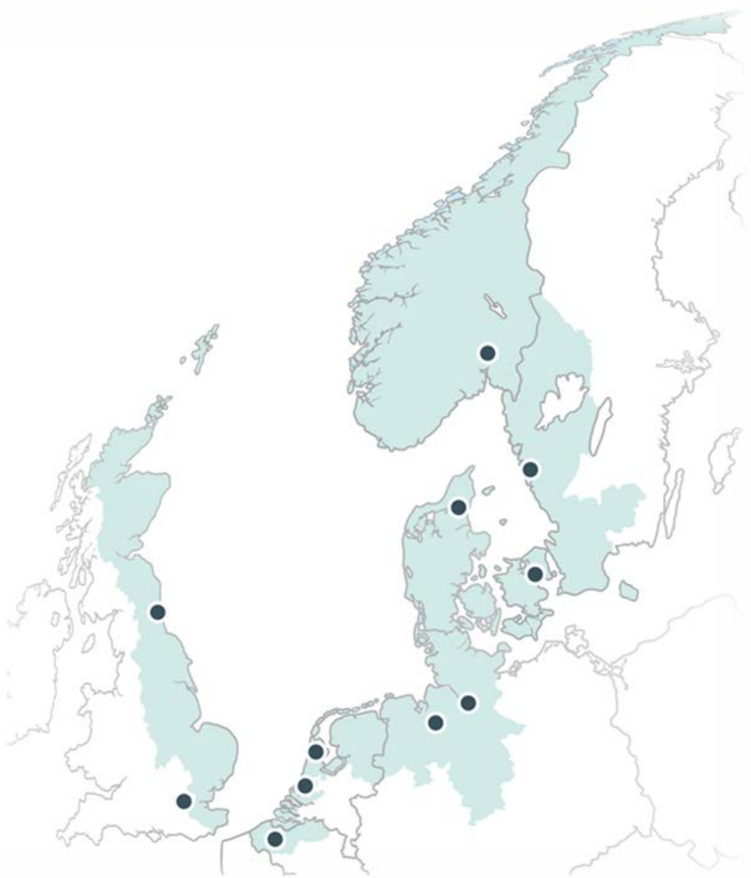
Transition to electric mobility: spatial aspects and multi-level policy-making

Sjoerd Bakker, Kees Maat, Jan Jacob Trip
Delft University of Technology
12 May 2014



Report written within the framework of Activity 3.7 'Transnational Learning'
of the Interreg IVB project E-Mobility NSR, file nr. 35-2-6-11

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region
European Union The European Regional Development Fund
TU Delft

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1 Introduction

1.1 E-Mobility NSR

At present, several cities and regions in Europe and the North Sea Region are developing strategies and action plans to bring forth electro mobility. To achieve this objective, a range of different incentives are currently being developed throughout Europe to seize the potential of electro mobility, especially in terms of local and regional traffic. However, to date many of these activities are neither well synchronized nor aligned with one another, so that realization is actually confined to only a few cities or regions. As a result, many opportunities for further development and growth of this future key mobility sector remain unexploited.

The EU-funded project North Sea Electric Mobility Network (E-Mobility NSR) will help to create favorable conditions to promote the common development of e-mobility in the North Sea Region. The project aims to increase accessibility by fostering the diffusion of e-mobility and stimulating the use of public and private electric car transport as well as freight across the North Sea Region (NSR). Transnational support structures in the shape of a network and virtual routes are envisaged as part of the project, striving towards improving accessibility and the wider use of e-mobility in the North Sea Region countries.

The North Sea Region Electric Mobility Network project is being undertaken in the framework of the Interreg IVB North Sea Region Programme. The project runs from October 2011 to September 2014.

Within the E-Mobility NSR project, various Work Packages deal with different aspects of the implementation of e-mobility. Specific project objectives are:

- to provide state of the art information which may help policy development in e-mobility in the NSR;
- to provide insight on gaps and needs in respect of infra-structure, logistics, and preliminary standards for multi charging techniques;
- to develop a NSR smart grid concept with charging points, hence increasing accessibility in the region;
- to provide a long-term basis upon which regional and local governments as well as other relevant stakeholders in the NSR may engage on e-mobility, among others by creating physical or virtual e-mobility information centres in each participating region or city;
- to integrate the urban freight logistics dimension into the e-mobility network promoting better accessibility and cleaner cities by stimulating the use of electric vehicles as a more efficient solution.

1.2 Overview of activities within Activity 3.7

Work Package 3 on 'Inventory of state of the art and stakeholder analysis' deals with the roles of various stakeholders and others involved in the implementation of electric mobility, including not only local and regional policy-makers but also , the energy sector, automotive industry and, last but not least, consumers.

Within WP3, Activity 3.7 specifically focuses on 'transnational' learning. It aims to stimulate discussion and the exchange of knowledge and experiences between the project partners, by organizing two expert meetings based on explorative discussion papers:

- 'Spatial aspects of the transition to electric vehicles', Haarlem, 9 October 2013. Hans Nijland from PBL Netherlands Environmental Assessment Agency in The Hague attended as an external expert. During the meeting the particiapiation of project partners was facilitated by the use of electronic voting devices.
- 'A systemic policy mix to support electric mobility development and adoption', London, 11 April 2014. This expert meeting was embedded in the final conference of the E-Mobility NSR project and was attended by a large number of participants from various fields of expertise. Various aspects of the theme were introduced by Dena Kasraian Moghaddam and Sjoerd Bakker from Delft University of Technology and Rogier van Schelven (Kwink Groep/NSOB).

These meetings focused on themes that emerged from the project, which were considered as relevant for partners and activities of the E-Mobility NSR project, but also as relatively new and unexplored. Starting point for both meetings was a discussion paper written by Delft University of Technology.

The application form of E-Mobility NSR mentiones two deliverables for Activity 3.7. First, the two expert meetings organized in Haarlem and London. Second, two discussion papers, to be bundled in one report. The current volume therefore presents the two discussion papers that preceeded the two meetings.

2 Spatial aspects of the transition to electric vehicles

First discussion paper written in the framework of WP3 Activity 7 of the NSR INTERREG IVB project E-Mobility NSR, file nr. 35-2-6-11. Expert meeting organized in Haarlem, 9 October 2013.

2.1 Introduction

The potential of electric vehicles (EVs) is dependent on a multitude of factors. During the stage of introduction and growth, financial incentives and the introduction of environmental and industrial standards play an important role (Sierzchula *et al.*, in process). In the maturity stage, more structural factors are important, in particular the physical and the built environment. The physical environment relates to the landscape, such as the natural landscape relief. The term built environment refers to the human-made surroundings that provide the setting for human activity, ranging from buildings to infrastructure and parks. The built environment is often expressed in terms of dwelling types, urban density, mix of uses, accessibility and street patterns.

