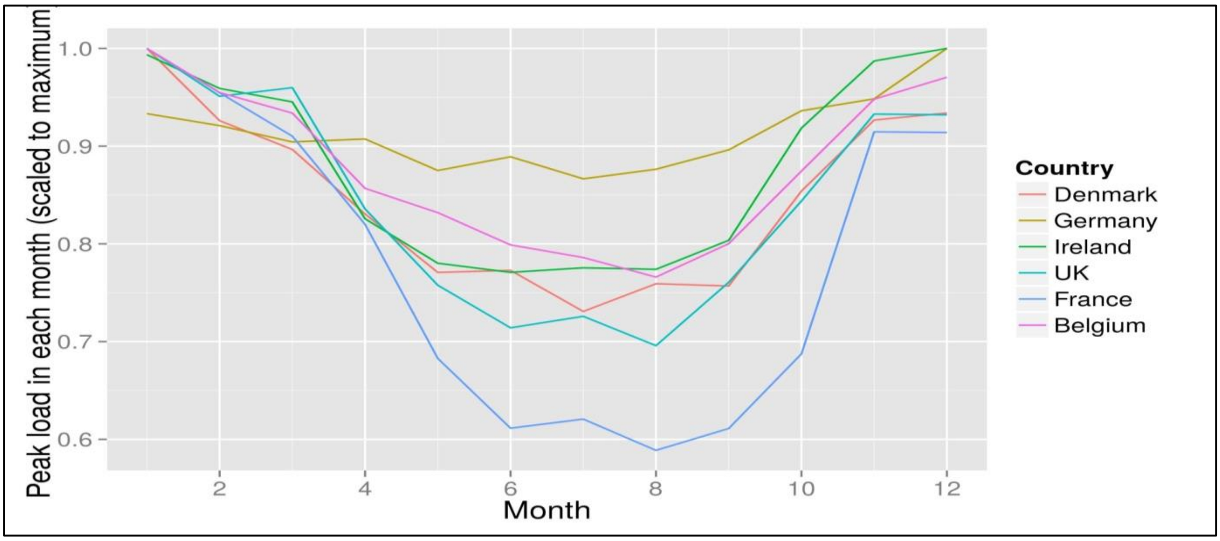


Figure 21. Monthly trend of the electric power requested to the grid.

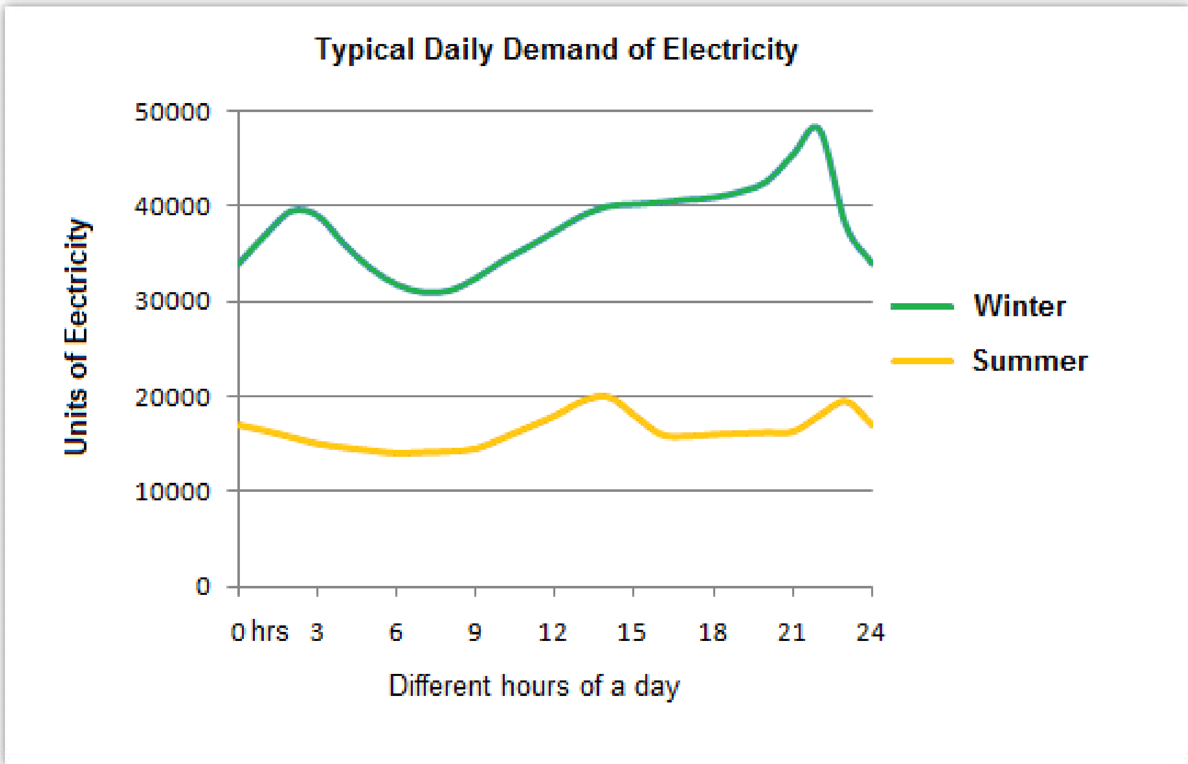


Figure 22. Daily trend of the electric power requested to the grid in winter and summer season.

5.2. Electric power required by the electric vehicle fleet to the grid

The evaluation of the power required by electric vehicles needs the definition of a time interval in which the vehicles' batteries are charged. It is hypothesised here that all vehicles will go back home in the time interval 4.00–7.00 pm, and then plug in their batteries.

The definition of the peak of required electric power depends on the precise plug-in time of each vehicle. Bearing in mind that the arrivals are equally distributed in the time interval 4.00–7.00 pm, the maximum power request will be in the time interval 7.00–9.00 pm.

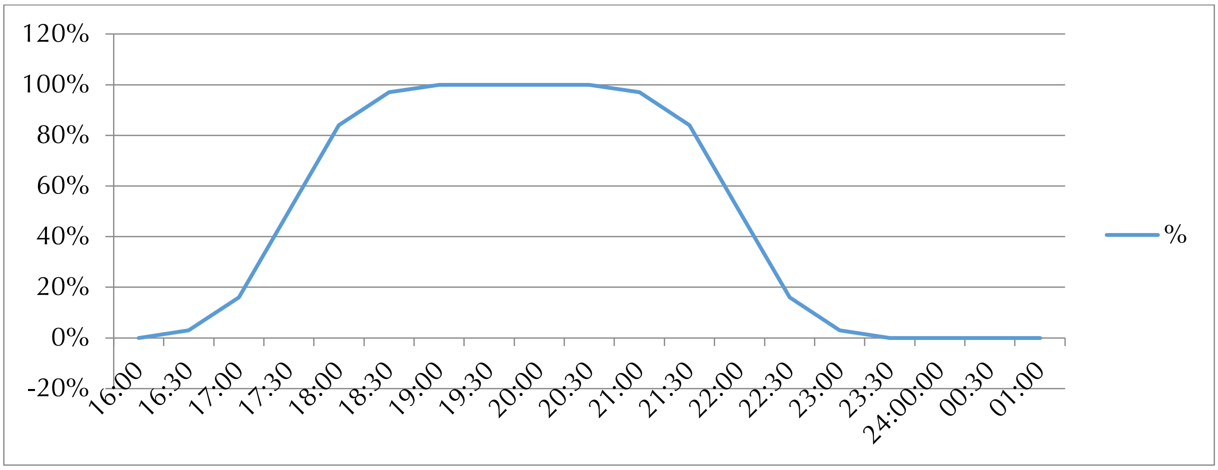


Figure 23. Characteristic of the frequency of EVs connected to the grid after work time [own elaboration].

In addition, two different values have been considered:

- the average electric power request, i.e. the values given that all the vehicles have to recharge their battery every day and the connection is regular,
- the maximum electric power, i.e. the values given that not all the vehicles have to recharge their battery every day, but that on each day the same average percentage of vehicles recharge their battery (36.7%). The power required to the grid in the improbable, but not impossible, extreme event that all the vehicles recharge in the same hour.

The average electric power request is important as it shows the amount of electricity that should be provided daily in the grid, while the other one gives an estimate of the maximum request that the grid could face at the same time.

In Table 32 the average and the maximum incidence in terms of power request by the electric fleet is presented for the year 2030. It is worth noting that in all of the scenarios the incidence is quite low. The average electric power request by EVs is more than 2% of the energy supply in two cases. The first one is Denmark, at a level of 5.2%, and a number of electric vehicles at the level of 19% of all cars, and the other one is Germany, at the level of 2.7%, and a number of EVs at the level of 12.3%. In Poland, the appropriate indicators are 1.1% and 3.4%. Indicators of maximum electric power demand show two examples of situations that can be dangerous for the safety of the grid. These are Denmark with an additional request to the grid at a level of over 25% and Germany with a level over 11%. The indicator for Poland is less than 5%.

The situation changes when the number of EV cars exceeds 25% in countries with a lower level of energy consumption per capita (Lithuania, Poland). As the percentage increases significantly (Lithuania over 11% and 48%; Poland 8% and 36%) it is necessary to adopt strategies in order to avoid the potential damages created to the grid capacity. In particular, creating an “intelligent” grid, able to decide “when” to provide power to batteries, would be very fruitful in order to shift the power request to hours in which this is lower, avoiding all of the possible problems of network overloading. This concept is at the basis of the “Vehicle to Grid” (V2G) or part of the “smart grid” strategy, according to which the vehicles can represent an additional element capable of storing electric energy to be used during peak demand (if the vehicles are connected to the network).

This conclusion is even more significant if one considers that people at home are also expected to use low-voltage (LV) electricity to charge their electric vehicle. Thus their impact on the LV grid will be much higher and infrastructural improvements should be taken into consideration.

Table 32. Incidence of the electric power peak daily request by the electric fleet for the year 2030 – all scenarios

Number of cars	E. energ. sup.	Year 2030	Scenarios of the EV fleet development					
COUNTRY			Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
3 310 905	79 072	Fleet Share (%)	0.48%	3.11%	4.97%	25%	30%	35%
Finland		Average incidence of electric power request (%)	0.050%	0.321%	0.513%	2.579%	3.095%	3.611%
		Maximum incidence of electric power request (%)	0.214%	1.386%	2.215%	11.141%	13.370%	15.598%
1 907 167	10 466	Fleet Share (%)	0.22%	1.08%	1.75%	25%	30%	35%
Lithuania		Average incidence of electric power request (%)	0.099%	0.485%	0.786%	11.224%	13.469%	15.713%
		Maximum incidence of electric power request (%)	0.427%	2.095%	3.394%	48.487%	58.184%	67.882%
22 181 051	161 837	Fleet Share (%)	0.43%	1.25%	3.40%	25%	30%	35%
Poland		Average incidence of electric power request (%)	0.145%	0.422%	1.148%	8.442%	10.130%	11.819%
		Maximum incidence of electric power request (%)	0.627%	1.823%	4.960%	36.469%	43.763%	51.057%
3 072 060	27 834	Fleet Share (%)	3.42%	14.09%	19.20%	25%	30%	35%

Denmark		Average incidence of electric power request (%)	0.930%	3.831%	5.221%	6.798%	8.158%	9.517%
		Maximum incidence of electric power request (%)	4.018%	16.552%	22.555%	29.368%	35.242%	41.115%
702 048	8 331	Fleet Share (%)	1.51%	5.44%	7.36%	25%	30%	35%
Estonia		Average incidence of electric power request (%)	0.313%	1.129%	1.528%	5.190%	6.228%	7.267%
		Maximum incidence of electric power request (%)	1.354%	4.879%	6.601%	22.423%	26.907%	31.392%
46 485 929	514 311	Fleet Share (%)	2.11%	8.84%	12.13%	25%	30%	35%
Germany		Average incidence of electric power request (%)	0.470%	1.969%	2.701%	5.567%	6.681%	7.794%
		Maximum incidence of electric power request (%)	2.030%	8.504%	11.669%	24.050%	28.860%	33.670%
5 141 665	114 627	Fleet Share (%)	2.56%	10.79%	14.73%	25%	30%	35%
Sweden		Average incidence of electric power request (%)	0.283%	1.192%	1.628%	2.763%	3.315%	3.868%
		Maximum incidence of electric power request (%)	1.222%	5.151%	7.032%	11.935%	14.322%	16.710%
2 792 241	111 159	Fleet Share (%)	8.59%	21.69%	28.03%	25%	30%	35%
Norway		Average incidence of electric power request (%)	0.532%	1.342%	1.735%	1.547%	1.857%	2.166%
		Maximum incidence of electric power request (%)	2.297%	5.799%	7.494%	6.684%	8.021%	9.357%

Note: Maximum incidence of electric power request (%) – all EVs that need charging (charging frequency is 36.7% of all EVs, which means that average charging for each EV is after 2.66 days) are connected at the same hour. Chargers need power of 3.375 kW (average of the 2.0 kW and 4.4 kW for chargers).

Knowledge of the daily demand for electric energy is necessary to analyse such possibilities. The assumption is accepted that the same characteristics of daily electric energy demand occur in all BASREC countries. Data about the daily demand for electric energy for the wintertime are presented (comp. Figure 22) in Table 33. Values of the daily electric energy demand in the summertime are definitely lower than in the wintertime so it is not necessary to conduct analysis for the summertime. Estimations of improvements are made taking into consideration:

- shifting the power request to hours in which this is lower,
- using a microgenerator of electric energy produced near to the recharging points,
- using EV batteries for storage of electric energy.

Table 33. Typical daily demand for electricity [own elaboration]

Hours (am)	12:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00
De-mand	3.65%	3.86%	4.08%	4.29%	3.97%	3.65%	3.33%	3.33%	3.33%	3.33%	3.49%	3.65%
Hours (pm)	**12:00**	**01:00**	**02:00**	**03:00**	**04:00**	**05:00**	**06:00**	**07:00**	**08:00**	**09:00**	**10:00**	**11:00**
De-mand	3.81%	3.97%	4.13%	4.29%	4.29%	4.29%	4.29%	4.40%	4.56%	4.83%	5.15%	4.40%

The maximal demand for electric energy is observed at 22:00. This is a demand of 5.15% of the daily volume of electric energy. This level of electric energy consumption is safe for the grid. If EVs use electric energy in each hour up to this level (5.15%), the demanded energy is supplied at not more than the maximal level (5.15%). This means we estimate the answer to the question: "How much electric energy can we use from the grid to recharge batteries without compromising the safety of the grid and without investment in additional generators of electric energy? It is about 27% of the daily supply. The results are presented in Table 34.

Table 34. Reserve of electric energy for EVs in the grid and capacity of EV storage of energy – data for optimistic scenario for 2030

COUNTRY	Maximal level of energy supply at 22:00 (5.15%) [GW]	Daily supply of electric energy [GWh]	Daily reserve of power for EVs [GWh]	EV daily demand [GWh]	Capacity of EV storage [GWh]
Finland	11.16	216.64	58.99	1.28	1.748
Lithuania	1.48	28.67	7.81	0.26	0.355
Poland	22.83	443.39	120.73	5.86	8.013
Denmark	3.93	76.26	20.76	4.58	6.267
Estonia	1.18	22.82	6.22	0.40	0.549
Germany	72.57	1409.07	383.69	43.75	59.912
Sweden	16.17	314.05	85.51	5.88	8.047
Norway	15.68	304.55	82.93	6.07	8.316

The estimated value of electric energy demand includes 15% losses caused by energy transmission and conversions. The conceptual idea of EVs created favourable technological conditions for using a distributed system of energy production as a source to supply EV batteries. In this case more than 50% of the mentioned losses could be reduced. The possible profit depends on accessibility to such a system.

