NORTH SEA REGION ELECTRIC MOBILITY NETWORK

e-mobility NSR

Stakeholder strategies regarding the realization of an electric vehicle recharging infrastructure

Report written within the framework of Activity 3.2
of the Interreg IVB project E-Mobility NSR

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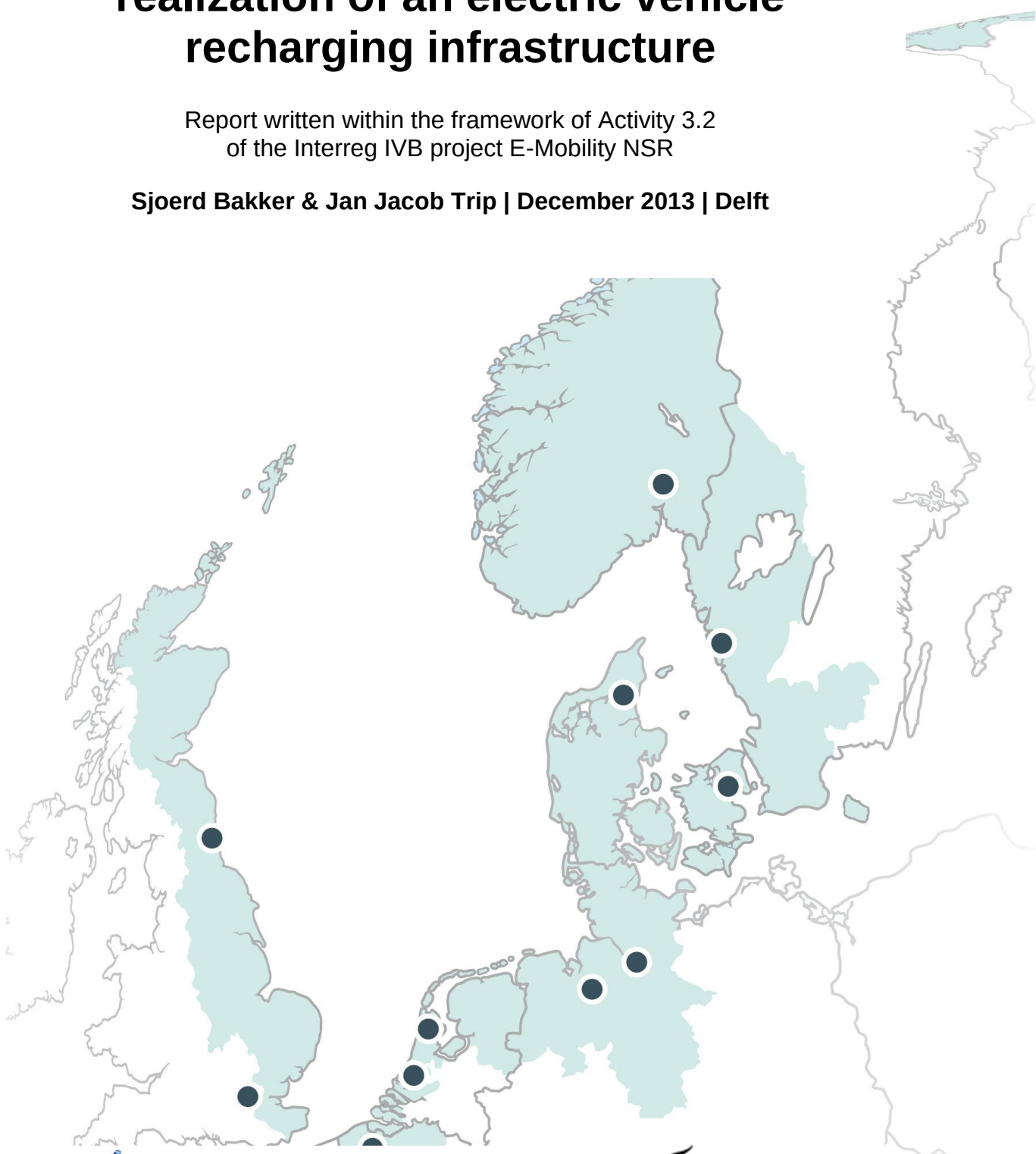

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region

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1. Introduction

The realization of a public recharging infrastructure is a prerequisite to the adoption of electric vehicles (EVs). Even though most EV drivers charge their cars at their homes or offices, a public recharging infrastructure is necessary for those without private parking facilities and for ad hoc charging during trips. A wide variety of stakeholders is involved in the realization and operation of charging stations, but the division of tasks between them varies between countries and regions. Furthermore, there is much uncertainty about optimal business models and the commercial viability of EV recharging networks. This report deals with these issues and presents the various ways in which recharging networks are organized and how tasks are divided between the stakeholders involved. The review of stakeholder strategies presented in this report is based on an analysis of documents and interviews with stakeholders and experts in the seven North Sea Region (NSR) countries. We show how stakeholder strategies differ between the countries as a result of differences in electricity industry structures, ambitions with regard to renewable electricity production, and varying (national) policies regarding EVs. The differences between the countries may be an additional challenge for European harmonization regarding the pace of the transition and the possibility of cross-border trips (i.e. international interoperability).