Not much is known about the spatial influence on the large-scale transition to EVs. In this brief discussion paper, we investigate which spatial aspects are required, or at least preferred, for a large-scale transition to EVs. We identify a number of characteristics in which EVs, both full electric (FEV) and plug-in hybrids (PHEV), differ from cars with an internal combustion engine (ICE), and identify whether and how these are affected by the physical or urban environment. Next we compare these spatial aspects on the basis of collected data for the seven NSR countries. As comparable data between the countries is scarce, we selected comparable data for all countries over detailed data for only one or a few countries.

The primary aim of this paper is to provide input for the discussion meeting in Haarlem. It concludes therefore with a brief discussion on the outline and aim of this meeting, rather than with a clear-cut conclusion. Its status as a discussion paper also implies referencing is less dense compare to a typical academic journal paper.

Finally, it should be noted that this paper concentrates on the impact of the environment on the uptake and use of EVs. Inversely, EVs have effects on the environment, ranging from changes in the built up area to cleaner air, but those are not discussed in the context of this paper.

2.2 Types of EVs

Conventional cars for the most part run on petrol, diesel or LPG. Nevertheless, their basic technological characteristics are similar, and differences in range or performance are defined by for instance weight or engine size, rather than by fuel type. In contrast to this, the electric vehicle is still in an initial stage of development, in which various types of vehicles co-exists that are based on quite different technical lay-outs. Important question are for instance whether there is a conventional engine or a fuel cell on board, whether this directly drives the wheels or serves as a generator (range extender), and whether the batteries serve as the main energy storage, or are mainly auxiliary. Depending on the answers, EVs vary widely in relevant aspects such as range and performance, costs and recharging or refuelling systems. Accordingly, the relation between the built and natural environment and large-scale EV implementation partly depends on which type will become prevalent in the long term. The discussion in this paper mainly concerns FEVs and PHEVs, but also points at some differences between these two EV types with regard to e.g. fast charging.

2.3 Assumptions on spatial effects of EV-characteristics

In this section we discuss briefly the implications of the environment on electric vehicles, based on the EV's main characteristics, which are partly complexities. Compared to ICE cars, EVs

- are clean, at least from a tailpipe perspective;
- are expensive to purchase, for a large part due to the expensive batteries
- are cheaper to drive, due to low costs of electricity;
- have a limited range of 80 to 150 km effectively;
- have to be charged, which typically takes 6 to 8 hours;
- can be fast-charged in 20 to 45 minutes, which is more expensive and worse for the batteries.

Clean vehicles

Cities suffer from the local emissions of ICE cars. The denser cities are populated, the more intense car traffic generally is, and the more CO_2 and local pollutants such as NOx they emit. It is in particular the lack of local (tailpipe) emissions that makes EVs highly interesting for dense cities. Well-to-wheel emissions depend very much on how the electricity is generated and are not related to local circumstances.

Costs

The purchase costs of EVs are considerably higher than that of an ICE car (although subsidies and tax exemptions may, for the time being, partly compensate for this) and are not likely to drop significantly in the foreseeable future. This is partly due to new, complex technology, and in the case of PHEV a double power train. For a large part, however, the price of EVs defined by the batteries, which may easily cost 10,000 euros or more.

On the other hand, the costs of driving an EV are less than that of an ICE car, because electricity is less expensive then fossil fuel, especially when cheap hydroelectric energy is involved. Also, maintenance costs of EVs are assumed to be less than those of conventional cars.

Charging

Full electric cars have to be charged. The combination of quite a long charging time and quite a short driving range, will make that most households want to be sure that the car is fully charged every day. Furthermore, it can be assumed that this does not only count for full electric cars, but also for plug-in hybrids. To get the higher investment back, owners of a plug-in hybrid car have to charge electricity instead of driving fossil fuels. Hence, it is assumed that they tend to maximize the use of the all-electric range. Heffner *et al*. (2009) indeed found such as preference, but Axsen and Kurani (2009) did not. For now, we'll presume that FEV owners *need* to charge regularly, PHEV owners *prefer* to charge regularly. An exception, but also a malfunction of the system, are the employees who drive a hybrid company car, receive a free filling pas from the employer (but have to charge electricity at home paid by themselves) – they are less inclined to charge, or to worry about empty batteries.

As a consequence of the need to have the option to charge at any time, EV owners need, at any time, access to a parking lot with charging facilities close to their home. The preferred option is to charge at the own premises. The possibilities for this depend on the type of dwelling involved (basically detached or semidetached versus multi-dwelling buildings). The alternative is to charge at public charging points in the own street or neighbourhood. Because EV drivers require certainly they can charge every time they need to, but part of the charging locations are likely to be occupied by EVs not actually charging (anymore), an oversupply of public charging points is required.

Range
Most electric passenger cars have an effective range of 80 to 150 km, significantly less than their manufacturers claim. New and larger EVs, notably the Tesla S, have a larger range, but this is still less than that of a comparable ICE car. This induces several assumptions about the use of EVs. For one thing, it is likely that EVs are mostly bought as a second household car, alongside a more all-round ICE car. This is supported by data from e.g. Norway. This does not necessarily mean the second car is the least driven, for example when it is used for daily commuting.

Furthermore, the limited range means EVs are mostly associated with use in urban areas. Indeed most EVs of the first generation such as the E-Wizz and the Mitsubishi iMev typically are city cars, but this is no longer true for later models such as the large Tesla S. Still, it may be assumed that most EVs are used primarily in the daily urban system, the area in which most of people's activities take place.

2.4 Spatial key characteristics of the NSR

Table 1 presents the population, area and population density of NSR countries, compared to the EU as a whole. We see Germany and the UK with over 80 and 60 million inhabitants respectively, Belgium and the Netherlands with between 10 and 20 million inhabitants, and three Scandinavian countries with a population of less than 10 million. In terms of area, Germany, Norway, Sweden and the UK are largest, with the other three countries considerably smaller. Population density is the largest in the Netherlands and Belgium, while Norway and Sweden are relatively sparsely populated.
It should be noticed that this paper reports national figures, and does not take into account some regional differences. For example, only the northern part of Germany with the cities of Hamburg and Bremen belongs to the NSR, but the figures also cover the densely populated Ruhr area.

Although driving an EV is relatively cheap, its purchase costs are considerably higher than that of an ICE car (although subsidies and tax exemptions may partly compensate for this) and are not likely to drop significantly in the foreseeable future. Moreover, most EVs are bought as second cars. Income is likely to be a relevant factor, therefore, for the implementation of EVs. As Table 2 shows, net income per capita is by far the highest in Norway, even if compensated for the higher price level. Differences between the other NSR countries are relatively small. As a whole, the NSR scores about 20% above the EU average.

Table 1: Population, area and population density (2011).

	inhabitants	*area in km²*	*inh./km²*
Belgium	11,000,638	30,528	360.3
Denmark	5,560,628	43,098	129.0
Germany	81,751,602	357,124	228.9
Netherlands	16,655,799	41,543	400.9
Norway	4,920,305	323,787	15.2
Sweden	9,415,570	441,369	21.3
UK	62,515,392	248,531	251.5
NSR	191,819,934	1,485,980	129.1
EU 27	502,369,211	4,501,339	111.6

Source: Eurostat.