Distributed energy systems based on the production of electric energy utilising renewable sources of energy such as solar energy or wind need to store energy. The intelligent integration of electric vehicles into the existing power grid as decentralised and flexible energy storage (V2G concept, e.g. see Smartgrids, 2009) might offer new possibilities for the global management of electric energy offer and demand.

The capacity of this storage in each EV is equal to the capacity of the part of a battery that is not needed to complete daily driving plus reserve. Let reserve be 10% of the daily consumption of EV energy. The estimated capacity of EV storage of energy is presented in Table 34. The results show that an intelligent integration of electric vehicles into the existing power grid as decentralised and flexible energy storage might offer new possibilities for the global management of electric energy offer and demand.

6. Model cooperation between vehicle owners, DSOs and energy retailers

6.1. Introduction

This chapter includes the results of the workshop "**The development of electric transport – its effect on the security of the electrical energy system and forecasting energy demand in eight chosen BASREC countries (Norway, Denmark, Germany, Sweden, Finland, Estonia, Lithuania and Poland)"** organised in Warsaw, 1–2 June 2015. The main purpose of the workshop was a general discussion on the model for cooperation "Vehicle owner – DSO – energy retailer". In total, 25 various people participated in the workshop. They were representatives of agencies dealing with e-mobility from six BASREC countries (Denmark, Finland, Germany, Lithuania, Poland and Sweden), DSOs, energy retailers and external and university experts.

Please find below the conclusions and recommendations of the workshop that are important in defining models of cooperation between vehicle owners, DSOs and energy retailers:

1. There were some doubts over whether EC overestimated the number of electric cars and the number of charging points per vehicle (two points per vehicle) in the presented countries. That was confirmed by all of the foreign guests. On the other hand, the CO_2 tax or new possibilities such as V2G are huge e-mobility development impact factors, but it is hard to introduce them at the political level. More precise estimation of e-mobility market development needs pilot projects giving answers to how the market responds to different market models and support systems.
2. Electric bus systems are fast emerging and both vehicle technology and charging equipment are available. It is recommended to start a project using TCO (**T**otal **C**ost of **O**wnership) as a means of facilitating the economically viable cases for electrification. The proposal is a systemic approach and the cooperation of key players is necessary in order to design an efficient e-bus system.
3. The crucial challenge for the development of e-mobility is to create proper economic signals in order to establish a "critical mass" and close cooperation between the government, car industry and power sector is essential. The electricity tariffs for charging EVs are highly dependent on political aspects, and the introduction of innovation. The tariffs should be dependent on the amount of energy in the power grid.
4. Technically EVs are ready for the introduction of e-mobility, but the cost of the battery still remains very high; the basic charging infrastructure is limited to charging at home; the power grid is ready to meet the need of EVs for electricity, but it is necessary to manage electricity, for example by using smart grids and

smart metering; the increasing electric energy demand of EVs can be balanced by driving them in an efficient way (low energy consumption). Flexible charging, i.e. charging at night, is beneficial for ensuring electricity security. However, there are still not enough economic initiatives in these directions.

5. The introduction of e-mobility on a larger scale will require changes in the power system. There are many business models but only a few will be followed for further analysis. One of them is public electric transport and long-term car-sharing (especially for companies) with special tariffs (charging at a certain time of day or night). The used batteries from the vehicles can be used for the storage of energy (in order to support the network).
6. A specific approach and engagement is needed for e-mobility from the DSO side because of challenges associated with uncontrolled charging and opportunities for controlled charging and smart grid integration. An important aspect in order to stabilise the grid is the local storage of energy. Charging stations might not be in the scope of DSO business interests. The development of a recharging point infrastructure should depend on market conditions. In the coming years, new models of DSO activities might appear – these will be driven by energy produced locally (renewable energy sources). Appropriate R&D (research and development) projects on the subject of EV integration into smart grids are recommended.
7. Electric mobility is a challenge. In general, the technology is ready, but there is a need for political support and initiative to shape a market model. The very first step will be to start with a national framework for the introduction of e-mobility and then the free market will shape the infrastructure. It will be necessary to define measures for e-mobility initiatives. Afterwards there can be financial support from local governments. Subsidies for e-mobility might be a solution at the beginning. CO_2 taxation was mentioned as a solution that may rapidly increase the development of e-mobility. The model cooperation between vehicle owners, DSOs and energy retailers plays a key role in the development of e-mobility. This model should include possible technologies to integrate EVs into the grid, such as G2V and V2G. There is no need to build a large-scale public infrastructure at the beginning. The infrastructure should be developed step by step. Ownership of the charging infrastructure is crucial: either private or public. It is important that it should be user-friendly.
8. Changing people's mentality in their view of e-mobility will be difficult. We should encourage people to use the current existing infrastructure. Try to keep it spontaneous and act upon the apparent needs of the market and that will determine the technical aspects of the future grid. There is a great need for a "critical mass" – the people who will buy the electric cars.

The above conclusions enable acceptance of some assumptions and indications concerning the development of e-mobility in each of the BASREC countries.

- DSOs can play a vital role and provide an unquestionable benefit for the electric system, its stability and efficiency due to the implementation of EV integration technology in the grid. Profitable conditions of services offered by DSOs for EV owners can have a significant impact on e-mobility development. Preconditions to reap the benefits from the services of DSOs are as follows:

- ✓ The first precondition to reap the benefits mentioned above is to have a sufficiently high number of electric vehicles in DSO service. The level of this "critical mass" will be specific for each country.
- ✓ The second is to get the right tools for electric vehicle grid integration technology ready for implementation. One of the technical advantages of EVs is on-board electronics. In practice, the tools should be represented by a suite of hardware and software technologies that enable EVs to participate in grid services, ready to be included in the appropriate computer system.
- ✓ The next precondition is to implement a model of a national electric system prepared to reach national targets of e-mobility development that will give price signals taking into account all levels of resources, including ancillary services, microgrids, smart grids and unconventional capacity. EVs can only provide grid services if electricity market rules treat energy, capacity and ancillary services resources separately. This allows non-generation resource providers to participate in the market and compete on an equal footing with generation. In order to foster non-generation market participation, a policy of fair and equal pricing of non-traditional resources is needed. The requirements for market participants, such as minimum capacity and performance expectations, need to be compatible with the capabilities that EV aggregation service providers could offer. In summary, a market model that aims for a competitive environment for e-mobility must allow for:
    - o Access of new entrants, competing with a wide range of products and services;
    - o A stable and long-term investment climate for e-mobility;
    - o Transparent services and prices, encouraging customer behaviour to reflect the costs involved (e.g. peak demand);
    - o Revenue creation that reflects value creation and actual costs, avoiding a transfer of costs to other actors.

Policies need to ensure that emerging business models for EV grid services are not unduly hampered by regulatory, administrative or market barriers.

- The numbers of electric vehicles circulating in each of the BASREC countries are very different. The development of e-mobility and the share of the EV fleet in the market is individual in each country and depends on the national frame of e-mobility development and on the system of support in the development of the EV market. <u>The value of DSO services for EVs is very low or even without any significance in the countries with low numbers of EVs.</u> In those countries, investment in the development of DSO infrastructure can cause an increase in the cost of e-mobility development and the cost of TCO, and also a decrease in the efficiency of EVs.

- For further analysis the assumption is made that the number of EVs is sufficiently high to create and develop DSO services for them.

6.2. Electric system management

Now we have to define the main points of the electric system management for further consideration of models of cooperation between vehicle owners, DSOs and energy retailers.

Regulators and operators of electric grids are responsible for making sure that electricity flows reliably to customers by matching the supply (generation) of electricity with the demand for it (also known as "load"). Maintaining stability in an electric system requires a strategy to ensure that ample generating capacity resources are available over the long term, that those resources are able to deliver energy when it is needed, and that the system can respond quickly to adjust for fluctuations in demand, as well as unplanned generator failures.

How this is undertaken depends on the electricity market structure. In a regulated electricity market, these resources are provided by central power generators, such as natural gas, coal, nuclear or hydro plants. The cost of providing them is bundled into a single price for electricity. There is little transparency in the value of each component, and it is impossible for non-generation resources to get paid to provide these services. Increasingly, though, market deregulation is leading system operators to break out these components and procure them individually. By creating open markets for these resources, system operators are creating new opportunities for alternative technologies. EU electricity markets start with a deregulation process, and market operators are looking to implement approaches to competitive procurement. A major outcome of this deregulation has been the rise of the demand response industry.

Resource planning in the European Union (EU) has, until recently, been a nationally coordinated function, although the EU has completed deregulation and unbundling of energy and transmission services, and is in the midst of deploying more robust, multi-country wholesale power markets. Competitively procured electricity is delivered to customers by distribution system operators (DSOs).

Capacity, energy and other resources

The technical challenge of balancing the electric grid in real time is the same across all market structures. Grid operators can avoid prolonged system imbalances by ensuring the ability to increase or decrease supply or load, working with generators and other market participants who supply a variety of "grid services". Each grid operator defines their own categories of grid services; the resources can be generally defined as capacity, energy and ancillary services:

- capacity resources are procured months or years before delivery to ensure that the system will have enough generating capacity to meet consumption needs,
- energy resources are procured days or hours before delivery, based on short-term forecasts of system load,
- ancillary services are procured within minutes or seconds of delivery, based on the very short-term needs of the system. These resources allow system operators to manage short-term frequency and voltage fluctuations based on changes in supply and demand.

As a system operator looks to meet these resource needs, they assemble a portfolio of resource providers that can provide flexible generation (e.g. from a power plant) or load management (e.g. by increasing or decreasing energy use in a facility).

The implementation of demand response solutions shows how price signals or incentive payments can be used to reduce electricity use, but demand response has participated mainly in the capacity markets, as opposed to energy or ancillary services. Experiences learned in the formation of demand response policy may be instructive to open deregulated markets to a broader range of unconventional capacity, energy and ancillary service providers.

6.3. Model cooperation between vehicle owners, DSOs and energy retailers

Models of cooperation will differ between individual solutions in each BASREC country because of different levels of e-mobility development and the particular conditions of each country. Market roles are independent of these. As a first step toward model definition, market roles are described. The roles have to be fulfilled in any functioning e-mobility market. For that we make use of a table worked out by EURELECTRIC ("Deploying publicly accessible charging infrastructure for electric vehicles: how to organize the market?", a EURELECTRIC concept paper, July 2013).

Role	Description
Electricity Supply Retailer	These are the present and future companies that hold licences (or are active on the market – not all countries have licences) to sell electricity that they produce themselves or purchase on the electricity markets to end-users, with whom they have power contracts with fixed locations for the supply.
Transmission System Operator (TSO)	A party that is responsible for a stable power system operation (including the organisation of physical balance) through a transmission grid in a geographical area. The system operator will also determine and be responsible for cross-border capacity and exchanges. If necessary, he may reduce the allocated capacity to ensure operational stability (ENTSO-E's Harmonised Electricity Role Model; p.19).

Distribution System Operator (DSO)	A party that currently holds and manages the assets for low-voltage (LV)/medium-voltage (MV)/high-voltage (HV) (110kV) distribution networks, responsible for connecting all loads to the electric system and maintaining a stable, safe and reliable network for the supply of electricity to all customers (EURELECTRIC Market Models paper, p. 16)
Balance Responsible Party	A party that has a contract proving financial security and identifying balance responsibility with the imbalance settlement responsible for the market balance area entitling the party to operate in the market. This is the only role allowing a party to nominate energy on a wholesale level (ENTSO-E; p.13).
Balance Supplier	A party that markets the difference between actual metered energy consumption and the energy bought with firm energy contracts by the Party Connected to the Grid. In addition, the Balance Supplier markets any difference with the firm energy contract (of the Party Connected to the Grid) and the metered production (ENTSO-E; p.13).
Metering Point Operator	This is the party responsible for metering duties allowing a consumer to purchase electricity on the supply market through the distribution grid. In most countries the role is played by the DSO. The metering information is critical to enable pay-per-use payment models when considered for e-mobility.
Charging Station equipment owner	A party that owns the charging station. *Example: a city owns the public charging stations but outsources the operation to a commercial party. Or in a public parking space a company can both own and operate the charging station.*
Charging Station Operator (CSO)	A party that operates the charging infrastructure from an "operational technical" point of view, i.e. access control, management, data collections, repair etc. There can be a differentiation between the "technical" operator and the "commercial operator" that offers services to the electric vehicle driver by using the charging infrastructure. The Charging Station Operators engaged in commercial activities may buy electricity on the supply market and sell a charging service all included, or may sell a charging service not including the electricity supply.
Private Network Operator	A party that acts as an electrical infrastructure operator, operating a private network to which charging stations are connected. This network is not managed by the DSO (e.g. home network, building network, shopping malls, etc.).

	This may be particularly applicable for semi-public locations. In some situations, the Charging Station Operator may also be the private network operator.
E-mobility Service Provider	A party that sells e-mobility services to e-mobility customers. For example, the service can be a fluid and money-free access to charging stations from different Charging Station Operators. It may be bundled with other services (EV location, parking etc.), it may include electricity supply and other services.
E-mobility customer	A party that consumes e-mobility services using an electric vehicle, including electricity and charging services.
Data clearing processor	A global platform between Charging Station Operators and e-mobility operators to organise and process their exchange of data for a fluid access to charging stations of any Charging Station Operators by e-mobility customers of any e-mobility service provider. It allows for authorisation of service requests identifying the operators involved, and sends service data summaries to these operators in order to let them invoice their customers.

6.3.1. Role of DSOs

Over 150 experts, including utility leaders, power generators and PUC commissioners, as well as NGO, academic and industry experts, prepared and vetted the eight white papers that form the foundation of America's Power Plan and top policy recommendations. At the end of 2014 they publicised (http://americaspowerplan.com/2014/09/trending-topics-in-electricity-today-the-distribution-system-operator/) Trending Topics in Electricity Today – The Distribution System Operator. They assume that: "As more technologies become available to customers to manage and generate energy, the distribution system is getting more and more complicated. Rather than being a one-way street for electricity to reach customers from faraway generators, customers are meeting their own energy needs or even exporting services to the grid. This new kind of distribution system needs a new kind of management." In the opinion of America's experts there are multiple views about managing a new distributing system but in principle there are only two models:

1. One for an integrated distribution planning process
2. A second model for a "Distribution System Platform" provider (DSP) or an "Independent Distribution System Operator" (IDSO or just DSO)

The European Union of the Electricity Industry, EURELECTRIC (www.eurelectric.org) ("Deploying publicly accessible charging infrastructure for electric vehicles: how to organise the market?", a EURELECTRIC concept paper, July 2013), allows the above opinion.

Short descriptions of these models are presented below.

6.3.2. Integrated infrastructure market model

This market model (see Figure 24) is already being implemented in **Italy** as part of early market phase tests, mandated by the Italian authority for electricity and gas; in **Ireland**, following a decision by the Irish government as part of the national roll-out plan for recharging infrastructure; and in **Luxembourg**.

Implementation runs on the basis of the scenario "roaming of electricity and service" by establishing a multi-vendor platform. E-mobility customers can use competitive offers between e-mobility service providers. Different charging processes are in service, and customers have access to the public charging infrastructure managed by the DSO and household electricity supplier. The DSO has a system that is able to "link" the customer to an e-Mobility Service Provider with whom the customer has a contract that includes electricity. **The DSO acts as the Charging Station Operator** installing and managing the public Charging Stations and allowing different e-Mobility Service Providers to compete by providing Business to Customer (B2C) services (e.g. basic and smart charging) to their customers at the charging stations.

