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COMPARISON OF LEADING ELECTRIC VEHICLE POLICY AND DEPLOYMENT IN EUROPE

Uwe Tietge, Peter Mock, Nic Lutsey, Alex Campestrini

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International Council on Clean Transportation Europe
Neue Promenade 6, 10178 Berlin
+49 (30) 847129-102

communications@theicct.org | www.theicct.org | @TheICCT

EXECUTIVE SUMMARY

In response to rising concerns about health and climate impacts, electrifying passenger cars is seen as a key measure to reduce pollutant and greenhouse gas emissions from road transportation. Electrification of passenger cars also allows for the diversification of energy sources in the transportation sector as it allows for a shift from fossil fuels to renewable energy sources. Major obstacles to mass-market uptake of electric vehicles (EVs) are the comparatively high vehicle price, limited driving range of EVs, and limited availability of charging infrastructure. Governments around the world are therefore using a wide array of incentives, including subsidies and investments in public charging infrastructure, to make EVs more attractive to consumers.

This study investigates incentives for EVs, including plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs), in the five largest EV markets in Europe. These are, in order of passenger car market size, Germany, the United Kingdom (UK), France, the Netherlands, and Norway. These markets together account for more than 80% of all European EV registrations in 2014. The analysis covers fiscal and non-fiscal incentives at the national level and uses 10 case studies of European cities/regions to investigate how local governments can complement national incentives. The analysis focuses on fiscal incentives, charging infrastructure density, and EV market shares as key indicators of countries' readiness to transition to electric mobility. The study analyzes the diffusion of EVs at the regional level, including maps of EV market shares and charging infrastructure for each market.

Figure ES-1 plots EV shares among new car registrations in 2014 in relation to fiscal incentives and charging infrastructure availability for the five countries and 10 cities/regions studied in the analysis. Market shares, indicated by the size of the marker and given more precisely within the adjacent parentheses, are plotted on a grid defined by fiscal incentives for EVs (horizontal axis) and charging infrastructure density (vertical axis). While no statistical inference is possible from the small dataset, the figure shows that higher shares of EVs can be found in countries and cities with higher levels of fiscal incentives and charging infrastructure.

For context, approximately 0.7% of all new cars in Europe are electric, meaning many markets analyzed here were well above the European average EV uptake in 2014. In the case of Norway, where incentives and charging infrastructure are much higher, EV shares are more than an order of magnitude higher than elsewhere. Nationwide EV uptake and charging infrastructure in France in 2014 was closest to the European average, but the German EV market is at an earlier stage of development. The figure also shows that the cities typically have higher shares of EVs and a higher density of charging infrastructure than their respective countries. An analysis of non-fiscal measures helped identify the wide range of complementary incentives that are in place.

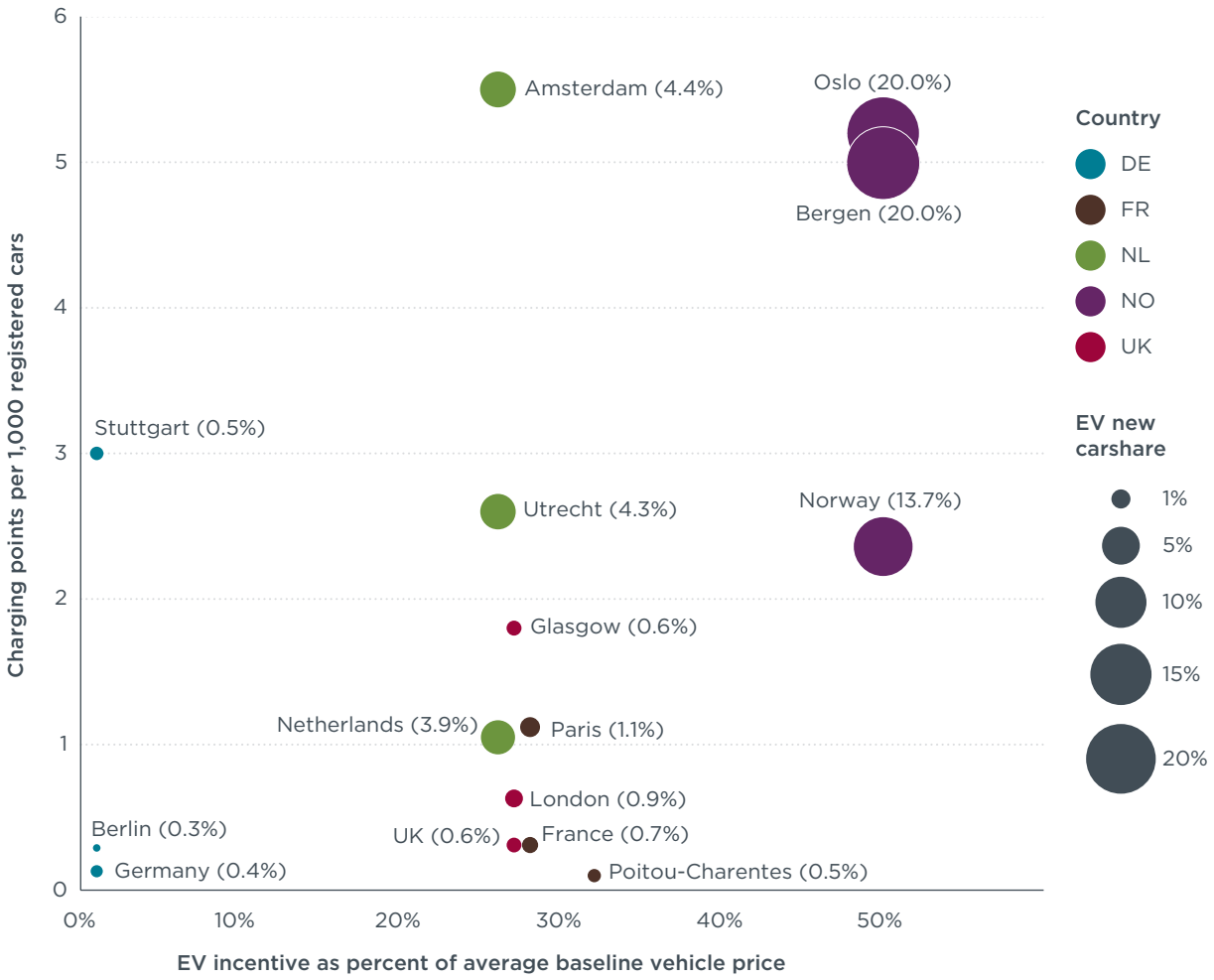

Figure ES-1. Plot of fiscal incentives for EVs and charging point density for five European countries and 10 cities/regions. The size of the marker represents the EV share of newly registered vehicles in 2014 (also presented more precisely within parentheses).

In addition to providing a snapshot of the largest European EV markets, this study identifies effective incentives for driving the uptake of electric vehicles:

» Direct consumer incentives: Substantial fiscal incentives are the most important driver of EV uptake. Countries and cities with high fiscal incentives have been more successful at transitioning to electric mobility. Among the countries in the comparison, Norway has the highest fiscal incentives and EV market shares while the opposite is true for Germany. Nevertheless, for the UK, France, and the Netherlands, the relationship between fiscal incentives and EV market shares is less clear, indicating that other factors must be considered as well.

» Indirect consumer incentives: Fiscal incentives alone are not sufficient to ensure uptake. Promotional activities are needed to create consumer awareness. Promotional activities such as preferential access to low-emission zones or high-occupancy vehicle lanes, electric car sharing platforms, introducing EVs into public fleets, and consumer outreach events are common and effective measures to raise awareness of electric mobility. For instance, EV deployment in the cities of Bergen, Oslo, and Utrecht – where a greater number of EV promotional actions are in

place — substantially exceed their nations' average EV market shares. It should be noted that EV sales mandates were not studied in the context of the five European countries, but have been effective in the California (U.S.) market at low public cost.

- Charging infrastructure: Availability of charging infrastructure is another prerequisite for electric mobility because it helps overcome range anxiety. Countries with dense public charging infrastructure were found to have higher EV market shares, though other factors such as availability of fast charging infrastructure and opportunities to charge at home should also be considered.
- Policy design: Information on incentives and electric mobility should be transparent and easily accessible because consumer awareness is a prerequisite for electric mobility. When designing policies, governments should take into consideration the financial sustainability of the policy, because stable incentives and secure funding ensure planning security and signal long-term support for EVs. By implementing strong countrywide incentives and developing national strategies for implementation, governments can ensure cohesiveness of EV incentives. Regional and city-level policies can complement national policies and tailor incentives to local needs.

This comparison of European markets provides examples of effective EV incentives that can inform policy decisions inside and outside of Europe. Most major vehicle markets around the world have incentives for EVs in place or are considering introducing incentives. Even though the EV markets and policies are in their nascence, some good practices, such as the the effective incentives outlined in this study, are beginning to emerge. These insights help avoid policy missteps in the future. Despite a growing body of literature on EV policy design, more research is needed on the cost effectiveness of various incentives.

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ABBREVIATIONS

ACEA	European Automobile Manufacturers Association
ADAC	Allgemeiner Deutscher Automobil-Club
AVERE	European Association for Battery, Hybrid and Fuel Cell Electric Vehicles
BEV	Battery electric vehicle
BMW	Bayerische Motoren Werke
CIA	Central Intelligence Agency
CO_2	Carbon dioxide
DC	Direct current
DE	Germany
EDF	Électricité de France
EEA	European Environment Agency
EMR	Electromobility Model Regions
EU	European Union
EUR	Euro
EV	Electric vehicle
EVUE	Electric Vehicles in Urban Europe
FR	France
GADM	Database of Global Administrative Areas
GBP	British Pound
GDP	Gross domestic product
GHG	Greenhouse gas
HOV lane	High-occupancy vehicle lane
IA-HEV	Hybrid & Electric Vehicle Implementing Agreement
ICCT	The International Council on Clean Transportation
MRA-E	Metropolregio Amsterdam elektrisch
NL	Netherlands
NO	Norway
NOK	Norwegian Krone
NO_x	Nitrogen oxides
OLEV	Office for Low Emission Vehicles (UK)
PHEV	Plug-in hybrid electric vehicle
PM	Particulate matter
SLAM	Schnellladenetz für Achsen und Metropolen
SUV	Sport utility vehicle
UK	United Kingdom
ULEV	Ultra-low emission vehicle
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
US EPA	United States Environmental Protection Agency
VAT	Value added tax
VW	Volkswagen
ZEV	Zero-emissions vehicle

1 INTRODUCTION

Europe's transportation sector is a key contributor to global climate change and local air pollution. Since 1990, carbon dioxide (CO_2) emissions from European road transport have increased by 17%, making road transport the only major sector that has seen an increase in greenhouse gas (GHG) emissions during this time. Road transport now accounts for roughly one fifth of the EU's GHG emissions (UNFCCC, 2015). The transportation sector is also a significant source of particulate matter (PM) and the main source of nitrogen oxides (NO_x) in Europe (EEA, 2014). Europe is facing air quality issues: 21% of the urban EU population lives in areas with PM levels considered unsafe while 8% of urban populations are exposed to unsafe NO_x levels.

Electrifying passenger cars, and thus reducing tailpipe emissions, is seen as a key measure to curbing GHG emissions and to ensuring a healthy environment for the European population. Automakers and governments alike therefore are vying for the pole position in electric mobility. Automakers are increasingly making bolder statements about their efforts at increasing their manufacturing scale, increasing their models' electric ranges, and reducing technology costs regarding their next-generation electric vehicles (Lutsey, 2015b). Several studies indicate that electric vehicles may be one of the key actions to meet transport climate change stabilization goals in the transport sector (e.g., see Creutzig et al., 2015; Lutsey, 2015a). Responding to this, many governments, including those of the Zero-Emission Vehicle Alliance, have committed to many actions to accelerate the shift to all electric vehicle sales by 2050 (The International Zero-Emission Vehicle Alliance, 2016). Numerous European governments, including Germany, France, the Netherlands, and the United Kingdom (UK), have introduced targets for their electric vehicle (EV) fleet. Many countries have also offered a wide range of incentives, ranging from fiscal incentives such as purchase subsidies to less tangible measures such as granting EVs access to bus lanes.

EV sales have been steadily increasing (see Figure 1). Electric vehicle sales in the EU have increased from hundreds in 2010 to more than 90,000 per year in 2014. As shown in the figure, about 60% of 2014 electric vehicle sales are all-electric battery electric vehicles (BEVs) and the rest are plug-in hybrid vehicles (PHEVs). Also shown in the figure, the markets of Germany, the UK, France, the Netherlands, and Norway make up more than 80% of the European 2014 new electric vehicle market. Even with the steady growth in sales, electric vehicles still only make up 0.7% of the EU new car sales in 2014. Frequently cited reasons for the slow uptake are the limited driving range and comparatively high price of EVs. Policies, incentives, and the growth of charging infrastructure are helping to make existing first-generation electric vehicles more viable for consumers.

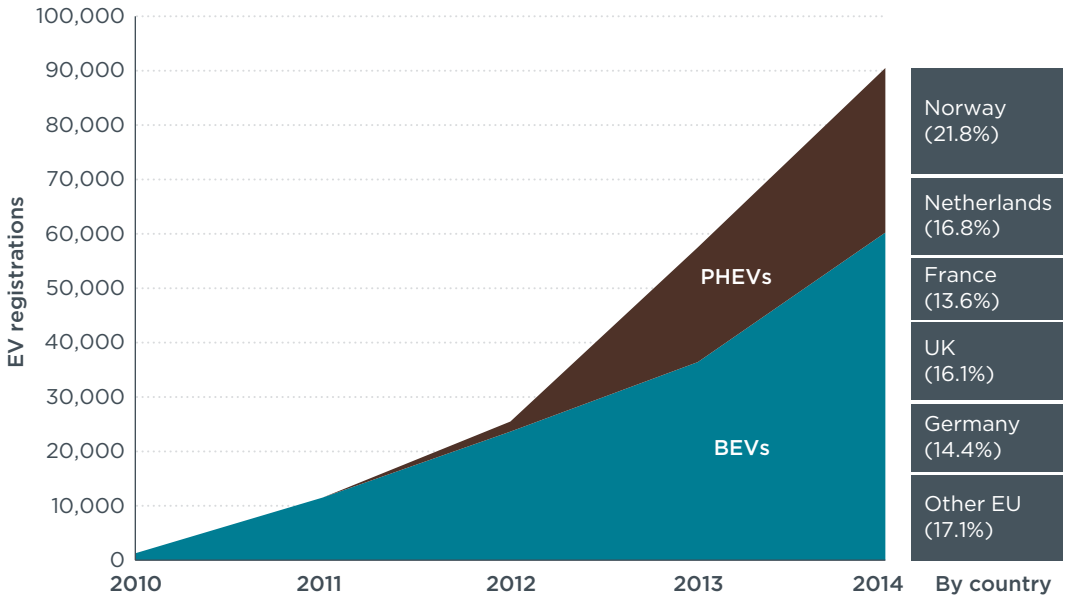

Figure 1. New registrations of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) in Europe, by year and country (Data from ICCT, 2015; Opplysningsrådet for Veitrafikken AS, 2016; Statistisk sentralbyrå, 2015a).

1.1 OBJECTIVE AND SCOPE

The overarching objective of this report is to identify policies to accelerate the electric vehicle market uptake. To identify effective policies, key policy measures at European, national, and city/regional levels are assessed and compared. The analysis focuses on five European countries selected as representing the five largest European EV markets in terms of 2014 sales. They also include the three largest European car markets. In order of car market size, they are: Germany (DE), UK, France (FR), Netherlands (NL), and Norway (NO). Figure 2 highlights how these five countries, ranging from roughly 13,000 registrations in Germany to about 20,000 registrations in Norway, greatly exceed other European countries in electric car deployment. The basis for the selection was to focus the analysis on the largest overall electric vehicle markets (i.e., by sales and share) and also to include a range of local and national markets with varying electric vehicle promotions in place to better discern links between policy action and market development.

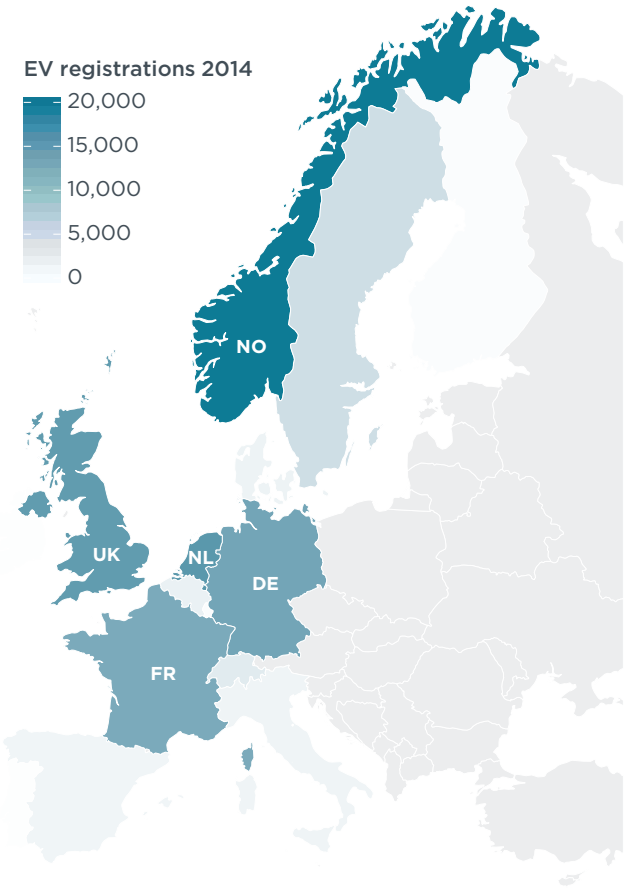

Figure 2. Number of new electric vehicle registrations in 2014 in European countries (Data from ICCT, 2015).

For each country, two cities were investigated as case studies. These case studies illustrate how national policies impact regional EV markets and show how regional governments can complement national EV incentives with local schemes. The key criteria for the selection of cities for the case studies are the size of the local EV fleet, the availability of local incentives for EVs, and the economic and political significance of each location in the context of the European and national vehicle markets. The case studies include many of Europe's largest cities and include several of the continent's leading electric vehicle markets. Figure 3 depicts the total number of new 2014 electric vehicle registrations in those 10 cities. Markets with lower electric vehicle sales, like Paris and Berlin, had less than 1,000 new registrations, whereas Europe's largest local electric vehicle market, Oslo, had approximately 12,000 new registrations in 2014.

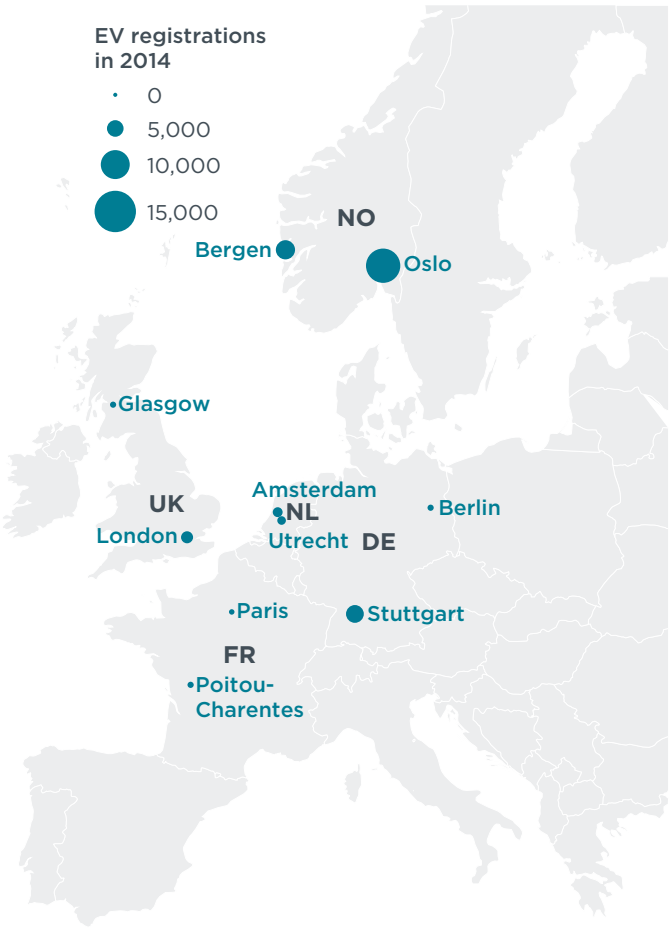

Figure 3. Number of new electric vehicle (BEVs and PHEVs) registrations in 2014 in the 10 European cities/regions selected as case studies.

Various types of electric powertrains can be installed in a wide range of vehicles. This analysis focuses on electric passenger cars, here defined as BEVs and PHEVs, but excludes non-plug-in hybrid electric vehicles. Passenger cars account for approximately 90% of European light-duty vehicles, so the study pays more attention to cars than vans or other vehicles. The analysis covers incentives for both private and company cars. Company cars are a common job benefit, or "benefit in kind," in many European countries and represent roughly half of new car registrations in Europe (Næss-Schmidt, Winiarczyk, European Commission, Directorate-General for Taxation and the Customs Union, & Copenhagen Economics, 2010). In terms of powertrain technologies, fuel cell vehicles may play a role in the future of electric mobility; however, fuel cell vehicles and hydrogen refueling infrastructure are in a much earlier stage of development than BEVs and PHEVs. As this study focuses on technologies currently competing for mass-market adoption, fuel cell vehicles are not discussed in detail. Because the analysis aims to identify policies that allow countries to become leading markets rather than leading suppliers of electric vehicles, the analysis focuses on incentives that drive market adoption. Measures supporting research and development of EVs are not looked at in great detail.

1.2 METHODOLOGY

Policy measures covered in the analysis fall into five categories: regulatory incentives, direct consumer incentives, indirect consumer incentives, charging infrastructure, and complementary policies. Table 1 lists incentive categories and provides examples of the policy survey framework. These incentive categories are investigated at the national and regional/city level for each of the countries and cities included in the study. For the case studies of cities, both city- and state/province-level incentives were considered.