Table 2: Net income per capita, 2009.

	nominal		*corrected for price level*	
	euro/inh.	% of EU average	euro/inh.	% of EU average
Belgium	22.852	139,2	20.349	124,0
Denmark	24.677	150,3	17.257	105,2
Germany	21.926	133,5	20.492	124,9
Netherlands	21.430	130,5	19.861	121,1
Norway*	38.395	233,8	27.543	167,9
Sweden	19.945	121,5	18.536	113,0
UK	18.098	110,2	18.696	114,0
NSR	21.107	128,5	19.842	120,9
EU 27	16.422	100,0	16.406	100,0

*2011.
Sources: Eurostat, Statistics Norway.

Private car ownership, controlled for population (Table 3) is roughly comparable between the NSR-countries, apart from a higher figure for Germany. Car sales roughly reflect population size, although different tax regimes and economic circumstances seem to influence the pattern (e.g. in Denmark and the Netherlands respectively). Nonetheless, it appears that the share of EV sales does not vary with total sales or total car fleet. According to Sierzchula *et al*. (in progress) this may be explained by financial incentives and by unique circumstances, such as cheap hydro power electricity, high incomes and high taxes on ICE vehicles in Norway.

Finally, Table 4 shows the share of households in the Netherlands owning one of more cars according to the degree of urbanisation of their living environment. Unsurprisingly, the share of households that does not own a car is the highest in dense urban areas, particularly historic inner cities, where parking space is scare and most one or two person households are found. Car ownership gradually increases as the degree of urbanisation decreases, reflecting typically a larger amount of space available, higher incomes (except perhaps for rural areas) and less public transport. This is also true for the share of households owning two or more cars. However, while it seems plausible that these figures reflect a general pattern, so far no comparable data could be found for other NSR countries.

Table 3: Car ownership (2009) and EV sales and market shares (2012).

	*passenger cars per 1,000 inh. (2009)**	*total car sales*	*PHEV sales*	*EV sales*[#]	*EV share (%)*
Belgium	479	486,732		827	0.17
Denmark	468	170,624		529	0.31
Germany	510	3,082,504	799	3,699	0.12
Netherlands	460	502,489	4,327[¶]	3,869	0.77
Norway	462	139,373	318	3,986	2.86
Sweden	460	279,899	662	952	0.34
UK	455	2,044,609		2,249	0.11
NSR	479	6,706,230		16,111	0.24

*Denmark: 2008; NSR: calculated on the basis of Eurostat and OECD data.

[#] Figures based on BEV sales also including Opel Ampera, but excluding other PHEVs. Germany includes Opel Ampera from April on, Norway sales adjusted from November to not identify imported used EV sales, United Kingom EV sales adjusted for 12-Months as official figures adjusted.

[¶] PHEV sales in the Netherlands are significant higher than EV sales, even if the latter include the sales of the Opel Ampera. This can be explained by the relatively very high sales of the Opel Ampera and the Toyota Prius Plug-in, the latter of which is not included in EV sales as presented here.

Source: car ownership: OECD, Eurostat. EV sales: AID (2013), by courtesy of Will Sierzchula. PHEV sales: Germany: Kvisle (2013), Netherlands: Tankpro (2013), Norway: Grønn Bil (2013), Sweden: Bekker (2013).

Table 4: Car ownership of households in the Netherlands according to degree of urbanisation and number of cars (2011).

	households	*no car*	*≥1 car*	*of which*		
				1	*2*	*>2*
extremely urbanised	1,703,623	0.48	0.52	0.41	0.10	0.02
strongly urbanised	2,129,910	0.30	0.70	0.50	0.17	0.03
moderately urbanised	1,375,405	0.23	0.77	0.52	0.21	0.05
hardly urbanised	1,524,631	0.21	0.79	0.50	0.23	0.06
not urbanised	739,869	0.17	0.83	0.52	0.25	0.07
total	7,473,438	0.29	0.71	0.49	0.18	0.04

Sources: Statistics Netherlands; ABF Real Estate Monitor.

2.5 Charging at home

Both full electric vehicles (FEV) and plug-in hybrids (PHEV) require charging. It is with no doubt that at least FEVs have to be charged as soon as they have been used or at least after they have been used substantially, depending on what the owner feels as save. Basically, this means that owners need the option to charge on a daily (or nightly) basis, and consequently need an ever-available charging lot. It can be assumed that the same counts for PHEV-owners, as they have the option to be discharged, but in practice do not like to drive on fuel as this is much more expensive than electricity.

Charging at home is the preferred option by far, but is not always possible. The possibility to charge at home depends mainly on the type of dwelling: ideal is a detached or semi-detached house on own premises. Heymann *et al*. (2011:19-20) suggest to use the number of single family dwellings as a rule of thumb for the possibility to charge at home, but this seems a rather crude measure.

Goudappel Coffeng (2011) estimated the possibilities for charging at home in the Netherlands (Table 5). A question is how these figures relate to the situation in other countries. Even if they would be similar, Table 6 indicates that considerable difference exist between NSR countries e.g. in terms of the share of detached and semi-detached houses.

Table 5: Estimation of the possibility for charging at home, per dwelling type, in the Netherlands.

dwelling type	*apartment, upstairs maisonette*	*house on a canal*	*row*	*semi-detached*	*detached, bungalow*	*farm*	*average*
charging on own premises	0%	10%	20%	80%	100%	100%	42%
charging in front of house	0%	100%	100%	100%	100%	100%	75%

Source: Goudappel Coffeng (2011).

Table 6: Housing stock according to dwelling type, 2008.

	single family	*multi-family*	*total*	*single-family*	*of which deta-ched*	*semi-det.*	*row*	*multi-family*	*of which high-rise*	*dwel-lings / buil-ding*
	x 1,000	*x 1,000*	*x 1,000*	*%*	*%*	*%*	*%*	*%*	*%*	
Belgium	3,330	1,205	4,535	73.4	-	-	-	26.2	16.0	7.6
Denmark	1,579	1,102	2,681	58.9	83.7		16.3	41.1	10.40	12.5
Germany	17,996	21,054	39,050	46.1	70.8		29.2	53.9	11.13	7.7
Netherlands	4,876	2,111	6,987	69.8	20.7	17.6	61.7	30.2	22.18	8.0
Norway	1,676	599	2,274	73.7	72.1	12.4	15.5*	26.3	-	16.7[#]
Sweden	1,776	2,471	4,247	41.8	-	-	-	58.2	-	-
UK	20,737	4,780	25,517	81.3	33.8	34.8	34.3	18.7	12.81	20.0
NSR	51,705	32,760	84,464	61.2	-	-	-	29.0	-	-
EU 27	106,131	94,116	200,247	53.0	-	-	-	47.0	-	-

* Row house, linked house and house with 3 dwellings or more.
[#] 2009.
Source: http://www.entranze.eu; Statistics Norway.