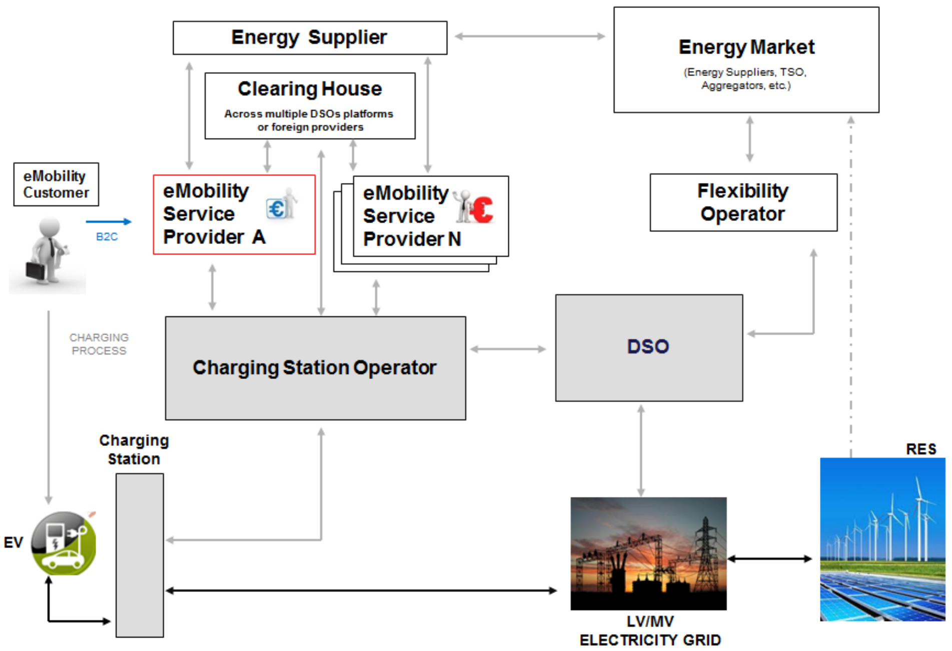


Figure 24. The integrated infrastructure market model (elaborated by the Union of the Electricity Industry – EURELECTRIC, www.eurelectric.org).

Legend:	Red-line box: final electricity customer
Blue arrow: B2C contractual relationship	Black arrows: physical connection

Grey arrows: B2B contractual relationship Grey boxes: roles performed by the DSO	Clearing House acts across multiple DSO platforms and foreign providers

The following assumptions are made for the model:

- e-Mobility Service Provider encompasses the role of the Electricity Supply Retailer,
- DSO acts as the Metering Point Operator
- public charging stations are equipped or are in communication with electricity meters at the Point of Delivery (meaning the public charging station).

The role of Charging Station Operator enables the DSO, under **non-discriminatory conditions, to offer the multi-vendor approach and access to all e-Mobility Service Providers.**

The e-Mobility Service Providers can either buy the electricity from an Electricity Supply Retailer – thus they act solely as e-Mobility Service Providers – or they can play both roles, Service provider and Charging Station Operator.

The DSO, as a Charging Station Operator, provides access to all possible e-Mobility Service Providers and is able to "identify" their electricity retailer through the Clearing House functionality that resolves the B2B relationship between the e-Mobility Service Provider and the Electricity Retailer. The billing settlement is guaranteed by the Charging Station Operator (DSO). The DSO sends transaction data of the charging process to the e-Mobility Service Provider and associated Electricity Retailer. The "fee" for the access to and usage of the Public Charging Station can be traded as a general service by the e-Mobility Service Provider to the e-Mobility Customer: e.g. pay per minute, pay per parking spot, flat rate, etc., depending on the conditions of the B2C contract.

The DSO also performs the role of Meter Point Operator and is able to send certified information about the consumed electricity to the e-Mobility Service Provider. The sale of electricity always happens through the relationship between an Energy Supply Retailer (linked to an e-Mobility Service Provider or acting as the e-Mobility Service Provider) and the final customer. Billing is enabled through the infrastructure managed by the DSO and using revenue-grade metering. The B2C relationship could be established through a previously valid contract or through a direct on-the-spot and contractless access (e.g. direct payment via credit card or sms), with the customer choosing his e-Mobility Service Provider at the time of accessing the Charging Station. Once the B2C contract is acknowledged, the DSO is able to send metering data to the specific Electricity Supply Retailer, which is beyond the B2C relationship between the e-Mobility Service Provider and the final customer.

The integrated infrastructure market model enables service and sale of electricity to the final e-Mobility Customer and the Electricity Supply Retailers to directly handle B2C relationships in the e-mobility market.

In this model all the technology of the publicly accessible charging infrastructure becomes part of the Regulated Asset Base of the DSO and is recovered by the charging infrastructure's regulated return on investment.

The implementation of an "integrated infrastructure model" is a governance decision that can only be taken by national governments and mandated to local DSOs.

6.3.3. Independent e-mobility market model

This model (see Figure 25) is currently being implemented in **Germany**, **France**, **Spain**, **Denmark** and **the Netherlands**.

"Any market participant" can manage the public charging station. The station is deployed independently from the "regulated" DSO/grid business. Owning and running the builing is a competitive activity, so actually more than one party might install charging stations in a town or on a single street.

The DSO carries out the calculation of the network fees. Metering for the charging station is conducted by the DSO or a third party may perform the duties of the Metering Point Operator and provide relevant data to the DSO.

For a **smart charging process** two possibilities may exist (depending on the national frameworks):

1. The DSO finds an aggregator through the Flexibility Operator that "sells" him all or part of the flexibility that might be included in a single recharging process.
2. The DSO has a direct contract with the owner of the network connection to which the charging stations themselves are connected (e.g. using a private network inside a building etc.) in relation to its electricity distribution role, which allows him to send technical signals requesting power reduction, or power increase, according to the local situation of the network.

The supply company itself may act as an e-Mobility Service Provider and Charging Station Operator and own the charging stations. The Charging Service Operator must be neutral to ensure access to the charging service for any e-Mobility Service Provider.

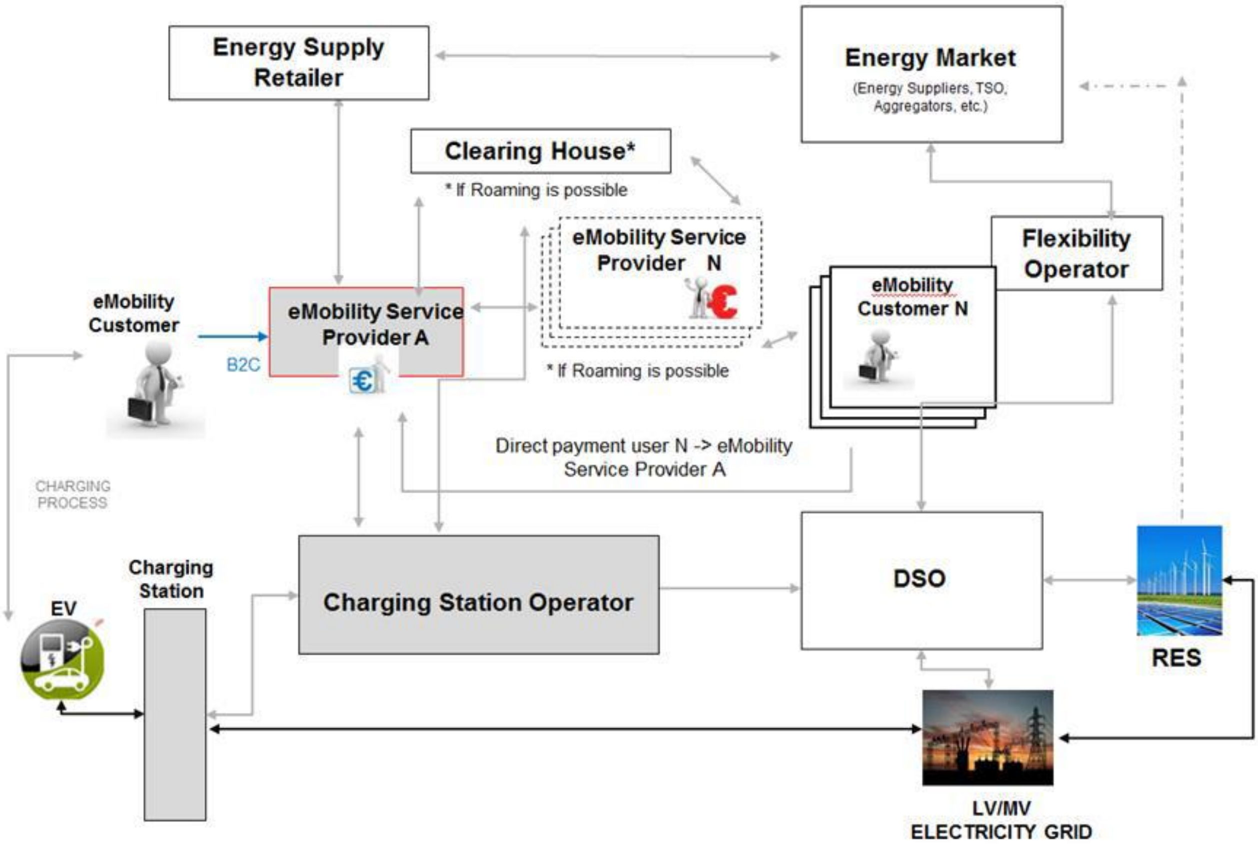


Figure 25. The independent e-mobility market model (elaborated by the Union of the Electricity Industry – EURELECTRIC, www.eurelectric.org).

Legend:

Blue arrow: B2C contractual relationship Grey arrows: B2B contractual relationship Grey boxes: roles may be performed by the same market actor	Red-line box: final electricity customer Black arrows: physical connection

Figure 26 shows the elements that enter into the calculation of a charging service fee that (in the absence of any public subsidies etc.) must be borne by the e-mobility customers in the independent e-mobility market model.

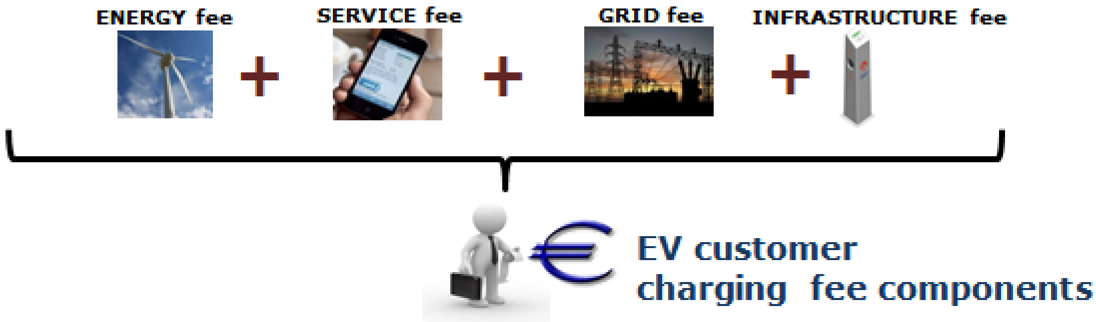


Figure 26. Components of e-mobility service fee (elaborated by the Union of the Electricity Industry – EURELECTRIC, www.eurelectric.org).

E-mobility customers may use different means to access the charging stations:

1. Customer signs a contract-type **subscription model** with the e-Mobility Service Provider that runs the public charging stations. The customer has access to these charging stations.
2. The customer signs a contract-type **roaming agreement** with the e-Mobility Service Provider. The customer has access to a charging station operated by a different e-Mobility Service Provider (this is a similar situation to the mobile phone market).
3. Possibility of **direct payment** systems (credit cards, sms etc.).

7. Regulation proposal for electric transport support by 2020

It should be remembered that the main factor shaping the e-mobility policies of the BASREC countries covered by the current analysis is Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of an alternative fuel infrastructure (this legal act is relevant for the European Economic Area, so it influences Norway as well, despite this country not being an EU member state). The general requirements of this Directive need to be implemented in each member state: however, the respective national governments may adopt for this purpose different detailed solutions. Therefore, the common denominator for the countries covered by this analysis is that the exact shape of future e-mobility policies is a subject of discussion, which also includes in general the proposals of various regulations in this field.

Poland

There are no official national-level documents on supporting e-mobility in Poland. However, as mentioned in Chapter 3, the working group under the patronage of the Polish Ministry of Economy was created, which was to deliver the draft strategy on supporting e-mobility in Poland. The strategy was subsequently (in 2012) approved by the Interministerial Team on Improving the Competitiveness of the Car Industry – however, the strategy's recommendations have not so far been implemented in the national law.

The document was entitled "Issues of implementation of integrated e-mobility system in Poland" ("Uwarunkowania wdrożenia zintegrowanego systemu e-mobilności w Polsce"). The recommendations presented were as follows:

a) From the car industry:

- bonuses regarding purchase of electric or hybrid vehicles (elimination of excise tax, decreasing income tax related to the purchase),
- elimination of parking fees, assigning access to bus-only lanes, allowing access to "low/zero-emission" areas in cities,
- preparing draft of separate Act of Parliament regulating the above-mentioned issues.

b) From the energy companies:

- exempting charging infrastructure (charging points, battery swap/replacement) from the sphere of regulation by the general Law on Energy and qualifying the former as one of the services available on the free market,
- preferences for the battery swap model for medium and long travel distances (with the goal of introducing EVs in Poland perceived in the context of Grid-to-Vehicle and Vehicle-to-Grid relations),

- securing the possibility of performing V2G services in order to better adjust grid parameters, and in future, in line with market enlargement, in order to improve the operation and security of the energy system.

c) From the city of Warsaw;

- conducting an information campaign in relation to the popularisation of e-mobility,
- construction of a network of public-access charging points by local authorities interested in e-mobility,
- elimination or decrease of parking fees by local authorities (with some amendments of national law needed for this purpose),
- allowing, by local authorities, access to bus-only lanes,
- allowing, by local authorities, access to areas with restricted access for private vehicles,
- exemption from registration fee to be introduced by local authorities (amendment of national law necessary for this purpose),
- drafting rules on setting location of public-access charging points and battery swap stations, taking into account both securing uninterrupted travel of EVs and overloading security of energy grid,
- analysing possibility of introduction, by local authorities, of special identifiers (such as holograms) for EVs,
- introducing special road signs marking parking spots dedicated to charging electric vehicles.

Nonetheless, there is a draft Act of Parliament that will have direct relevance for the development of e-mobility. This Act is supposed to amend the Law on Environmental Protection and several other legal acts. Thanks to the new legal provisions, municipalities would be able to establish low-emission zones for vehicles in their respective areas. If implemented, these measures will obviously favour electric vehicles, especially if the given local authorities choose to introduce relatively strict emission standards, at least in some parts of the city areas.

Germany

The issues of e-mobility development in Germany are covered by the broad political consensus, whose participants are both political parties and other stakeholders. The most important body comprising professional stakeholders is the German National e-mobility Platform (NPE). In order to achieve the national goals, the NPE recommends that the following measures be taken during the forthcoming development phase of the e-mobility market:

1. Introduction of a special depreciation allowance for business users (amounting to an annual loss in tax revenue of around 0.2 billion euros).

2. Rapid implementation of a set of legislative measures for promoting electric mobility.

3. Strengthening of investment partnerships for building a semi-public or public charging infrastructure.

4. Implementation of the EU directive on alternative fuels, including the expansion of the charging infrastructure in accordance with the recommendations of the Standardisation Roadmap.