Table 1. Categories of electric vehicle incentives covered in the analysis

Incentive Category	Fiscal/Non-fiscal	EXAMPLES
Regulatory incentives	Non-fiscal incentives	• CO_2 standards • EV sales targets
Direct consumer incentives	Fiscal incentives	• Vehicle purchase subsidy or tax incentives • Vehicle registration fee exemptions
Indirect consumer incentives	Non-fiscal incentives	• Preferential access (access to bus lanes, free or preferential parking, access to low-emission zones, etc.)
Charging infrastructure	Non-fiscal incentives	• Funding for charging infrastructure • Funding for home chargers
Complementary policies	Non-fiscal incentives	• Public procurement preference for electric vehicles • Consumer outreach and education • Research and development support

Direct incentives for electric mobility were monetized whenever possible. Policies that only provide direct fiscal incentives to subsets of EV owners (e.g., free parking for EVs, free access to toll roads) and thus are inherently difficult to quantify were classified as indirect incentives. Quantifiable direct incentives were discounted using a 6% annual discount rate. For private cars, an ownership period of six years was assumed, while the holding period for company cars was assumed to be three years. A number of incentives could not be monetized and are thus described qualitatively. For the purpose of summarizing the results, the term "fiscal incentives" applies to all incentives that could be monetized, while the remaining policies were termed "non-fiscal incentives."

In Europe, fiscal incentives for electric mobility frequently are framed as tax exemptions for EVs. Because vehicle taxes typically depend on vehicle characteristics (e.g., CO_2 emission values, engine displacement, engine power), PHEVs, BEVs, and conventional, gasoline-fueled cars were selected to represent three broad vehicle segments (see Table 2). These three segments are used in figures throughout the analysis to show the relative impact of the incentives in the various European markets. The fiscal incentive derived from tax exemptions for electric vehicles was calculated as the difference between tax levels for electric vehicles and tax levels for the baseline vehicle, which is to say a comparable conventional car in the same vehicle segment.

Table 2. Overview of vehicle models used to calculate EV incentives for different car segments. Baseline vehicle for each segment marked with an asterisk.

Segment	Model	Powertrain	CO_2 emissions (g/km)
Small	VW up*	Gasoline	95
	VW e-up	Electric	0
Medium	VW Golf 1.4 TSI BMT*	Gasoline	116
	VW Golf GTE	Gasoline plug-in hybrid	35
	VW e-Golf	Electric	0
Large	Mitsubishi Outlander 2.0*	Gasoline	157
	Mitsubishi Outlander PHEV 2.0	Gasoline plug-in hybrid	44

Lastly, as charging infrastructure is seen as a key prerequisite for EV uptake, this topic receives special attention. The metric used in the analysis is charging point density, defined as the number of public charging points per 1,000 registered passenger cars. A number of different data sources, including government websites and user-based charging point maps, were used to evaluate the charging infrastructure of the different countries.

Although the analysis attempts to focus on publically available charging infrastructure, some semi-public charging points, such as charging points that are only available to employees of a certain company, may be included in the figures.

1.3 STRUCTURE OF THE STUDY

The remainder of the study investigates EV incentives at different regional levels. The analysis first turns to EU-wide incentives for EVs and charging infrastructure. The analysis then covers incentives in five European markets and delves into two case studies for each market. The subnational units of analysis are states of Germany, regions of the UK, regions (departments) of France, provinces of the Netherlands, and counties of Norway. For the case studies, the regional definition (e.g., city, urban area, metropolitan area, city, state) varies due to differences in national classifications and data availability. The comparison of incentives and EV market shares of the different countries, regions, and cities then serves to identify effective measures to advance the uptake of electric cars. The discussion and conclusion identify effective policies for incentivizing electric mobility.

2 THE EUROPEAN CONTEXT

This section sets the scene for country-level analyses by summarizing EU-wide incentives for EVs and charging infrastructure. In addition, a brief comparison of which electric vehicles are offered in different countries investigates whether model availability may affect EV uptake.

2.1 REGULATORY INCENTIVES

Since 2009, a mandatory CO_2 standard applies to new passenger cars and light-commercial vehicles in the EU. The regulation requires each automaker to deploy low-CO_2 vehicles to meet increasingly stringent CO_2 targets. The targets allow each manufacturer to achieve varying levels of average CO_2 emissions, depending on the weight of their new vehicle fleet. On average, new passenger cars in the EU must not exceed 130 g CO_2/km in 2015 and 95 g CO_2/km in 2021. While all manufacturers must meet their CO_2 targets, the targets do not apply to individual member states. From 2009 to 2020, EU CO_2 standards will reduce average CO_2 emission values of new passenger cars by roughly 5% per year, and force new technologies (e.g., more efficient gasoline and diesel engines, electric powertrains) into the market. Norway is not a member state of the EU and introduced a more ambitious CO_2 standard for new passenger cars in 2012: By 2020, new cars must on average not exceed 85 g CO_2/km (Norwegian government, 2012). In contrast to the EU-wide CO_2 standard, the Norwegian scheme does not stipulate fiscal penalties for non-compliance with CO_2 targets.

Although increasingly stringent CO_2 targets incentivize EVs, it is widely acknowledged that the prevailing standard (i.e., 95 g/km by 2021 in EU) is not sufficient to drive large-scale commercialization of EVs. Dozens of diesel and gasoline vehicle models already meet the 2021 regulation emission levels. Numerous technical studies indicate that advanced gasoline and diesel engines as well as transmission technologies can increasingly be deployed to help the new vehicle fleet comply with the adopted target with minimal use of electric-drive technology (see Meszler, German, Mock, & Bandivadekar, 2012; Meszler, German, Mock, Bandivadekar, & Tu, 2014; Ricardo & SRA, 2011; US EPA, 2012). In practice, manufacturers will make use of different technological pathways to meet their individual CO_2 emission fleet targets. Premium brands are introducing more EVs, given the co-benefits in terms of drivability (e.g., improved acceleration performance) that help to market these vehicles, particularly in the premium vehicle segment. For mass-market brands, at least in the short term, a stronger focus on conventional combustion engine technologies is expected.

Acknowledging that the CO_2 regulations are not sufficient to ensure mass-market adoption, the EU's CO_2 regulation includes additional incentives to promote EVs. The two primary regulatory incentives used are (1) to account for BEVs and fuel cell vehicles (FCVs) as 0 g CO_2/km and (2) to increase the weighting of each low emission vehicle in the calculation of average fleet emissions by using "super credits" or "multipliers." These incentives make the deployment of EVs more compelling from a manufacturer's perspective, although they introduce some risk of reducing the overall regulatory program benefits as the share of EVs increases (Lutsey & Sperling, 2012). There are no direct EV sales requirements, such as the Zero Emission Vehicle (ZEV) regulation in California, in place in European nations.

Within the EU's passenger car targets, multipliers or super-credits are used as regulatory incentives for ultralow carbon vehicles, defined as vehicles with less than 50 g CO_2/km.

For the 2015 target of 130 g CO_2/km, the multiplier for ultralow carbon vehicles was set at 3.5 in 2012 and will be phased out by 2016. With respect to the 2021 target of 95 g/km, a second round of multipliers will be applied. These multipliers will be reduced from two in 2020 to one in 2023 (European Commission, 2014). Between 2020 and 2022, the total impact of multipliers will be limited to 7.5 g CO_2/km for each manufacturer's average fleet emissions, whereas there are no such limitations before 2020.

Within the European type-approval process based on the New European Driving Cycle, 0 g CO_2/km accounting is used for BEVs and FCVs but not for PHEVs. Emissions from PHEVs are determined by an electric drive portion, equivalent to 0 g CO_2/km, and a portion of driving when the battery is depleted. The ratio of electric drive to conventional drive in the calculation of aggregate emissions is determined by the vehicle's electric range. Although 0 g CO_2/km accounting does not apply to PHEVs, they may still qualify for super-credits as long as they emit 50 g CO_2/km or less. The vast majority of PHEVs sold in the EU during 2014 qualified for super-credits; only premium, high-performance models such as the Porsche Panamera and Mercedes S-Class PHEVs did not.

Figure 4 illustrates the effect of 0 g CO_2/km accounting and super-credit multipliers for a number of manufacturers. For example, Nissan's average CO_2 emissions would have been 118 g CO_2/km in 2014 without these incentives, but were lowered by 2% (3 g CO_2/km) due to 0 g CO_2/km accounting and 3% (4 g CO_2/km) due to super-credits. In total, the incentives for EVs reduced Nissan's average emissions by 7 g CO_2/km. The effect is strongest for Mitsubishi, with about 20% of the brand's 2014 sales being electric.

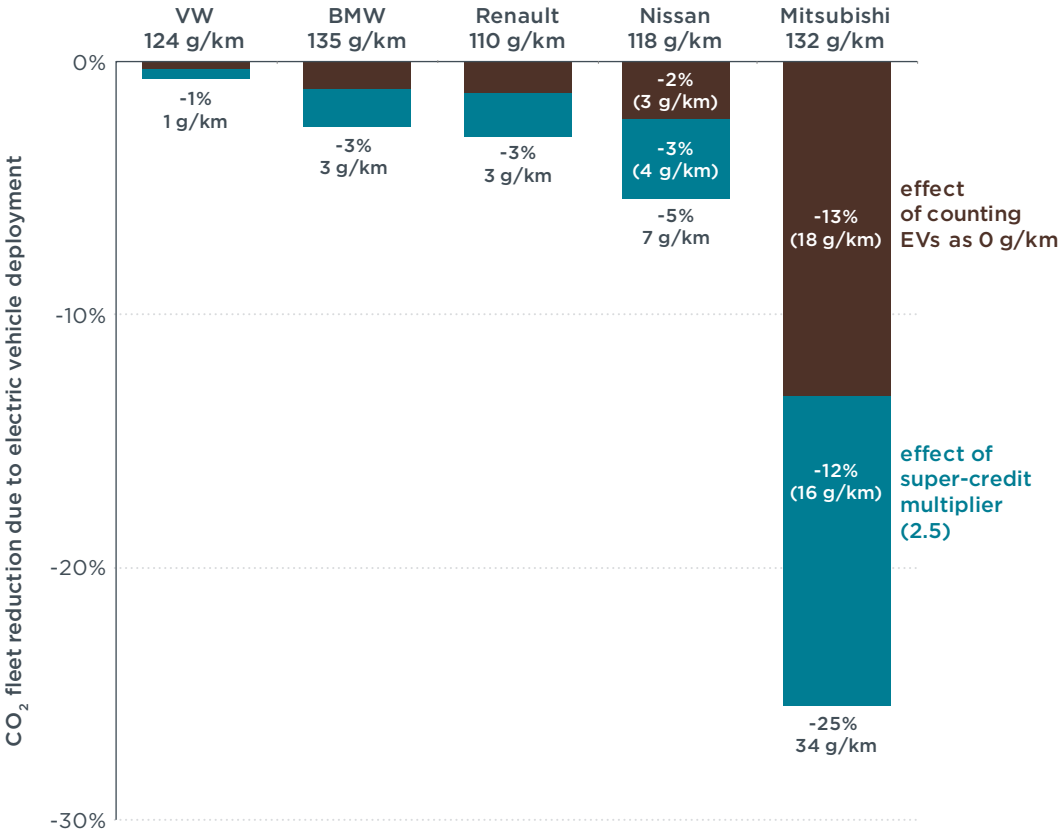

Figure 4. Effect of counting 0 g/km accounting for BEVs and FCVs and the super-credit multiplier for ultralow carbon vehicles in the EU for selected vehicle brands.

2.2 DIRECT CONSUMER INCENTIVES

A number of direct incentives are applicable at the EU member state and regional levels, as described in sections below; however there are no known direct incentives for EVs at the EU-level.

2.3 INDIRECT CONSUMER INCENTIVES

A number of indirect incentives are applicable at the EU member state and regional levels, as described in sections below; however there are no known indirect incentives for EVs at the EU-level.

2.4 CHARGING INFRASTRUCTURE

From 2007 to 2013, the EU's TEN-T program invested more than 4 million euros funding in 155 fast charging stations along main motorways in northern Europe (European Commission, 2015a). Projects under the TEN-T program typically combined EU and national funding. In addition to funding charging infrastructure, the EU also sets targets for the provision of renewable fuels for transportation. Directive 2009/28/EC, the Renewable Energy Directive, mandates that by 2020 20% of all energy consumed in the EU will come from renewable sources, and it sets differentiated targets for individual member states. The directive further stipulates that every member state should ensure that 10% of energy consumption in the transport sector is derived from renewable energy sources. In addition to biofuels, electricity from renewable energy sources used in the transportation sector counts toward this target.

The use of renewable electricity in transportation is incentivized by applying a multiplier of 2.5 in the calculation of the share of renewable energy sources in each member state's transport sector (Council of the European Union, 2009). A proposal for amendment of the Renewable Energy Directive suggests raising the multiplier to 5 for road transport (Council of the European Union, 2014). Such multipliers at the fuel cycle stage are meant to account for how electric vehicles are approximately three to four times more efficient than vehicles using combustion engines (Lutsey, 2012; Yang, 2013). Hydrogen fuel derived from renewable energy sources also counts toward the transport sector target.

2.5 COMPLEMENTARY POLICIES

There are numerous programs in the EU that aim to support research and development as well as EV manufacturing. These programs are beyond the scope of the study. The total investment of the electro-mobility research and development projects is estimated to add up to 196 million euros, with about 83% of this funding provided by the EU, and the rest being co-funding from individual member states (Zubaryeva, Panagiota, & Maineri, 2015). A majority of the projects is part of the European Green Vehicles Initiative, with vehicle manufacturers' participation.

3 COUNTRY AND REGIONAL ANALYSIS

3.1 GERMANY

3.1.1 Introduction

COUNTRY PROFILE (2014 DATA)	
Population (in millions)	80.9[a]
Size (in km²)	357,022[a]
Gross domestic product (in trillions of euros)	2.79[a]
Passenger vehicle sales	3,036,629[b]
Passenger vehicle stock (in millions)	~44.4[c]
New passenger car CO_2 emissions (in g/km)	132[b]
Passenger new vehicle market share · **Battery electric vehicles** · **Plug-in hybrid electric vehicles**	 0.3%[b] 0.1%[b]
Company car share of new registrations	63.8%[d]

[a] *Central Intelligence Agency, 2015,* [b] *ICCT, 2015,* [c] *Kraftfahrt-Bundesamt, 2015a,* [d] *Kraftfahrt-Bundesamt, 2015c*

Germany is the EU's most populous country and central market in the European economy and transportation sector. With a gross domestic product (GDP) approaching 3 trillion euros and the highest trade surplus in the world, the German economy is the largest in the EU. Germany counts passenger cars among its chief exports and is home to a large number of car manufacturers including Audi, BMW, Mercedes-Benz, Opel, Volkswagen, and the Ford Motor Company subsidiary Ford Germany. Roughly one third of all passenger cars registered in the EU in 2014 were of German origin (ICCT, 2015). As the leading economy and the most populous member state, Germany also plays a vital role in the political processes of the EU. The combination of political influence and strong car industry also implies that Germany is a key player in setting the EU's transportation policies.

German's new vehicle market stands out in a number of ways in the European context. Germany is the largest vehicle market in the EU and accounted for almost a quarter of all new car registrations in 2014 (ICCT, 2015). The German new car fleet averages rank among the largest (footprint of 4.1 m^2), heaviest (1,474 kg), and most powerful (103 kW) (ICCT, 2015). Germany also has the lowest share of electric vehicles among the five countries compared in this study. This combination of large, powerful cars and low market penetration of electric drive technologies results in high CO_2 emission levels, placing Germany near the bottom of vehicle CO_2 rankings in the EU.

Despite the slow uptake of electric vehicles, Germany has ambitious targets to become the leading market (Leitmarkt) and leading supplier (Leitanbieter) for electric vehicles (Federal Ministry of Transport, Building, and Urban Development, 2011). With approximately 50,000 electric vehicles on the road, the German government aims to introduce one million EVs by 2020 (Federal Ministry for Education and Research, 2009) and six million by 2030 (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2014). The government's strategy for electric mobility outlines EV policies during the 2011 to 2014 time period that focus primarily on readying the German EV market through demonstration projects as well as research

and development activities. Higher levels of consumer incentives are to follow in the 2015 to 2017 time frame, with mass-market adoption of EVs foreseen for 2018 to 2020 (Nationale Platform Elektromobilität, 2014).

Figure 5 shows the EV share of new registrations in 2014 in German states as well as the two German case studies, Berlin and Stuttgart. It should be noted that the map does not include PHEVs registration because PHEV registration data for German states was not publically available. The highest share of EVs was achieved in the city-state Bremen and the states Baden-Württemberg and Lower Saxony. With a 0.12% market share, Saxony-Anhalt had the lowest share of electric vehicles among German states in 2014.

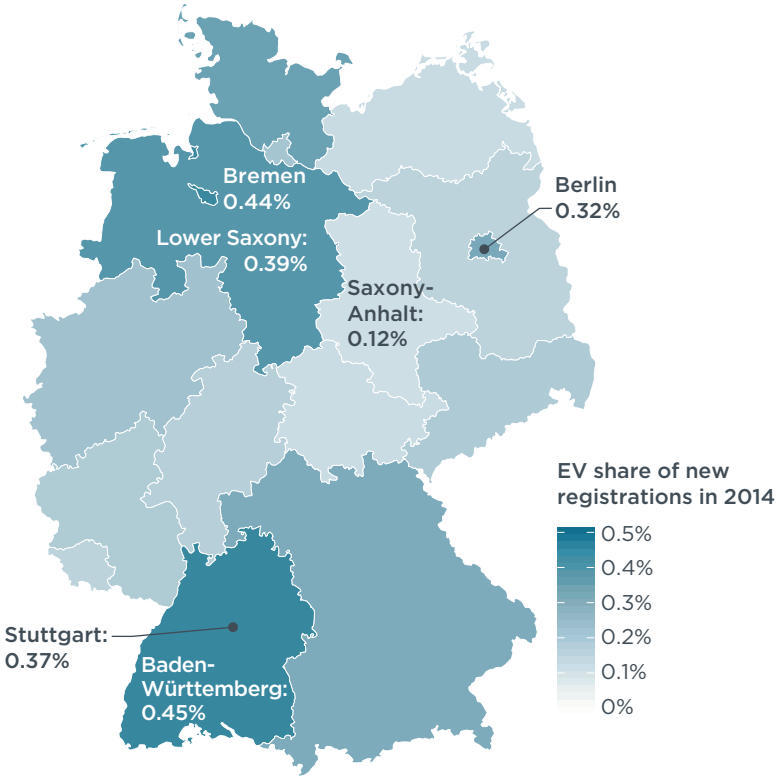

Figure 5. EV share (only BEVs) of new car registrations (2014) in the German states (source: Federal Motor Transport Authority; map: GADM).

3.1.2 Direct consumer incentives

Germany has two primary fiscal incentives in place for the purchase of EVs. First, BEVs registered before 2016 are exempted from the ownership tax for 10 years and vehicles registered between 2016 and 2020 are exempted for five years (Federal Ministry of Justice and Consumer Protection, 2015). The savings from the ownership tax exemption varies because German road taxes are calculated based on engine capacity and CO_2 emissions (see Figure 6). While PHEVs are not exempt from the ownership tax, they may still incur lower taxes as they typically have lower CO_2 emissions values.

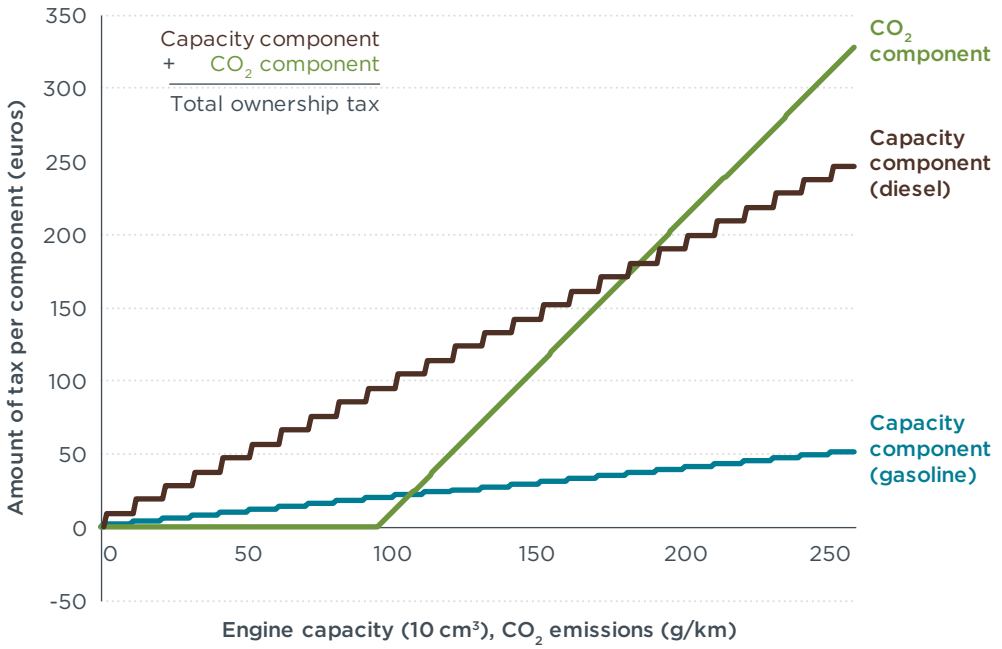

Figure 6. Amount of German ownership tax in 2015 for each tax component, including engine capacity and CO_2 emissions (ACEA, 2015).