Dwelling types in turn depend on factors such as income and the type of urban environment. Figure 1 and Table 7 show large difference between NSR countries and regions in terms of urbanisation types and share of build-up areas. The sparsely populated northern part of Norway and Sweden stands out, but if this is left out of the consideration the picture is more homogeneous.

Figure 1: Urban-rural typology, 2010.

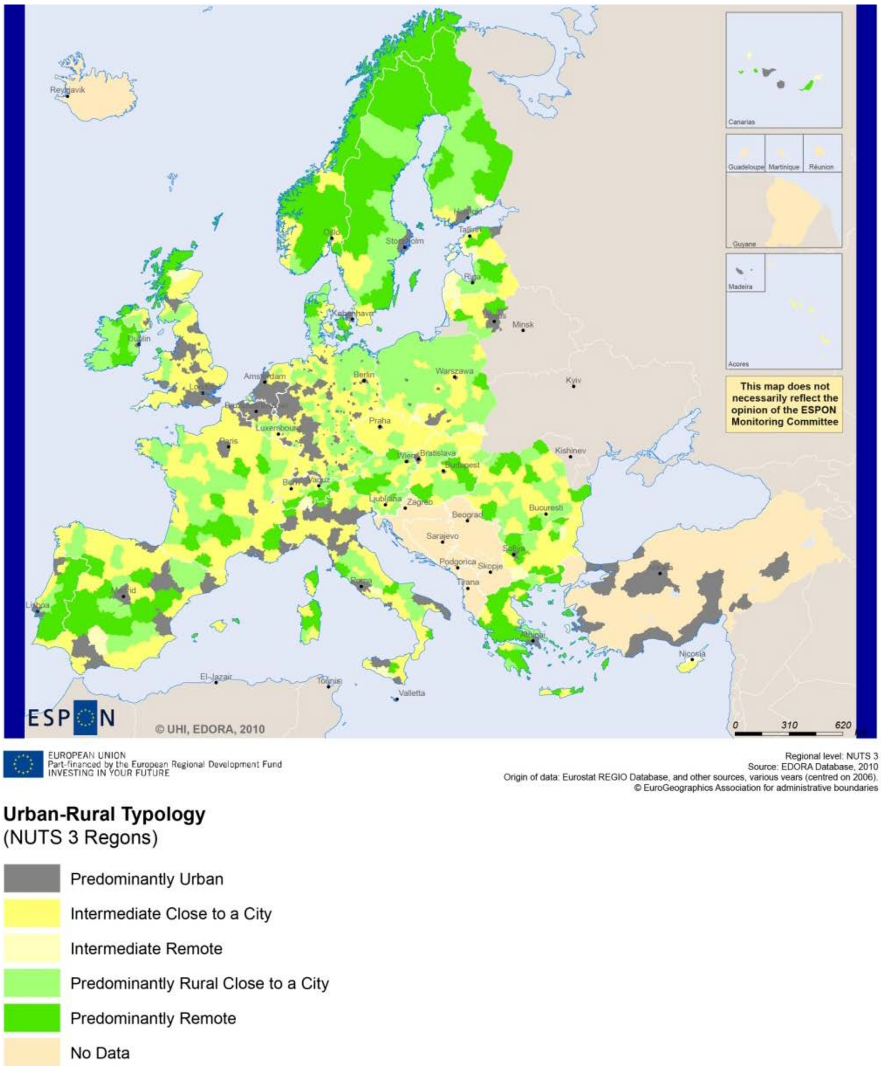


Table 7: Share of urban fabric in the total area, 2006.

	%
Belgium	16.82
Germany	6.27
Denmark	4.56
Netherlands	7.98
Norway	0.56
Sweden	0.91
UK	5.11
NSR	3.28

Source: © ESPON M4D Project.

Table 8: Distribution of population by degree of urbanisation and dwelling type, 2007.

	all dwellings	*houses*	*detached*	*semi-detached and row*	*flat*	flat in a building with <10 dwellings	*flat in a building with ≥10 dwellings*
TOTAL	%	%	%	%	%	%	%
Belgium	100.0	80.2	38.5	41.8	19.2	13.7	5.5
Denmark	100.0	72.0	58.5	13.5	28.0	5.8	22.2
Germany	100.0	45.4	29.1	16.2	53.3	35.3	17.9
Netherlands	100.0	79.0	17.3	61.8	16.7	4.7	11.9
Norway	100.0	83.6	65.5	18.1	15.6	4.5	11.1
Sweden	100.0	59.8	51.3	8.5	39.8	9.1	30.7
UK	100.0	86.5	25.1	61.4	13.3	8.0	5.3
NSR*	100,0	66,0	30,2	35,8	32,9	19,7	13,2
EU 27	100.0	57.1	34.2	22.9	41.6	17.2	24.4
DENSELY POPULATED							
Belgium	53.5	37.3	11.4	25.9	15.8	10.8	5.0
Denmark	33.3	15.5	10.4	5.0	17.8	2.2	15.7
Germany	50.7	15.2	6.4	8.8	35.0	20.7	14.2
Netherlands	62.8	45.4	5.1	40.3	14.6	4.2	10.4
Norway	50.0	36.9	25.5	11.5	12.7	3.5	9.2
Sweden	20.2	6.6	4.8	1.8	13.6	1.3	12.3
UK	75.9	63.6	14.4	49.2	12.3	7.2	5.1
NSR	58,0	34,9	9,7	25,2	22,7	12,4	10,2
EU 27	48.5	20.0	7.3	12.7	28.1	9.7	18.4
INTERMEDIATE URBANIZED							
Belgium	42.5	39.2	24.5	14.8	3.1	2.7	0.5
Denmark	41.7	33.9	28.6	5.4	7.8	2.4	5.3
Germany	34.5	20.4	14.7	5.7	13.5	11.0	2.5
Netherlands	34.8	31.5	11.2	20.3	2.0	0.5	1.5
Norway	17.8	16.2	13.6	2.6	1.5	0.5	1.0
Sweden	14.7	8.9	6.8	2.0	5.8	1.2	4.6
UK	19.3	18.3	8.0	10.4	0.8	0.7	0.2
NSR	28,9	21,5	12,8	8,7	7,0	5,3	1,7
EU 27	26.4	18.2	11.6	6.6	7.7	4.6	3.1
THINLY POPULATED							
Belgium	4.0	3.7	2.6	1.1	0.3	0.2	0.0
Denmark	25.0	22.6	19.6	3.0	2.4	1.3	1.2
Germany	14.8	9.8	8.0	1.8	4.8	3.6	1.2
Netherlands	2.4	2.2	1.0	1.2	0.1	0.0	0.1
Norway	32.2	30.5	26.4	4.1	1.4	0.5	0.9
Sweden	65.0	44.3	39.7	4.6	20.4	6.6	13.9
UK	4.7	4.6	2.7	1.8	0.2	0.1	0.0
NSR	13,0	9,7	7,7	1,9	3,3	2,0	1,3
EU 27	25.1	18.9	15.2	3.7	5.8	2.9	2.9

* NSR: own calculation weighed for population size.
Source: Eurostat.