5. Roll-out of private and public procurement initiatives.

6. Continuing research and development into new topics and securing its funding through federal government support (public funding of approximately 360 million euros per year).

7. Joint research into and promotion of the establishment of a cell manufacturing facility in Germany.

Lithuania

Similarly to Poland, in Lithuania the discussion on methods and specific solutions connected with the implementation of Directive 2014/94/EU is ongoing. The most relevant document regarding the future e-mobility policies in this country is the exhaustive report on e-mobility transportation prepared for the Lithuanian government. The report focuses on efficient policies and methods concerning the popularisation of e-mobility. Taking into account both the current international situation and the behaviour of car drivers, the report contains the following recommendations in relation to charging infrastructure:

- the public-access charging stations should include the IEC 62196-2 charging points in the Mode 3 Type 2 standard (up to 22 kW),
- in households and at workplaces electric vehicles should be charged either at the Mode 3 points or at standard wall sockets connected to the electric grid,
- with regard to very fast charging (Mode 4), Lithuania should wait for the development of such a network until the new common European standards in this regard are ready,
- due to the relevant technologies not being sufficiently developed in this country, battery swap stations are not recommended.

In order to popularise e-mobility, special incentives are necessary. The report recommends implementation of the following incentives:

- incentives of a financial nature (possible tax reductions for companies and tax refunds for EV users; this aspect includes, for example, VAT compensation),

- establishing a tax for users of vehicles with internal combustion fuels (30 Lit/year), which would be significant in terms of both generating additional income and its influence on consumer behaviour,
- development of a charging infrastructure with free charging at public-access stations, which will attract EV producers to the market and will provide comfort for EV users.

The introduction of the aforementioned measures would be divided into two stages. The first stage would be devoted to the implementation of measures that can be feasibly launched within a short period of time, while the second would comprise specific pilot projects, to be started in the period from 2015. Three types of pilot project are recommended in the report:

- support of purchase of electric cars as the government's initiative: possible collective purchase of around 200 EVs with various financial incentives for companies, public institutions and individual users,
- EVs used as taxi cars: 10 EVs co-financed by the government would be added to the fleet of one or more taxi companies,
- possible winning of an EV as a prize: adding an electric car to the prizes available in some lotteries, which are popular in Lithuania, at the same time would constitute promotion of electric mobility in the country.

Finally, with regard to financing e-mobility support, it would require around 655 million Lit until the year 2025. The funding would primarily come from two sources: from the above-mentioned tax for users of conventional cars (which, according to estimations, may bring an additional 500 million Lit to the national budget) and from the assistance available in the EU 2014–2020 financial perspective.

With regard to geographical distribution and focusing the development of e-mobility, there are different options being considered by experts. E-mobility actions have focused hitherto – in addition to the main motorways – on the largest Lithuanian cities (Vilnius, Kaunas, Klaipėda). Currently there are also other areas under consideration, e.g. Šiauliai/Panevėžys, Neringa municipality and national parks.

Denmark

E-mobility in Denmark enjoys strong support from the government, which is connected with the general Danish strategy on gradually becoming independent from imported fossil fuels and developing renewable energy sources, which deliver "clean" electricity to power EVs.

The most relevant projects in this country concern the development of a map of the national charging infrastructure, a smartphone application that tracks how far a person is driving, service costs for EVs and solutions for charging EVs for urban dwellers.

Specific cities have their own e-mobility plans. For instance, Copenhagen wants to have 85% fossil-free transportation by 2020, while the Odense municipality envisages a complete conversion of its fleet to EVs in four years.

It is also legally possible for municipalities to make parking free of charge for EVs.

Another incentive for EVs in Denmark is a tax rebate on power purchases when used for charging these vehicles.

With regard to taxation, in Denmark differentiation of car-related taxes, taking into account environmental aspects, has a relatively long tradition. For instance, EVs became exempt from certain taxes in 1987. The rules for the year 2011 were as follows:

- the annual circulation tax was based on fuel consumption.
    - ✓ petrol cars: rates varied from 520 Danish Kroner (DKK) for cars covering at least 20 km per litre of fuel to DKK 18,460 for cars covering less than 4.5 km per litre of fuel,
    - ✓ diesel cars: rates varied from DKK 160 for cars covering at least 32.1 km per litre of fuel to DKK 25,060 for cars covering less than 5.1 km per litre of fuel.
- registration tax was based on price. An allowance of DKK 4,000 was granted for cars for every kilometre in excess of 16 km (petrol) and 18 km (diesel), respectively, that they can run on 1 litre of fuel. A supplement of DKK 1,000 was payable for cars for every kilometre less than 16 km (petrol) and 18 km (diesel), respectively, that they can run on 1 litre of fuel.

While for the year 2015:

- the annual circulation tax is still based on fuel consumption. This fee is paid twice a year. For petrol cars, the rates are from 620 DKK/year for cars doing more than 20 km/l to 21,660 DKK/year for cars doing less than 4.5 km/l. For diesel cars, the rates vary from 240 DKK/year (above 32.1 km/l) to 33,040 DKK/year (less than 5 km/l). Diesel cars get an allowance of 1,000 DKK/year (tax rebate) if they have a particle filter.
- the Danish registration tax remains based on price. A new car pays 105% of its value in taxes up to 81,700 DKK, and 180% of the remaining value (from 81,700 DKK). Furthermore, 25% VAT is added to both the value and the tax. However, cars doing more than 16 km/l (petrol) or 18 km/l (diesel) can deduct 4,000 DKK per km/l. For instance, a petrol car doing 20 km/l can deduct 4x4,000=16,000 DKK from the taxes. This is applicable all the way down to a minimum registration tax of 20,000 – for instance, a BMW i3 REX doing (theoretically) 166 km/l can deduct 600,000 DKK. It must, however, pay the minimum tax of 20,000 DKK.

Electric cars are currently exempt from both taxes (as well as VAT) throughout 2015. As for the period after then, there is still no political agreement on how to tax EVs. This is connected with the fact that Denmark recently elected a new government, so there is a waiting period until the e-mobility policy of the new government is formulated. It will cover both proposals for regulations concerning supporting electric transport development and proposals for support mechanisms (including financial mechanisms) for electric transport development. However, the new regulations will be most likely based on the current ones, hence the above summary of the current state of affairs in this field.

Norway

As mentioned in Chapter 3.8, e-mobility in Norway is very strongly supported by both the central government and other levels of public administration. In addition to the vast financial resources available for e-mobility support and the high level of income of citizens, this has led to the substantial popularity of electric vehicles in this country.

There have also been a number of incentives introduced on the local level, which have been a major factor in the growing popularity of EVs in Norway. For example, motorists in Oslo have reported saving an hour on their daily commute by driving in bus lanes and by gaining easy access to dedicated EV-only car parks across the city. A recent survey by the Norwegian EV Drivers Association found that 64% of the 1,859 respondents felt that their electric car saved them time. These local incentives are administered and funded by the municipalities themselves.

A cross-party political agreement set the intention for incentives to remain until 2017 or when 50,000 EVs are registered in Norway. However, as the market grows the continuing viability of certain measures is to be kept under review. One such example is access to bus lanes.

As transportation expert Tom Nørbech stated, “these incentives have been in place for many years and have proven to be very popular, with few issues or concerns. Today we have almost 40,000 BEVs on the road in Norway and we are only just starting to see some localised issues in bus lanes in parts of Oslo. This will have to be phased out at some point, but on the basis of experience to date I’m sure that many other cities could enjoy benefits from implementing similar measures to support the early market for EVs.”

Currently, as the threshold of 50,000 EVs registered in Norway will be reached soon, before 2017, there is a need for discussion on new rules on supporting e-mobility in the country. No decisions have been made in this field yet on the national level. However, we should not expect Norwegian e-mobility support to cease – only detailed arrangements in this field will be reformulated. It should be added as well that, regardless of the national-level schemes, municipalities are still launching their own e-mobility incentive measures. For instance, the local authorities in Trondheim, when introducing toll tax, exempted electric vehicles from this tax. Similar actions are likely to be continued in the mid-term future.

Finland

In Finland, the parliamentary election took place in May 2015 and the new government was established. The government announced that there will be some changes, which are still under discussion at the time of elaborating this chapter.

In the meantime, taxation still remains the main instrument for supporting e-mobility in Finland. In addition to that, the country has in place a system of so-called “energy support” where purchases of charging infrastructure (public charging of private cars, but also charging for public transport) and electric vehicles (fully electric vehicles for company fleets and commercial vehicles such as buses) have been supported by 30% by the Ministry of Employment and the Economy. However, these support funds have already been used up and further decisions on continuation are pending, depending on the results of discussions taking place on the national level.

With regard to taxation, Finland has in place both a registration tax on new vehicles and an annual vehicle tax (i.e. ownership tax).

The vehicle tax comprises a base tax and a tax on driving power. The tax on driving power is imposed on vehicles that are powered by some other force or fuel than motor petrol – which includes electric vehicles. The base-tax component of the vehicle tax is based on the CO_2 emission data provided by the car's manufacturer. If the car does not have emission data in the Vehicular and Driver Data Register or was produced before 2001, the tax is based on the total mass of the vehicle.

Tax for vehicles whose sole driving power is electricity is determined according to an emission level of 0 g/km.

The new rates of annual vehicle tax have already been approved and are to come into force on 1 January 2016. In accordance with the new regulations, the base tax will be calculated as follows: for each g of CO_2/km the tax will amount to an additional 0,01 euro/day, but it cannot be lower than 0,191 euro. Therefore, for electric vehicles classified as emitting 0 g of CO_2/km, the base tax will be equal to 0.191 euro/day, which multiplied by 365 days makes 69,71 euro/year.

The new proposal on registration tax for the 2015–2019 period has not been accepted yet. In accordance with the new provisions, the registration tax will gradually decrease year by year. In consecutive years the registration tax for cars emitting 0 g of CO_2/km – therefore also EVs – will amount to, respectively, 5.0%/4.4.%/3.8%/3.3%/2.7%. Therefore, within five years the registration tax for EVs will be reduced by 46%, which is a significant decrease.

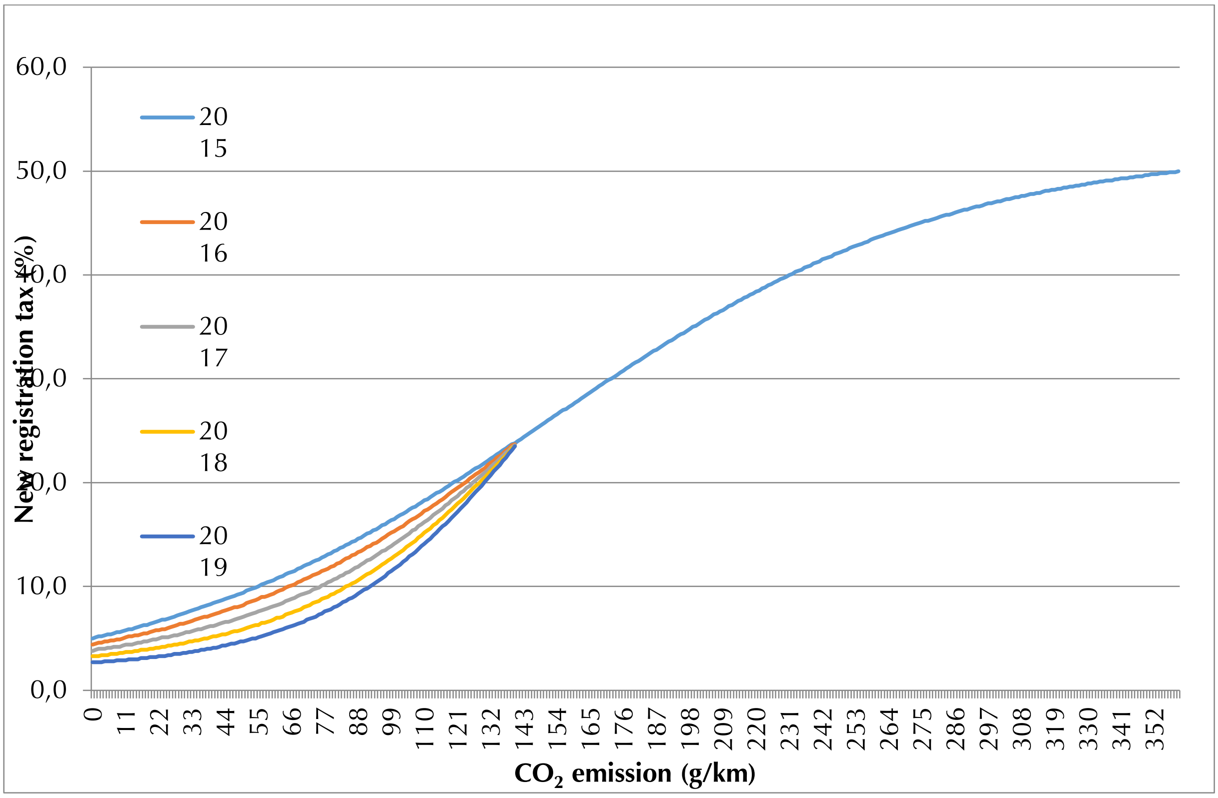


Figure 27. The expected evolution of registration in Finland in the years 2015–2019 [source: Tuomo Suvanto, Finnish Ministry of Transport and Communications].

The current philosophy behind the taxation is that the progressive tax on emissions will actively guide choices towards low-emission vehicles. However, other, non-financial incentives for e-mobility are to a huge extent lacking and this is the challenge that should be tackled by the current Finnish administration.

Sweden

The electricity system in Sweden is very well established – a large-scale introduction of EVs will not have a significant impact on electricity networks. The Swedish grids are dimensioned for cold winter days, when the electricity demand from industry and households peaks. Approximately 65% of the Swedish population has easy access to electrical outlets at home or at work, through engine block heaters, and these can be used to plug in a car.

These factors influence the continued support from the public administration for the e-mobility development in this country. This support is likely to be continued and further developed, although no firm decisions resulting from the requirements of Directive 2014/94/EU on the deployment of an alternative fuel infrastructure have been made yet.

The hitherto binding taxation rules are as follows:

- the annual circulation tax for cars meeting at least Euro 4 exhaust emission standards is based on CO_2 emissions. The tax consists of a basic rate (360 Swedish kroner) plus SEK 20 for each gram of CO_2 emitted above 120 g/km. This sum is multiplied by 2.55 for diesel cars. Diesel cars registered for the first time in 2008 or later pay an additional SEK 250 and those registered earlier an additional SEK 500. For alternative fuel vehicles, the tax is SEK 10 for every gram emitted above 120 g/km.

- a five-year exemption from the annual circulation tax applies for "environmentally friendly cars":
  - ✓ Petrol/diesel/hybrid cars with CO_2 emissions up to 120 g/km,
  - ✓ Alternative fuel/flexible fuel cars with a maximum consumption of 9.2 l (petrol)/8.4 l (diesel)/9.7 dm^3/100 km (CNG, biogas),
  - ✓ Electric cars with a maximum consumption of 37 kWh/100 km.

The most important factor is support for e-mobility measures delivered by the Swedish Energy Authority. This institution undertook coordination of the pilot project on national Swedish procurement of EVs and PHEVs (plug-in hybrid electric vehicles) by both public and private institutions, including:

- test fleet of 50 EVs,
- coordinated procurement process,
- funding for 1,000 EVs/PHEVs.

The total budget amounted to 248 million SEK. Support from the Swedish Energy Authority equalled 25% of the budget, which is 62 million SEK (out of which 55 million SEK was dedicated to funding for vehicles).