More specifically, this report aims to address the roles of the following types of stakeholders:

- **National government**
- **Local government**
- **Grid operators**
- **Electricity producers and retailers**
- **Traditional gas station operators**
- **Dedicated charging network operators and service providers**

From the country-specific analyses, five major themes emerge that will be discussed to highlight and explain major differences between the countries:

- **Task division between owners, operators, and service providers**
- **Nationwide and regional networks**
- **The role of regular, semi-fast, and fast charging in public infrastructure**
- **Flat-rate and pay-per-charge models**
- **The role of EVs in future energy systems**

Within the framework of the E-Mobility NSR project, this report relates to the following other studies. These studies are available for download at: http://e-mobility-nsr.eu/info-pool/

- **Standardization of EV Recharging Infrastructures**
  Describes the standardization process of EV recharging infrastructures from both a national and international perspective and provides an overview of standards in use in the NSR countries and efforts to realize (international) interoperability.
- **Electric vehicle charge point map websites in the North Sea Region**
  An overview and assessment of the various charge point websites. These websites are potentially powerful tools to monitor the standardization process in the respective countries. They were used for this report in a qualitative manner, and may also be used

to quantify degrees of standardization, provided that they are truly reliable and provide full coverage of actual charging stations.

- **Electric mobility policies in the North Sea Region countries**
  An overview of supportive policies for both vehicle adoption as well as infrastructure build-up
- **Danish Experiences in Setting up Charging Infrastructure for Electric Vehicles with a Special Focus on Battery Swap Stations**
  A detailed description of developments Denmark concerning the realization of the Danish infrastructure, with a focus on Better Place's swapping stations.
- **Micro to Macro Investigation**
  A detailed description of the British Plugged-in-Places initiative with a focus on the role of public stakeholders.

2. Definitions

In this report several terms are used that have different meaning in different countries and to avoid any confusion, we provide definitions of these below.

- **Regular charging**, AC (alternating current) charging with power levels up to 7 kW mostly, it therefore includes charging off regular mains sockets as well as dedicated charging equipment with Mode 2, Type 1 and/or Type 2 connectors.
- **Semi-fast charging**, AC charging from 3-phase power connections with power levels up to 44 kW. These chargers make use of Type 2 connectors.
- **Fast charging**, DC (direct current) charging with typical power levels of 50 kW. All fast chargers currently comply with the CHAdeMO standard.
- **Charging network operator**, an organization that is responsible for the operation, management, and maintenance of charging stations. The operator is not necessarily in direct contact with consumers (i.e. when there is a separate service provider).
- **Charging station owner**, an organization that owns the charging equipment. The owner does not necessarily operate the station itself and may leave this to a (commercial) operator and/or service provider. This is often the case for, for instance, municipalities, shops or parking companies.
- **Charging service provider**, an organization that deals directly with the drivers using the charging network. Such service providers thus act as a middleman between the network operator and the end users.
- **Public recharging infrastructure**, charging points that are either located in public space or at publicly accessible locations such as shopping centres and parking garages. When relevant, the latter type of locations is sometimes referred to as semi-public.

3. Developments in the NSR Countries

3.1 United Kingdom

Since 2010, the backbone of the UK recharging infrastructure is formed by national government's Plugged-in-Places (PiPs) program. The PiPs program consists of 8 regional networks in which both local public organizations as well as private entities have cooperated to install recharging stations in both public as well as semi-public locations. The PiPs are meant to support the uptake of EVs, but also to create learning opportunities for (local) governments and businesses. In fact, the UK has taken a regional approach in order to increase learning opportunities by stimulating diversity and it therefore refrained from imposing a national standard so early on in the development of electric mobility and its infrastructure. Such learning can relate to the technology itself, the charging behaviour of EV drivers and the viability of various business models. To stimulate and coordinate the learning process, all PiPs are required to collect and share information on, for instance, charging behaviour.

The commonly used model in the PiPs is one in which the charging stations are owned and hosted by several organizations (both public and private) and are operated by one central organization for each PiP. This means that, with the help of public match-funding, the hosts have procured one or more chargers and these are connected to the network and drivers in the region can make use of all chargers in the network. Examples of such networks are the Charge Your Car[1] network in the North East of England and Source London[2] in the greater London area. Currently the central network operator is typically a (semi-)public organization, but for instance in the London case, a tender is organized to transfer this task to a commercial operator (and service provider).

From 2010 onwards, there are subsidies available targeted specifically at recharging installations for home charging and for local governments and railway stations.

The role of grid operators and electricity producers is modest in the UK. As a subsidiary of RWE, NPower sells charging equipment (as developed by RWE) and provides additional consultancy to several PiPs and private customers. Apart from this, NPower nor any other electricity supplier is directly involved in the creation of charging networks as such. The same goes for EDF Energy[3] and British Gas[4] who also focus the installation of home chargers. In contrast to other countries, the expected influx of renewable electricity is no reason to invest in EV infrastructures today. A notable exception is formed by Ecotricity, a producer and retailer of renewable electricity which operates its own EV charging network[5]. It does so with Welcome Break service stations acting as host to the chargers, including both AC semi-fast and DC fast chargers.