The second incentive offered by the government applies to electric company cars. Germany levies income tax on the benefits arising from private use of company cars, which typically is calculated as adding 1% of the vehicle's list price to the monthly personal income (ACEA, 2015). Since 2013, the list price is reduced by 500 euros for each kilowatt-hour of electric energy storage included in the vehicle. This tax benefit is being reduced by 50 euros each year after 2013. At the same time, the total reduction was not allowed to exceed 10,000 euros in 2013, and this limit is being reduced by 500 euros each year. In 2015, this meant that 400 euros were deducted from the list price for each kilowatt-hour of electric storage, but this reduction could not exceed 9,000 euros. For instance, for a medium-sized BEV with a 24 kWh battery registered in 2015, the calculated reduction of the list price was 400 euros/kWh × 24 kWh = 9,600 euros, but was limited to 9,000 euros. The reduced list price was then added to the employee's income and was subject to income taxes.

A number of other direct consumer incentives are available, but their fiscal impact is negligible. For example, BEVs are exempt from the emission inspection, which constitutes a part of the general vehicle inspection. This exemption reduces inspection costs by approximately 20 euros per year. Other examples of direct incentives are difficult to quantify: Through its development bank KfW, the German government offers low-interest loans for companies intending to purchase an electric vehicle with CO_2 emissions less than 50 g/km or more than 40 km electric range (KfW, 2015). The loan can amount to the full list price of the vehicle and interest rates can be as low as 1%, although the specific conditions are contingent on the loan duration, company size, and other parameters. Examples of direct consumer incentives at the state- or city-level are covered in section 3.1.6.

Figure 7 summarizes direct consumer incentives for EVs in Germany. The vehicle list price and the value added tax (VAT) account for the vast majority of costs for all vehicles. In

comparison, the ownership tax over a period of six years amounts to less than 5% of the costs. For EVs, the ownership tax exemption reduces total discounted costs from approximately 100 euros for small vehicles to 650 euros for larger vehicles over a six year period, but is not enough to offset the higher VAT for electric vehicles. The ownership tax exemption is particularly low for small vehicles, where the BEV costs more than twice as much as its gasoline-powered counterpart. For company cars, the reduction of the taxable income is typically not sufficient to offset the higher list price of BEVs and PHEVs so that electric vehicles typically yield higher income taxes than comparable vehicles with conventional powertrains. In short, while tax exemptions are granted to private and company cars with electric powertrains, consumers typically still pay higher taxes for EVs than they would by purchasing a conventional vehicle. As a result, German consumers have little to no direct incentives to purchase an electric vehicle.

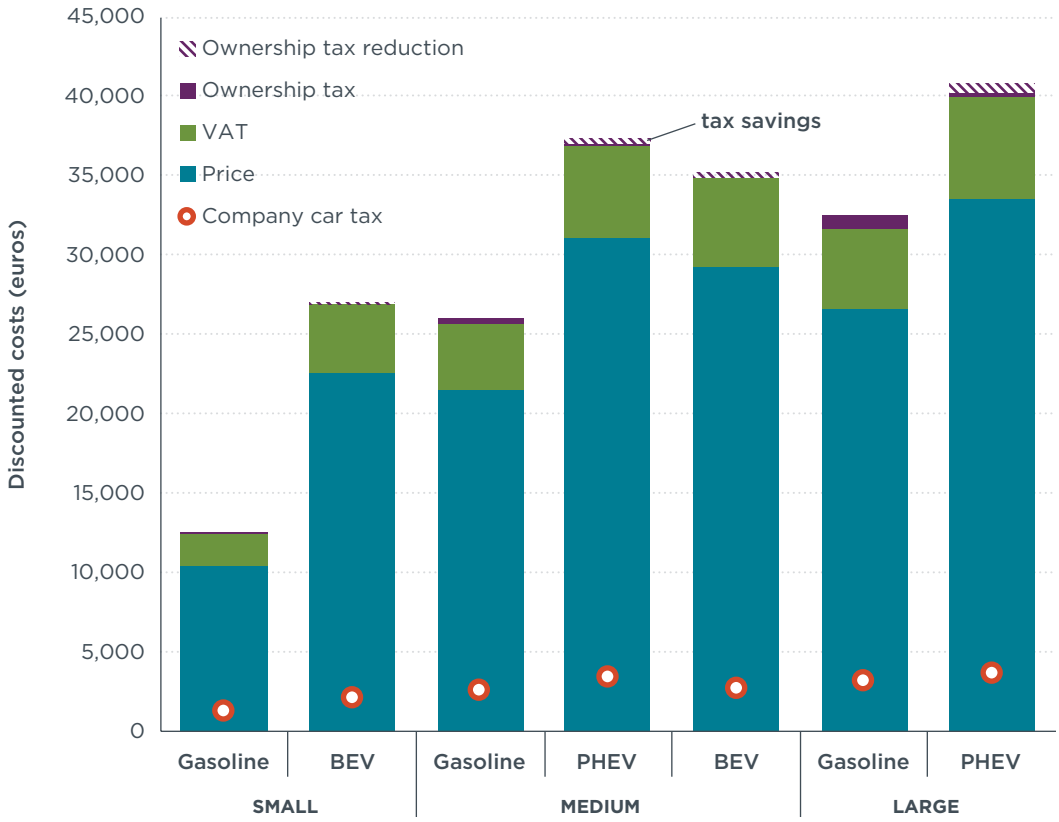

Figure 7. Summary of direct EV incentives in Germany for different vehicle sizes and powertrains.

3.1.3 Indirect consumer incentives

Germany introduced its federal electric mobility regulation (Elektromobilitätsgesetz) in June 2015. With the introduction of this regulation, municipalities can grant special privileges to low emission vehicles, defined as vehicles that do not exceed 50 g CO_2/km or have an electric range of 40 km or more. Special privileges that may be granted include preferential or free parking, access to high-occupancy vehicle (HOV) lanes, and access to restricted traffic zones (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2014a). In order to facilitate the enforcement of the law and to increase the visibility of electric vehicles, electric cars will receive a special license plate ending with the suffix "E". Because the regulation devolves the

implementation of privileges to municipalities, it does not ensure that incentives are actually introduced. The local implementations of the electric mobility regulation are covered in the case studies in section 3.1.6. The regulation is set to expire by mid-2030.

3.1.4 Charging infrastructure

Figure 8 depicts the density of public (non-residential) charging points in German states and in the Berlin and Stuttgart case studies. On average, 0.19 public charging points are available for every 1,000 cars registered in Germany. Berlin, Baden-Württemberg, and Hamburg have the highest concentrations of chargers among German states, while Saarland is the state with the lowest charging point density, according to available data.

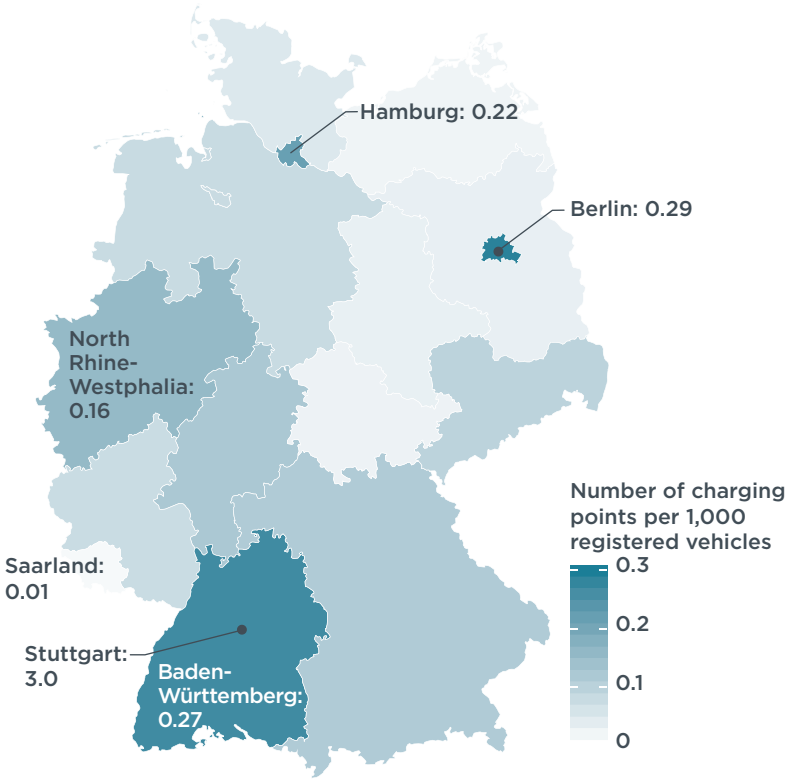

Figure 8. Number of charging points per 1,000 registered vehicles in German states (source: ADAC, 2015; map: GADM)

Funding for electric vehicle charging infrastructure primarily relies on private-public partnerships. A number of projects in the Electromobility Model Regions and the Showcase Regions for Electric Mobility (see section 3.1.5) include financing of charging infrastructure. For instance, more than 90 million euros of public funding and 80 million euros of private financing were invested in charging infrastructure in the Electromobility Model Regions (Lutsey, Chambliss, Tietge, & Mock, 2015). While these projects operate on a local scale, the SLAM (*Schnellladenetz für Achsen und Metropolen*) project uses federal funds (9 million euros) and private funds to finance the construction of 400 direct current fast charging outlets in metropolitan areas and along main motorways by 2017 (Federal Ministry of Economic Affairs and Energy, 2014).

3.1.5 Complementary policies

Germany has implemented a wide range of complementary policies that predominantly focus on demonstrating suitability of electric mobility for everyday use. These measures include government projects showcasing electric mobility concepts, research and development support for vehicle manufacturers, and government fleet targets and procurement incentives.

The German government introduced two programs that promote electric mobility, both of which combine government and industry funding and expertise. The Electromobility Model Regions is a funding program that supports cross-sectoral development of electric mobility concepts in a number of regions in Germany. The program includes more than 100 projects that focus on making electric mobility suitable for everyday use (National Organisation Hydrogen and Fuel Cell Technology, 2015a). These projects combine government funding ~140 million euros between 2011 and 2014) and industry funding. In a second program, four Showcase Regions for Electric Mobility bring together public funding of approximately 180 million euros and private funding of approximately 120 million euros. The funding flows into roughly 90 projects, in turn consisting of more than 300 activities, which investigate technical and societal barriers to the uptake of electric mobility. Both the Electromobility Model Regions and the Showcase Regions for Electric Mobility emphasize research and development activities and provide funding for research related to customer acceptance, technology deployment, and charging behavior, among other topics.

The German government introduced a nonbinding electrification target for its vehicle fleet, stating that 10% of new government vehicles should have CO_2 emissions lower than 50 g/km (Federal Ministry for Education and Research, 2011). Germany provides an incentivize for the procurement of low-carbon government vehicles by raising the limit on expenditure for vehicles from 15,500 euros to 23,500 euros for low-carbon cars with a rated engine power below 70 kW and from 28,900 euros to 33,500 euros for low-carbon cars with a rated power between 70 and 150 kW.

3.1.6 Case studies

Berlin and Stuttgart were selected as case studies for Germany. Both cities are home to a wide range of projects related to electric vehicles and are part of the Electromobility Model Regions and Showcase Regions for Electric Mobility programs.

3.1.6.1. City-state Berlin

CITY PROFILE	
Population	3,375,222[a]
Size (in km²)	~892[a]
Registered vehicles	1,165,215[b]
Registered electric vehicles (BEVs only)	849 (0.07%)[b]
Charging points	~340[c]

[a] Statistisches Bundesamt, 2014, [b] Kraftfahrt-Bundesamt, 2015a; no PHEV registrations data available
[c] ADAC, 2015

Description

Berlin is the capital of Germany and the country's largest city. In contrast to Stuttgart, the city-state is not known for its car industry — only Daimler manufactures cars in Berlin. Among major German cities, Berlin ranks lowest in terms of vehicle density, with approximately 0.35 registered vehicles per capita.

In 2015, Berlin formulated its binding climate mitigation target, aiming to reduce CO_2 emissions by 20% by 2020, 30% by 2030, and 85% by 2050 against a 1990 baseline (State of Berlin, 2015). The transportation sector accounts for 23% of the city's GHG emissions, with the vast majority coming from road transportation (Senatsverwaltung für Stadtentwicklung und Umwelt, 2014). Electric mobility has therefore been recognized as a key measure in Berlin's efforts to reduce CO_2 emissions.

Figure 5 shows that less than 1% of cars registered in Berlin in 2014 were BEVs. Data for PHEVs was not available. At the end of 2014, approximately every 1,000th car registered in the city was a BEV. In terms of charging infrastructure, Berlin has approximately 0.29 charging points per 1,000 registered cars, which is the highest density of charging infrastructure among German states, though the density is considerably lower than the city of Stuttgart's 2.5 charging points per 1,000 cars.

National policies

Berlin and its neighboring city Potsdam are one of the Electromobility Model Regions. As part of the funding program, a car sharing program including 75 hybrid and electric vehicles was funded by the German government (~5 million euros) and industrial partners (~3 million euros) (National Organisation Hydrogen and Fuel Cell Technology, 2015a). Another project introduced three light commercial vehicles and two heavy-duty vehicles as part of commercial fleet testing. Other projects in the Electromobility Model Region program predominantly focus on research and development activities.

Berlin and Brandenburg, the state that surrounds Berlin, are also part of the Showcase Program. The showcase includes approximately 30 projects covering a wide range of activities related to consumer outreach, charging infrastructure, and vehicle technology, among others. Taken together, the Showcase Berlin-Brandenburg combined 34 million euros of industry funding with 36 million euros of federal and 20 million euros of state funding. The projects are expected to culminate in approximately 1,000 charging points and 900 electric vehicles (Berlin Agency for Electromobility, 2014). With funding from the Showcase Program, the state governments of Berlin and Brandenburg also aim to ensure that 10% of new government vehicles use electric powertrains.

Regional Policies

The project InitiativE BB provides funding for EVs in Berlin and Brandenburg. Companies, government agencies, and private individuals can apply for subsidized leasing rates for BEVs and PHEVs at the Berlin Agency for Electromobility. The project covers 45% of the costs arising from the electrification of the vehicle, which is to say the additional cost of a BEV or PHEV compared to a conventional passenger vehicle. The stated goal is to introduce 500 EVs by the end of 2016. The project relies on funding from the Federal Environment Ministry, Berlin's chamber of commerce, a number of local guilds, and other organizations.

3.1.6.2. City of Stuttgart, state of Baden-Württemberg

CITY PROFILE	
Population	597,939[a]
Size (in km²)	~207[a]
Registered vehicles	288,622[b]
Registered electric vehicles (BEVs only)	1,061 (0.37%)[b]
Charging points	~860[c]

[a] Statistisches Bundesamt, 2014, [b] Kraftfahrt-Bundesamt, 2015b ; no PHEV registrations data available, [c] ADAC, 2015

Description

Stuttgart is the sixth largest city in Germany and Baden-Württemberg's largest city and capital. Stuttgart has a rich tradition of automotive engineering and is home to the headquarters of Mercedes-Benz and Porsche as well as automobile component suppliers Bosch and Mahle. The city introduced its climate action plan Klimaschutzkonzept Stuttgart (KLIKS) in 1997. The overarching goal to reduce CO_2 emissions was translated into 10 action points in 2007, one of which focuses on environmentally friendly transportation (Schuster, 2007). Among major German cities, Stuttgart ranks first with regard to vehicle density with approximately 0.58 registered passenger vehicles per capita. With more than 800 charging points, or approximately 3.0 charging points per 1,000 registered vehicles, the city also outclasses other major German cities such as Berlin and Hamburg (see Figure 8).

National policies

Stuttgart is one participant in the Electromobility Model Regions funding program. As part of the Electromobility Model Region Stuttgart, three projects combined 1.8 million euros of private funding with 3.8 million euros of public funding to construct roughly 80 charging stations in the Stuttgart region (National Organisation Hydrogen and Fuel Cell Technology, 2015b). In addition, approximately 20 electric passenger vehicles and 170 electric light commercial vehicles were acquired as part of two projects of the Electromobility Model Region.

Projects of the Showcase Region Baden-Württemberg address charging infrastructure and car sharing in Stuttgart. From 2012 to 2013, 500 charging points were constructed during Showcase Region project ALIS (Aufbau Ladeinfrastruktur Stuttgart und Region) (LivingLab BWe mobil, 2015). In collaboration with the Showcase Region, the car sharing platform car2go introduced 500 electric passenger cars, though no public funding was made available (e-mobil BW, 2014). Other projects of the Showcase Region Baden-Württemberg focus on electric mobility at the state level rather than focusing on the city of Stuttgart. For example, one project provided 6.8 million euros funding for the introduction of electric vehicles and hybrid vehicles in the government fleet of Baden-Württemberg with the goal of reducing the fleet's average to 130 g CO_2/km by 2015.

Regional policies

Outside of the two national funding platforms, Stuttgart also grants special privileges to electric vehicles by issuing special parking permits (Sonderparkausweis) to electric vehicles. Using these permits, electric vehicles benefit from free parking on public

parking lots in the city region until the end of 2017 (Amt für öffentliche Ordnung Stuttgart, 2015).

3.1.7 Summary

Table 3 summarizes EV incentives available in Germany. National direct incentives include tax exemptions for private and company electric vehicles, while decisions on indirect incentives for electric mobility are generally left to municipalities. Two prominent programs, the Electromobility Model Regions and the Showcase Regions for Electric Mobility, support research and development of electric mobility and serve to raise consumer awareness. The cities of Berlin and Stuttgart are part of these programs and have implemented few incentives outside of the programs. Charging infrastructure and car sharing projects of the Electromobility Model Region Stuttgart and the Showcase Region Baden-Württemberg also explain in part the comparatively high density of charging infrastructure and electric vehicles in Stuttgart, demonstrating that local initiatives can shape the conditions for EV markets.

Table 3. Summary of EV incentives in Germany

Type	Germany	Stuttgart	Berlin
Regulatory incentives	• Non-binding target of one million EVs on the road by 2020 and six million EVs by 2030		
Direct consumer incentives	• Road tax exemption for five to 10 years for BEVs • Company vehicles: reduced taxable income • Low-interest loans for company EVs		• Reduced leasing rates through *InitiativE BB*
Indirect consumer incentives	• Municipalities can grant EVs special privileges • Special license plate for EVs	• Free parking in public parking lots	
Charging infrastructure	• Electromobility Model Regions • Showcase Regions for Electric Mobility • SLAM	• Model region projects • Showcase projects	• Model region projects • Showcase projects
Complementary policies	• Consumer outreach and R&D as part of EMR projects and Showcase Program • Increased allowable spending for government EVs • Non-binding target for government vehicles	• Consumer outreach and R&D as part of model region and showcase projects • Car sharing link with car2go through model region project	• Consumer outreach and R&D as part of model region and showcase projects

3.2 UNITED KINGDOM

3.2.1 Introduction

COUNTRY PROFILE (2014 DATA)	
Population (in millions)	64.1[a]
Size (in km²)	243,610[a]
Gross domestic product (in trillions of euros)	1.98[a]
Exchange rate (GBP to euros in 2014)	£1 ≈ €0.81[b]
Passenger vehicle sales (in thousands)	~2,476[c]
Passenger vehicle stock (in millions)	~30.5[d]
New passenger car CO_2 emissions (in g/km)	125[c]
Passenger new vehicle market share • **Battery electric vehicles** • **Plug-in hybrid electric vehicles**	 0.3%[c] 0.3%[c]
Company car share of new registrations	54.1%[d]

[a] Central Intelligence Agency, 2015, [b] Eurostat, 2015a, [c] ICCT, 2015, [d] Department for Transport, 2015a

With a GDP of 1.98 trillion euros, the United Kingdom is the third-largest economy in Europe. Only a fifth of the GDP comes from its industry, which includes car manufacturers such as Vauxhall, Mini, Land Rover, and smaller companies. The UK is also home to assembly plants of Nissan, Honda, Toyota, and Ford, among other foreign vehicle manufacturers. While the UK has fossil fuel resources, it has been a net importer of energy since 2005 due to declining reserves (Central Intelligence Agency, 2015). The government's strategy for low-emitting vehicles recognizes that electrification of road transport is a key measure to reduce dependence on fossil fuel imports and to mitigate climate change (Office for Low Emission Vehicles, 2013a).

With around 2.5 million registrations in 2014, the United Kingdom is the second-largest car market in Europe and accounts for roughly one fifth of new cars registered in the EU. The British new car fleet emits 125 g CO_2/km on average, slightly above the EU average of 123 g CO_2/km. Sales of EVs in the UK quadrupled from 2013 to 2014, though EVs still only make up 0.6% of the new passenger car market. In terms of vehicle models, the Mitsubishi Outlander and the Nissan Leaf dominated the British EV market and together accounted for more than 60% of new EV registrations in 2014 (ICCT, 2015).

Figure 9 shows EV shares of 2014 new car registrations in regions of Great Britain. Northern Ireland was excluded from the map as suitable data could not be identified. The uptake of EVs was particularly high in the two case study regions of London and Glasgow and in the regions East of England and North East England.

The UK government's vision for electric mobility is documented in its strategic plan *Driving the Future Today — A strategy for ultra low emission vehicles in the UK* (Office for Low Emission Vehicles, 2013a). This document, along with the government's package of policy measures in *Investing in ultra low emission vehicles in the UK, 2015 to 2020*, allocate 600 million pounds (~740 million euros) for the uptake of ultra-low emission vehicles between 2015 and 2020 (Department for Transport, 2015b). The policy measures focus on incentivizing the uptake of EVs, investments in charging infrastructure, and supporting national EV technology innovation. While the UK does not have an explicit sales target for EVs, the government's strategic plan for electric mobility projects is that EVs will account for 5% of car registrations by 2020 (Office for Low

Emission Vehicles, 2013a).