The results of the pilot project were satisfactory for EV users, which should contribute to further popularisation of e-mobility in Sweden. Surveys conducted among EV drivers in the period 2011–2014 demonstrate that:

- 85% recommend others to drive an EV,
- 78% are more positive after driving an EV than they were before they first got the vehicle,
- 33% would like to drive an EV as a private car,
- 87% are very satisfied with the charging,
- The number of drivers with anxiety about range, experiencing the shorter range to be a problem, has decreased.

However, the situation regarding further e-mobility development in Sweden is not unequivocally optimistic in terms of the mid-term future. Electric cars face significant competition from vehicles propelled by biofuels, which are well established in the Swedish market. This is one of the reasons why Sweden – despite being overall an innovative, progressive and environmentally friendly country – still does not have a clear technological preference in terms of the goals of its transportation policy. Since the 1970s Sweden has been at the forefront of developing alternative fuel technology for personal vehicles, which in practice has favoured the adoption of biogas and ethanol flexi-fuel vehicles (among others, due to the policy framework that required fuel providers to make renewable alternatives available at petrol stations). Nowadays, the government does not show similar support for e-mobility – while, for example, measures enforcing the construction of a charging infrastructure in selected areas would have a significant influence on the market.

Estonia

It should be remembered that Estonia is the most developed country in terms of e-mobility schemes and support among all the "new" member states of the European Union (see Chapter 3.4). It has developed a nationwide programme in relation to the popularisation of e-mobility.

The Electric Mobility Programme was launched on the initiative of the Ministry of Economic Affairs and Communications. The aim of the programme was to introduce electric cars as environmentally friendly transport in Estonia using the funds of the Assigned Amount Units of the Kyoto Protocol trade system.

The programme was launched at the beginning of 2011 and was fully implemented by 2015. The programme includes three parts:

- The Ministry of Social Affairs was supposed to take into use 507 Mitsubishi i-MiEV electric cars as samples (they came to be used by social workers),
- The Ministry of Economic Affairs and Communications was to develop a grant scheme to support the acquisition of electric cars,
- A charging infrastructure for electric cars, covering the whole territory of Estonia, would be built.

Estonia has also obtained a network of quick charging points for electric cars – around 200 of them were planned countrywide. The chargers were installed along all primary and secondary roads at intervals of 40–60 kilometres and in all cities and settlements with at least 3,000 inhabitants.

In the framework of the electric car project, individuals and legal persons were eligible for up to €18,000 of support for the purchase, made possible by the national foundation KredEx. In addition, up to €1,000 of support was provided for charger purchases and related installation.

The ELMO network was officially opened in February 2015, consisting of 165 CHAdeMO standard quick chargers. The ELMO network turned out to be a huge success, rapidly increasing in popularity over the last two years. In February 2013, the network was used 1,000 times, while in January 2015 that number rose to 11,000 charges per month. The system has 1,100 regular customers, with an average loading time of 20 minutes for each customer.

The support scheme also became successful. In the 2011–2014 period KredEx allocated grants amounting in total to EUR 10.5 million; the average grant per car amounted to EUR 16,500. The grant for the purchase of electric cars helped to deliver more than 650 electric cars onto the Estonian roads.

While decisions on full-scale similar programmes for the coming years have not been made yet, Estonia remains committed to supporting the development of e-mobility. One example of this is the fact that on 1 May 2015, the new Act of Parliament amending the Traffic Act and the State Fees Act entered into force. This regulation permits electric vehicles with a fully electric traction drive to use bus-only lanes.

8. Proposal for support mechanisms for electric transport development

According to a deep and comprehensive analysis made by a group of scientists in Flanders, the most important factors that have to be influenced are the cost of purchase and exploitation costs of electric vehicles. The charging time, maximum speed and driving range are also very important and should be taken into account.

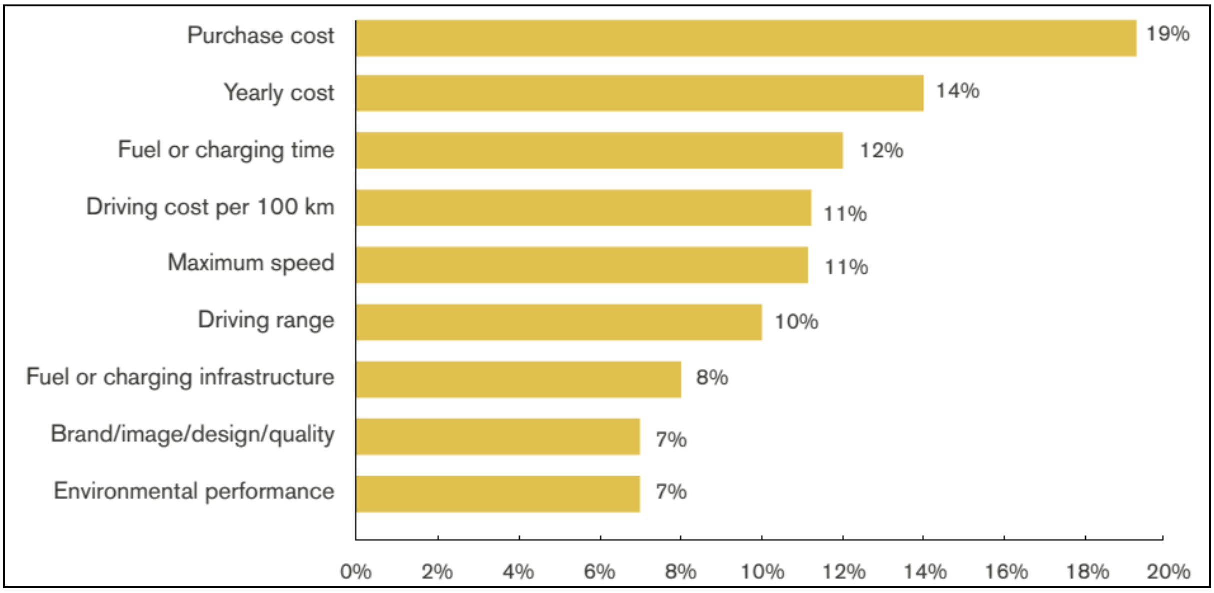


Figure 28. Importance of attributes in decision-making process of a new car [source: The market potential for plug-in hybrid and battery electric vehicles in Flanders: a choice-based conjoint analysis. Transportation Research Part D 17:592-597].

However, the example of Norway shows that sometimes there is a need for a long-lasting and combined mixture of measures to make a tipping point reality. The graph below (Figure 29) shows the most important support measures over the last 20 years in Norway and demonstrates how difficult it is to boost the real growth of electric vehicles.

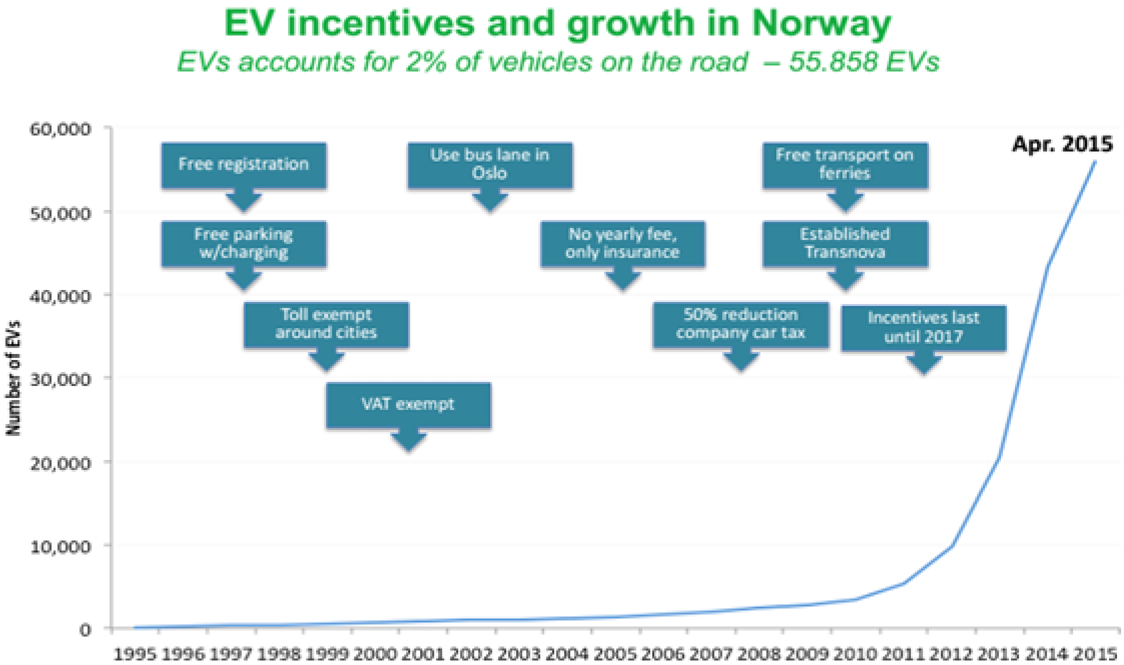


Figure 29. Norway initiatives to stimulate e-mobility development [EVs in Norway, Leif Naess, PhD, MBA Cluster Leader, Electric Mobility Norway].

As we can see, only the accumulation of financial incentives makes the development of the EV market a reality. Of course, it is important to remember that pure EVs were introduced to the market only in 2011. However, in Norway the market was developed by the Norwegian company Think Global, which brought some EV models to the Norwegian market, but mainly prototypes. But as is presented in the first graph, the purchase cost is essential for potential customers of EV retailers.

The financial incentives and EV adoption shown in Figure 30 display a positive and significant relationship. Even so, there is substantial variation among the data. In addition, there appears to be two groups of countries. The first is constituted by approximately the bottom half of our study sample (14 countries) as represented by nations with financial incentives of less than $2,000. They exhibited lower EV market shares with the exception of Sweden (0.30%) and Switzerland (0.23%), and to a lesser extent Germany (0.12%) and Canada (0.13%). Consequently, 10 countries showed little EV activity as measured by either financial incentives or EV adoption. The other group in Figure 30 is distinguished by the countries with higher levels of financial incentives and greater variation in their EV market shares. Some countries such as Norway and Estonia matched high financial incentives with increased EV adoption. However, this relationship was not uniform as other countries, including Denmark and Belgium, offered high financial incentives but had relatively low levels of adoption. Figure 29 suggests that there are factors other than financial incentives that influence EV adoption. For instance, consumers in Estonia bought 55 EVs in 2011, but the government decided to purchase approximately 500 i-MiEVs in 2012. That single purchase largely explains why it had such a high market share in 2012. Conversely, Norway installed an extensive charging infrastructure in 2009, and has experienced a more gradual increase in EV adoption rates since 2010, predominantly through household consumers. An additional factor that is not captured by the financial incentive variable is the subsidy's recipient. Through their purchase of a majority of EVs through 2012, fleet managers were identified as being very important early adopters. But Belgium's financial incentives were directed specifically toward households, so they may have largely missed engaging the fleet market, thereby hurting the country's adoption figures.[45]

[45] William Sierzchula, Sjoerd Bakker, Kees Maat, Bert van Wee, *The influence of financial incentives and other socio-economic factors on electric vehicle adoption*, Energy Policy 68 (2014) 183–194.

Financial incentives by country and corresponding EV market share for 2012

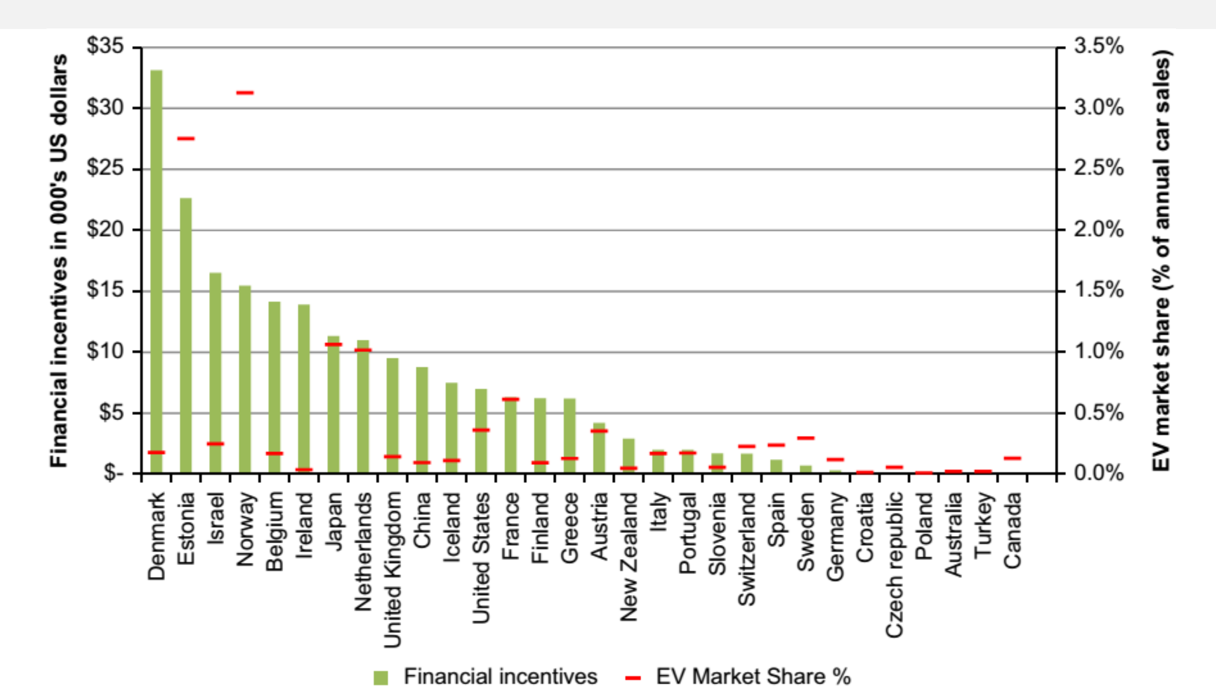


Figure 30. Financial incentives by country and corresponding EV market share for 2012 [source: The influence of financial incentives and other socio-economic factors on electric vehicle adoption, Energy Policy 68 (2014) 183–194].

Countries across the world, including some BASREC countries, have employed several different types of financial incentives based on a vehicle's tonnage, company car status, emissions and power train, which can be broadly categorised as either registration or circulation subsidies. Figure 30 identifies how countries approached financial incentives according to those policy categories. The most available EV financial incentives (78%) came in the form of registration as opposed to circulation subsidies. The difference between the two is that registration funds were offered the year that the EV was purchased while those based on a vehicle's annual circulation provided benefits over a multiple-year time span.[46]

[46] Ibidem.