Some of the local grid operators are involved in the PiPs in order to learn about the impact of EVs on the electricity grid. For instance, the grid operator for London, UK Power Networks, participates in the Source London network to monitor charging behaviour.[6] Concerns over grid stability have made it difficult to install DC fast chargers in the inner city of London. Currently there is only one and it is unlikely that more will follow, given the constraints imposed by the (old) electricity grid in the city.

[1] http://chargeyourcar.org.uk/about/
[2] https://www.sourcelondon.net/
[3] http://www.edfenergy.com/products-services/for-your-home/electric-vehicles/
[4] http://www.britishgas.co.uk/products-and-services/energy-saving/electric-vehicles.html
[5] http://www.ecotricity.co.uk/for-the-road
[6] http://www.ukpowernetworks.co.uk/internet/en/news-and-press/press-releases/Invitation-to-electric-vehicle-owners.html

Interestingly, one charging equipment manufacturer, Chargemaster, operates its own recharging network. In other countries the manufacturers by and large act as mere suppliers, but Chargemaster is setting up its own Polar Network which is strategically located to connect the various PiPs.[7]

3.2 Belgium

The national (federal) government of Belgium has left the support for EVs and their infrastructure to the regional Flanders, Brussels, and Walloon governments. Financial support for recharging infrastructure is however not available, except for a tax incentive for environmentally friendly investments.[8] Instead, the Flanders government has set up 5 so-called Living Labs (Proeftuinen) for EVs. Within these projects there is limited infrastructure build-up to support the EVs that are deployed.[9]

Especially the EVA and Olympus projects have added to the public recharging infrastructure. The EVA project is led by grid operator EANDIS and entails a test fleet of EVs and a supporting recharging infrastructure. EANDIS aims to learn about the impact of EVs on the electricity grid and plans to develop solutions that can prevent overloading of the grid by reducing the power levels going to the vehicles when necessary. Next to EANDIS, charging station developer eNovates and related service provider BlueCorner are also involved.

The Olympus project is led by the Belgian railway operator NMBS which, in the context of the project, installs charging stations at 34 railway stations to support the integration of EVs in intermodal travel.

The electricity producers in Belgium are mostly active in home charging and, at the moment, do not invest in public recharging infrastructures. The aforementioned service provider BlueCorner is also targeting the home charging market, but is planning to realize a public recharging network as well.

Total has installed DC fast chargers at 12 of its gas stations in Belgium.[10] These are mainly used to learn about the willingness to pay for fast charging by EV drivers and to learn about secondary earnings from those drivers visiting the station's shop. The New Motion of the Netherlands also operates several fast chargers in Belgium. It plans to install 25 chargers in total and it does so in cooperation with Nissan and with local hosting organizations such as shops (e.g. Delhaize) and restaurants (e.g. Van der Valk).[11]

3.3 The Netherlands

Dutch national government supports the introduction and adoption of EVs in several ways (e.g. tax incentives for both private consumers and businesses), but in relation to the recharging infrastructure it has done relatively little. In fact, the only national support for infrastructure build-up is provided indirectly through a set of pilot projects (or Living Labs: Proeftuinen) of which some focus on experimentation with charging systems and managed charging. Local governments are much more active in this respect and this goes especially for the cities of Amsterdam[12], Rotterdam[13], Utrecht[14], and The Hague[15] that have each

[7] http://www.polarnetwork.com/
[8] http://www.agentschapondernemen.be/themas/our-services
[9] Vlaamse Proeftuin Elektrische Voertuigen 2013, Jaarverslag over het eerste werkingsjaar, www.proeftuin-ev.be
[10] http://www.total.be/nl/stations/brandstoffen/plug-to-drive/plug-to-drive-finder.html
[11] http://www.thenewmotion.com/press/Belgische_snellader.pdf
[12] http://www.essent.nl/content/overessent/actueel/archief/2011/amsterdam_gunt_essent_opdracht_elektrische_laadpalen.html#
[13] https://doetdoet.nl/nieuws/2012-08-19-cofely-wint-aanbesteding-laadpalen-rotterdam
[14] http://www.zerauto.nl/2012/10/24/ballast-nedam-bouwt-utrecht-vol-met-oplaadpalen/
[15] http://www.denhaag.nl/home/bewoners/to/Den-Haag-krijgt-er-300-laadpalen-bij.htm

commissioned the installation of hundreds of chargers in the urban environment. In this model, the city pays (to a large extent) for the equipment and installation of the equipment and the winning tender consortia get to operate the infrastructure. These consortia are rather mixed and consist of electricity producers (e.g. NUON/Vattenfall, Essent/RWE), construction companies (e.g. Heijmans, BAM, Ballast Nedam), and charging equipment manufacturers (e.g. Enovates, Alfen, RWE). In some cases an additional service provider is also involved (e.g. The New Motion, BlueCorner). These cities have done so, and are able to allocate the necessary resources, because of the air quality problems they face and the need to comply with European air quality norms. Failure to meet these norms would have significant economic implications as further urban development projects would be forced to stop as a result of court decisions. A similar tender was also organized in 2013 by the Metropolitan Region of Amsterdam (a combination of multiple municipalities in the greater Amsterdam region) in addition to the inner city infrastructure in Amsterdam itself.