2.6 Charging in the public space

This does not refer to fast-charging, which is discussed below. Regular charging in the public space is necessary when charging at home is not possible, or home is beyond the remaining range. This implies charging in the public space is mainly relevant in urban areas, particularly inner cities, where charging at home is a problem (see Table 8 for distribution of population over urbanization types). Moreover, in urban areas there is a larger support basis for public charging infrastructure. Nevertheless the possibilities to accommodate charging infrastructure in public space seem larger in less densely built areas.

Some issues can be raised with respect to charging in the public space, which mostly relate to parking:

- Should EV owners who depend on public charging have a reserved parking space or not? Reserved parking spaces mean certainty for the EV driver since he can be sure of a charging point at all times. It also means inefficient use of parking spaces because the parking space most likely remains unused for long periods. Local authorities generally do not favour reserved parking spaces.
- No reserved parking spaces, on the other hand, mean uncertainty for EV drivers, because they cannot be sure of a charging point. This is even more true during 'peak hours' (evening and nights) and for charging points close to home (what most drivers prefer).
- In both cases quite a lot of charging points are needed because EVs will stay parked also when they are fully charged. With non-reserved parking this might be prevented by e.g. setting a time limit. Heymann *et al*. (2011:19) mention a ratio of 900,000 charging points for 1 million EVs. Most of these will be private charging points, but nevertheless the large number of public charging points may raise worries from an urban design perspective.

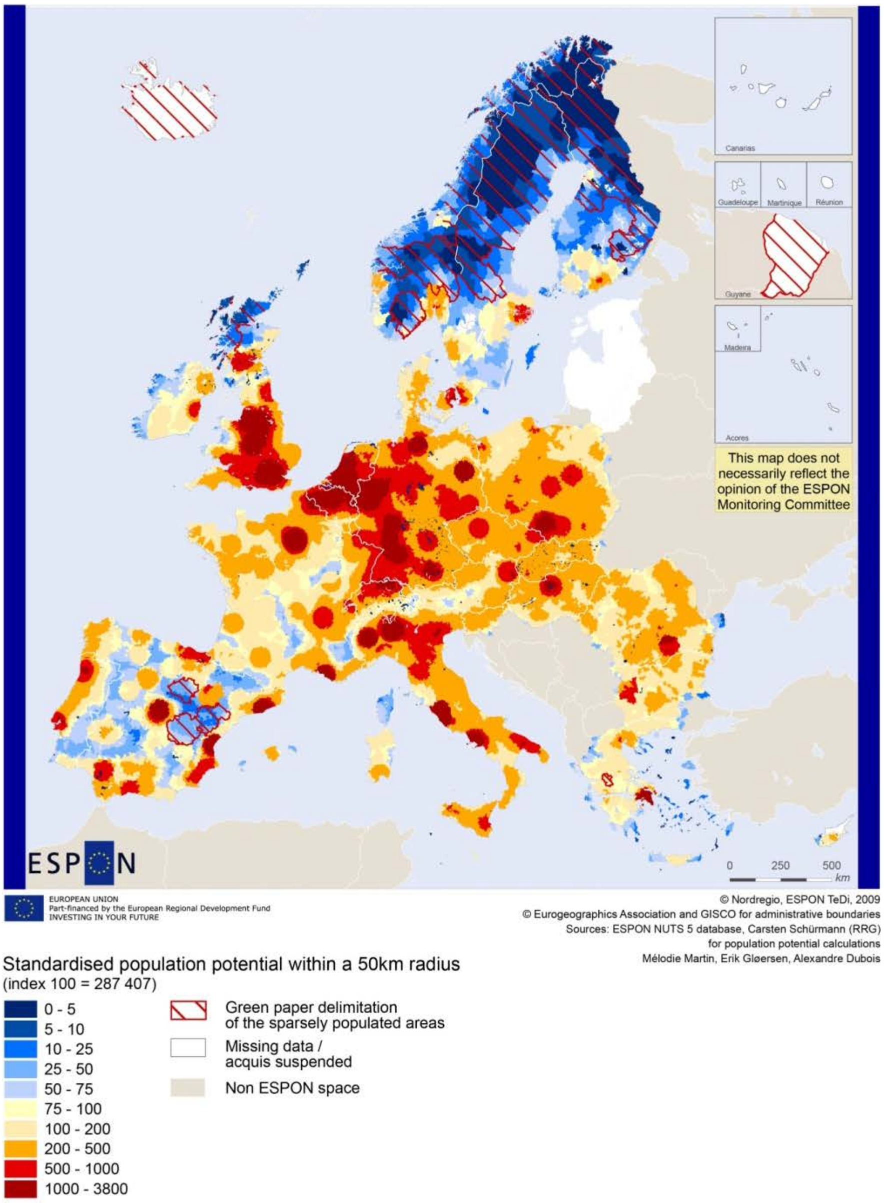
2.7 Fast charging

Fast charging is mainly required when travelling, and helps to overcome range anxiety. This means it is important for FEV drivers, but not so much to drivers of PHEVs, because fast charging is likely to be not much cheaper (or equally expensive) than fuelling the range extender. It is said that fast charging will not be the preferred option for EV drivers as it is most expensive and assumingly detrimental to the life span of the batteries (one of the main worries of potential EV buyers). This poses a dilemma because a sufficient number of users is required to cover the high costs of fast charging infrastructure. This may be a problem both in rural and urban areas.

A network of fast chargers may be required in urban areas. It is likely that these serve mainly as a back-up for drivers that stay in or close to the abovementioned daily urban environment but still experience range anxiety. As an indication of this, Figure 2 shows, as an index, how much people can be reached within 50 km range, i.e. are accessible by EV.

In less densely built areas fast chargers are required along the road to cover larger distances. The distance between Bergen and Olson in Norway is an example of this, but also smaller 'corridors. e.g. between the Amsterdam and Groningen or Maastricht in the Netherlands. This basically limits the number of potential users to those travelling more than, say, 100 to 150 kms. Moreover, because even fast charging takes 15 or 30 minutes, in practice you need several fast charging points together. How much, and what does this mean for the power grid?

Figure 2: Population potentials and sparsely populated areas, 2007.