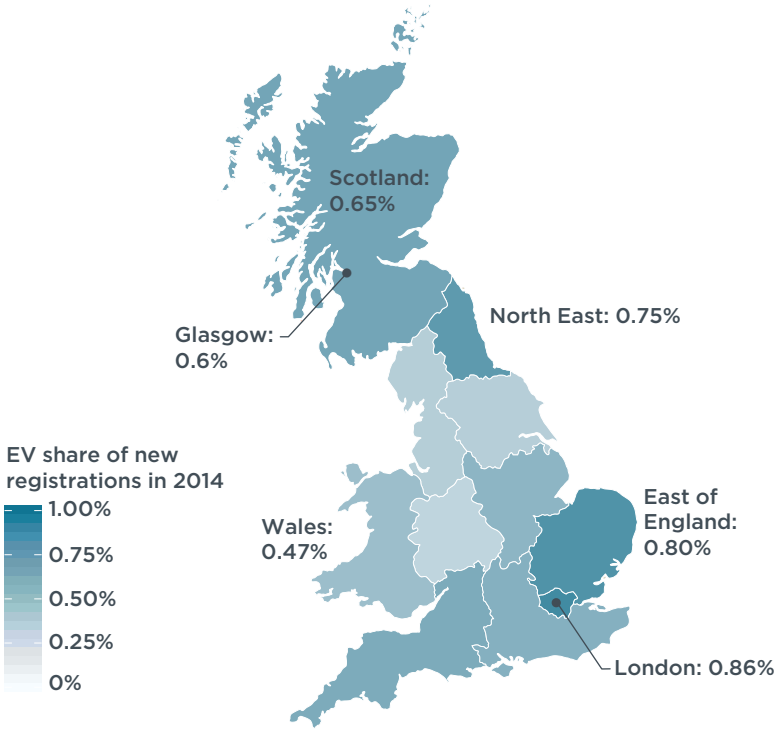

Figure 9. New vehicle market share of electric vehicles (BEVs and PHEVs) in regions of Great Britain (source: Department for Transport, 2015a, map: Office for National Statistics). Contains National Statistics data © Crown copyright and database right 2015. Glasgow data based on estimates.

3.2.2 Direct consumer incentives

In the UK three policies provide direct financial incentives for electric vehicles. These policies include the Plug-in Car Grant, CO_2-based annual ownership taxes, and reduced taxes on the private use of company cars with low CO_2 emissions.

In 2011, the Office for Low Emission Vehicles introduced the Plug-in Car Grant. This subsidy covered 25% of the eligible cars' list price up to a value of 5,000 pounds (~6,200 euros) at the point of purchase. In April 2015, the incentive was raised to 35% of the vehicle's value, but is still capped at 5,000 pounds, which benefits lower priced EVs (UK Government, 2015). Eligible cars include BEVs and FCEVs as well as PHEVs with CO_2 emissions of 75 g/km or lower (see Table 4). The Plug-in Van Grant is available for light commercial vehicles and covers 20% of the list price up to a maximum of 8,000 pounds (~9,920 euros). In late 2015, 27 car and nine van models were eligible for the grants. The Plug-in Car Grant initially was intended to cover up to 50,000 grants or a time frame up to 2017 (Office for Low Emission Vehicles, 2014c, 2015c). After the 50,000-grant threshold was reached in 2015, the scheme was extended into 2018 and the level of the grant was reduced to 4,500 pounds for category 1 vehicles while category 2 and 3 vehicles receive 2,500 pounds (Office for Low Emission Vehicles, 2015d). Two hundred million pounds have been secured for the Plug-in Car Grant for the period 2015 to 2020 (Office for Low Emission Vehicles, 2015c).

Table 4. Categories of cars eligible for the Plug-in Car Grant

Category	CO_2 emissions	Zero emission range
Category 1	< 50 g/km	At least 70 miles
Category 2	< 50 g/km	Between 10 and 69 miles
Category 3	50-75 g/km	At least 20 miles

Other direct incentives for electric vehicles are products of CO_2-based vehicle taxes. Annual ownership taxes on private cars, the so-called Vehicle Excise Duty, can reach upwards of 600 euros, but cars with CO_2 emissions of up to 100 g/km are exempt from annual taxes. A higher ownership tax applies during the first year after first registration; this tax is also reduced for low-carbon vehicles (see Figure 10). Taxes on the private use of company cars are also determined based on the vehicle's CO_2 emission value. In 2015, the taxable income derived from the private use of company cars ranged from 5% of the car's list price for vehicles with CO_2 values below 50 g/km to 37% for high-emitting cars (ACEA, 2015) (see Figure 10). A 3% surcharge is levied on cars with diesel powertrains.

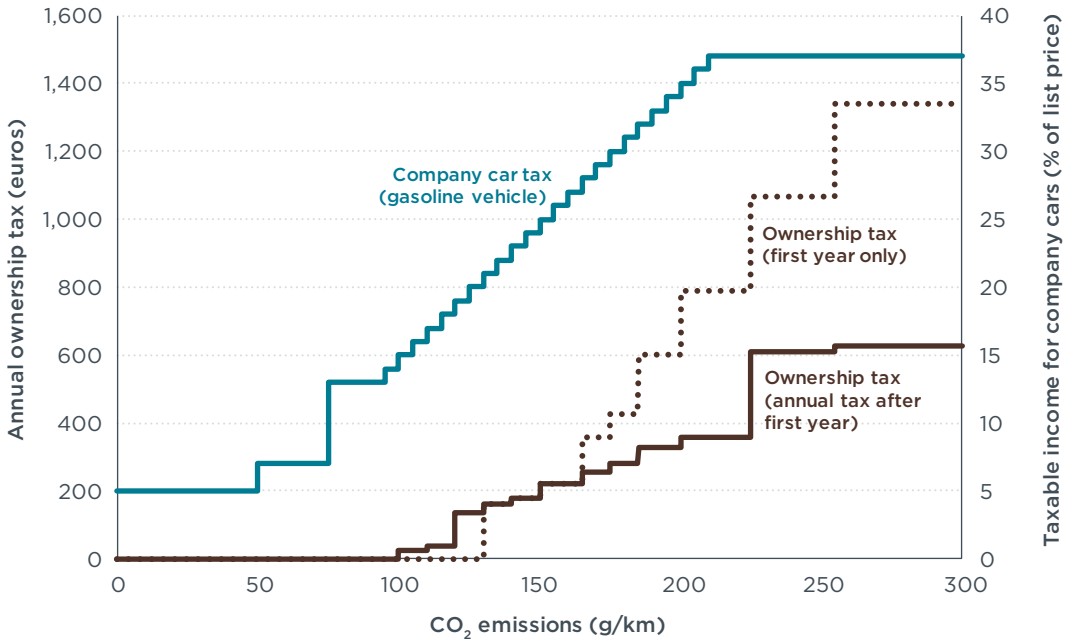

Figure 10. Left y-axis: Regular ownership tax (solid black line) and a special ownership tax levied during the first year after registration (dotted black line) for cars in the UK. Right y-axis and blue line: Taxable income for the private use of company cars as a percentage of the vehicle's list price.

Figure 11 summarizes the different direct incentives for EVs in the UK. The vehicle price and VAT are generally the most important cost components for both EVs and conventional vehicles while the ownership tax is comparatively low. In terms of fiscal incentives, the Plug-in Car Grant is the most important incentive for private cars and in some cases, such as for medium-sized PHEVs and BEVs, reduces the total cost of EVs below the cost of conventional cars. The reduced company car tax for low carbon vehicles can also offer a substantial incentive for purchasing an EV, particularly in vehicle segments with high average CO_2 emissions. For example, company car taxes

for EVs in the medium and large vehicle segments are reduced by more than 5,000 euros for EVs when compared to conventional cars. On the whole, the Plug-In Car Grant and company car tax reductions offer substantial cost reductions for EV owners and can in some instances reduce the costs of EVs below the level of a comparable gasoline-powered vehicle.

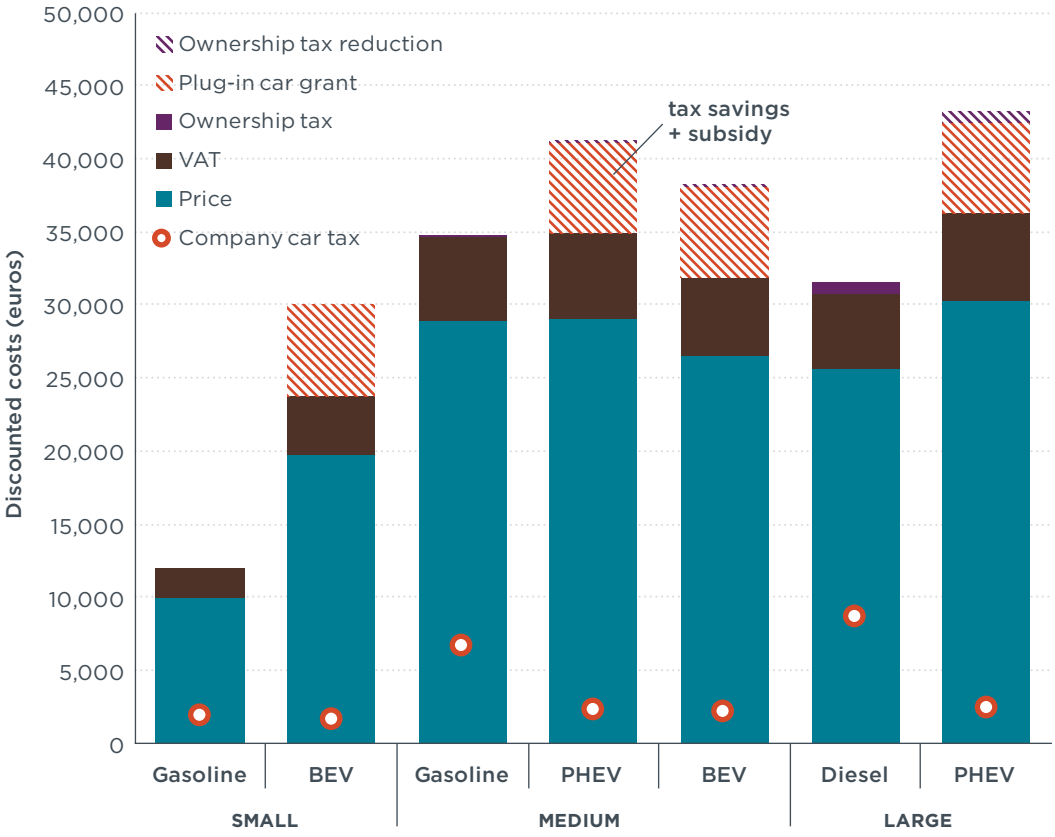

Figure 11. Summary of direct incentives for EVs in the UK for different vehicle sizes and powertrains.[1]

3.2.3 Indirect consumer incentives

Although some regional governments have implemented indirect EV incentives, no national policies have been introduced. The national Go Ultra Low City Scheme (see section 3.2.5) will promote indirect incentives at the city level.

3.2.4 Charging infrastructure

Figure 12 depicts the density of public charging infrastructure in regions of Great Britain and the two case study cities, London and Glasgow. On average, 0.31 charging points are available for every 1,000 cars registered in Great Britain. The highest concentration of charging points can be found in North East England, London, and Scotland. The two cities covered in the case studies have a comparatively high density of charging infrastructure, with Glasgow exceeding the national average by an order of magnitude. In contrast, Yorkshire & The Humber is the region with the lowest concentration of charging points in proportion to registered vehicles.

1 Because the Mitsubishi Outlander is not sold with gasoline powertrains in the UK, a comparable diesel powered variant was selected in the "Large" category.

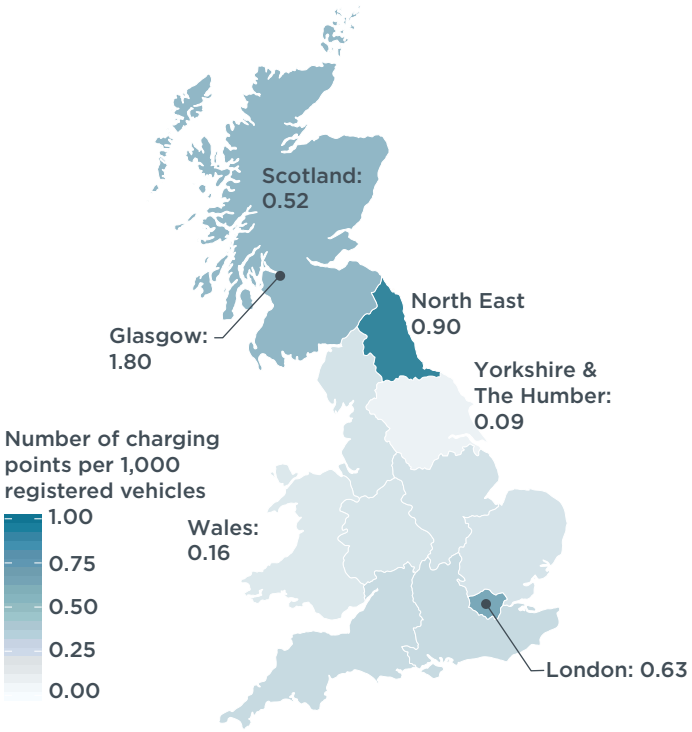

Figure 12. Number of public charging points per 1,000 registered vehicles in regions of Great Britain (source: Office for Low Emission Vehicles, 2015a; map: Office for National Statistics). Contains National Statistics data © Crown copyright and database right 2015.

The Electric Vehicle Homecharge Scheme subsidizes the installation of private chargers in the UK. EV owners can apply for this subsidy, which covers a maximum of 75% or 700 pounds (~873 euros) of the total installation cost (Office for Low Emission Vehicles, 2014a). To qualify for the grant, residents must prove that they are the registered owner or primary user of an eligible EV. The grant will continue until the end of March 2016 or until the scheme's budget is exhausted.

In addition, the Plugged-in Places program complemented the subsidy of home chargers with funding for public and semi-public charging infrastructure until 2013. Under this program, the government matched private investments in charging infrastructure with public funds. The program focused on eight regions of the UK, namely: East of England, Greater Manchester, London, Midlands, Milton Keynes, North East England, Northern Ireland, and Scotland. Three of these regions—North East England, London, and Scotland—have a distinctly higher density of charging points compared to the rest of the UK (see Figure 12). Roughly 5,500 charging points were installed through the Plugged-in Places program, 65% of which are publically accessible (Office for Low Emission Vehicles, 2013a, 2013b).

Looking forward, a total of 32 million pounds (~40 million euros) are available for charging infrastructure for the time frame 2015 to 2020. Out of the 32 million pounds, 15 million pounds (~19 million euros) are going to the Electric Vehicle Homecharge Scheme, 8 million pounds (~10 million euros) are going to public charging infrastructure, and 9 million pounds (~11 million euros) are going to other infrastructure investments (Office for Low Emission Vehicles, 2015b).

3.2.5 Complementary policies

A wide range of complementary policies supports the uptake of electric vehicles in the UK. Two policies incentivized the uptake of EVs in company fleets. The Low Carbon Vehicle Public Procurement Program ran from 2008 to 2013 and targeted public sector van fleets, providing public funding for the additional expenses of electrifying vans compared to conventional vehicles. The program introduced 700 hybrid and electric vans into 77 public sector fleets (Speers, Evans, Walsh, & Vinsome, 2015). A second policy enabled companies to make use of accelerated asset depreciation rates for low-carbon cars. While the standard rate allows for an 8% annual write-down, an 18% rate applies to cars with CO_2 emissions between 95 and 130 g/km (Office for Low Emission Vehicles, 2014b). Cars emitting 75 g CO_2/km or less can qualify for a 100% write-down.

To promote local EV incentives, the national government introduced the Go Ultra Low City Scheme, a platform that offers 40 million pounds (~50 million euros) of funding to two to four cities. The funding will be invested in various EV incentives such as bus lane access, electric car sharing support, charging infrastructure investments, parking policies, and public EV fleets (Office for Low Emission Vehicles, 2014c). Four cities, Nottingham, Bristol, Milton Keynes, and London, have been awarded funds (UK Government, 2016). Through the Ultra Low Emission Vehicle Taxi Scheme, 20 million pounds (~25 million euros) will also be made available to local authorities that support the uptake of low emission vehicles in the taxi fleet (Office for Low Emission Vehicles, 2014c).

The UK government supports low emission vehicle research and development through the Advanced Propulsion Centre, a public-private partnership focusing on developing low-carbon vehicle technologies. From 2015 to 2020, the government will provide 135 million pounds (~124 million euros) in funding (Office for Low Emission Vehicles, 2014c).

The Office for Low Emission Vehicles (OLEV) was set up to coordinate activities related to electric mobility. OLEV's website provides useful information for consumers, including guidance and calculators for EV and charging infrastructure incentives, thus playing an important role in consumer outreach and education.[2] Along with a number of car manufacturers and the UK Society of Motor Manufacturers and Traders, the OLEV also supports the Go Ultra Low campaign, a campaign aimed at raising awareness and educating consumers about electric mobility. The campaign's website (www.goultralow.com) provides information on available low-emission vehicles, ownership costs, and charging infrastructure.

Lastly, the UK government has made available 5 million pounds (~6 million euros) during 2014 to 2015 for the electrification of its own fleet under the ULEV Readiness Project. The project includes a fleet review to identify the most suitable vehicles to be replaced with EVs and then provides fully subsidized two-year lease agreements for EVs (Department for Transport, 2014).

3.2.6 Case studies

London and Glasgow were singled out as case studies due to their comparatively high share of EVs and density of charging infrastructure. The two cities were also part of the Plugged-in Places program and have implemented a wide range of local EV incentives.

2 See https://www.gov.uk/government/organisations/office-for-low-emission-vehicles

3.2.6.1. Greater London

CITY PROFILE	
Population	8,538,689[a]
Size [in km²]	1,572
Registered vehicles	2,606,060[b]
Registered electric vehicles	2,140 (0.08%)[b]
Charging points	~1,700[c]

[a] Office for National Statistics, 2015, [b] Department for Transport, 2015a, [c] Office for Low Emission Vehicles, 2015a

Description

London is the capital city of the UK and the most populous city of the European Union (Office for National Statistics, 2015). This case study focuses on the county and region of Greater London, which counts the city of London among its boroughs. London formulated its climate change mitigation and energy strategy in 2011 and targets a 60% reduction of CO_2 emissions against a 1990 baseline by 2025 (Greater London Authority, 2011). In order to meet this target and to tackle local air quality issues, London introduced its first EV strategy in 2009. The EV strategy aimed to install 25,000 charging points in London by 2015, 2,500 of which were meant to be public while the rest were intended to be semi-public and suitable for workplace charging (Greater London Authority, 2009). It also aimed to introduce 1,000 EVs in the local governments' fleet by 2015 and to increase the number of EVs registered in London to 100,000 as soon as possible. The Mayor's Air Quality Strategy further commits the city to a 100,000 EV fleet by 2020 (Greater London Authority, 2010). In order to meet this target, 15 action points were formulated in London's ultra low emission vehicle delivery plan in 2015 (Transport for London, 2015a). See the regional policies section for details.

National policies

London was one of the eight Plugged-in Places. As part of the Plugged-in Places project, the city-wide charging network Source London received 9.3 million pounds (~11.5 million euros) in funding from the Department for Transport, matching funding from a private-public consortium of partners led by the local government body Transport for London (Transport for London, 2013). Since 2014, IER, a subsidiary of the Bolloré Group, manages the Source London network, which includes more than 1,300 public charging points. London also was awarded 13 million pounds (~16 million euros) as part of the Go Ultra Low City Scheme in early 2016, which will be invested in charging infrastructure and priority parking for EVs among other measures (UK Government, 2016).

Regional policies

In addition to national incentives for EVs, London exempts most EVs from its Congestion Charge. The Congestion Charge is a 11.50 pound (~14.27 euros) fee for entering the city center during working days. Cars and vans with CO_2 emissions of 75 g/km or lower while meeting the Euro 5 emission standard are exempted from the Congestion Charge (Transport for London, 2015b). Some London boroughs also offer free or reduced parking rates for EVs (Transport for London, 2015c). For example, parking at public car parks in Westminster and the parking permit in Richmond is free. To ensure that ample charging infrastructure for EVs is available, the London Plan, London's strategic planning document,

requires that 20 percent of residential parking spaces are fitted with charging points by 2030 (Greater London Authority, 2015). Although Transport for London investigated the possibility of opening bus lanes to EVs, it found that this incentive would not prove effective at incentivizing EV ownership and could potentially disrupt public transportation operations. London also collaborates with a number of European cities in the Electric Vehicles in Urban Europe (EVUE) project of URBACT, a program that supports knowledge exchange on the topic of sustainable urban development between different cities (URBACT, 2014).

3.2.6.2. Greater Glasgow (Glasgow urban area), Scotland

CITY PROFILE	
Population	~1,200,000
Size (in km²)	370
Registered vehicles	~222,000[a]
Registered electric vehicles	165 (0.08%)[a]
Charging points	~400[b]

[a] Department for Transport, 2015a, [b] Office for Low Emission Vehicles, 2015a

Description

Glasgow is the largest city of Scotland and the fourth largest city in the UK. Greater Glasgow, or the Glasgow urban area, consists of the city of Glasgow and adjacent settlements. Glasgow's Energy and Carbon Masterplan targets a 30% reduction of CO_2 emissions by 2020 against a 2006 baseline (Glasgow City Council, 2014). As the transportation sector contributes 22% of CO_2 emissions, the promotion of EVs is seen as a key measure to curb Glasgow's climate impact.

National Policies

In addition to being one of the regions in the Plugged-in Places program, Scotland introduced a number of incentives for EVs. Through the Energy Saving Trust, Scottish businesses can apply for interest-free loans of up to 100,000 pounds (~125,000 euros) for electric cars and vans with a repayment period up to six years (Energy Saving Trust, 2015d).[3] Consumers can also apply for an interest-free, six-year loan of up to 50,000 pounds (~62,000 euros) for an EV purchase. As of March 2016, when it was scheduled to expire, the scheme's 2.5 million pound (~3.1 million euro) fund had been exhausted (Energy Saving Trust, 2015b). Public and private organizations that have a demonstrable need for on-site charging equipment can also apply for funding for chargers from Transport Scotland (Energy Saving Trust, 2015a). Lastly, the government-funded nonprofit organization Energy Saving Trust created the Electric Vehicle Network, which allows potential EV buyers to contact a network of EV owners about the everyday experience of driving EVs (Energy Saving Trust, 2015c).