The role of electricity producers is strongly related to the urban networks and living labs and the producers are hesitant to invest heavily in the public recharging infrastructure. Still they aim to learn about the use of EVs and charging infrastructure and their impact on electricity demand. Furthermore, they recognize that EVs can play a role in future balancing between supply and demand when a large share of electricity is generated from wind and solar. For this reason, and because of short term market opportunities, they focus on home charging.

Unique to the Netherlands is the role of the grid operators. These have, almost all of them, united themselves in a foundation, E-Laad, and have invested in the build-up of a national recharging infrastructure. At first E-Laad placed charging stations at the request of municipalities, later on these were placed at the request of actual EV drivers who needed a charger at (or close to) their homes. E-Laad is the owner and operator of these charging stations, but it is not allowed to act as service provider to them since grid operators are not allowed to sell electricity. Until 2012, the E-Laad chargers could be used for free in combination with a national ‘charging card’. Since then, separate service providers started issuing cards on a membership basis and charging was no longer free. Instead, EV drivers now pay on a charging-time basis. Since 2013, E-Laad, is no longer allowed to install and operate chargers on its own initiative. This was decided by the Department of Economic Affairs to enable the development of commercial business models for charging stations and to prevent the grid operators from extending their (regulated) task domain. Currently it is not exactly clear which stakeholder(s) are able and willing to invest in the public recharging infrastructure. Even though it is generally agreed upon that enough chargers are installed for ad hoc charging, there remains a challenge to provide EV drivers with charging spots close to their homes. These chargers are needed for drivers who don’t have their own parking facilities and therefore have to rely on chargers in public space.

The Netherlands has also taken a unique approach to DC fast chargers. There are no national subsidies for these, but still relatively many have been installed so far (approximately 50) and more are to follow. Some of these fast chargers have been installed by oil companies BP and Total, others have for instance been installed at Nissan dealerships or at specific locations to serve fleets of electric taxis. The chargers that will follow will be installed by 6 service providers who have won concessions from the national road authorities for installations along highways. Among these concession holders are The New Motion, the ANWB (the national automobile association), and Fastned which holds the fast majority of concessions. All of these fast chargers are to be operated on a commercial basis and especially Fastned believes that there is a business case for these. Others regard fast chargers rather as an element in a broader business model that also includes home charging for instance.

3.4 Germany

Germany has, similar to the UK, opted for a regional approach to the realization of a public recharging infrastructure. Germany's national (federal) government has supported this through 8 so-called model regions (Modellregionen) and later on by means of 4 Showcase regions (Schaufenster). The rationale behind this regional set-up is that learning and innovation is prioritized over large scale adoption of EVs. Furthermore, German car manufacturers had, at the time of analysis, not yet brought their EVs to the market (except for the Opel Ampera) and there was thus no reason (nor industry lobbying) for the national government to start with large scale support efforts yet. In the meantime several manufacturers have released limited numbers of EVs, but Germany is still one of the few countries where there are no significant purchase grants or tax incentives[16] for EVs.

In this regional set-up, local and regional governments have supported 'their' projects as well. They have commissioned the installation and operation of charging stations in public space (e.g. Berlin, Hamburg). Furthermore, the local and regional governments have also provided subsidies for charging equipment at semi-private parking spots (supermarkets, privately operated parking garages). This equipment is then owned by the local hosts. These chargers are operated under one overarching organization to form one (or more) regional networks to ensure that EV drivers can use several chargers in the region. The city of Hamburg is considering a slightly different model in which EV drivers make use of infrastructure operated by a third party which does not actually sell the electricity. Drivers are then billed by their own energy provider at all charging stations. In such a model, there are thus no dedicated service providers.

One complicating factor to creating local networks of chargers is that the actual installation of the chargers is typically done by the larger electricity producers and they have not agreed on a single standard or on interoperability between 'their' networks. This goes especially for RWE and Vattenfall who have installed most chargers and who have also issued separate charging cards for their respective networks. Because of this, roaming is not possible between their networks in the Berlin region for instance. Apart from this, several local utilities are also quite active in installing and operating infrastructure. They do so amongst others through the Ladenetz initiative which brings together over 25 local utilities and their networks. Roaming will be possible between these networks and the related E-Clearing.net initiative aims to expand their platform to international roaming as well. Interestingly, there is also a private initiative, Hubject, to realize an international roaming network[17].

The disintegration of utilities (i.e. separation of grid operation from electricity production) has taken place in Germany, but in many cases the two tasks are performed by organizations that are part of a single holding. This goes for local utilities (Stadtwerke) but also for the larger corporations such as RWE and Vattenfall. Early on in the process, it was decided by the federal government that the EV infrastructure could not be considered as a part of the distribution system and the grid operators were thus not allowed to invest in the infrastructure or to operate it. The electricity producers have taken up the role of installing chargers in public space, but only when authorities supported them financially. Energy producer Vattenfall, for instance, does not recognize a viable stand-alone business model in public recharging, there might be one for private charging and most promising in Vattenfall's opinion is (company) fleet charging for which additional (consultancy) services can be offered as well.