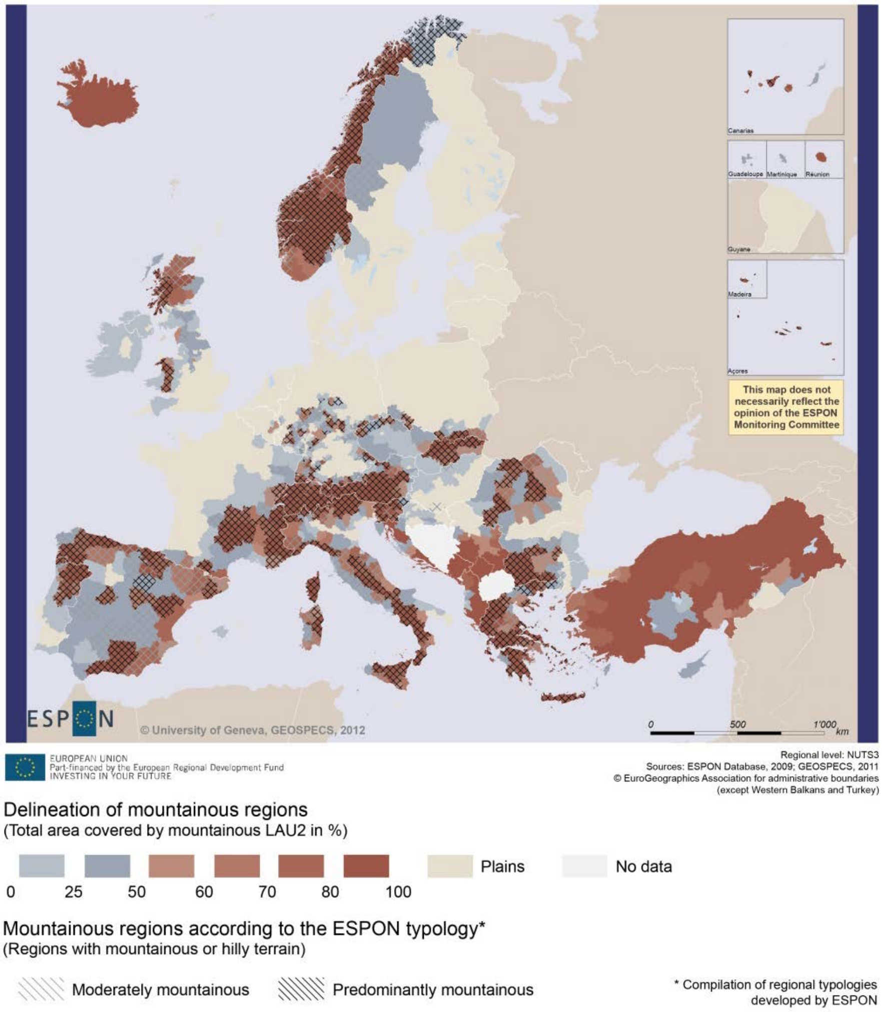
2.8 Natural environment

Spatial aspects of EV implementation and use not just concern the built environment. Some aspects of natural environment are relevant as well, mainly because they may reduce the effective range of EVs:

- Hills and mountains (Figure 3) increase energy consumption. The extra energy needed to climb a hill is not compensated by the additional regeneration of energy during descent. This is similar to ICE cars, but much more of an issue for EVs because of their shorter range.
- Climate, particularly temperature. Cold temperatures reduce battery capacity and thereby the range of EV. This is an issue in particularly in Scandinavia, although for local markets EVs may be adapted for use in cold temperatures. Recent tests in Norway indicate that the impact if low temperatures on the EV's range is less than that of relief or driving style.

- Very high temperatures are said to reduce the lifespan of the batteries. This seems less of a problem in the NSR, but it may be e.g. in the Mediterranean.

Figure 3: Mountainous areas in Europe.



2.9 E-bikes

Electric bikes may be a replacement option for cars, but they may also replace non-electric bikes or public transport. Regarding the first, they may be an alternative for an expensive electric vehicle. If they replace normal bikes, the result is an increase in the range of the biker, and a larger possibility to commute by bike − eventually resulting in a larger share of bike commuting as a whole. Until now, however, electric bikes seem most popular among retirees and, partly as a result of that, are considered less ‘cool’ by younger people. Electric scooters, as used e.g. by some pizza deliverers in the Netherlands, may be a more attractive option for them.

The use of electric bikes is likely to be affected by the same physical aspects that influence the use of non-electric bikes: hills and mountains, wind and rain. Nevertheless, moderate relief seems less of a problem for e-bikes than for human-powered ones.

2.10 Concluding remarks

The primary aim of this paper is to provide input for the discussion meeting in Haarlem. The aim of this meeting will be twofold: to stimulate discussion and the exchange of knowledge and experiences between project partners, and to gain information and feedback from stakeholders and practitioners.

In view of this, the above sections mainly aim to provide 'food for discussion', rather than clear-cut answers. A more in-depth analysis is planned for the next phase of research, but at this moment we confine ourselves to a number of propositions or questions based on the above, which will be presented and discussed at the meeting in Haarlem. This may address questions such as: In which type of urban or rural environment do EVs fit best? What minimal charging possibilities are required to buy an EV? Will EVs continue to be mainly second household cars? What role does the distance of commuting and other trips play when consumers select an EV? What will be the role of fast chargers?

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3 A systemic policy mix to support electric mobility development and adoption

Second discussion paper written in the framework of WP3 Activity 7 of the NSR INTERREG IVB project E-Mobility NSR, file nr. 35-2-6-11. Expert meeting organized in London, 11 April 2014.

3.1 Introduction

Most activities carried out within Work Package 3 of the E-Mobility NSR project in some way address policy-making, and the dynamics between policies, policy-making, and a variety of affected stakeholders at different levels. We regard the multilevel nature of policies for e-mobility as a key precondition to the successful introduction and adoption of EVs. Creating a well-working set of policies at various levels is however a complex process, as policies may for instance have unintended consequences at other levels, or questions of legitimacy or conflicts of interest between policy levels may arise.

From an empirical perspective, WP3 has learnt us that the transition to e-mobility differs from country to country, and even from region to region, throughout the North Sea Region. These differences relate to the speed of the transition, but also to the direction in which the transition is heading. With the latter we refer to, for instance, the difference between a focus on full-electric or on plug-in hybrid electric vehicles. Another example is the difference between countries where early standardization was prioritized and countries in which freedom to explore and innovate was given priority. These differences in speed and direction at various levels go to show that local circumstances and local policies have a strong impact on an otherwise global transition.

Such a mix of policies on different levels of government resonates with earlier ideas about systemic policy mixes that aim to simultaneously stimulate the supply and demand side of (radical) innovations (Smits and Kuhlmann, 2004; Wieczorek and Hekkert, 2012). These ideas have emerged as an answer to decades of policy making targeting either the supply side or the demand side (Smits and Kuhlmann, 2004). In the case of e-mobility, we will show how the transnational side has most clearly affected the supply side and that national policies mostly affect the demand side. Especially on the local level, mixtures of supply and demand side policies have emerged.

In this brief discussion paper we aim to further explore and structure this topic, and to propose some issues for discussion at the workshop held during the London conference.

3.2 Levels of policy-making

Policies to stimulate the implementation of electric mobility can be distinguished roughly on three levels of government: transnational, national and, local (or regional). Below we p resent an overview of the most relevant types of policies. This overview is by no means comprehensive, but it provides the basis for our further discussion of the interplay between these policies and their cumulative impact in terms of the momentum generated for e-mobility.