Breakdown of financial subsidy types offered by countries

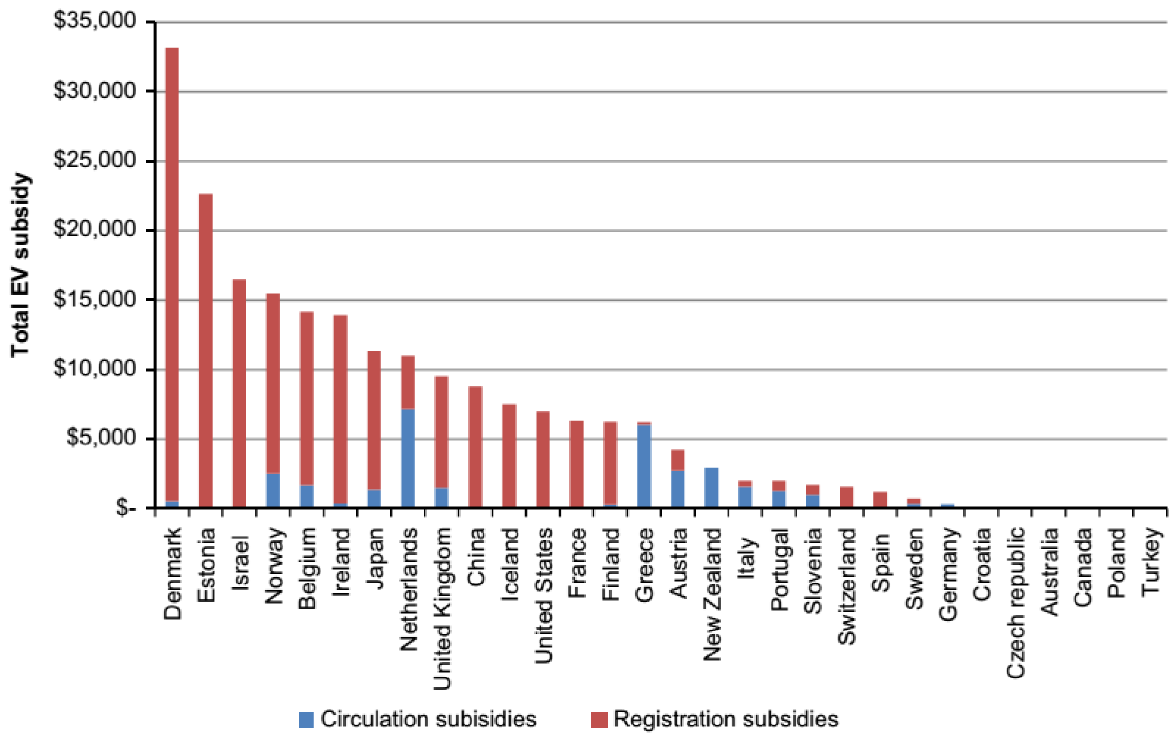


Figure 31. Breakdown of financial subsidy types offered by countries [source: The influence of financial incentives and other socio-economic factors on electric vehicle adoption, Energy Policy 68 (2014) 183–194].

Other factors that influenced the EV share in the car market were also analysed by W. Sierzchula, S. Bakker, K. Maat and B. van Wee, especially charging infrastructure availability and the number of EV models available.

National charging infrastructure by country and corresponding EV market share for 2012

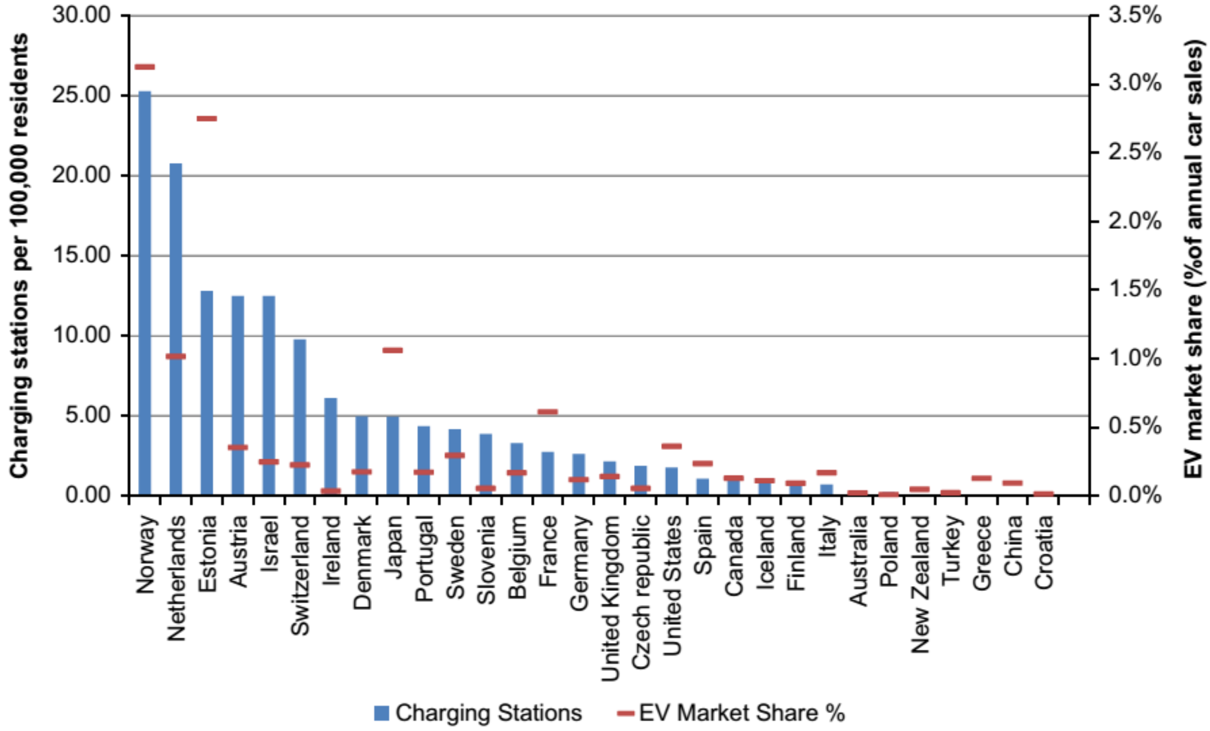


Figure 32. National charging infrastructure by country and corresponding EV market share for 2012 [source: The influence of financial incentives and other socio-economic factors on electric vehicle adoption, Energy Policy 68 (2014) 183–194].

Figure 32 proves the existence of a significant relationship between charging stations (adjusted for population) and EV adoption rates. Despite an overall positive correlation, there were examples of wide discrepancies in the data as evidenced by Estonia and Israel. Both countries had similar proportions of charging stations, but Estonia had an EV adoption level 11 times higher than that of Israel.[47]

[47] Ibidem.

Number of EV models available for purchase, production facilities and national market shares

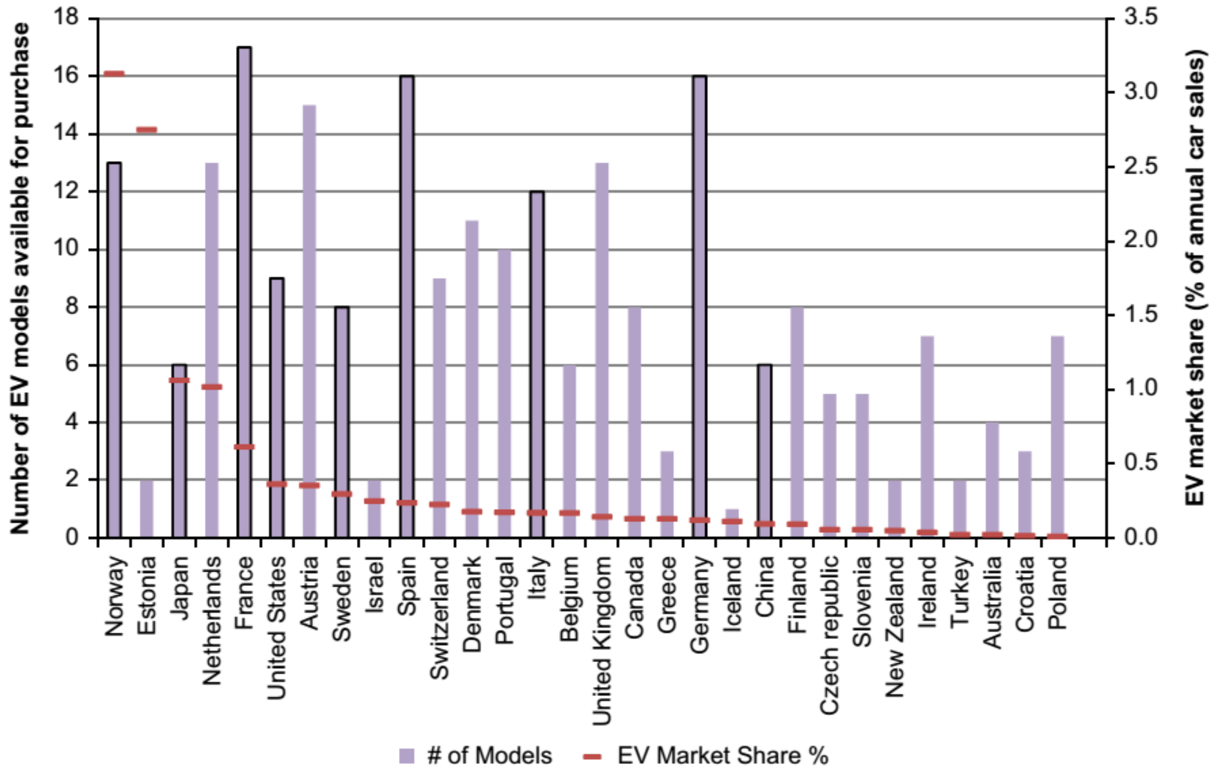


Figure 33. Number of EV models available for purchase, production facilities and national market shares [source: The influence of financial incentives and other socio-economic factors on electric vehicle adoption, Energy Policy 68 (2014) 183–194].

As identified in the correlation matrix, many of the EV-specific variables displayed strong correlations. In order to better understand how these factors interact, Figure 33 looks at three such variables: the number of models available for purchase; whether a country produced EVs locally (bolded columns); and adoption rates. In total, 45 different types of EV were purchased in 2012, although a small number of models such as the Nissan Leaf, Chevy Volt/Opel Ampera and Toyota Plug-in Prius accounted for the lion's share (62%) of those sales. The Mitsubishi i-MiEV was the most widely available, being adopted in 26 of the countries in our sample. There was a positive correlation between a country's EV adoption rate and the number of models that were available for purchase. Countries where native manufacturers heavily invested in EVs, e.g. Japan, France and the US, had some of the highest EV market shares. Other countries with EV production facilities but low adoption rates, including Germany and Italy, did not have EVs made by native manufacturers broadly available. This suggests a strong relationship between consumer adoption of EVs and their being manufactured by native firms. Several of the larger countries were much more prone to adopt native models, specifically China and Japan, where only EVs from native manufacturers were purchased.[48]

Based on the presented outcomes of the above-mentioned very comprehensive study, the main conclusion for governments is that they should provide subsidies for potential consumers of EVs and develop the number of charging stations. At this stage of the development of EVs, they should be treated as a radical innovation, and a strong financial incentive with the possibility of widening the deployment of charging infrastructure can only lead to higher market shares and a substantial growth in e-mobility.

[48] Ibidem.

9. Environmental effects of e-mobility development

The use of electric vehicles is preferable to traditional fuels for reasons such us:

- lower emissions,
- low cost of maintenance,
- less noise provoked by the engine,
- lower fuel consumption.

These aspects make electric vehicles ideal for urban areas, which usually face a lot of traffic.

The results obtained in numerous projects clearly show that electric vehicles can contribute to the overall CO_2 abatement strategy in the transport sector. An ICE car travelling around 50 km/day requires an average of 40 kWh/day compared to the 10 kWh/day for an electric vehicle.[49]

Share of renewables in electricity generation, 2014 (in %); Source: Eurostat (online data code: nrg_105a, nrg_105m)

The IEA's Monthly Electricity Statistics

Although electric vehicles locally have zero emissions, the electricity production required to power them has environmental impacts. The emissions of CO_2 depend on the electricity production process. Indeed the results depend on the percentage of electric energy produced by means of power plants using fossil fuels. The appropriate data are presented below in Table 35.

Table 35. Fuel type in the electric energy generation system and corresponding CO_2 emission factors [own elaboration based on Eurostat, Share of renewables in electricity generation, 2014, online data and the IEA's Monthly Electricity Statistics]

Source	Fuel	Average percentage of use in EU	CO_2 emission factor [kg/GJ]	CO_2 emission factor [kg/GWh]	Average [kg/GWh]
Thermal	Solid	59%	100	360,000	298
	Natural gas and other gases	37%	56	201,600	
	Petroleum	4%	76	273,600	
	Total thermal	100%	x	x	
Renewable	Hydro	45%	0	0	0
	Wind	27%	0	0	
	Solar	9.3%	0	0	
	Biofuels	18%	0	0	
	Geothermal	0.7%	0	0	

[49] MacKay, 2009.

	Total renewable	100%	x	x	

Indeed, given that a high percentage of electric energy is produced by means of power plants using fossil fuels as in Poland (90%), the impact of greenhouse gases has to be seen at a global level. The assumption is made that the structure of the electric energy generation from conventional fuels is the same for each country and is equal to the European average. In Table 35 the average share of fuel type use in EU countries and CO_2 emission factors for each type of fuel are presented.

The impact of greenhouse gases has to be seen at a global level, evaluating the actual reduction of the total CO_2 emitted. Table 36 illustrates the general picture of the "electric mix" in each BASREC country. It is clear, from the combined information from Table 35 and Table 36, that in the case of Poland, over 92% of electric energy derives from non-renewable energy sources. This leads to significant emissions of CO_2 into the atmosphere. Less, but still over 50% of electric energy, is generated from non-renewable sources in Denmark, Lithuania and Germany. Less than 50% of electric energy derives from non-renewable sources in Estonia and Finland. Two BASREC countries have a level of renewable energy production higher than 90% – Sweden and Norway.

Share of renewables in electricity generation, 2014

Table 36. Share of renewables in electricity generation, 2014 [%] [source: Eurostat, Share of renewables in electricity generation, 2014, online data]

Country	**Combustible**		**Nuclear**		**Hydro**		**Geot/Wind/ Solar/Other**		**Supplied 2014**
	GWh	%	GWh	%	GWh	%	GWh	%	GWh
Denmark	18 520	55.30%	0	0%	33	0.10%	14 937	44.60%	33 490
Germany	349 344	64.00%	86 790	15.90%	24 563	4.50%	85 153	15.60%	545 850
Estonia	3 328	39.80%	1 697	20.30%	1 313	15.70%	2 023	24.20%	8 361
Lithuania[50]	50 957	56.90%	0	0%	23 195	25.90%	38 598	17.20%	89 555
Poland	136 692	92.80%	0	0%	2 799	1.90%	7 807	5.30%	147 297
Finland	35 815	43.00%	28 902	34.70%	16 825	20.20%	1 749	2.10%	83 291
Sweden	12 149	9.00%	55 213	40.90%	57 237	42.40%	10 395	7.70%	134 994
Norway	2 775	2.20%	0	0%	121 095	96.00%	2 271	1.80%	126 141

The starting point of the evaluation is to estimate the electric energy required by the EV fleet to the grid at the 2030 time horizon. This energy has to be produced from a mix of production technologies, which in turn will produce a certain amount of emissions (see Table 35).

[50] The IEA's Monthly Electricity Statistics (Eurostat (online data code: nrg_105a, nrg_105m)).