[16] There is a reduction of the so-called Kfz-Steuer (a yearly car tax) for EVs, This amounts to about 50 Euros per year, lasting 10 years.

[17] The E-Mobility NSR **"Standardization of EV Recharging Infrastructures"** provides more details about tge activities of Ladenetz and Hubject.

There are very few fast chargers in Germany and most of these were installed as part of pilot projects. Eon has installed one along the Bavarian highways of its own accord. There are no subsidies available for these nor are there any plans to install more fast chargers in a network setup.

3.5 Denmark

The Danish government is a strong supporter of EVs. As a result, no country provides more valuable financial incentives than Denmark for the adoption of (full-electric) EVs. At the same time however, national government has not done much to stimulate or support the build-up of a recharging infrastructure. So far this was left to local governments and private companies, but 40 million Kroner will be made available for recharging infrastructure build-up. The city of Copenhagen will invest directly in a recharging infrastructure, but this will mainly be for its own fleet and only a limited number of these stations will actually be open to other EV drivers. Next to that, the city will make 500 parking spots available for EV charging, but other stakeholders need to install and operate the equipment there. It is possible that the newly announced national funds will be used for these parking spots. Furthermore, until 2011 EVs were exempted from parking fees in Copenhagen, but this was not allowed according to national laws. Still, in practice, EV drivers are not fined for parking without paying.

Currently there are about 720 public charging stations in Denmark, but chances are that this number will not grow a lot significantly in the coming years. This is about one third of what was originally planned. The private companies focus on home-charging and semi-public charging (at shops and restaurants and such). One of the problems with public charging spots is that the parking spots that are used may be claimed for use for other purposes at any time. To install the equipment, a service provider would at least need the guarantee that a spot can last for 5-10 years.

The Danish grid operators are not afraid of the impact of EVs on grid stability. They are used to the high share of wind power in Denmark (30% of electricity production) and this does not cause any issues with grids. On the long run there may be a need, according to the operators, for smarter grids to balance even higher shares of wind power with the demand for electricity from large numbers of EVs. The growing share of wind power is an incentive to electricity producers to support the adoption of EVs. It should be noted that the disintegration of the utilities has taken place only to the extent that the two tasks are now legally divided in different organizations, but that these are still part of the same holding (i.e. similar to Germany). The private company Clever for instance is set up by 5 electricity producers which are part of larger holding that also include grid operators. Clever (formerly known as ChoosEV) operates a network and acts as service provider for both home chargers and chargers in semi-public locations. Many of the semi-public chargers are in fact DC fast chargers and this makes Denmark one of the countries where fast charging is already operated on a commercial basis (next to Norway and to a lesser extent the Netherlands and the UK). Until Better Place went bankrupt, it was the other major service provider and network operator in Denmark. Better Place offered its well know swapping stations (18 in Denmark), next to home chargers and semi-fast AC charging stations in public space.

Another, albeit smaller, network is operated by CleanCharge of which most chargers are actually home chargers. CleanCharge operates only a small amount of chargers in (semi-) public space but is an interesting stakeholder nonetheless. It is one of the few, if not the only, network operators that truly focus on a business model based on the added value of managed charging. Through its partnership with RWE, it installs chargers that are designed to support managed (or: smart) charging and it believes that balancing supply and demand by means of EVs can indeed bring about added value and that producers and grid operators may be willing

to pay for this. Currently this is not the case as there are not only small numbers of EVs on the road and the share of renewables is still too limited. In the future this will change however, according to CleanCharge, due to the ambitions and hard milestones set by government. Furthermore regulatory frameworks are expected to change as well, allowing grid operators to actually pay for the flexibility in usage that EVs can offer. Flexible transport tariffs would be needed for this and more flexibility in energy tariffs for end users is needed as well in order to provide EV drivers with the right incentives to take part in this model.

3.6 Sweden

The Swedish national government has been rather passive in relation to supporting the uptake of EVs and the realization of a recharging infrastructure. For instance, if offers a 4k Euro purchase grant for EVs and this is by far among the lowest incentives in the EU. Swedish government is currently contemplating its position in relation to EVs and is expected to come up with a plan by the end of 2013. This lack of clarity has apparently led to a vacuum because of which other stakeholders are also reluctant to invest.

A notable exception is the city of Stockholm. The parking company of the city (which is fully owned by the city) is the major installer of recharging equipment. It has installed about 350 charging spots in indoor parking facilities as well as on parking grounds outside. 200 of these are installed in a new parking garage where all parking spots are equipped with a charge point. The charging costs are included in the parking fees and these are charged by the hour (for visitors) or per month for permanent users. The hourly rate is (until now) not different from regular parking tariffs, but the monthly rate is somewhat higher. Basic charging equipment can be used in this system, as no metering is necessary, and this easily offsets the costs of the (more or less) free electricity. The parking company strives to install chargers at 20 to 30% of all its parking spots in the future.