Regional policies

The Glasgow City Council is funding electricity for free charging of EVs at chargers installed as part of the Plugged-in Places program (Glasgow City Council, n.d.). Parking is also free during the charging process.

3 As of March 2016, the Low Carbon Transport Business Loan is oversubscribed for 2015/16.

3.2.7 Summary

Table 5 summarizes different incentives for electric vehicles in the UK. The Plug-in Car Grant offers the greatest direct incentive for private cars while CO_2-based company car taxation can provide substantial incentives to purchase EVs as company cars. Indirect incentives are primarily part of local schemes, such as the Go Ultra Low City Scheme. A wide array of complementary policies supports research and development of electric mobility and raising consumer awareness. Both public and private charging infrastructure is subsidized or funded by the government. In addition to UK-wide incentives, Scotland also introduced a number of generous funding and loan schemes for companies and consumers, which affect the Glasgow case study. Other local incentives in the case study areas include exemptions from congestion charges, free or reduced parking for EVs, and interest-free loans for electric mobility investments.

Table 5. Summary of EV incentives in the UK

Type	UK	London	Glasgow
Regulatory incentives		• 100,000 EVs by 2020	
Direct consumer incentives	• Plug-in Car Grant: 35% of list price up to 6,200 euros • Reduced ownership tax • Low company car tax for low emission vehicles	• Vehicles with ≤75 g CO_2/km exempted from Congestion Charge	• Scotland: interest-free loan for private electric cars
Indirect consumer incentives	• Go Ultra Low City Scheme		
Charging infrastructure	• Electric Vehicle Homecharge Scheme: up to 75% or 868 euros of total cost • Plugged-in Places program up until 2013 • 40 million euros for 2015 to 2020	• Plugged-in Places: ~11.5 million euros in national funding	• Scotland: funding for companies to install charging equipment • Glasgow: free charging at chargers of the Plugged-in Place program
Complementary policies	• Low Carbon Vehicle Public Procurement Program (2008-2013) for company vans • Accelerated asset depreciation for low-carbon cars • Go Ultra Low City Scheme: national funding for urban EV initiatives • Ultra Low Emission Vehicle Taxi Scheme: 25 million euros for low-emission taxis • Advanced Propulsion Centre with 124 million euros for R&D support (2015-2020) • Go Ultra Low website for consumer education	• Free or reduced parking in some London boroughs	• Scotland: interest-free loan for electric company cars and vans • Scotland: Electric Vehicle Network: knowledge network for potential EV buyers

3.3 FRANCE

3.3.1 Introduction

COUNTRY PROFILE (2014 DATA)	
Population (in millions)	66.6[a]
Size (in km²)	551,500[a]
Gross domestic product (in trillions of euros)	2.02[a]
Passenger vehicle sales (in thousands)	~1,765[b]
Passenger vehicle stock (in millions)	~32.2[c]
New passenger car CO_2 emissions (in g/km)	115[b]
Passenger new vehicle market share **Battery electric vehicles** **Plug-in hybrid electric vehicles**	 0.6%[b] 0.1%[b]
Company car share of new registrations	not available

[a] *Central Intelligence Agency, 2015,* [b] *ICCT, 2015,* [c] *Ministry of Ecology, Sustainable Development and Energy, 2014*

With a GDP of roughly 2 trillion euros, France is the second-largest economy in Europe. The country is home to a number of vehicle manufacturers, including Renault, Peugeot, and Citroën, as well as manufacturing plants of foreign brands. The domestic manufacturer Bolloré, a small car maker exclusively focusing on EVs, claimed an 11% share of French new EV registrations in 2014 (ICCT, 2015).

France is Europe's third-largest new car market and accounted for 14% of Europe's new car registrations in 2014. With average CO_2 emissions of 115 g/km and an average vehicle mass of 1,303 kg, France has one of the most efficient and lightest new car fleets in Europe. Domestic manufacturers made up almost half of the French new car market in 2014 and more than 60% of the new electric car market. The Renault Zoe alone accounted for almost half of all EV sales during 2014 (ICCT, 2015). With roughly 12,000 EVs registered in 2014, France has the smallest EV market in the comparison, though the low carbon intensity of France's electricity production makes the country an ideal market for electric road transportation.

In 2009, the French government introduced its 14-point plan designed to drive the mass-market adoption of EVs. The plan introduced a subsidy for low-carbon vehicles (see section 3.3.2) and aims to bring 2 million EVs to French roads by 2020. The plan also combines private and public funding for charging infrastructure and set aside 1.5 billion euros to install 1 million charging points by 2015 (Green Car Congress, 2009). The French Energy Transition for Green Growth Act of 2014 reinforced the need to transition personal road transportation toward electric vehicles.

Figure 13 maps EV shares of new vehicle registrations in regions of France and the two case study regions, the city of Paris and the region Poitou-Charentes. Because data on PHEV registrations was not available at the regional level, the map includes only BEVs; on the national level, PHEVs accounted for 0.1% of new car registrations in 2014 while BEVs made up 0.6%. The region around Paris, the Île-de-France, has the highest concentration of EVs, followed by Centre and Alsace. In contrast, the island Corse has the lowest share of EVs. The city of Paris has an EV share similar to its surrounding region, while the other case study, the region of Poitou-Charentes, is near the national average with a 0.5% EV share of new registrations.

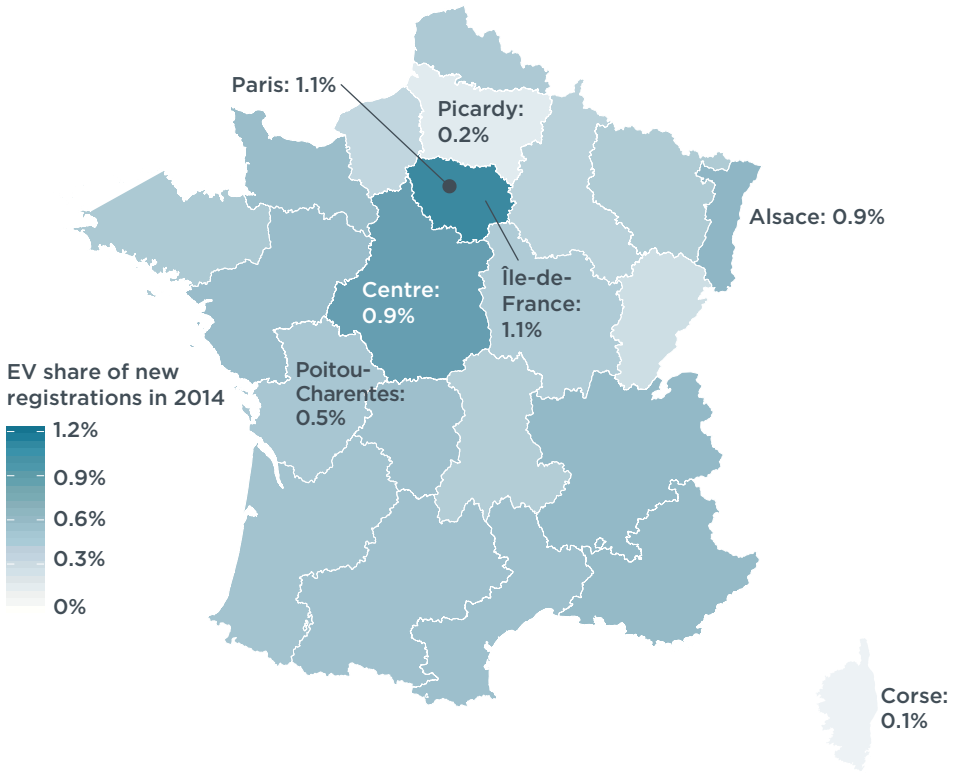

Figure 13. New vehicle market share of BEVs in French regions (source: Ministry of Ecology, Sustainable Development and Energy, 2015b; map: GADM).

3.3.2 Direct consumer incentives

There are two primary direct consumer incentives for EVs in France, namely the environmental bonus and the conversion bonus. The bonus/malus feebate tax is a mechanism that penalizes vehicles with comparatively high CO_2 emissions values (≥130 g/km) and subsidizes low-emitting vehicles (≤110 g/km). The bonus ranges up to 27% of the vehicle's list price up to 6,300 euros while the penalty can amount to 8,000 euros (see Figure 14) (ACEA, 2015). Because the tax revenue from the penalty can be used to finance the bonus, this type of feebate system can be cost neutral or even generate revenues.

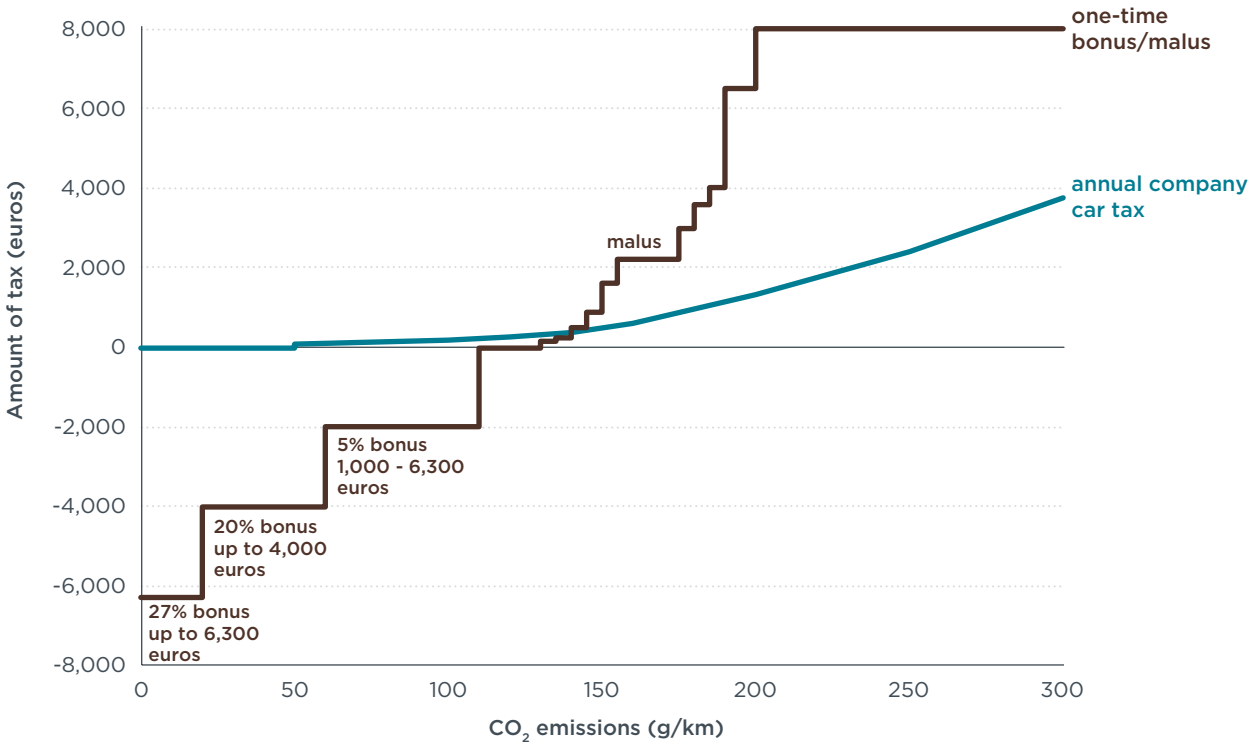

Figure 14. The feebate (bonus/malus) one-time tax and the annual company tax for cars registered in France in 2015.

Table 6. Bonus for low-carbon passenger cars in France (source: ACEA, 2015)

CO_2 emissions	Bonus in 2015
0-20 g/km	27% of list price (incl. VAT), capped at 6,300 euros
21-60 g/km	20% of list price (incl. VAT), capped at 4,000 euros
61-110 g/km (provided that the car has an electric motor that can provide an output of 10 kW for at least 30 minutes)	5 percent of list price (incl. VAT), capped at 2,000 euros but no lower than 1,000 euros

In addition to the feebate program, a "super bonus" applies to consumers scrapping old diesel cars. Consumers scrapping a diesel vehicle registered before 2001 receive a 3,700 euro subsidy when purchasing a car with CO_2 emissions of 20 g/km or less and a 2,500 euro subsidy when purchasing a car with CO_2 emissions between 21 and 60 g/km (AVERE, 2015a). The feebate and the scrappage bonuses can be combined for a maximum total subsidy of 10,000 euros.

Other than the direct subsidies offered through the feebate and scrappage systems, a number of vehicle taxes are based in part on CO_2 emissions, thus providing incentives to purchase low-carbon vehicles. Vehicle ownership taxes are solely determined by the vehicle's CO_2 emission value. For private cars, a 160 euro tax applies to vehicles with CO_2 emission values of 190 g/km or more (ACEA, 2015). The vehicle ownership tax on company cars is calculated as a progressive function of CO_2 emissions values and ranges

from 0 to 27 euros per g/km (see Figure 14). HEVs and PHEVs with CO_2 emissions below 110 g/km are exempt from the company car tax for two years after first registration. Lastly, registration taxes are determined by the vehicle's so-called fiscal horsepower (cheval fiscal), which is calculated based on CO_2 emissions and engine power.[4] The amount of registration tax varies among regions of France and ranges from 27 to 51.2 euros per unit of fiscal horsepower. Regions may also opt to reduce the registration tax by 50% or 100% for electric vehicles and alternative fuel vehicles.

Figure 15 summarizes direct fiscal incentives for EVs in France. The bonus/malus feebate scheme generally offers the most significant incentive for EVs followed by the registration tax, which is particularly important in larger vehicle segments. The company car tax makes little difference compared to the other incentives, while the ownership tax, starting at 190 g CO_2/km, had no effect on any of the vehicles used in the calculation of fiscal incentives.

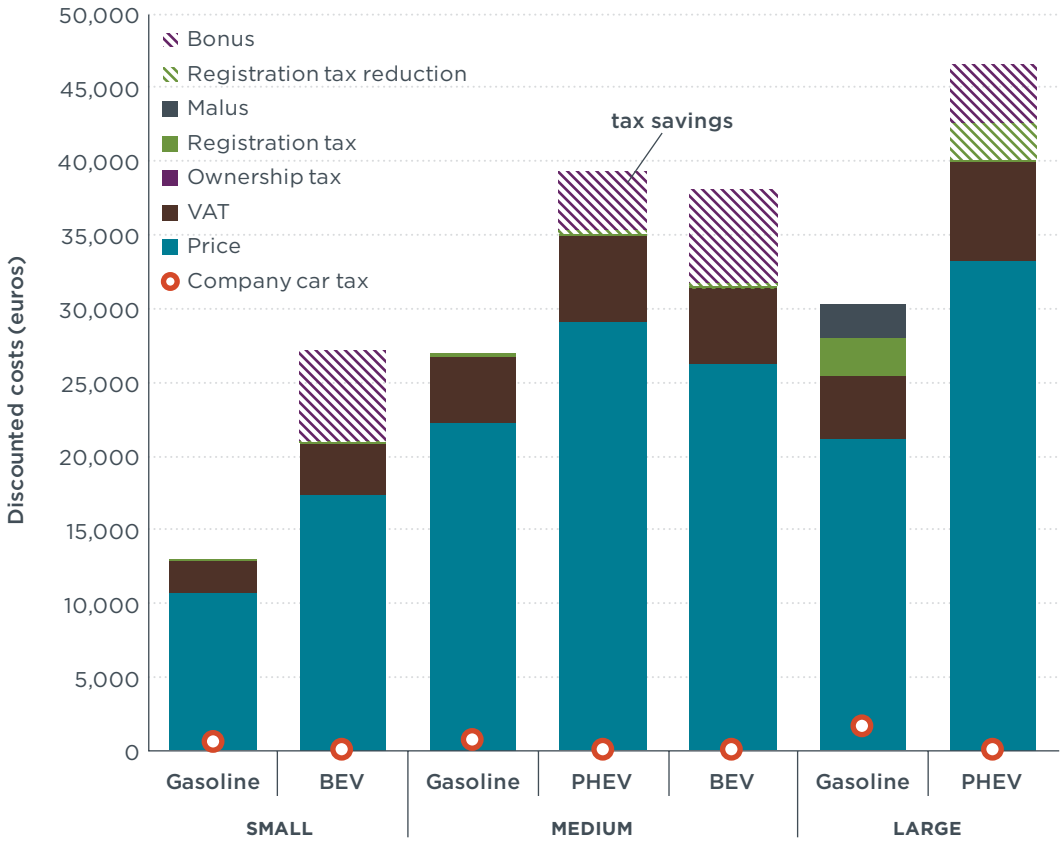

Figure 15. Summary of direct incentives for EVs in France for different vehicle sizes and powertrains[5].

3.3.3 Indirect consumer incentives

Some indirect consumer incentives are provided at regional or local levels, but no national indirect incentives are known.

4 Fiscal horsepower = $\frac{CO_2\left(\frac{g}{km}\right)}{45} + \left(\frac{\text{Engine power ()}}{40}\right)^{1.6}$

5 Because registration taxes vary by region, the registration tax for Paris was used in the summary.

3.3.4 Charging infrastructure

There is considerable uncertainty about charging point availability in France. According to the government's registry, roughly 1,200 charging points were available in October 2015 (Etalab, 2015), while the Energy Transition for Green Growth documentation claims that 10,000 public charging points were available in mid-2015 (Ministry of Ecology, Sustainable Development and Energy, 2015a). According to the user-based registry Chargemap.com, the number of charging points is much higher, with roughly 20,000 public and semi-public registered charging points (Chargemap.com, 2015b). The analysis assumes that the data from Energy Transition for Green Growth documentation are the most reliable, although data from the government registry was used for regional comparisons because it was the only source that published spatial data. It should be noted that these data likely underestimate the density of charging points in French regions.

Figure 16 maps the density of public charging points in regions of France as well as the Paris and Poitou-Charentes case study regions. According to the government registry, the case study region Poitou-Charentes has the highest density (0.1 charging points per 1,000 registered cars) of public charging points in France. Other regions with high charging point density include Pays de la Loire and the region surrounding Paris, Île-de-France. The city of Paris has a density of 0.3 charging points per 1,000 registered vehicles according to the data at hand.

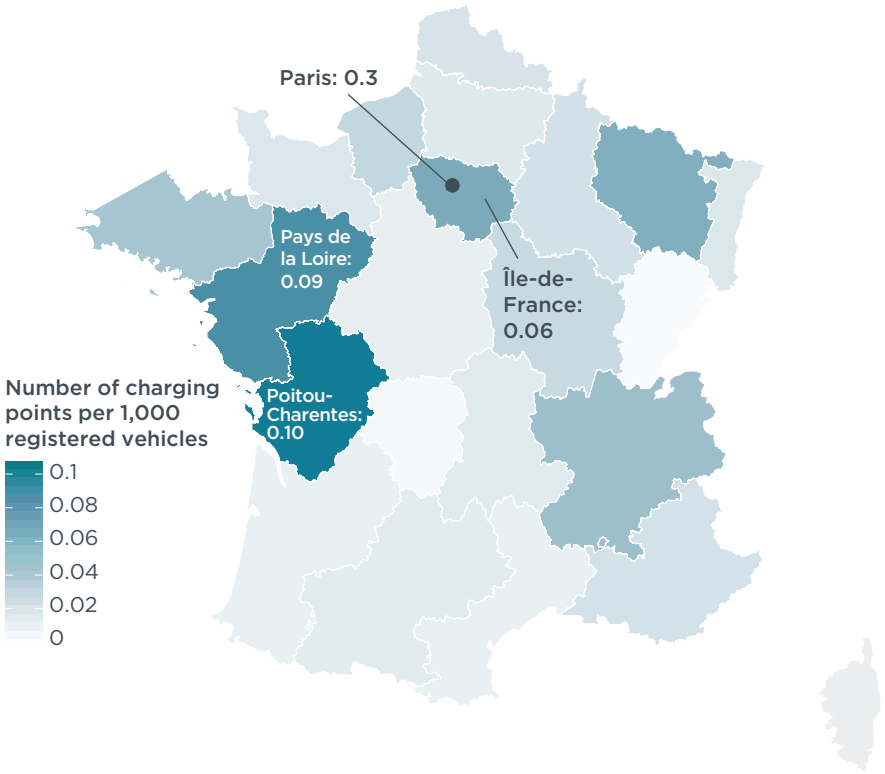

Figure 16. Number of public charging points per 1,000 registered vehicles in regions of France (source: Etalab, 2015; map: GADM, 2015).

The Energy Transition for Green Growth requires that 7 million charging points (including private chargers) be available in France by 2030. To this end, the Investments for the Future Program operated by the French Environment and Energy

Management Agency (ADEME) has provided funding for public charging infrastructure since 2013. Most of the 50 million euro budget has been exhausted and resulted in the installation of approximately 13,200 charging points (AVERE, 2015b). In addition, the partly publically owned energy utility Compagnie Nationale du Rhône plans to install an additional 52 fast charging points by the end of March 2017. Similarly, the state-owned energy utility Électricité de France (EDF) plans to install 200 fast charging stations along main motorways as part of the Corri-Door project. The project combines funding and expertise from EDF, the European Commission, Renault, Nissan, Volkswagen, and BMW (AVERE, 2015c). As for privately funded projects, the Bolloré Group plans to install 8,000 charging points by the end of 2016 and 8,000 additional charging points thereafter.

The French government grants tax credits on a number of energy efficiency and renewable energy measures, including the installation of charging equipment for EVs. Until the end of 2015, the tax credit amounted to 30% of the cost of equipment and materials, excluding labor (Ministère du Logement, de l'Égalité des territoires et de la Ruralité, 2015). The credit is limited to 8,000 euros for a single person and 16,000 euros for a two-person household. Tax exemptions also are granted to companies operating public charging infrastructure (IA-HEV, 2015).