Table 37. Electric vehicle energy consumption for the year 2030 – all scenarios [own elaboration]

Number of cars	E. energ. sup.	Year 2030		Yearly electric energy consumption					
COUNTRY				Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
3 310 905	79 072	Fleet Share (%)		0.48%	3.11%	4.97%	25%	30%	35%
Finland		EV power request	%	0.05%	0.32%	0.51%	2.58%	3.10%	3.61%
			GWh	39.54	253.82	405.64	2 039.27	2 447.28	2 855.29
1 907 167	10 466	Fleet Share (%)		0.22%	1.08%	1.75%	25%	30%	35%
Lithuania		EV power request	%	0.10%	0.49%	0.79%	11.22%	13.47%	15.71%
			GWh	10.36	50.76	82.26	1 174.70	1 409.67	1 644.52
22 181 051	161837	Fleet Share (%)		0.43%	1.25%	3.40%	25%	30%	35%
Poland		EV power request	%	0.15%	0.42%	1.15%	8.44%	10.13%	11.82%
			GWh	234.66	682.95	1 857.89	13 662.28	16 394.09	19 127.52
3 072 060	27 834	Fleet Share (%)		3.42%	14.09%	19.20%	25%	30%	35%
Denmark		EV power request	%	0.93%	3.83%	5.22%	6.80%	8.16%	9.52%
			GWh	258.86	1 066.32	1 453.21	1 892.16	2 270.70	2 648.96
702 048	8 331	Fleet Share (%)		1.51%	5.44%	7.36%	25%	30%	35%
Estonia		EV power request	%	0.31%	1.13%	1.53%	5.19%	6.23%	7.27%
			GWh	26.08	94.06	127.30	432.38	5 18.85	605.41
46 485 929	514 311	Fleet Share (%)		2.11%	8.84%	12.13%	25%	30%	35%
Germany		EV power request	%	0.47%	1.97%	2.70%	5.57%	6.68%	7.79%
			GWh	2 417.26	10 126.78	13 891.54	28 631.69	34 361.12	40 085.40
5 141 665	114 627	Fleet Share (%)		2.56%	10.79%	14.73%	25%	30%	35%
Sweden		EV power request	%	0.28%	1.19%	1.63%	2.76%	3.32%	3.87%
			GWh	324.39	1 366.35	1 866.13	3 167.14	3 799.89	4 433.77
2 792 241	111 159	Fleet Share (%)		8.59%	21.69%	28.03%	25%	30%	35%
Norway		EV power request	%	0.53%	1.34%	1.74%	1.55%	1.86%	2.17%
			GWh	591.37	1 491.75	1 928.61	1 719.63	2 064.22	2 407.70

In Table 37 it is shown that the share of electric energy derives from non-renewable sources, thereby causing significant emissions of CO_2 into the atmosphere. Assuming that the energy required by electric vehicles will be produced using the national energy mix and taking into consideration the emission factors reported also in Table 35, it is not difficult, using data from Table 37, to evaluate the total emissions (which are reported in Table 41) for the different scenarios. It is important to highlight that for the evaluation it has been hypothesised that in 2030, CO_2 emissions due to electric energy production will not change. In addition, an efficiency of 96% has been considered for the electric energy production system.

A similar approach has been used for the evaluation of the CO_2 emissions generated by the number of vehicles equal to the number of electric vehicles estimated for the year 2030 in the different scenarios.

In this case, however, due to the constant technological improvements, it is not realistic to think that in 2030 the vehicles' CO_2 emissions will have the same efficiency as today. For this reason three cases have been evaluated:

1) 2030 emission factors equal to those in 2005 (considering only EURO IV technology) as reported in Table 38,
2) 2030 emission factors reflecting the European 2012 objective to have **an average of 120 g CO_2/veh*km** in the passenger car fleet and a **50% emission reduction** for LDVs as reported in Table 39,
3) 2030 emission factors reflecting the European 2020 objective to have **an average of 95 g CO_2/veh*km** in the passenger car fleet and a **50% emission reduction** for LDVs as reported in Table 40.

It is important here to highlight that while the null hypothesis is quite pessimistic, those in points 1 and 2 are very optimistic since the European objectives refer to a standard driving cycle whose emission factors are lower than those derived when considering an urban real driving cycle.

Table 38. Average CO_2 emission factors for the present fleet – case 1) in urban conditions (g/veh*km)[51]

Passenger Cars			
	Fuel engine dimensions		
Type of fuel	<1.4	1.4–2.0	>2.0
Petrol	218	364	462
Diesel	247	247	247
Other fuel	222	222	222
Light duty vehicles (LDV)			
Petrol	518		
Diesel	337		

Table 39. Average CO_2 emission factors for the future – case 2) fleet of passenger cars in urban conditions (g/veh*km)[52]

Passenger Cars			
	Fuel engine dimensions		
Type of fuel	<1.4	1.4–2.0	>2.0
Petrol	65	120	150
Light duty vehicles (LDV)			
Petrol	259		
Diesel	169		

Table 40. Average CO_2 emission factors for the future – case 3) fleet of passenger cars in urban conditions (g/veh*km)

Passenger Cars	
	Fuel engine dimensions

[51] Emissions refer to EURO IV vehicle technologies.
[52] Emissions refer to the 2012 objective to have in Europe an average emission factor of 120 g/veh*km for passenger cars while for LDVs a very optimistic 50% emission reduction has been considered.

Type of fuel	<1.4	1.4–2.0	>2.0
Petrol	50	95	125
Light duty vehicles (LDV)			
Petrol	259		
Diesel	169		

Table 41. Estimate of CO_2 emissions due to electric vehicle energy demand [own elaboration]

FINLAND		EV level of CO_2 emission is 20 g/km					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		0.48%	3.11%	4.97%	25%	30%	35%
Electric vehicle consumption (GWh)		39.54	253.82	405.64	2 039.27	2 447.28	2 855.29
Gross electric energy required (GWh)		41.52	266.51	425.92	2 141.23	2 569.64	2 998.05
Electric energy generation CO_2 emissions (kt)		5.32	34.15	54.58	274.38	329.27	384.17
Number of electric cars		15 892	102 969	164 552	827 726	993 272	1 158 817
Total distance covered by electric cars (10^6 Veh[a]km)		234	1 514	2 419	12 167	14 601	17 034
Number of electric LDVs		1 445	9 360	14 958	75 240	90 288	105 336
Total distance covered by electric LDVs (10^6 Veh[a]km)		32	205	328	1 648	1 977	2 307
Case 0	CO_2 EV (kt)	74	482	770	3 876	4 651	5 426
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	15	98	157	788	946	1 103
TOTAL		90	580	927	4 663	5 596	6 529
Case 1	CO_2 EV (kt)	27	173	276	1 388	1 665	1 943
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	8	49	78	394	473	552
TOTAL		34	222	354	1 782	2 138	2 494
Case 2	CO_2 EV (kt)	21	138	220	1 109	1 331	1 553

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	8	49	78	394	473	552
TOTAL		29	187	299	1 503	1 804	2 104
Overall CO_2 potentially saved (%)	case 0	94.06%	94.11%	94.11%	94.12%	94.12%	94.12%
	case 1	84.45%	84.59%	84.59%	84.60%	84.60%	84.60%
	case 2	81.57%	81.74%	81.74%	81.75%	81.75%	81.75%

LITHUANIA		**EV level of CO_2 emission is 26 g/km**					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		0.22%	1.08%	1.75%	25%	30%	35%
Electric vehicle consumption (GWh)		10.36	50.76	82.26	1 174.70	1 409.67	1 644.52
Gross electric energy required (GWh)		10.88	53.30	86.37	1 233.44	1 480.15	1 726.75
Electric energy generation CO_2 emissions (kt)		1.84	9.04	14.65	209.14	250.98	292.79
Number of electric cars		4 196	20 597	33 375	476 792	572 150	667 508
Total distance covered by electric cars (10^6 Veh^{a}km)		62	303	491	7 009	8 410	9 812
Number of electric LDVs		381	1 872	3 034	43 340	52 008	60 677
Total distance covered by electric LDVs (10^6 Veh^{a}km)		8	41	66	949	1 139	1 329
Case 0	CO_2 EV (kt)	20	96	156	2 232	2 679	3 125
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	4	20	32	454	545	635
TOTAL		24	116	188	2 686	3 224	3 761
Case 1	CO_2 EV (kt)	7	35	56	799	959	1 119
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	2	10	16	227	272	318
TOTAL		9	44	72	1 026	1 232	1 437
Case 2	CO_2 EV (kt)	6	28	45	639	767	894

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	2	10	16	227	272	318
TOTAL		8	37	61	866	1 039	1 212
Overall CO_2 potentially saved (%)	case 0	92.20%	92.21%	92.21%	92.21%	92.21%	92.21%
	case 1	79.58%	79.62%	79.61%	79.62%	79.62%	79.62%
	case 2	75.79%	75.84%	75.84%	75.85%	75.85%	75.85%
POLAND		**EV level of CO_2 emission is 43 g/km**					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		0.43%	1.25%	3.40%	25%	30%	35%
Electric vehicle consumption (GWh)		234.66	682.95	1 857.89	13 662.28	16 394.09	19 127.52
Gross electric energy required (GWh)		246.39	717.10	1 950.78	14 345.39	17 213.79	20 083.90
Electric energy generation CO_2 emissions (kt)		68.14	198.31	539.48	3 967.13	4 760.37	5 554.08
Number of electric cars		95 379	277 263	754 156	5 545 263	6 654 315	7 763 368
Total distance covered by electric cars (10^6 Veh^{a}km)		1 402	4 076	11 086	81 514	97 816	114 119
Number of electric LDVs		8 670	25 203	68 553	504 064	604 877	705 690
Total distance covered by electric LDVs (10^6 Veh^{a}km)		190	552	1 501	11 039	13 247	15 455
Case 0	CO_2 EV (kt)	447	1 298	3 531	25 964	31 156	36 349
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	91	264	718	5 279	6 334	7 390
TOTAL		537	1 562	4 249	31 242	37 491	43 739
Case 1	CO_2 EV (kt)	160	465	1 264	9 296	11 155	13 014
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	45	132	359	2 641	3 169	3 697
TOTAL		205	597	1 623	11 936	14 324	16 711
Case 2	CO_2 EV (kt)	128	371	1 010	7 430	8 916	10 402

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	45	132	359	2 641	3 169	3 697
TOTAL		173	504	1 370	10 071	12 085	14 099
Overall CO_2 potentially saved (%)	case 0	87.32%	87.31%	87.30%	87.30%	87.30%	87.30%
	case 1	66.81%	66.77%	66.77%	66.76%	66.77%	66.76%
	case 2	60.66%	60.62%	60.61%	60.61%	60.61%	60.61%

DENMARK		**EV level of CO_2 emission is 26 g/km**					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		3.42%	14.09%	19.20%	25%	30%	35%
Electric vehicle consumption (GWh)		258.86	1 066.32	1 453.21	1 892.16	2 270.70	2 648.96
Gross electric energy required (GWh)		271.80	1 119.64	1 525.87	1 986.77	2 384.24	2 781.41
Electric energy generation CO_2 emissions (kt)		44.79	184.51	251.45	327.41	392.91	458.36
Number of electric cars		105 064	432 853	589 836	768 015	921 618	1 075 221
Total distance covered by electric cars (10^6 Veh[a]km)		1 544	6 363	8 670	11 290	13 548	15 805
Number of electric LDVs		9 550	39 346	53 616	69 813	83 775	97 738
Total distance covered by electric LDVs (10^6 Veh[a]km)		209	862	1 174	1 529	1 835	2 140
Case 0	CO_2 EV (kt)	492	2 027	2 762	3 596	4 315	5 034
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	100	412	561	731	877	1 024
TOTAL		592	2 439	3 323	4 327	5 192	6 058
Case 1	CO_2 EV (kt)	176	726	989	1 287	1 545	1 802
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	50	206	281	366	439	512
TOTAL		226	932	1 270	1 653	1 984	2 314
Case 2	CO_2 EV (kt)	141	580	790	1 029	1 235	1 441

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	50	206	281	366	439	512
TOTAL		191	786	1 071	1 395	1 674	1 953
Overall CO_2 potentially saved (%)	case 0	92.43%	92.43%	92.43%	92.43%	92.43%	92.43%
	case 1	80.19%	80.20%	80.19%	80.20%	80.19%	80.20%
	case 2	76.52%	76.53%	76.53%	76.53%	76.52%	76.53%
ESTONIA		**EV level of CO_2 emission is 18 g/km**					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		1.51%	5.44%	7.36%	25%	30%	35%
Electric vehicle consumption (GWh)		26.08	94.06	127.30	432.38	518.85	605.41
Gross electric energy required (GWh)		27.38	98.76	133.67	454.00	544.79	635.68
Electric energy generation CO_2 emissions (kt)		3.25	11.71	15.85	53.85	64.62	75.39
Number of electric cars		10 601	38 191	51 671	175 512	210 614	245 717
Total distance covered by electric cars (10^6 Veh^{a}km)		156	561	760	2 580	3 096	3 612
Number of electric LDVs		964	3 472	4 697	15 954	19 145	22 336
Total distance covered by electric LDVs (10^6 Veh^{a}km)		21	76	103	349	419	489
Case 0	CO_2 EV (kt)	50	179	242	822	986	1 150
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	10	36	49	167	200	234
TOTAL		60	215	291	989	1 187	1 384
Case 1	CO_2 EV (kt)	18	64	87	294	353	412
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	5	18	25	84	100	117
TOTAL		23	82	111	378	453	529
Case 2	CO_2 EV (kt)	14	51	69	235	282	329

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	5	18	25	84	100	117
TOTAL		19	69	94	319	382	446
Overall CO_2 potentially saved (%)	case 0	94.56%	94.56%	94.55%	94.55%	94.55%	94.55%
	case 1	85.77%	85.75%	85.75%	85.75%	85.75%	85.75%
	case 2	83.13%	83.11%	83.11%	83.11%	83.11%	83.10%
GERMANY		**EV level of CO_2 emission is 30 g/km**					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		2.11%	8.84%	12.13%	25%	30%	35%
Electric vehicle consumption (GWh)		2 417.26	10 126.78	13 891.54	28 631.69	34 361.12	40 085.40
Gross electric energy required (GWh)		2 538.12	10 633.12	14 586.12	30 063.27	36 079.18	42 089.67
Electric energy generation CO_2 emissions (kt)		484.07	2 027.95	2 781.86	5 733.67	6 881.02	8 027.34
Number of electric cars		980 853	4 109 356	5 638 743	11 621 482	13 945 779	16 270 075
Total distance covered by electric cars (10^6 Veh^{a}km)		14 418	60 406	82 888	170 832	204 999	239 165
Number of electric LDVs		89 160	373 540	512 562	1 056 393	1 267 671	1 478 950
Total distance covered by electric LDVs (10^6 Veh*km)		1 953	8 181	11 225	23 135	27 762	32 389
Case 0	CO_2 EV (kt)	4 592	19 240	26 401	54 413	65 296	76 178
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	934	3 912	5 368	11 063	13 275	15 488
TOTAL		5 526	23 152	31 769	65 476	78 571	91 666
Case 1	CO_2 EV (kt)	1 644	6 889	9 453	19 482	23 378	27 274
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	467	1 957	2 685	5 534	6 641	7 747
TOTAL		2 111	8 846	12 138	25 016	30 019	35 022
Case 2	CO_2 EV (kt)	1 314	5 506	7 555	15 571	18 686	21 800