A large share of electricity in Sweden is generated with hydropower (about 44%) and nuclear (about 40%).[18] These are both predictable sources and, on top of that, hydropower is also very flexible and power generation can be regulated to meet demand. With such a low carbon electricity industry, there is no direct need for Sweden to move to intermittent and unpredictable renewable sources like wind and solar energy. This implies that there is no future need for storing the energy from these sources to balance supply and demand of electricity like in other coutnries such as Denmark that (have to) rely more on thoe types of sources. In other words, there is no particular need for EVs for such energy balancing and this makes that Swedish energy producers are less interested in investing in recharging infrastructures, also because they don't see any opportunities to operate these commercially.

Grid operators are much more active and for instance the Stockholm area, but also in Malmö (where EON operates the grid) and in Jämtland where Jämtkraft is the local grid operator. Like many other grid operators throughout the NSR, these operators want to learn about charging patterns (driver behaviour) and the impact of EVs on the local grid.

There are hundreds of thousands of engine pre-heater sockets in Swedish parking garages and other parking spots. These can be used to charge an EV, but it is advised that some adjustments are made to do so safely. Despite these being a strong argument in favour of EV deployment in Sweden, not much has happened with this proto-infrastructure yet.[19]

[18] www.iea.org/textbase/nppdf/free/2013/sweden2013_excerpt.pdf
[19] Elforsk 2010, Laddningsinfrastruktur – Marknadsinventering och rekommendationer, http://www.elforsk.se/Programomraden/Omv--System/Rapporter/?rid=10_60_

3.7 Norway

The Norwegian national government is an important stakeholder in the realization of the public recharging infrastructure. It provides funding for the actual chargers and it has defined a national strategy for the deployment of the infrastructure. This strategy implies that the larger cities focus on regular charging and that fast-chargers are used to create EV corridors between the cities. Since 2009 there's been a 7 million Euro support program for regular chargers to support municipalities and businesses in their investments. About 4 thousand Euros were available per charger. Private consumers were thus excluded from this.
For fast chargers, 25 thousand Euros are available for the first chargers and half of that amount for subsequent chargers at the same location[20]. All stakeholders (again with the exception of private consumers) can apply for these subsidies. In many cases, local governments have applied for these funds and have thus invested in charging equipment. National government's current focus on fast chargers relates to the large distances between Norwegian cities and the notion that regular chargers are not appropriate to support drivers on these stretches.
As the nation's capital, Oslo is by far the most active city in Norway when it comes to supporting EVs. To complement a set of (financial) incentives to EV drivers, the city has funded 500 charging stations and 200 more are to follow from a new tender. In contrast to other municipalities, Oslo is acts as the network operator to its own chargers. The operation is relatively easy as the stations are basic and do not have metering equipment. These are thus free to use and no membership is charged either. The next series of chargers will be 'smart', but there are no plans yet to have drivers pay for the electricity as electricity is relatively cheap due to the large share of hydropower. The city has considered letting EV drivers pay for parking, in return for free electricity, but national law demands that EVs can park for free in public space. Parking garage operators with charging spots can however include charging costs in their parking fees.
Other stakeholders do not really take an interest in the build-up and operation of regular recharging infrastructure. As these are free to use in Norway, there are no commercial opportunities yet. Also, because of the hydropower dominated electricity mix in Norway there is no need to use EVs as electricity buffers in the grid such as it considered in other countries. In contrast to solar and wind, hydropower both a reliable as well as a flexible source of renewable energy. Some stakeholders fear that the current situation will be detrimental on the long run and feel that drivers will have to pay for their electricity use in order to develop a realistic and commercially viable business model and to save energy as well. It will not be easy however to substitute all current chargers with metering-ready chargers that do enable billing.

Instead, (local) grid operators and electricity producers do take an interest in fast chargers and they have created several commercial subsidiaries that operate (regional) networks of DC fast chargers. In some cases, these companies have invested in the chargers on their own (with the help of the national subsidy scheme). In other cases they merely operate the chargers (and act as service providers) on behalf of the actual owners which are often local or regional governments. Two examples of such operators are Grønn Kontakt and EV Power.
Statoil Fuel & Retail operates 3 fast chargers at its gas stations as a pilot to learn about their usage. ZERO, a leading environmental organization in Norway, has actually offered the first of these chargers to Statoil F&R which had to pay for the installation and grid connection

[20] This amount corresponds roughly to half the costs of the charger itself and its installation. The second charger is expected to be cheaper because most of the installation costs are one-time costs per location. These costs include the ground-work needed for additional power lines and these costs obviously vary from location to location depending on the distance to the existing grid.

costs. The other two stations and a further two which are to be installed in 2013 are paid for by Statoil with help from Transnova (a governmental platform supporting environmentally friendly transport solutions). Payment takes places on a charging time basis (to prevent drivers for occupying the chargers for too long). Statoil F&R does not believe in a membership model and disapproves of flat-rate fees as they stand in the way of truly commercial operation of the chargers.

4. Cross country comparison

The country descriptions have show how the realization of public recharging infrastructures differs per country. We now conclude with a cross-country comparison in which we discuss the commonalities and differences between the countries for five specific issues. Additional tables present an overview of the, somewhat generalized, findings for each of the countries.