3.3.5 Complementary policies

The Energy Transition for Green Growth Act sets EV targets for government and business car fleets. Half of all new vehicles of the national government must be low-emission vehicles, while local authorities have a lower target of 20% (Ministry of Ecology, Sustainable Development and Energy, 2015a). Car rental and taxi firms are also required to purchase 10% low-emission vehicles when renewing their fleets.

The French government provided substantial funding for research and development activities related to low-emission vehicle technologies during the infancy of electric mobility. Although a detailed discussion transcends the scope of this study, financial support included a 3 billion euro low-interest loan to Peugeot-Citroën and Renault to help finance research and development of low-emission vehicles (IA-HEV, 2010) as well as financial support for electric mobility through the Investments for the Future Program. This program was launched by the French government in 2009 to improve France's international competitiveness by funding research, education, and sustainable development.

3.3.6 Case studies

Paris was selected as a case study due to the city's high share of EVs. The Poitou-Charentes region was studied due to its high availability of charging infrastructure and its purchasing subsidy for EVs.

3.3.6.1. City of Paris, Île-de-France

CITY PROFILE	
Population	2,240,621[a]
Size (in km²)	105.4[a]
Registered vehicles	630,987[b]
Registered electric vehicles (only BEVs)	621 (0.10%)[b]
Charging points	705[c]

[a] Institut national de la statistique et des études économiques, 2016, [b] Ministry of Ecology, Sustainable Development and Energy, 2014. [c] Chargemap.com, 2015a; diverges from data presented in Figure 16 due to use of different data sources

Description

Paris is located in the region Île-de-France and is France's most populous city and capital. While the City of Paris has a population of approximately 2 million, the extended area is home to more than 10 million people. Paris is also France's economic center, and automobile manufacturers are an important part of its economy.

In its 2012 Regional Climate, Air and Energy Action Plan, the regional government of Île-de-France aimed to reduce GHG emissions from road traffic by 20% (2012 baseline) while achieving significant reductions in air pollution by 2020. To achieve this goal, the regional government plans to have 400,000 EVs on the road by then (Direction Régionale et Interdépartementale de l'Environnement et de l'Énergie, 2012). At the moment, roughly 6,000 BEVs are registered in the Île-de-France. Among the departments (sub-regions) of Île-de-France, Paris has one of the highest densities of charging points and EVs.

Regional policies

Low-emission vehicles registered in Paris benefit from free parking. Owners of EVs and non-plug-in hybrid electric vehicles with CO_2 emissions below 60 g/km can apply for a low emission vehicle card, which grants them free parking under certain conditions, including (City of Paris, 2015):

- Visitor parking for up to two hours in any one location
- Residential parking for up to seven consecutive days in any one location
- Parking for work-related purposes for up to seven hours with a parking card

Paris is also home to the prominent electric car sharing service Autolib'. The Autolib' service was first introduced in 2011 as a public-private partnership between the Bolloré Group and the city of Paris, which invested 35 million euros in the scheme (Rose, 2013). The Autolib' fleet consists of 3,000 BEVs, namely the Bolloré Bluecar. To make an electric car sharing service possible, Autolib' also operates a network of approximately 4,000 charging stations in and around Paris, which also can be used by other EV owners (Autolib', 2015).[6]

6 The 4,000 charging stations that can be used by Autolib' users are not fully reflected in any of the national data sources on charging infrastructure in France.

3.3.6.2 Poitou-Charentes

CITY PROFILE	
Population	1,783,991[a]
Size (in km²)	25,920[a]
Registered vehicles	949,077[b]
Registered electric vehicles (only BEVs)	855 (0.09%)[b]
Charging points	98[c]

[a] *Institut national de la statistique et des études économiques, 2016*
[b] *Ministry of Ecology, Sustainable Development and Energy, 2014*
[c] *Etalab, 2015; large uncertainty about number of charging points*

Description

The region of Poitou-Charentes is the 15th largest region in France by population. It promotes energy efficiency by reducing energy consumption and developing schemes to introduce renewable energies. The region aims to reduce emission of greenhouse gases by a factor of four by 2050. Through a special fund, the region's council supports the purchase of electric vehicles and the expansion of a charging infrastructure. The region's strategy set targets for electric mobility, including a sales target of 4,000 BEVs and PHEVs by 2015, and charging infrastructure of 1,000 charging points by 2015.

Regional policies

The Council of Poitou-Charentes offered a 1,000 euro subsidy for EVs to individuals, non-profit organizations, and small and medium-sized enterprises (<500 employees). In 2015, a maximum of 500 grants were made available (Région Poitou-Charentes, 2015a). Furthermore, the region supported the deployment of charging infrastructure. Businesses with less than 500 employees and nonprofit organizations could receive a 50% subsidy of equipment and installation costs, not exceeding 20,000 euros in total (Région Poitou-Charentes, 2015b). The installation cost to which the subsidy was applied was limited to:

- 5,000 euros for normal charging points (3kW)
- 8,000 euros for faster charging points (3 to 22 kW)
- 55,000 euros for fast charging points (43 kW)

The region of Poitou-Charentes also promotes electric mobility with indirect incentives and complementary policies. Poitou-Charentes is home to an electric car rally, an event serving to create awareness of electric mobility. The region also participates in the Régionlib, a platform for electric car sharing operating in a number of French communities (Régionlib, 2015).

3.3.7 Summary

Table 7 summarizes the different incentives for EVs in France and the two case study areas, Paris and Poitou-Charentes. To reach the stated goal of 2 million registered EVs by 2020, the French government offers a substantial subsidy for electric cars as part of its feebate registration tax. Other direct incentives include a scrappage bonus for old diesel vehicles, tax exemptions for company car BEVs, and reduced registration taxes. The national government also provides funding for public charging infrastructure through a 50 million euro funding platform as well as public-private partnerships and offers tax credits

for private charging equipment. The two case studies, Paris and Poitou-Charentes, also have stated targets for EV registrations and offer a combination of incentives and funding for charging infrastructure to meet these targets. France and the two case study regions thus have a wide array of incentives in place to meet national and regional EV targets.

Table 7. Summary of EV incentives in France, Paris, and the region Poitou-Charentes

Type	France	Paris	Poitou-Charentes
Regulatory incentives	• Two million EVs by 2020	• 400,000 EVs by 2020	• 4,000 EVs by 2015
Direct consumer incentives	• Feebate system with a bonus up to 6,300 euros • Scrappage bonus up to 3,700 euros for old diesel vehicles • Progressive company car taxes, BEVs exempted • Reduced registration tax for EVs		• Up to 500 1,000-euro subsidies for EVs in 2015
Indirect consumer incentives		• Free parking with low emission vehicle card	
Charging infrastructure	• 50 million euros funding for charging infrastructure • Public-private partnerships • Tax credit for home charging equipment	• Charging equipment installed by Autolib' electric car sharing service	• 50% subsidy for charging equipment for SMEs up to 20,000 euros in total
Complementary policies	• EV targets for government and business fleets • Subsidy for car rental and taxi firms • R&D funding	• Electric car sharing service Autolib'	• Electric car sharing service Régionlib • EV rally

3.4 NETHERLANDS

3.4.1 Introduction

COUNTRY PROFILE (2014 DATA)	
Population (in millions)	16.9[a]
Size (in km²)	41,543[a]
Gross domestic product (in billions of euros)	598.1[a]
Passenger vehicle sales	387,825[b]
Passenger vehicle stock (in millions)	~8.0[c]
New passenger car CO_2 emissions (in g/km)	108[b]
Passenger new vehicle market share • **Battery electric vehicles** • **Plug-in hybrid electric vehicles**	 0.9%[b] 3.1%[b]
Company car share of new registrations (in 2008)	54%[c]

[a] *Central Intelligence Agency, 2015,* [b] *ICCT, 2015,* [c] *Næss-Schmidt et al., 2010*

Despite its relatively small size and population, the Netherlands is among the top 10 European countries in terms of economic output and passenger car registrations. As one of the most densely populated countries in Europe and the most densely populated country in this comparison, approximately 90% of the Dutch population lives in urban areas. The Netherlands is not home to any large car manufacturers and has a limited vehicle and automobile parts manufacturing industry.

In response to growing GHG emissions from the transport sector, the Dutch government introduced its first action plan on electric vehicles in 2009 (Dutch government, 2009). The action plan outlined three key activities that were planned for 2009 to 2011. First, it recommended setting up of a task force (Formula-E team) responsible for spurring the adoption of electric vehicles. Second, a wide range of activities were endorsed, including pilot projects, research and development activities, installing charging infrastructure, and introducing financial incentives for EVs. Lastly, the action plan set targets for the wide-scale adoption of EVs: 15,000 to 20,000 registered EVs by 2015, 200,000 by 2020, and 1 million electric vehicles by 2025. The government set aside 65 million euros for direct incentives and up to 500 million euros for economic stimuli for companies, regional authorities, and other organizations that indirectly affect the EV market. The action plan was extended in 2011 and covers 2011 through 2015.

The action plan's target of 20,000 registered EVs by 2015 was met two years in advance. By the end of 2014, roughly 44,000 electric vehicles were registered in the Netherlands. The markets share of electric vehicles among new registrations increased rapidly after 2011 and peaked in 2013 at 5.4% (ICCT, 2015). By 2014, the market declined slightly to 3.9% due to reduced incentives for EVs (see Figure 19). As a result of the high share of EVs and high taxes on inefficient cars, the Netherlands had the lowest average CO_2 emissions for new cars (107 g/km) among all EU member states in 2014 (EEA, 2015).

Figure 17 shows the EV share of new car registrations in 2014 in Dutch provinces and in the two case studies covering Amsterdam and Utrecht. EVs were most frequently registered in the provinces Noord-Holland, Utrecht, and Flevoland, although car leases may bias these registration numbers. Lease vehicles may be registered in the province home to the leasing company, the company leasing the vehicle, or the employee driving the vehicle. Because a disproportionate share of company cars are registered in the

provinces of Flevoland and Utrecht, and EVs are more common among company cars than private cars, Figure 17 may not be reflective of where vehicles are being used. Limburg, a province in the southeast of the Netherlands, had the lowest share of electric vehicles in 2014.

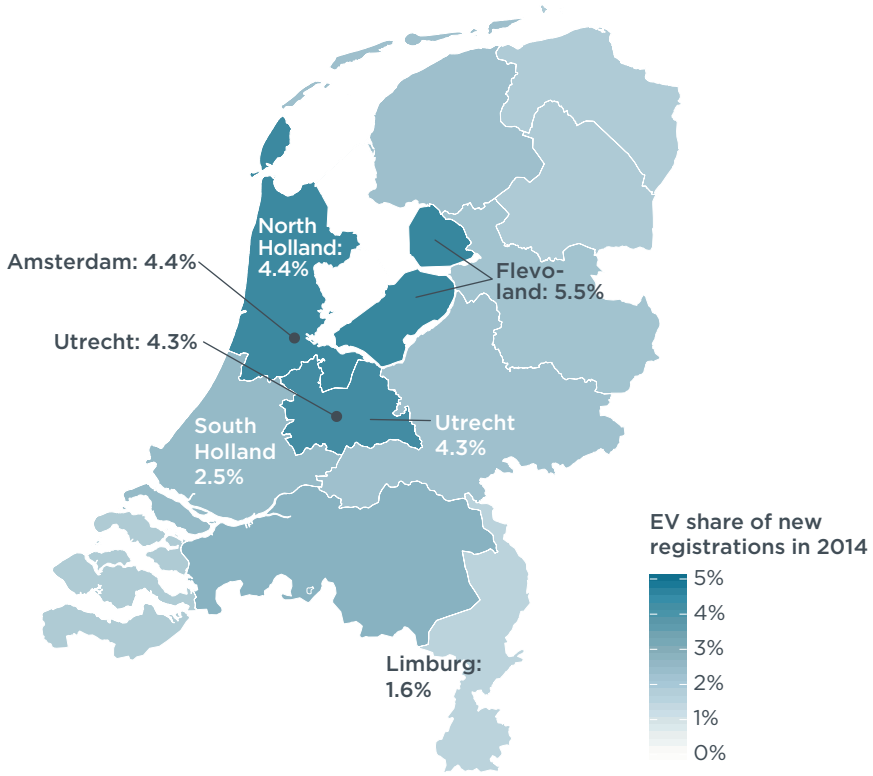

Figure 17. New vehicle market share of electric vehicles (BEVs and PHEVs) in Dutch provinces in 2014 (source: Centraal Bureau voor de Statistiek, 2015; map: GADM, 2015).[7]

3.4.2 Direct consumer incentives

Three types of vehicle taxation schemes are relevant for EV owners in the Netherlands, including the registration tax, road tax, and tax on private use of company cars. The Dutch government levies a registration tax (belasting personenauto's en motorrijwielen) on new passenger cars (Belastingdienst, 2015b). The registration tax increases with the car's CO_2 emission value and a surcharge is levied on diesel cars with more than 70g CO_2/km. Because the taxation scheme is progressive, gasoline vehicles with CO_2 emission values less than 83 g/km incur comparatively low registration taxes; zero emission vehicles are exempted (see Figure 18). For cars with high CO_2 emissions, the registration tax can amount to tens of thousands of euros.

7 New vehicle registrations data were not available for Amsterdam and Utrecht. EV market shares in these cities were assumed to be equal to the shares in their respective provinces.

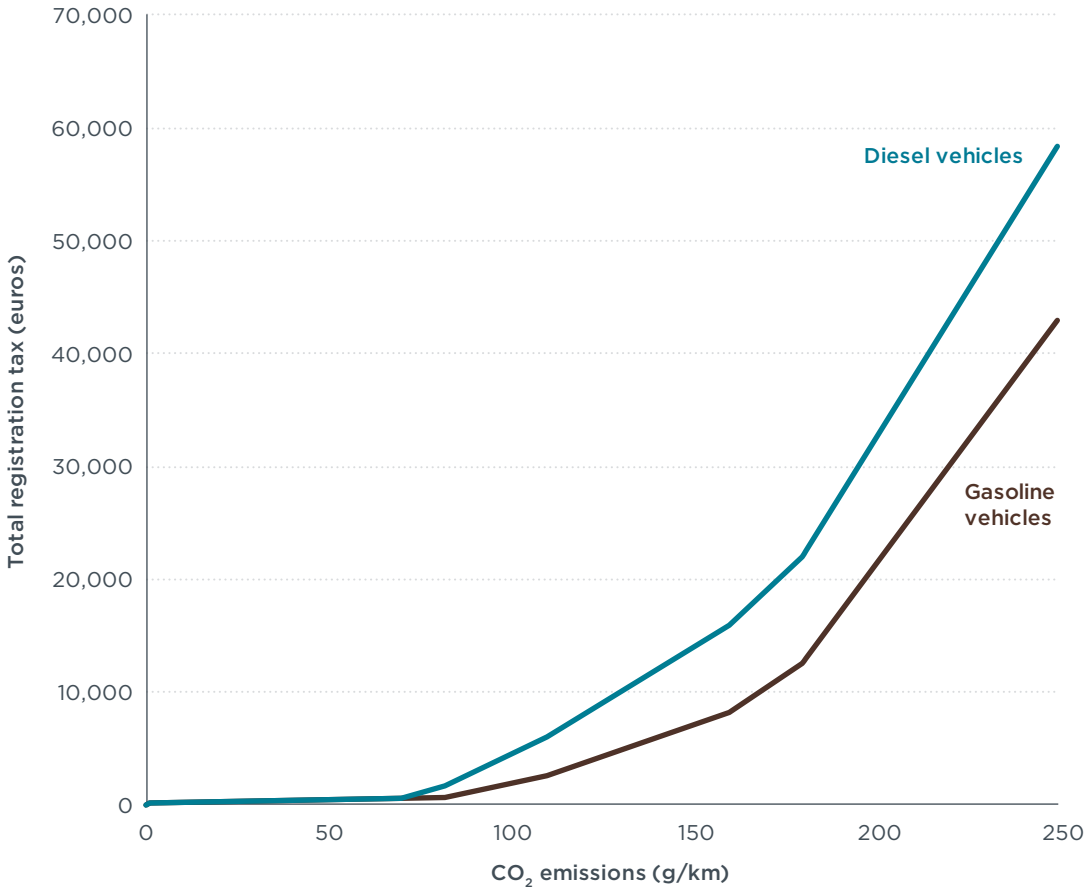

Figure 18. Amount of Dutch registration tax in 2015 for gasoline and diesel vehicles as a function of CO_2 emission values (ACEA, 2015).

The ownership tax (Motorrijtuigenbelasting) is determined by the curb weight and type of powertrain, and the tax varies from one province to another. For an average vehicle with a curb weight of 1,246 kg, the annual road tax ranges from 552 euros to 624 euros for gasoline vehicles and 1,172 euros to 1,244 euros for diesel vehicles (Belastingdienst, 2015a). Cars with CO_2 emission values less than or equal to 50 g/km were exempted from the road tax until January 1, 2016. Cars with 0 g/km CO_2 emissions will continue to be exempt, while cars between 1 g/km and 50 g/km will incur half of the regular road tax from 2016 onward. For hybrid electric vehicles, the vehicle mass is reduced by 125 kg in the calculation of the road tax.

The Dutch government levies a tax on the private use of company cars. Because 92% of all EVs registered at the end of 2014 were registered by companies (Netherlands Enterprise Agency, 2015d), this tax is particularly important for incentivizing the purchase of electric vehicles. If the private use of a company car exceeds 500 km per year, a portion of the vehicle's list price, the so-called taxable benefit, is added to the employee's annual income during the first five years following first registration. The taxable benefit is determined by the car's CO_2 emission value and ranges up to a quarter of the vehicle's list price (see Table 8).

Table 8. Taxable benefit arising from private use of company cars in the Netherlands in 2015 (ACEA, 2015)

CO_2 emissions (g/km)	Taxable benefit (% of list price)
0	4
1-50	7
51-82	14
83-110	20
>110	25

The three foregoing taxes—the registration tax, the road tax, and the company car tax—have increased over time. Figure 19 illustrates the increase in the tax on private use of company cars for four CO_2 emission values: From 2013 to 2016, the taxable benefit increased relative to the four CO_2 values. For example, while a vehicle with a CO_2 value of 50 g/km was exempt from the company car tax in 2013, the same vehicle would be taxed 15% in 2016. Registration taxes also have been adjusted over time, increasing the financial penalty for high-emitting vehicles while reducing the CO_2 threshold for vehicles that benefit from low taxation levels. In 2012, a vehicle with up to 102 g CO_2/km was exempt from the registration tax. By 2015, only zero emission vehicles were completely exempt from the registration tax. This gradual tightening of the taxation schemes adds pressure on consumers to purchase zero emission vehicles, but it also contributed to the decline in PHEV registrations between 2013 and 2014.

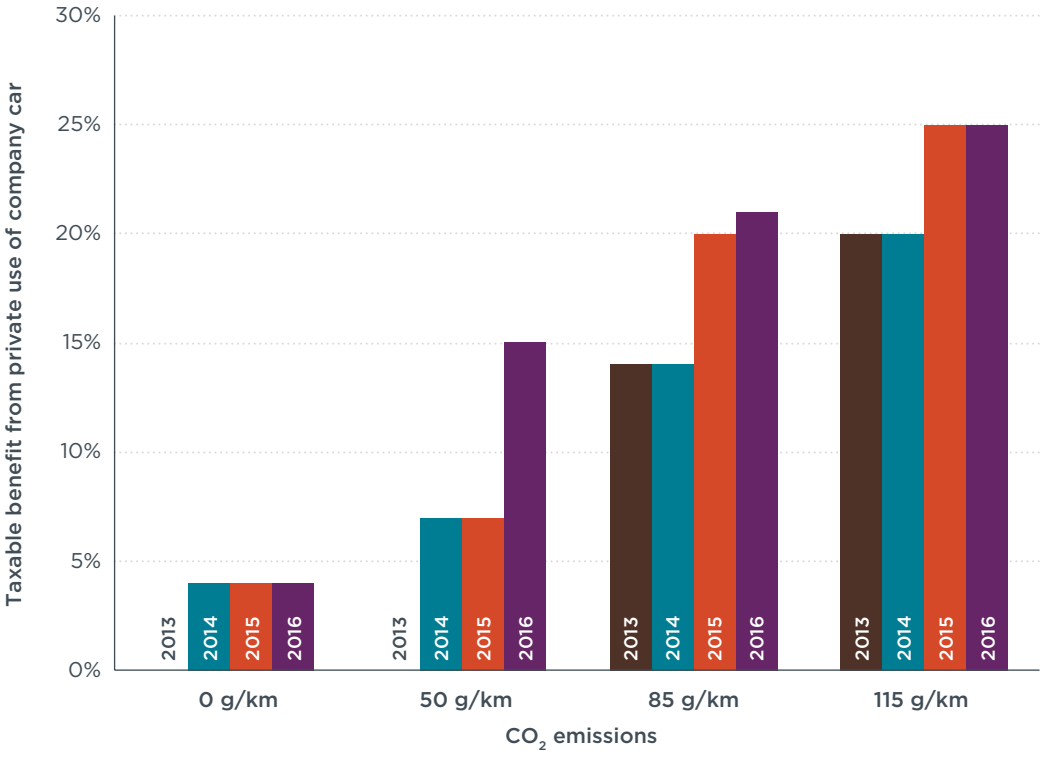

Figure 19. Taxable benefit arising from the private use of company cars for different CO_2 emission levels in 2013-2016.

Figure 20 summarizes the different vehicle taxation schemes and highlights the tax savings arising from purchasing an EV. The three taxes, namely the ownership tax, registration tax, and company car tax, typically increase with vehicle size because they are calculated based on CO_2 emission values or curb weight. Consequently, the incentive to purchase an electric vehicle is particularly high for large vehicles. Figure 20 also shows that the "large" category, calculated based on the SUV Mitsubishi Outlander, is the only category for which the EV is less expensive than the conventional counterpart, particularly when the company car tax is taken into consideration. This bias is reflected in vehicle registrations: more than half of all EVs registered in the Netherlands in 2014 were SUVs.