Transnational

Transnational regulation defines part of the context in which local and national policy-makers operate. First and foremost this relates to the EU norms forcing the automotive industry to develop and commercialize cleaner vehicles. These norms prescribe that each car manufacturer on the European market should achieve an average of 95 grams of CO_2/km for all of the cars it sells in the EU in 2021 (European Commission, 2012) though there is some differentiation between manufacturers of small cars (e.g. Fiat) and manufacturers of larger and heavier cars (e.g. Daimler), all manufacturers are forced to develop alternative fuel vehicles to meet these norms. While these norms do not call for electric vehicles per se, there is a bonus for low-(tailpipe-)emission vehicles which favours strongly the development of (PH)EVs and hydrogen fuel vehicles. These regulations clearly push the supply side of EVs and these are in fact supplemented by a large number of EU support programs for R&D towards electrification of cars and other vehicles.

Simultaneously, the European ambient air quality directive pushes nations, regions, and cities to develop policies to improve their local air quality. Cities that do not meet these targets in 2015 may face a hold on urban development projects (to prevent further air pollution) and this threat has proven a powerful argument to support, amongst others, the uptake of e-mobility. Such regulations thus directly and indirectly affect the demand side of e-mobility. These may even lead to an (informal) competition between cities and countries to attract as many EVs as possible as all (large) cities face the same challenge and see the same opportunity.

The transnational level also prevails with regard to policies that aim to stimulate standardisation of charging infrastructure. The best known example of this is the standardisation of charging plugs. In January 2012 the EU announced a directive that would select two types of plugs (Type 2 and Combo 2) to become the European standard; at the moment this is still in the proposal phase.

Private parties, particularly the MNC's in the automotive sector, are quite influential as well. Both the definition of standards and emission norms tend to involve negotiations between public policy-makers, industry (e.g. car manufacturers and utilities) and other expert and interest groups (IEA, AVERE, etc.) demanding less stringent of tougher regulation.

National

Transnational policies provide a strong incentive to manufacturers to develop EVs, but they do not affect the demand side directly. Demand side incentives are by and large provided through car tax schemes and these are, obviously, a matter of national governments. The extent to which countries support EV adoption differs from country to country. A country like Germany provides maximum tax exemptions of several hundreds of euros, while in Denmark these exemptions may amount to as much as 30 thousands euros or even more. Most popular among national governments are exemptions from vehicle purchase taxes. Interestingly, but not surprisingly, countries with relatively high car purchase taxes often provide full exemptions from these for (PH)EVs. These countries, like Denmark, Norway and The Netherlands, do not have a domestic car manufacturer and thus have had little lobbying (nor political interest in) for low car taxes. At the same time, these countries have had little lobbying from reluctant car manufacturers who do not want too much public interference in their market (e.g. support for foreign EVs or support for vehicles with minimal profit margins in general).

Road use taxes may also be used to provide an (additional) incentive for EV adoption. These incentives are not as valuable as the purchase tax exemptions, but may be significant nonetheless as they provide a longer lasting and perhaps more visible incentive. That is to say, car purchase taxes (included in sticker price) are not as visible as road use taxes which are an annual or otherwise regular burden.

A very specific incentive is provided in The Netherlands to employees driving a company. These employees normally pay hundreds of euros per month as part of a fringe benefit tax scheme. Until the end of 2013 these taxes did not apply to full EVs and PHEVs and this has proven to be the most powerful incentive in the Netherlands leading to roughly 15 thousand (PH)EV registrations in 2013. This is quite a stark contrast with other nations were most incentives are directed at ownership by individual consumers.

Next to direct demand side policies, national governments also support R&D programs that affect the supply side and programs that support the build-up of recharging infrastructures (which can be considered an indirect support for market development) and the use of vehicles in all sorts of test and demonstration projects.

Local and regional

On the local and regional level an even greater diversity of measures can be adopted. We list a number of these below:

- support for or direct commissioning of regular (all countries) or fast charging infrastructure (especially Norway);
- purchase subsidies for cars and/or (private, off-street) charging equipment
- free parking for (PH)EVs or priority parking licenses for (PH)EV drivers
- allowing the use of bus lanes or exemption from tolls;
- provision of information and other promotional events;
- support for electric car sharing schemes;
- inclusion of (PH)EVs in municipal vehicles fleets.

Local and regional policies in particular involve the implementation of EVs in the built environment. This includes for instance how and where charging infrastructure is located, whether and how free parking for EVs is implemented, and whether EVs are allowed to make use of bus lanes. These policies are directly related to the behaviour and preferences of EV drivers: where they want to park and charge, their willingness to pay for facilities, etc.

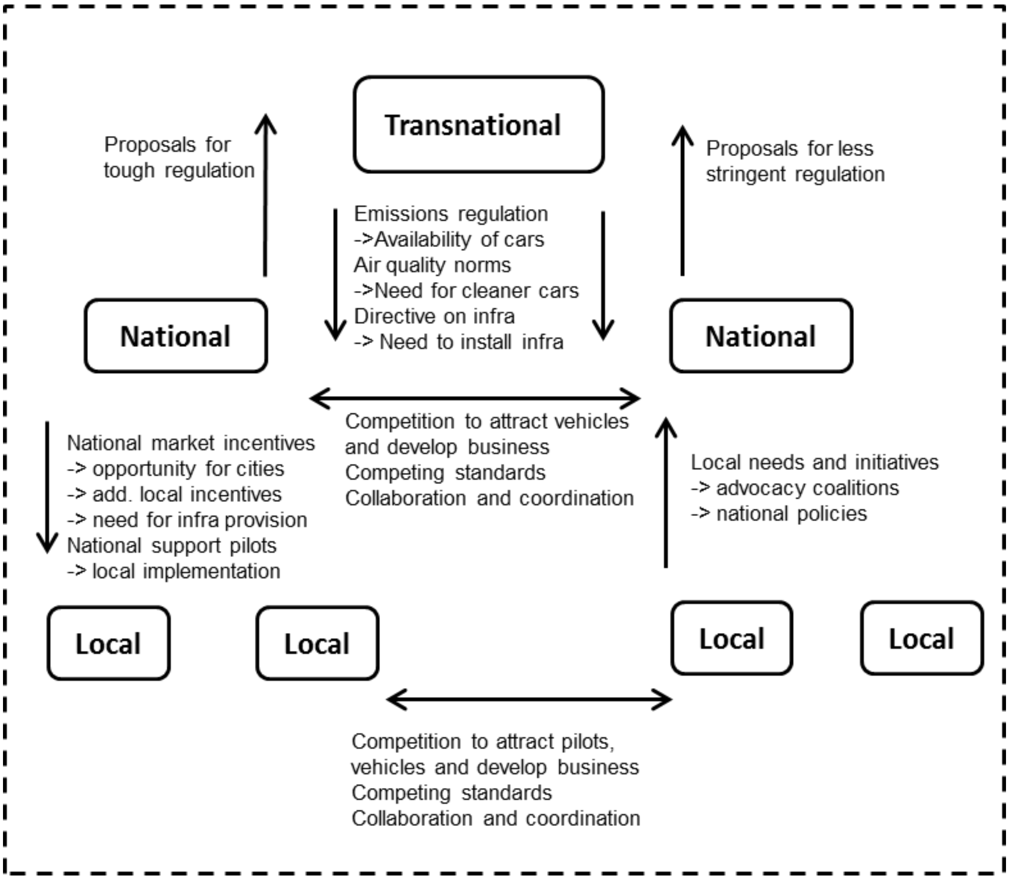
Another issue decided partly on a local or regional scale is the inclusion of EVs or hybrid vehicles in the municipal fleet or in local public transport (e.g. the 2008 hybrid New Routemaster bus in London). Actors on higher levels may be involved in this as well, such as public transport companies operating regionally or nationally.