4.1 Task division between owners, operators, and service providers

The division of tasks between stakholders varies from country to country (see Table 1). In public space, most charging stations are either owned by municipalities or by (local) grid operators. In the case of the municipalities, these have generally commissioned other actors to operate the chargers and to act as service providers. The cities of Oslo and Stockholm are an exception to this rule, but these cities offer free electricity to their drivers and this makes it far less complex to operate the chargers. In the case of grid operators owning the equipment, an additional service provider takes care of the customers and their subscriptions and charging bills. In countries with a strict separation between grid operation and electricity production, this is required as the grid operators are not allowed to sell electricity. This is basically the case in the EU. In Norway this disintegration has not taken place in the same manner and the roughly 150 local utilities still perform both roles. Consumer are however free to choose their own electricity supplier.

In semi-public space, most chargers are owned by the local hosts such as supermarkets, restaurants, and gas stations. These stakeholders were generally supported through national subsidies or through a specific project such as the Plugged-in-Places in the UK or the Model Regions in Germany. Like the local governments, these hosts have left the operation of their charger(s) to a dedicated network operator or service providers.

In most cases, the dedicated operators and service providers do not invest in regular chargers, but only in fast chargers. The rationale behind this is that fast chargers have more commercial potential. This goes especially in countries where regular charging is (still) free, but also in general there is a greater potential profit margin on fast-charging. Norway is the only country that provides subsidies for fast charger to make the business case more attractive. It thus recognizes that fast chargers are a necessary element of the recharging infrastructure.

Statoil Fuel and Retail, BP and Total are the only gas station operators that have invested in (fast) chargers in the NSR.

Table 1 Stakeholder roles in the realization of the recharging infrastructure

Stakeholder roles	UK	Belgium	Netherlands	Germany	Denmark	Sweden	Norway
National government	Sponsor of projects	Sponsor of projects	Sponsor of projects	Sponsor of projects	Subsidies for chargers		Subsidies for chargers
Local and regional authorities	Co-financing of projects	Co-financing of projects	Investments in equipment	Co-financing of projects	Investments in equipment and provision of energy	Investments in equipment and provision of energy	Investments in equipment and provision of energy
Grid operators	No clear role	Project participant	Investments in public recharging and operation of their spots.	Project participants, operator	No clear role	Operation of some chargers	Operation of (fast) chargers
Electricity producers	Private chargers only	Private chargers only	Private chargers and public charging services	Project participants, service provider	Participate in dedicated firms	Operation of some chargers	Operation of (fast) chargers
Dedicated firms	Semi-public chargers and services	Private chargers and public charging	Private chargers and public charging	N/A	Operation and services for both public and	N/A	Operation of (fast) chargers

		services	services, fast chargers		private (fast) chargers		

4.2 Nationwide and regional networks

There is a clear difference between countries that have tried to deploy EVs as fast as possible and those countries that have opted for a more modest learning and innovation based approach. The latter countries include the UK, Belgium, and Germany. These countries have had no general support schemes for infrastructure realization and they have (knowingly) stimulated diversity in terms of technological and organizational designs. In practice this means that they have supported (regionally oriented) pilot programmes in which a variety of solutions could be tried in practice. As a result, some local lock-ins have emerged that have prevented the emergence of a national network(s) of chargers. These countries also have poor roaming options between the networks.

On the other hand, countries like Norway, Denmark, and the Netherlands have had the ambition to get as many EVs on the road as possible. They have done so for a variety of reasons and in various ways, but at least these countries have in common that nationwide networks have emerged. In the Netherlands and Denmark this was not because of a strong national support program for the infrastructure itself, but rather because EVs were strongly supported and because local governments have invested in these networks. Furthermore, the Dutch situation is unique because of the unprecedented role of the united grid operators and the resulting interoperability between virtually all regular chargers.

4.3 The role of regular, semi-fast, and fast charging in public infrastructure

The share of fast chargers in the recharging infrastructure seems to reflect a country's ambitions regarding electric mobility. Sweden and Germany for instance have little to no fast chargers installed, while Denmark and Norway have many more. This difference can be explained by the availability of governmental subsidies for fast chargers (Norway) and the presence of dedicated service providers (Demark, the Netherlands, and to a lesser extent the UK). As noted above, fast chargers are seen as a valuable addition to a charging service package. Mostly these fast chargers are hosted by highway restaurants and hotels or petrol stations. The Netherlands are quire unique in that respect with its concessions for fast chargers along the highways. These chargers are not hosted by restaurants or gas stations and will be installed on public parking grounds.

Semi-fast (i.e. three-phase power AC) chargers are especially popular in the Netherlands and Germany. This may be a result of these countries' decision in an early stage to adopt the Type 2 plug standard which enables semi-fast charging. Another reason may be that these countries also aim for relatively early commercialization of the infrastructure and the related need to install smart chargers which are capable of identifying the user and of metering the power use (which are also necessary to enable 'smart charging', see also Section 4.5). Other countries, especially the Nordic countries, do not see a need for pay-per-charge systems, and can therefore do with basic regular chargers which are often mere home sockets. In other words, the availability of cheap hydropower electricity is a disincentive to invest in a semi-fast charging infrastructure.