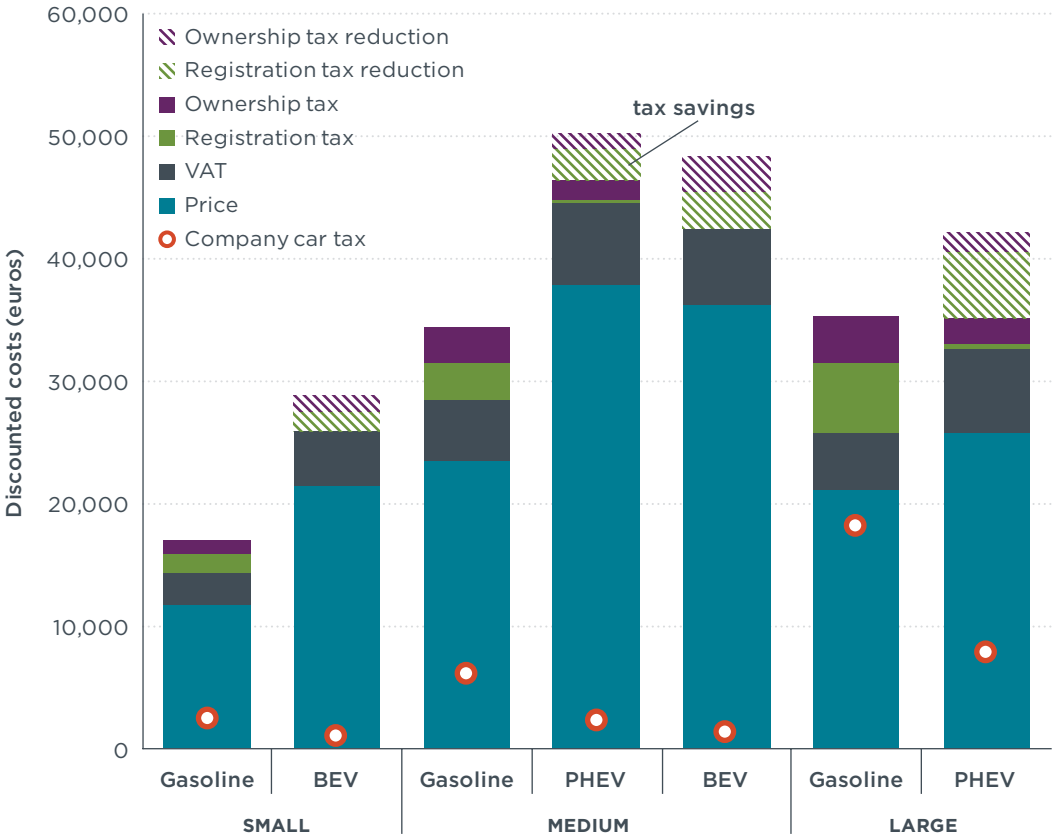

Figure 20. Summary of direct incentives for different vehicle sizes and powertrains in the Netherlands in 2015.

3.4.3 Indirect consumer incentives

Indirect incentives, such as access to low emission zones, are in place in some municipalities but have not been implemented on a national scale.

3.4.4 Charging infrastructure

On average, 1.1 charging points are available per 1,000 registered vehicles in the Netherlands. Figure 21 shows the density of charging points in Dutch provinces and in the two case study cities, Amsterdam and Utrecht. The highest density of charging points is achieved in the provinces of North Holland, South Holland, and Utrecht, with particularly high concentrations in the two cities covered in the case studies. While Flevoland is the province with the highest share of EVs among new registrations (see

Figure 17), the province has a comparatively low density of charging infrastructure. This inconsistency presumably is a product of leased cars that are registered in Flevoland but driven elsewhere.

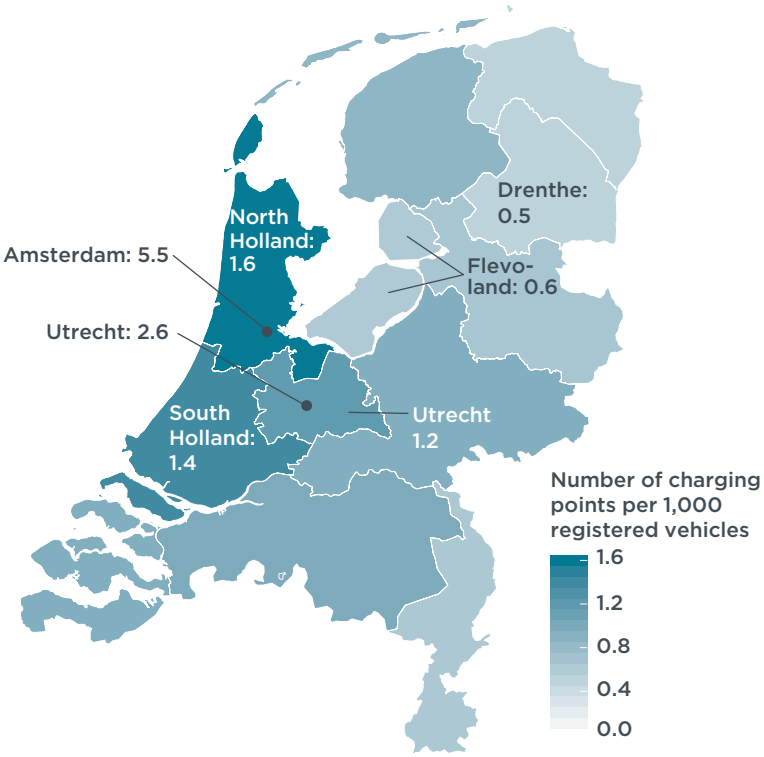

Figure 21. Number of charging points per 1,000 registered vehicles in Dutch provinces and the two case study cities, Amsterdam and Utrecht (source: Open Charge Map, 2015; map: GADM, 2015).

The installation of charging infrastructure in the Netherlands primarily relied on public-private partnerships. The E-laad foundation was a consortium of electricity grid operators that set out to install public charging infrastructure. The consortium included the state-owned national grid operator TenneT as well as regional grid operators (ElaadNL, 2015). With a budget of 25 million euros, the consortium installed approximately 3,000 charging stations between 2010 and 2014. More recently, public-private partnerships have become less important, with major cities contracting energy suppliers to install charging infrastructure. In addition to funding for charging infrastructure, the National Charging Infrastructure Knowledge Platform Foundation, a partnership supported by the Netherlands Enterprise Agency, promotes collaborative projects to lower the cost of charging infrastructure and to foster knowledge exchange (Netherlands Enterprise Agency, 2015c).

After the dissolution of the E-laad foundation, the Dutch government supports sustainable business projects based on its Green Deal scheme. Green Deals refer to public-private partnerships that aim to reduce barriers to sustainable innovation and may include government support in the form of removing legal or regulatory obstacles, providing access to networks, or providing funding (Netherlands Enterprise Agency, 2015c). For charging infrastructure, the Dutch government instigated a 33 million euro funding scheme for the installation of charging points, of which 5.7 million

euros were funded by the Dutch government with regions, provinces, municipalities, and the private sector accounting for the rest (European Commission, 2015b). Local authorities can apply for financial support from the central government for the installation of public charging infrastructure. Only projects that combine funding from local authorities and the private sector are eligible for financial support. The scheme was introduced in 2015 and is set to expire by July 2018.

Lastly, operating between the national and provincial levels, the Metropoolregio Amsterdam Elektrisch (MRA-E) partnership brings together a wide range of actors including the provinces North Holland, Utrecht, and Flevoland, and more than 80 local governments, among others. MRA-E plans to install 1,200 additional charging points in the provinces North Holland, Flevoland, and Utrecht and began construction in 2014 (Netherlands Enterprise Agency, 2015c).

3.4.5 Complementary policies

The Dutch government devised a number of policies to incentivize businesses to purchase electric vehicles. First, until the end of 2014, the Ministry of Infrastructure and the Environment offered a 3,000 euro subsidy for electric taxis and delivery vans (Netherlands Enterprise Agency, 2015c). In a number of cities the subsidy was increased to 5,000 euros per vehicle. In addition, some local governments, including the city of Amsterdam, offered an additional subsidy 3,000 euros to 5,000 euros per vehicle. Second, the Dutch government grants an Environmental Investment Rebate to companies. The Environmental Investment Rebate refers to a tax deduction of up to 50,000 euros or 36% of an eligible investment (Netherlands Enterprise Agency, 2015c). Until 2015, this tax deduction also applied to electric vehicles with CO_2 emission values lower than 50 g/km (Netherlands Enterprise Agency, 2011). Lastly, the so-called Vamil scheme allows for favorable depreciation rates for eligible environmental investments, including electric vehicles (Netherlands Enterprise Agency, 2015c).

A number of other policies are in place to prepare consumers and companies for electric mobility. Education and promotion events include showcasing Dutch electric mobility concepts at international trade shows (Netherlands Enterprise Agency, 2015c). Other events include the electric vehicle national Test Drive Day and Clean Air Rallies in seven Dutch cities (Netherlands Enterprise Agency, 2015c). The website Netherlands electric (Nederland elektrisch) also educates consumers on electric mobility and summarizes financial incentives for EVs. Other complementary policies include Green Deals, activities by the public-private partnership for electric mobility Formula-E team, and research on electric drive technologies that is partly funded by the Dutch government.

3.4.6 Case studies

Amsterdam and Utrecht were identified as suitable case studies for the Netherlands due to the comparatively high share of EVs and the abundance of charging infrastructure in these cities.

3.4.6.1. Amsterdam municipality, North Holland province

CITY PROFILE	
Population	810,937[a]
Size (in km²)	~219
Registered vehicles	200,259[a]
Registered electric vehicles	2,334[b] (1.2%)[9]
Charging points	~1,100[c]

[a] Centraal Bureau voor de Statistiek, 2014, [b] Netherlands Enterprise Agency, 2015a, [c] City of Amsterdam, 2015d

Description[8]

Amsterdam is the capital and the most populous city of the Netherlands. The city is located in the province of North Holland and is famous for its bicycle-friendly transportation system. Bicycles account for approximately 32% of all distance traveled while cars account for 22% (City of Amsterdam, 2015b).

The city introduced its electric vehicle strategy in 2009, aiming to bring 10,000 EVs to the streets of Amsterdam by 2015 (City of Amsterdam, 2010). The city's Sustainable Amsterdam agenda aims to expand the EV charging infrastructure up to 4,000 charging points in 2018 to reduce the transportation sector's impact on air quality and to facilitate the shift to renewable energy sources (Municipal Council of Amsterdam, 2015).

Other prominent examples of electric mobility in Amsterdam are the all-electric car sharing platform car2go consisting of 350 BEVs and the 176 Tesla Model S taxis operating at the city's airport (Netherlands Enterprise Agency, 2015c).

National Policies

The Ministry of Infrastructure and the Environment's subsidy for electric taxis and delivery vans was increased to 5,000 euros instead of the regular subsidy of 3,000 euros (Netherlands Enterprise Agency, 2015c). This subsidy expired at the end of 2014.

Regional Policies

In addition to the Ministry of Infrastructure and the Environment's 5,000 euro subsidy for electric delivery vans and taxis, the municipality of Amsterdam paid an additional subsidy of 5,000 euros for vehicles with an electric range of at least 60 km. This additional subsidy expired at the end of 2015 (Netherlands Enterprise Agency, 2015c). In its place, the city of Amsterdam pays a 5,000 euro subsidy for fully electric cars, vans, and taxis registered by companies (City of Amsterdam, 2016a). In order to qualify for the subsidy, the vehicles must have an annual mileage of 8,000 km or more within the city of Amsterdam.

In January 2016, the city of Amsterdam contracted the energy utility Nuon to install public charging points (City of Amsterdam, 2016b). EV owners who live or work in Amsterdam can request a public charging point. As long as certain conditions are met, for example that the EV owner does not have access to private parking, public charging infrastructure may be installed at no cost to the EV owner. Parking conventional vehicles in parking

8 Leased vehicles can be registered at the location of the leasing company rather than the end user. These figures may thus not accurately reflect the number of electric vehicles in Amsterdam.

spaces with public chargers is prohibited (City of Amsterdam, 2015c). EV owners are also granted priority access to parking permits. For owners of conventional cars, the waiting time for parking permits can be several years, particularly in the city center.

The city uses its web portal "Amsterdam elektrisch" to inform consumers about electric mobility (City of Amsterdam, 2015a). The website also informs potential buyers about the different regional incentives for EVs.

3.4.6.2. Utrecht municipality, Utrecht province

CITY PROFILE	
Population	328,164[a]
Size (in km²)	~99
Registered vehicles	97,277[a]
Registered electric vehicles	1,783[b] (1.8%)[9]
Charging points	~255[c]

[a] Centraal Bureau voor de Statistiek, 2014, [b] Netherlands Enterprise Agency, 2015b, [c] A. Meijles, personal communication, January 21, 2016

Description

With a population of approximately 330,000, Utrecht is the fourth largest city in the Netherlands and the capital of the Utrecht province. Similar to Amsterdam, the city's transportation system relies heavily on bicycles and scooters, which account for 30% of all passenger transportation (Utrecht 2040, 2014). Utrecht was the first Dutch city to introduce a low emission zone, banning diesel passenger and delivery vehicles manufactured before 2001 from the city center (Netherlands Enterprise Agency, 2015c)

Despite its comparatively small size, Utrecht has the second highest number of electric vehicles and the highest number of non-plug-in hybrid vehicles among Dutch cities. The municipality aims to be climate neutral by 2030 and its action plan for clean transportation for 2015 to 2020 aims to increase the number of electric cars to 10,000 by 2020 and supports the installation of charging infrastructure (City of Utrecht, 2015a). The city also has a clean freight action plan and is collaborating with 25 Dutch municipalities in a Green Deal aiming to reduce emissions from urban transportation (Netherlands Enterprise Agency, 2015c).

National Policies

Similar to Amsterdam, the subsidy for electric delivery vehicles and taxis was increased from 3,000 euros to 5,000 euros in Utrecht until the end of 2014 (Netherlands Enterprise Agency, 2015c).

Regional Policies

Utrecht currently has an estimated 255 public charging points, 130 of which were financed by the E-laad foundation (A. Meijles, personal communication, January 21, 2016). The city of Utrecht also subsidizes the installation of charging points on private properties with a maximum of 500 euros; if the charging point is made available to the public, the subsidy

9 Leased vehicles can be registered at the location of the leasing company rather than the end user. These figures may thus not accurately reflect the number of electric vehicles in Utrecht.

increases to 1,500 euros (City of Utrecht, 2015c). By 2015, 77 semi-public and 97 private charging points had been installed (City of Utrecht, 2015a). Parking spaces at public charge points are reserved and free of charge for electric vehicles.

As part of its action plan for clean transportation, Utrecht introduced 35 EVs and 27 electric scooters into its municipal fleet (City of Utrecht, 2015a). Similar to Amsterdam, Utrecht instituted an information portal (Utrecht elektrisch) to provide information on electric mobility and incentives in Utrecht (City of Utrecht, 2015b).

3.4.7 Summary

Table 9 summarizes national EV incentives in the Netherlands and regional incentives in Amsterdam and Utrecht. Direct consumer incentives include three taxation schemes that favor electric vehicles, namely the registration tax, the ownership tax, and company car taxes. While the Netherlands still offers substantial direct incentives, these incentives have been decreasing over time. The Netherlands also makes use of a wide variety of indirect incentives and complementary policies and provides funding for charging infrastructure through a number of partnerships and funding platforms. Amsterdam and Utrecht both set sales targets for electric vehicles and use indirect incentives related to parking spaces to promote electric mobility. Both cities also offer additional funding for private and semi-public chargers and engage with consumers through web portals and other complementary policies.

Table 9. Summary of EV incentives in the Netherlands and the two case study cities, Amsterdam and Utrecht

Type	Netherlands	Amsterdam	Utrecht
Regulatory incentives	• 200,000 EVs by 2020 • 1 million EVs by 2025	• 10,000 EVs by 2015	• 10,000 EVs by 2020
Direct consumer incentives	• Comparatively low registration tax for EVs • Ownership tax exemption • Reduced company car tax		
Indirect consumer incentives		• Parking spaces attached to charging stations are reserved for EVs • Priority access to parking permits	• Parking spaces attached to charging stations are reserved and free for EVs
Charging infrastructure	• E-laad foundation: 3,000 charging stations with 25 million euros • Green Deal: 33 million euros • MRA-E: 1,200 charging stations	• Up to 500 euro subsidy for private chargers • Up to 1,000 euro subsidy for semi-public chargers	• Up to 500 euros for private chargers • Up to 1,500 euros for semi-public chargers

Complementary policies	• 3,000/5,000 euro subsidy for electric vans and taxis • Environmental Investment Rebate tax deductible • Favorable asset depreciation rates for EVs • Education and promotional events • Innovation incentives for SMEs • Web portal "Netherlands electric" • Research of EV technologies	• Additional 5,000 euro subsidy for electric vans and taxis • Web portal "Amsterdam electric" • Preference for EVs in municipal fleet	• 35 EVs in municipal fleet • Web portal "Utrecht electric" • Preference for EVs in municipal fleet

3.5 NORWAY

3.5.1 Introduction

COUNTRY PROFILE (2014 DATA)	
Population (in millions)	5.2[a]
Size([in km²)	323,802[a]
Gross domestic product (in billions of euros)	259.8[a]
Currency	1 Norwegian kroner (NOK) ≈ 0.12 euro [b]
Passenger vehicle sales	144,196[c]
Passenger vehicle stock (in millions)	~2.6[d]
New passenger car CO_2 emissions (in g/km)	110[c]
Passenger new vehicle market share • **Battery electric vehicles** • **Plug-in hybrid electric vehicles**	 12.6%[c] 1.2%[c]
Share of company cars of new registrations	42.1%[e]

[a] Central Intelligence Agency, 2015, [b] Eurostat, 2015a, [c] ICCT, 2015, [d] Statistisk sentralbyrå, 2015a
[e] P. J. Bruhn, personal communication, September 3, 2015

Norway stands out in a number of ways among the countries in this comparison. As the most northerly country, Norway has the coldest climate with an annual average temperature of 3.8°C in the country's capital, Oslo (World Meteorological Organization, 2015). Norway is also the most sparsely populated country, though approximately 80% of the Norwegian population is concentrated in urban areas (The World Bank, 2015). From an economic perspective, Norway stands out with the highest GDP per capita and has built an economic safety net around its petroleum reserves: The Norwegian government saves revenues from the petroleum sector in the world's largest sovereign wealth fund, valued at over 650 billion euros, which partly is used to finance public expenses (Central Intelligence Agency, 2015). Lastly, Norway is also a unique country in terms of power supply: Nearly all of Norway's electricity is derived from hydropower, resulting in an ample supply of virtually carbon-free electricity.

These geographic and socioeconomic features shape the Norwegian transport sector and have important implications for the electrification of passenger transport. Out of the five countries in the analysis, the Norwegian passenger transport sector is the most reliant on cars, with 90% of all motorized passenger kilometers traveled in cars, conditioned by relatively low population density and the limited rail network (Eurostat,

2015b). The country's road transport sector also shows the highest growth in GHG emissions since 1990 among the five countries and accounts for approximately 19% of Norway's GHG emissions (UNFCCC, 2015).

In order to curb the transport sector's environmental impact, the Norwegian government put in place a number of policies to decarbonize passenger transport. As the only non-EU country in the comparison of European EV incentives, Norway has stipulated a more ambitious CO_2 emissions target for new vehicles, 85 g/km by 2020 (Norwegian government, 2012), compared to the EU-wide target of 95 g/km by 2020. To achieve this target, the Norwegian government provides considerable incentives for electric vehicles and a progressive vehicle registration tax is levied based on CO_2 emission values among other vehicle parameters.

Norway is widely considered a forerunner in the field of electric mobility. In April 2015, Norway registered its 50,000th BEV, indicating that approximately 2% of Norway's passenger cars are electric vehicles. In 2014, electric vehicles accounted for roughly 14% of car sales, which reduced average new vehicle CO_2 emissions from 126 g/km when only considering conventional vehicles to 110 g/km when including electric vehicles (ICCT, 2015).

Figure 22 shows the share of electric vehicles among new car registrations in 2014 in Norwegian counties and the two case study cities, Oslo and Bergen. On average, almost 14% of all cars registered in 2014 were BEVs or PHEVs. Electric vehicles are more common in the south of Norway compared to the northern and inland parts of the country. The counties with the largest number of electric vehicles are Akershus, Oslo, and Hordaland (Statistisk sentralbyrå, 2015a), which are also among the counties with the highest shares of new registrations of electric vehicles during 2014. Every fifth car registered in the cities of Oslo and Bergen in 2014 was an EV.

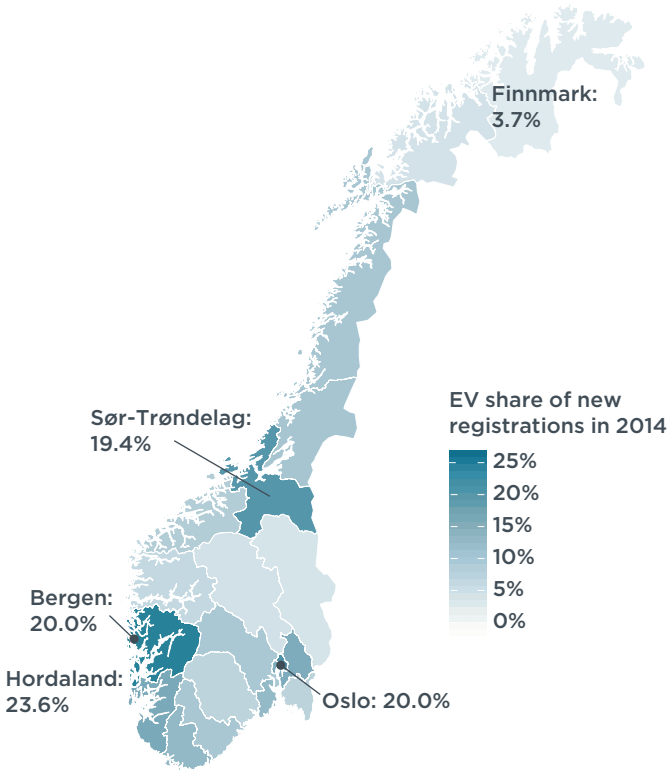

Figure 22. New vehicle market share of electric vehicles (BEVs and PHEVs) in Norwegian counties in 2014 (source: Grønn Bil, 2015b; map: GADM, 2015).