3.3 Multi-level dynamics

Figure 4 summarizes the various policies made on the local, national and transnational level. It also presents an indicative scheme of the dynamics between these levels. These may take various forms, some of which have already been mentioned above. At least three types of relations may be distinguished:

- a policy made on one level directly affects another level (e.g. national subsidies for EVs lead to an increasing demand and shortage of chargers at the local level; European regulation induces national and local policies to increase the number of EVs);
- Some actors may be active on multiple levels of governance (e.g. a national public transport company introducing electric busses in local transport; a national energy company providing charging infrastructure in the framework of a local EV support programme);
- a policy made on one level cascades down to a low lever (e.g. EU regulation on air quality is implemented through national legislation in each member state which in turn trickles down to local policy making).

Figure 4 Indicative scheme of multi-level dynamics in policy-making regarding electric mobility



Such multi-level dynamics raise the question if and to what extent conflicts of interest between policies at different levels may emerge, whether this triggers competition between policies (and governmental bodies) at the same or at different levels, or even questions of legitimacy. As for the latter, for instance, the question could be raised what issues should be regulated at the transnational level, in view of the prevailing concept of subsidiarity which suggests policies should be developed at the lowest possible level.

A second question is whether and to which extent such problems - if they occur - actually hinder the effective development and implementation of policies to stimulate the use of EVs. One could for instance argue that transnational policies are not or less effective when they are not complemented by the right mix of policies on lower levels or whether they lead to an undesirable level of competition rather than cooperation among these lower levels.

During our workshop in London we would like to discuss the issues above, as well as related issue such as:

- how to develop coherent policy packages across levels of policy making? How to define coherent sent of policies that include various policy levels?
- how to facilitate policy transfer? How to define policies that are specific enough to be effective by sufficiently generic to be transferred from one region to another?
- How to prevent conflicts between policies on different levels and unproductive policy competition among national and regions? How to deal with transnational directives and the need for standardization in relation to local contexts and specific needs?
- Should one party take the lead or coordinate, and if so which one and on which level? How should this be legitimized? How does the idea of subsidiarity (policy should be developed at the lowest possible level) relate to the need for coordination?

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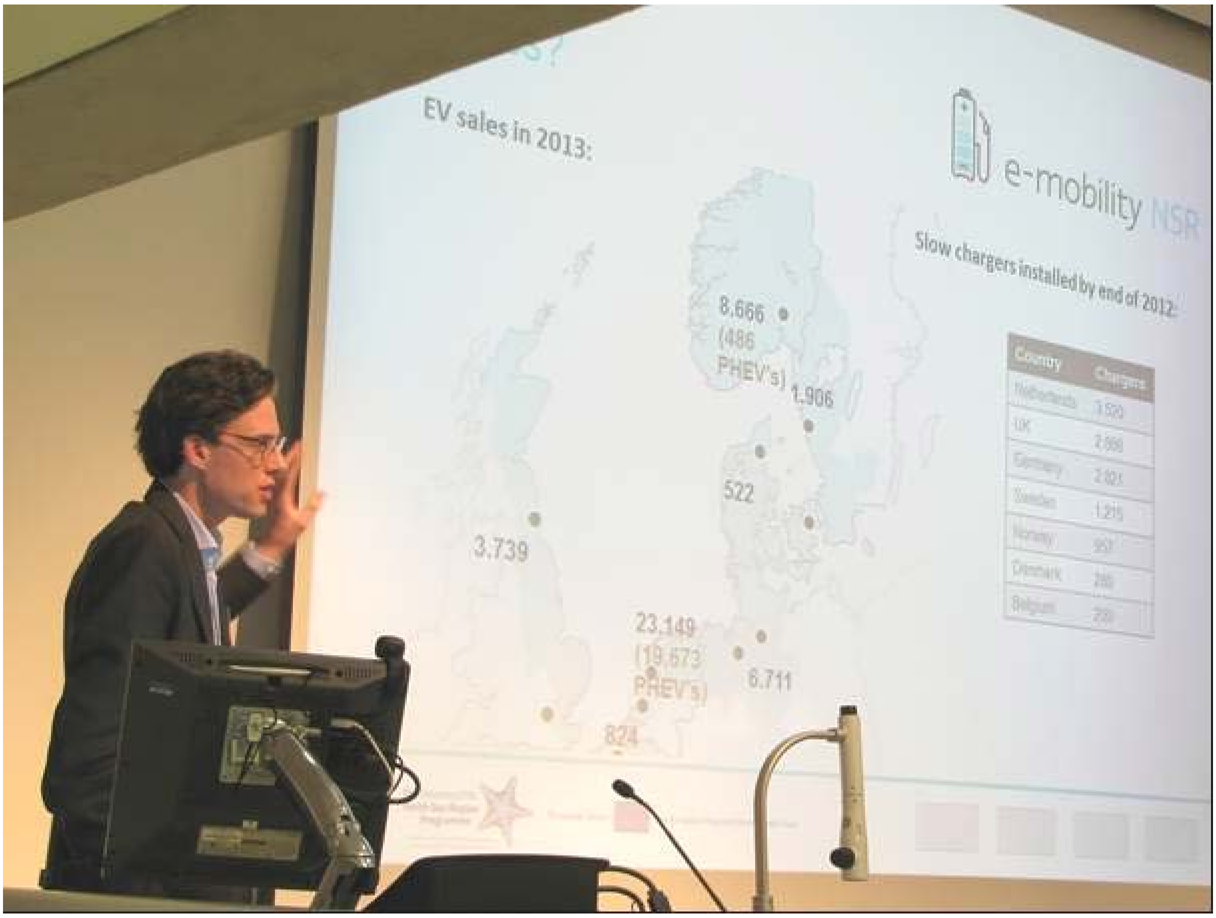
Calculating EV potential


Momentum for Electric Mobility
Dynamics of multi-level governance
Dr. Sjoerd Bakker


EV sales in 2013:
e-mobility NSR
Slow chargers installed by end of 2012:
8.666
(486
PHEV's)
1.906
522
3.739
23.149
(19.673
PHEV's)
6.711
824