4.4 Flat-rate and pay-per-charge models

As noted above, the Nordic countries will continue to offer free charging and/or flat rate subscriptions. Other countries see a need to introduce pay-per-charge models to provide an inventive for market actors to invest the infrastructure and to enable them to develop profitable business models. Also, in relation to the role of EVs in future energy systems, pay-per-charge models are needed to be able to provide price incentives to trigger drivers to charge at the 'right' moments.

4.5 The role of EVs in future energy systems

Motivations of stakeholders to get involved in the recharging infrastructures differ per country. Insofar as they are truly independent, the dedicated network operators and service providers are the only actors who aim to make a profit off EV charging as such. The other stakeholders, including operators that are linked to grid operators or electricity producers, have more complex interests in relation to EVs.

To focus on the electricity industry, their interests relate strongly to the position of EVs in future energy systems. Especially electricity producers appreciate EVs as an opportunity to balance demand and supply when large shares of intermittent renewables (particularly wind and solar power) come into the mix. In such a scenario, EVs are charged in times of energy surplus and, possibly, discharged to feed back to the grid in times of low energy shortage. Even though this is a long term vision, it is part of the rationale of energy producers to invest in recharging infrastructure. The extent to which this is a relevant scenario depends however on the countries' specific electricity mix. Most vocal about this option are the Dutch and Danish electricity producers. In Norway and Sweden however this scenario is irrelevant as their electricity is produced from reliable and flexible hydropower. A more cynical perspective on such a role of EVs reveals that they can be used as well for so-called valley filling. This means that EVs are charged at night and the difference in electricity demand between night and day is reduced and effectively this implies that the base load increases and that the share of cheaper, and less flexible, sources (i.e. coal fired power plants or nuclear) can be increased.

The electricity producers are considering price incentives to achieve this and they plead for highly flexible and fine-grained differentiated electricity tariffs that can actually trigger drivers to, for instance, postpone the charging of the vehicle several hours or even days to wait for cheaper electricity. Such incentives are probably most effective in the case of home charging. Most kWh's are charged at home during the night and drivers are probably more flexible in their charging behaviour at home, as compared to ad hoc charging during a short stop in the middle of a longer trip. This is not to say though that the public recharging infrastructure can have no role in the energy system whatsoever. Many city dwellers rely on on-street charging at night when they have no private parking facilities.

5. Conclusions

The stakeholder analysis presented in this report shows that, in each of the seven countries around the North Sea, stakeholders have taken up different roles and have adopted different strategies regarding the realization of an EV recharging infrastructure. These differences relate to national and regional ambitions and subsequent policy measures, but also to the structure of the energy sector and prevalent electricity production methods. In general we conclude that ambitious countries have created conditions for the emergence of nationwide networks of regular and (semi-)fast chargers and the emergence of dedicated start-up companies. They have done so first and foremost by stimulatating EV adoption through financial incentives for consumers and businesses. Complementary support for infrastructure build-up was mostly provided by local branches of government. In these ambitious countries, enough momentum was created to trigger a wide variety of stakeholders to engage with the developments, including stakeholders that have no clear stake in the success of EVs. Less ambitious countries have concentrated their efforts in regional networks in order to realize critical mass on a local level. These countries have created conditions for technological innovation and learning, but have not created the momentum needed to realize a nationwide recharging infrastructure. In other words, not enough stakeholders have experienced a sense of urgency to engage themselves with EVs and EV infrastructures.

The sense of urgency among stakeholders relates only partly to immediate commercial opportunities. That is to say, only a handful of (start-up) companies aim to develop a business model solely on the basis of public recharging. Most stakeholders that have invested have done so either to learn about EV-related developments and to 'be ready for the future'. True commercial activities around EV recharging infrastructures are rare and these are, as said, especially seldom in the case of charging stations in public space. Instead, commercial activities are by and large focused on charging on private grounds and on semi-public locations such as restaurants. These are the locations where EV drivers have to stop anyway and where charging is not an additional burden. These are also the locations where additional financing is available from the local hosts and where installation of equipment is often less expensive because of the availability of a power line. In public space, perceived commercial opportunities are limited to fast charging stations for which EV drivers may be willing to pay a premium price. It should be noted though that none of these initiatives is profitable as such. Instead, fast chargers are either considered as long-term investments or as investments made as part of broader service packages.

Beyond commercial interests, many stakeholders recognize other opportunities presented by EVs. The most powerful argument in that respect is the potential synergy between EVs and ever increasing renewable electricity shares and many stakeholder activities aim at learning about this opportunity. These activities are however quite limited in scale and mostly focused on off-street charging.Therefore they do not add, significantly, to the realization of a public recharging infrastructure. The latter also relates to the common assumption that smart charging (i.e. charging when there is an excess of renewable power) will take place at (fast-) chargers in public space. These are the chargers that are used on an ad hoc basis and for which it is therefore difficult to realize any added value beyond the mere kWh's sold to the car.

Finally, whether or not stakeholders continue their efforts, depends mostly on the question whether national governments (continue to) support EV adoption. As long as there are cars, there will be stakeholders with an interest in developing recharging infrastructures.

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About E-Mobility NSR

The Interreg North Sea Region 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. 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.

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