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	467	1 957	2 685	5 534	6 641	7 747
TOTAL		1 781	7 463	10 240	21 105	25 326	29 547
Overall CO_2 potentially saved (%)	case 0	91.24%	91.24%	91.24%	91.24%	91.24%	91.24%
	case 1	77.07%	77.07%	77.08%	77.08%	77.08%	77.08%
	case 2	72.82%	72.83%	72.83%	72.83%	72.83%	72.83%
SWEDEN		**EV level of CO_2 emission is 4 g/km**					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		2.56%	10.79%	14.73%	25%	30%	35%
Electric vehicle consumption (GWh)		324.39	1 366.35	1 866.13	3 167.14	3 799.89	4 433.77
Gross electric energy required (GWh)		340.61	1 434.67	1 959.44	3 325.50	3 989.88	4 655.46
Electric energy generation CO_2 emissions (kt)		9.14	38.48	52.55	89.19	107.01	124.86
Number of electric cars		131 627	554 786	757 367	1 285 416	1 542 500	1 799 583
Total distance covered by electric cars (10^6 Veh^{a}km)		1 935	8 155	11 133	18 895	22 674	26 453
Number of electric LDVs		11 965	50 430	68 845	116 844	140 213	163 582
Total distance covered by electric LDVs (10^6 Veh^{a}km)		262	1 104	1 508	2 559	3 071	3 582
Case 0	CO_2 EV (kt)	616	2 598	3 546	6 018	7 222	8 426
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	125	528	721	1 224	1 468	1 713
TOTAL		742	3 126	4 267	7 242	8 690	10 139
Case 1	CO_2 EV (kt)	221	930	1 270	2 155	2 586	3 017
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	63	264	361	612	735	857
TOTAL		283	1 194	1 630	2 767	3 320	3 874
Case 2	CO_2 EV (kt)	176	743	1 015	1 722	2 067	2 411

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	63	264	361	612	735	857
TOTAL		239	1 008	1 375	2 334	2 801	3 268
Overall CO_2 potentially saved (%)	case 0	98.77%	98.77%	98.77%	98.77%	98.77%	98.77%
	case 1	96.78%	96.78%	96.78%	96.78%	96.78%	96.78%
	case 2	96.18%	96.18%	96.18%	96.18%	96.18%	96.18%
NORWAY		**EV level of CO_2 emission is 1 g/km**					
Year 2030		Scenario 1	Scenario 2	Scenario 3	Under assumption	Under assumption	Under assumption
Fleet share (%)		8.59%	21.69%	28.03%	25%	30%	35%
Electric vehicle consumption (GWh)		591.37	1 491.75	1 928.61	1 719.63	2 064.22	2 407.70
Gross electric energy required (GWh)		620.94	1 566.34	2 025.04	1 805.61	2 167.43	2 528.09
Electric energy generation CO_2 emissions (kt)		4.07	10.27	13.28	11.84	14.21	16.57
Number of electric cars		239 854	605 637	782 665	698 060	837 672	977 284
Total distance covered by electric cars (10^6 Veh^{a}km)		3 526	8 903	11 505	10 261	12 314	14 366
Number of electric LDVs		21 803	55 052	71 144	63 454	76 144	88 835
Total distance covered by electric LDVs (10^6 Veh^{a}km)		477	1 206	1 558	1 390	1 668	1 945
Case 0	CO_2 EV (kt)	1 123	2 836	3 665	3 268	3 922	4 576
CO_2 potentially emitted EURO IV technology	CO_2 LDV (kt)	228	577	745	664	797	930
TOTAL		1 351	3 412	4 410	3 933	4 719	5 506
Case 1	CO_2 EV (kt)	402	1 015	1 312	1 170	1 404	1 638
CO_2 potentially emitted European 2012 objective	CO_2 LDV (kt)	114	288	373	332	399	465
TOTAL		516	1 304	1 685	1 503	1 803	2 104
Case 2	CO_2 EV (kt)	321	811	1 049	935	1 122	1 309

CO_2 potentially emitted European 2020 objective	CO_2 LDV (kt)	114	288	373	332	399	465
TOTAL		436	1 100	1 421	1 268	1 521	1 775
Overall CO_2 potentially saved (%)	case 0	99.70%	99.70%	99.70%	99.70%	99.70%	99.70%
	case 1	99.21%	99.21%	99.21%	99.21%	99.21%	99.21%
	case 2	99.07%	99.07%	99.07%	99.07%	99.07%	99.07%

As expected, the results reported in Table 41 clearly show that even in the most optimistic case, the emissions due to ICE vehicles are much higher than those from electrical power generation. In particular, the abatement of CO_2 emissions ranges from the highest of 99.7% (Norway) in scenario case 1) to the lowest of 60.7% (Poland) with the most optimistic scenario for ICE vehicles in case 3).

Furthermore, the presented model allows us to estimate the average vehicle emissions value under which the introduction of electric vehicles would not lead to any emission abatement. With regard to CO_2, the highest value of 43 g CO_2/km (for Poland) and the lowest of 1 g CO_2/km (for Norway) have been estimated. It is worth highlighting that this result strengthens what is claimed here, namely the potential impact on emissions of introducing electric vehicles instead of funding further the development of engines that are only apparently “clean”.

The reduction of CO_2 depends upon the electric vehicle penetration in the vehicle fleet, and thus on the particular scenario considered. It is interesting to calculate the level of the EV share in the car fleet to reach a 20% of global CO_2 emission reduction in the group of passenger cars.

The results are shown in Table 42.

Table 42. Estimate of the share of EVs needed to reach 20% of CO_2 reduction

COUNTRY	case 0	case 1	case 2
FINLAND	21.26%	23.68%	24.52%
LITHUANIA	21.69%	25.13%	26.39%
POLAND	22.90%	29.94%	32.97%
DENMARK	21.64%	24.94%	26.14%
ESTONIA	21.15%	23.32%	24.06%
GERMANY	21.92%	25.95%	27.46%
SWEDEN	20.25%	20.67%	20.79%
NORWAY	20.06%	20.16%	20.19%

In order to reach a 20% of global CO_2 emissions reduction, in 2030 electric vehicles should represent an approximate share of 30% of the entire fleet of passenger cars and light duty vehicles in Poland, 25% in Finland, Lithuania, Denmark, Estonia and Germany, and 21% in Sweden and Norway only.

Although this could seem quite difficult to achieve, this target may represent a practical objective for policymakers. Indeed, bearing in mind that road traffic accounts for 15–20 % of the total CO_2 emissions, the possible benefits of pushing towards this technology will have a considerable impact at a global level. At least this is, probably, much more effective and faster than persevering to improve the efficiency of internal combustion engines.

10. Summary and conclusions

The main point of this study was to develop the analysis of the development of electric transport and how does it affect security of electrical energy system and forecasting energy demand in eight BASREC countries which were: Norway, Denmark, Germany, Sweden, Finland, Estonia, Lithuania and Poland.

In October 2014 the Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on **the deployment of alternative fuels infrastructure** has been published. Nowadays the transportation sector is highly depended on oil and influences badly the environment. It is necessary to switch into alternative fuels step by step. However in the broader view it is important to keep in mind that other types of alternative fuels like hydrogen or biofuels will also play an important role in the future with regards to decarbonisation of transportation sector.

As far as the scope of this study is concerned passengers electric cars and buses were taken into account. In terms of electric cars three types of vehicles were analyzed:

- **Pure Electric Vehicle** = vehicle powered solely by a battery charged from the electricity system. Currently, typical pure-electric cars have a range of approximately 100-150 km. In the study they occur under an abbreviation - EV,
- **Extended-Range Electric Vehicles** + **Plug-In Hybrid Electric Vehicles**. Regarding to the first type it has a plug-in battery pack and electric motor, as well as an internal combustion engine. The other one is a hybrid electric vehicle that uses rechargeable batteries that can be recharged by connecting a plug to an external electric power source (usually an electric wall socket). However, because of the slightly difference between these two types of electric vehicles in terms of functionalities for users, they were merged into one group and abbreviated by PHEV.

The buses were considered in the analysis as pure electric vehicles.

The important part of the study was dedicated to prognosis of e-mobility development in terms of the forecasted numbers of cars and buses which influence the charging infrastructure development.

The situation of e-mobility development in the analyzed BASREC countries is different, especially with regards to car segment. The leader in BASREC region and worldwide – Norway – has exceeded 50 000 threshold of new registered cars in late April 2015. For example in March 2015, nearly 25 per cent of all cars sold in Norway were electric. The example of Norway shows that there is a need for long-lasting and combined mixture of stimulating measures to reach a critical mass. The most important support measures over the last 20 years in Norway shows how difficult it is to boost number of electric vehicles.

There are several benefits thanks to the development of electric transport. Regarding to the environment these are:

- clean air,
- reduced noise,
- less CO_2 emission.

The CO_2 reduction highly depends on the energy mix of every country so it differs a lot within the countries covered by the analysis.

On the other side there is a group of countries that are at the very beginning of electric vehicles development (Finland, Lithuania, Poland). However, even in a country like Poland where incentives for electric vehicles are very limited and there is no any governmental policy in this area, some growth of electric cars can be observed. In 2013 there were about 1 900 new registration of all electric cars. In 2014 it was almost 4 000.

The examples of Norway and Poland show two different paths for electric vehicles development. The first one, Norway, with a broad scope of public incentives and very expensive in terms of public sources. The other one, Poland, with very autonomous bottom-up growth based on users' demand. Both paths have their pros and cons and each government has to decide, taking into consideration all of the costs and benefits, which way is the most convenient for it.

The future energy demand is associated with number of electric vehicles on the market. Two different types of effect of electric transport on the grid were analyzed: electric vehicles demand to grid and electric power required by the electric vehicles fleet to the grid. The results obtained show that even with a very high future market penetration the impact of the vehicles on the annual energy consumption will be quite ineligible (the share of this requirement in the yearly energy consumption is higher than 1% in two countries, in Denmark at the level of 2,75% and in Germany 1,4%. In all others countries the level is below 1%).

On the contrary they also show that without an appropriate regulation (e.g. the intelligent integration of electric vehicles into the existing power grid as decentralized and flexible energy storage), they could heavily impact on the daily electric power request. Actually this is most evident when considering the scenarios with the highest future electric vehicles market share (20–25%) in 2030. The maximum electric power demand show examples of situations that can be dangerous for the safety of the grid. Denmark with an additional request to the grid at a level of over 25% and Germany with a level over 11%. Indicators for all others countries are between 2,2% and 7,5%. In addition, in countries with a lower level of energy consumption per capita (Lithuania, Poland), when the number of EV cars exceeds 25%, the percentage of electric power demand increases significantly (Lithuania 48%; Poland 36%). It is necessary to adopt strategies in order to avoid the potential damages created to the grid capacity. In particular, creating an “intelligent” grid, able to decide “when” to provide power to batteries, would be very fruitful in order to shift the power request to hours in which this is lower, avoiding all of the possible problems of network overloading. The shift of power request can solved the grid problem because, as it is shown in Table 43, in each country, the reserve of electric energy in the grid is higher than EVs demand, and daily demand of electric vehicle is lower than capacity of EV storage of energy.

On the other hand, the study also tries to evaluate the potential benefits in terms of global CO_2 emissions reduction deriving from the introduction of electric vehicles. The results show that the possible outcome might be very positive.

In order to reach the goals under the Directive on the deployment of alternative fuels infrastructure each EU member should establish a national policy framework (NPF) on the development of electric vehicles market. While realizing the obligations under the Directive each country will at the same time contribute to reaching a goal of 20% reduction of energy consumption and greenhouse gases emissions by 2020.

The Directive requires Member States to adopt the national policy frameworks. The first step of the work is to design and formulate the NPF should focus on acceptance of national targets. The results of analysis in these points are as follow: Denmark: achieve 200 000 EVs on the road for 2020 and phasing out fossil fuels completely by 2050; Finland: biofuels will replace 12.5 % of the fossil fuels and 7% of vehicle fleet renewal per year in 2020; Germany**:** until 2020 at least one million e-cars will be in use in Germany; Lithuania: until year 2025 10% all new vehicles registered in Lithuania should be electric; Norway: 200 000 electric vehicles on the road in 2020; Sweden: the country's vehicle fleet free of fossil fuel use by 2030. National targets for Estonia and Poland are not determined and accepted yet.

Several pilot projects should be conducted to accelerate and take a profit from the future e-mobility development:

- **models of cooperation between vehicle owners, DSOs and energy retailers -** pilot projects giving answers to know how the market responds to different market models and support systems. This model should include possible technologies to integrate EVs into the grid, such as G2V and V2G,
- **TCO (T**otal **C**ost of **O**wnership) implementation for the electric buses fleet development,
- appropriate R&D (research and development) projects on the subject of EV integration into smart grids are recommended,
- concept of e-mobility market model until it reaches 'critical mass' tipping point.

Appendix 1

The main features of fully electric vehicles (cars and light duty vehicles) already present in the market or expected to be commercialised in the near future (energy consumption is not well to wheel).

Technical information has been retrieved from different official and non-official sources. Official sources have been reported in the references (Alke, 2009, Atea, 2009a,b, Piaggio CH, 2009, Coda, 2009, Italia speed, 2009, LDV, 2009, Lighting, 2009, Miles, 2009, Mini, 2009, Mitsubishi, 2009, Nice, 2009, Phoenix, 2009, Tesla, 2009.).

Brand	Model	Capacity (kWh)	Range (km)	Consumption (kWh/100 km)	Classification
Cars					
Audi	e-Tron EV	42.40	248	17.10	Large
BMW	MINI-E	35.00	180	19.44	Large
BYD Auto	BYDe6	72.00	400	18.00	Large
Chery Automobile	S18 EV	15.00	135	11.11	Small
Chrysler Dodge	CircuitEV	26.00	175	14.86	Large
CODA	Sedan-EV	33.80	180	18.78	Large
Daimler	SmartED	14.00	125	11.20	Small
Detroit	e63	25.00	180	13.89	Mid-Size
Fiat	Panda	19.68	120	16.40	Mid-Size
FIAT	500	22.00	113	19.53	Mid-Size
Ford	Focus Ev	23.00	160	14.38	Mid-Size
Ford	Transit Connect	24.00	160	15.00	Mid-Size
Heuliez	WILLEV	18.00	300	6.00	Small
Hyundai	i10Ev	16.00	140	11.43	Small
Lighting	GTS	35.00	175	20.00	Large
LoremoEV	LoremoEv	10.00	150	6.67	Mid-Size
Lumeneo	SmeraEV	10.00	150	6.67	Small
Mercedes	SLSeDrive	48.00	160	30.00	Large
MILES	ZX40S/ZX40ST	10.00	105	9.56	Small
Mitsubishi	i-MiEV	20.00	160	12.50	Mid-Size
NICE	Micro-Vett	10.50	80	13.05	Small
Nissan	Leaf	24.00	160	15.00	Mid-Size
Peugeot	iOn	20.00	140	14.29	Small
Phoenix	SUV/SUT	35.00	209	16.73	Mid-Size
Pininfarina	Bluecar	30.00	250	12.00	Small
PSA	C1 Citroen	16.00	110	14.55	Small
Renault	Kangoo	15.00	160	9.38	Small
Renault	Zoe ZE	15.00	160	9.38	Small
Renault	Twingo QuickshiftE	21.45	129	16.60	Mid-Size
Renault	Fluence	30.00	160	18.75	Mid-Size

REVA	NXR	14.00	160	8.75	Small
REVA	NXG	25.00	200	12.50	Small
Rud.Perf.Roadstar	Spyder	16.00	125	12.80	Large
SUBARU	R1e	9.00	80	11.25	Small
SUBARU	Stella	9.00	80	11.25	Small
Tata Motors	Indica	25.00	200	12.50	Mid-Size
TESLA	Roadster/ModelS	55.00	300	18.33	Large
Think	City	28.50	180	15.83	Small
Toyota	FT-Ev	11.00	150	7.33	Small
Volkswagen	E-Up!	18.00	130	13.85	Small
Volvo	C30BEV	24.00	150	16.00	Mid-Size
Zenn	CityZENN	52.00	400	13.00	Mid-Size
LDVs					
AIK	_eATX	8.40	70	12.00	LDV
Piaggio	Porter	25.74	110	23.40	LDV
Melex	XTR	4.32	60	7.20	LDV
Modec	Delivery	50.00	100	50.00	LDV