3.5.2 Direct consumer incentives

The sales of electric vehicles have been bolstered by wide-ranging incentives for low emission vehicles, including generous tax exemptions. For one, BEVs are exempted from the VAT, which normally adds 25% of a vehicle's list price to the total cost (Toll, 2015).[10] Taxes on company cars, which accounted for 42.1% of new vehicle registrations in the first eight months of 2015, are also reduced for BEVs. In 2015, the taxable amount from company cars is 30% of the first 286,000 kroner (~34,300 euros) of the car's list price

10 The VAT is calculated based on the vehicle's list price including import costs and excluding the registration tax.

and 20% of the car's value exceeding 286,000 kroner (Altinn, 2015). For BEVs, the list price is reduced by 50% in the calculation of the company car tax, the reasoning being that BEVs provide less of a benefit in private use due to limited range.

Another significant fiscal incentive for electric vehicles is the exemption of BEVs from the registration tax. The registration tax has three large progressive components including a mass, engine power, and CO_2, and a small linear NO_x component. Figure 23 shows the amount of tax resulting from different levels of the four tax components. Taken together, these four components of the registration tax amount to 30% for vehicles included in the comparison, thereby significantly increasing the cost of purchasing a car. While the exemption of BEVs is expected to run out at the end of 2020, BEVs would incur comparatively low registration tax levels as BEVs have no taxable engine power or NO_x emissions while the CO_2 tax component is negative.[11] For PHEVs, the electric powertrain is excluded from the mass of the vehicle in the calculation of the registration tax, which is approximated by reducing the vehicle weight of PHEVs by 26% in the calculation of the registration tax. The tax curves in Figure 23 are adjusted each year in conjunction with the review of the national budget to take into account the technical development of new vehicles. In addition to the exemption from the registration tax, BEVs are also subject to a reduced annual motor vehicle tax (435 kroner or ~52 euros instead of 3,060 kroner or ~367 euros) (Skatteetaten, 2016)

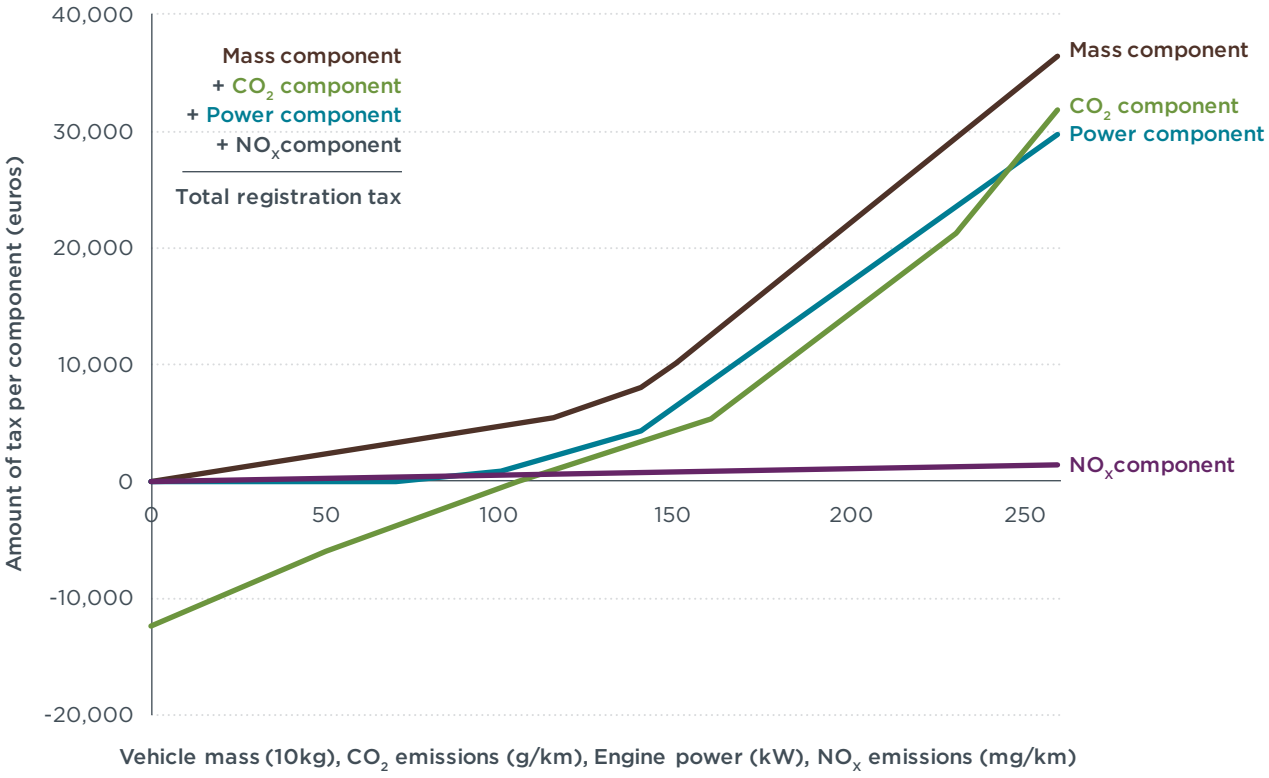

Figure 23. Amount of Norwegian registration tax in 2015 for each cost component, including vehicle mass, CO_2 emissions, engine power, and NO_x emissions (Norwegian government, 2014).

11 No tax is levied on the electric motor power.

Figure 24 summarizes the tax incentives for a number of vehicles from different vehicle segments and powertrains. The exemption from the registration tax is generally the most important fiscal incentive, followed by the VAT exemption for BEVs. While PHEVs are not exempt from the registration tax, they still incur lower registration taxes than conventional vehicles due to lower CO_2 emission values. The favorable vehicle taxes for EVs generally imply that the cost of purchasing an EV for private use is lower than a comparable conventional car. For company cars, the reduced list price in the calculation of the company car tax also offers a substantial incentive for BEVs and can reduce discounted costs by as much as 7,000 euros for a medium-sized BEV.

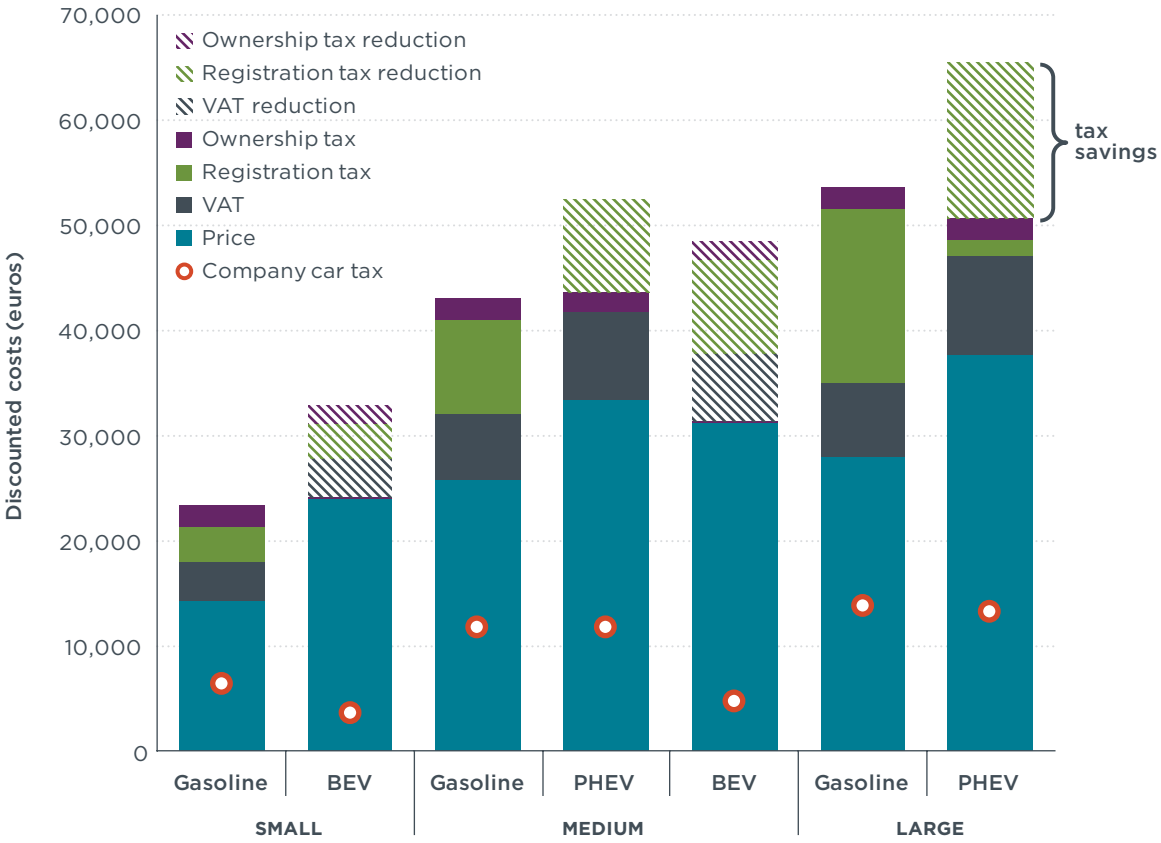

Figure 24. Summary of direct incentives for different vehicle sizes and powertrains.

3.5.3 Indirect consumer incentives

The Norwegian government implemented a number of non-fiscal incentives for electric vehicles. Norwegian BEV owners have preferential access to large parts of public infrastructure, including free access to toll roads, reduced ferry rates, free parking, access to bus lanes, and free charging at public charging stations. While these privileges are regional in nature, the national government regulates these subsidies. The reduced ferry rates are gradually being phased out. While difficult to measure precisely, these incentives were estimated at approximately 16,000 kroner (~1,915 euros) per year for an electric vehicle owner (Assum, Kolbenstvedt, & Figenbaum, 2014). These incentives apply only to BEVs. PHEVs are allowed to charge for free at public charging stations in some municipalities, but must pay the standard parking fee. To facilitate the enforcement of these measures, electric vehicles receive a special registration plate using the prefix "EL." These special registration plates also increase the visibility

of electric vehicles (Figenbaum & Kolbenstvedt, 2015b). As these indirect incentives have the largest applicability to the southwest of the country, where tolled roads and ferry routes are more abundant, they also contribute to the higher share of EVs in the southern and coastal regions compared to northern and inland regions.

3.5.4 Charging infrastructure

On average, 2.4 charging points are available for every 1,000 vehicles registered in Norway. Figure 25 shows the number of public and semi-public charging points per 1,000 registered vehicles in Norwegian counties and the two case study cities, Oslo and Bergen. Similar to the market share of electric vehicles (see Figure 22), the density of chargers decreases from the south to the north, with a particularly high charge point density in the counties of Oslo and Hordaland and the two cities covered in the case studies, while the northernmost county, Finnmark, has the lowest density.

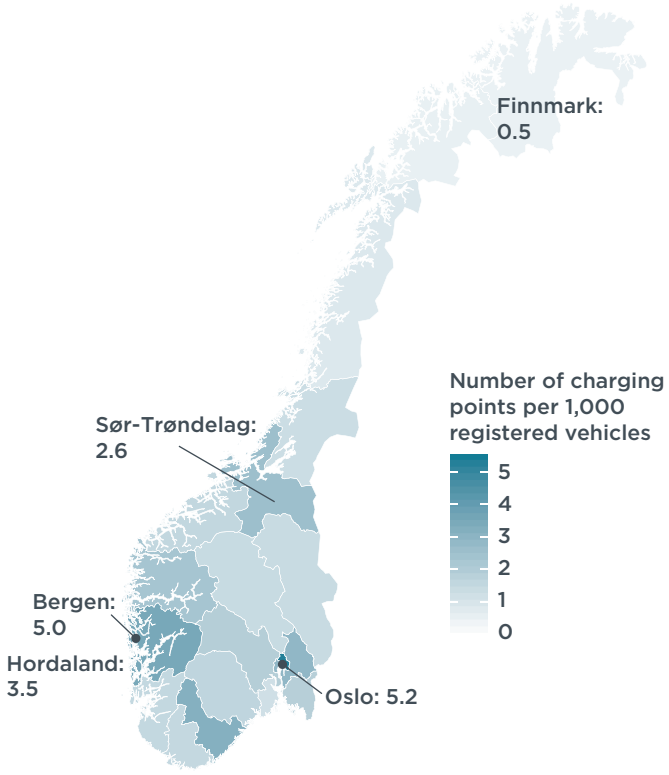

Figure 25. Number of charging stations per 1,000 registered vehicles in Norwegian counties (charging point data: Grønn Bil, 2015a; vehicle registrtation data: Statistisk sentralbyrå, 2015a; map: GADM, 2015)

Between 2009 and 2010, the Norwegian government supported the construction of charging stations with approximately 50 million kroner (~6 million euros), which were used to subsidize public charging points with up to 30,000 kroner (~3,590 euros) per point (Nordic Council of Ministers, 2014). More recently, funding for fast chargers has been made available by Enova, a public enterprise now comprising the agency formerly known as Transnova, which is funded by the public Energy Fund and is overseen by the Ministry of Petroleum and Energy. In 2013, Transnova supported fast charging infrastructure with 6 million kroner (~720,000 million euros). Enova is currently working on a proposal for funding fast charging infrastructure along Norwegian transport

corridors (Enova, 2015). Cities such as Oslo and Bergen, and counties such as Akershus and Hordaland, also provide incentives for charging stations (see section 3.5.6).

3.5.5 Complementary policies

In addition to consumer-facing incentives, the Norwegian government aims to decarbonize its own vehicle fleet. In 2008, the Norwegian government set a limit of 120–140 g CO_2/km for new vehicle acquisitions in the government fleet (Norwegian government, 2007) and is investigating the possibility of having a CO_2-neutral fleet by 2020. The Norwegian government also is participating in the EU Green Public Procurement initiative, a voluntary instrument that provides guidelines promoting the acquisition of low-carbon public vehicles.

In contrast with other countries in the comparison, Norway has no car manufacturing industry to speak of. For two decades, the Norwegian car company Think Global developed and produced a small number of electric vehicles, but the company filed for bankruptcy in 2011. As a result, Norwegian policies focus on user behavior, raising awareness, and charging infrastructure. For example, Transnova (now Enova) received 50–100 million kroner (~6–12 million euros) per year to support the introduction of carbon neutral technologies in the transport sector and to finance charging infrastructure for electric vehicles (Figenbaum & Kolbenstvedt, 2015b). Transnova also funded Grønn Bil (green car), which aims to accelerate the uptake of electric vehicles by publishing statistics on electric vehicle registrations and charging points.[12]

3.5.6 Case studies

Oslo and Bergen are the two most populous cities in Norway. Among larger cities, they are also the cities with the highest number of registered EVs and represent the provinces with the highest share of EVs among new car registrations in 2014 (see Figure 22).

3.5.7 Oslo municipality, Oslo county

CITY PROFILE	
Population	650,733[a]
Size (in km²)	~450
Registered vehicles	275,180[b]
Registered electric vehicles	12,140 (4.4%)[c]
Charging points	1,820[d]

[a] Statistisk sentralbyrå, 2015b, [b] Statistisk sentralbyrå, 2015a, [c] Grønn Bil, 2015b, [d] Grønn Bil, 2015a

Description

Norway's capital, Oslo, is located in the southeast of the country. The city plans to halve its GHG emissions by 2030 and expects to be climate neutral by 2050 (Eltis, 2014). Electric mobility is seen as a key pillar in the city's strategy to achieve this goal. With more than 12,000 registered electric vehicles, Oslo has the highest EV density of any global capital, and the city promotes itself as the electric vehicle capital of the world.

12 As of April 2016, the Grønn Bil website is defunct.

National policies

The national policy of granting BEVs free access to toll roads is significant in Oslo, as a regular passage into the city's "toll ring" costs 32 kroner (~4 euros). Similarly, as the municipality with the highest number of registered cars, BEV owners in Oslo benefit disproportionately from access to the city's bus lanes as well as free parking and charging of electric vehicles in public car parks. In contrast, reduced ferry rates have no immediate effect for the Oslo region.

Regional policies

In addition to national incentives, the municipality of Oslo introduced a number of incentives for electric vehicle acquisition and charging infrastructure. On the charging side, Oslo installed 400 charging points between 2008 and 2011 at a cost of approximately 16 million kroner (~1.9 million euros) (Agency for Urban Environment, 2013). In 2014, the municipality added another 300 charging points and hopes to reach a total of 1,100 points by the end 2015 (Eltis, 2014). Oslo also supports the installation of charging stations in non-public areas, including apartment buildings and shopping malls. Organizations that install charging points for electric vehicles can apply for financial support covering up to 10,000 kroner (~1,120 euros) or 60% of the final cost. More than 350 charging points have qualified for this subsidy (Stein, 2015).

While consumer-facing incentives arguably are the city's most important tools for supporting electric vehicles, Oslo also introduced a number of other initiatives to raise awareness. For one, Oslo was aiming to replace its municipal fleet of approximately 1,000 vehicles with electric vehicles by the end of 2015. Oslo also collaborates with a number of European cities in the Electric Vehicles in Urban Europe (EVUE) project of URBACT, a program that supports knowledge exchange on the topic of sustainable urban development between different cities (Agency for Urban Environment, 2013). Lastly, the car sharing company Move About operates electric vehicles in Oslo and is sponsored by the publically owned energy utility Statkraft (Statkraft, 2009), creating a public-private partnership for car sharing.

3.5.8 Bergen municipality, Hordaland county

CITY PROFILE	
Population	257,737[a]
Size (in km²)	~465
Registered vehicles	110,891[b]
Registered electric vehicles	6,050 (5.5%)[c]
Charging points	554[d]

[a] Statistisk sentralbyrå, 2015b, [b] Statistisk sentralbyrå, 2015a, [c] Grønn Bil, 2015b, [d] Grønn Bil, 2015a

Description

Bergen is the largest city in and administrative center of Hordaland, a county located along Norway's southwestern coast. With more than 250,000 inhabitants, Bergen is the second-largest city in Norway. Complex networks of fjords and archipelagos shape the geography of Bergen, as the city itself is located on a peninsula. Hordaland is among the counties with the highest share of electric vehicles and Bergen has a density of electric vehicles even higher than Oslo.

National policies

Similar to Oslo, EV owners in and around Bergen benefit disproportionately from national incentives when compared to more rural areas. For example, EVs can drive in bus lanes and are granted free access to the city's "toll ring," which costs 25 kroner (~3 euros) for conventional passenger cars. In contrast to Oslo, EV owners in Hordaland also benefit from toll exemption on bridges and subsea tunnels and from reduced ferry fares. Car ferries operate approximately 20 routes in the county, with regular rates ranging from 60 kroner (~7 euros) to more than 200 kroner (~24 euros).

Regional policies

Policies related to Bergen's transport sector are set at the county and municipal level. In its 2014 Climate Plan, Hordaland county stipulates that GHG emissions from the road transport sector are to be reduced by 20% by 2020 and 30% by 2030 against a 1991 baseline (Hordaland Fylkeskommune, 2014). Among other measures to meet this target, the county requires at least 20% of all light-duty vehicles to be zero emission vehicles by 2020; this value is increased to 40% by 2030. Hordaland also is aiming to finish its expansion of fast charging infrastructure by 2020 using national funds made available by Enova in addition to the county's funds. The county also requires 20% of new public parking spaces to include chargers.

Additional climate and transport targets are stipulated at the municipal level. Bergen's Climate and Energy Action Plan requires the municipality to halve CO_2 emissions by 2030 against a 1990 baseline (Bergen kommune, 2010). In 2007, Bergen municipality decided to reduce CO_2 emissions of the government's car fleet by 25% by 2011 and 50% by 2015. Similarly, in 2013, the city stipulated that all new car acquisitions for the municipal fleet should be zero emission vehicles (Bergen kommune, 2013). Similarly, Bergen requires subcontractors with significant transportation needs to switch to electric vehicles.

3.5.9 Summary

Norway has implemented extensive fiscal and non-fiscal incentives for EVs, while the cities Oslo and Bergen have complemented national schemes with local policies. Table 10 summarizes the incentives available in Norway and within the case study cities. Generous direct incentives are available at the national level but have important local implications. Indirect incentives are also set at the national level and have a particularly large impact on the southern and coastal regions as these regions have a disproportionate share of toll roads and ferry connections due to archipelagoes. Both Oslo and Bergen provide limited local incentives for electric vehicles, including targets for municipal fleets.

Table 10. Summary of EV incentives in Norway and the two case study cities, Oslo and Bergen

Type	Norway	Oslo	Bergen
Regulatory incentives	• 85 g CO_2/km by 2020 for new cars		• Hordaland: 20%/30% reduction of GHG emissions from road transport by 2020/30 • Hordaland: 20% of registered vehicles electric by 2020
Direct incentives	• Registration tax exemption for BEVs and reduction for PHEVs • VAT exemption of BEVs • Reduced company car tax for BEVs		
Indirect incentives	• Free access to toll roads for BEVs • Reduced ferry rates for BEVs • Free parking in municipal parking lots • Free charging at public chargers • Access to bus lanes		
Charging infrastructure funding	• Funding for charging stations 2009-2010: ~12 million euros • Funding for fast chargers 2013: ~0.7 million euros • Ongoing funding for fast chargers	• Funding for conventional chargers 2008-2011 • Subsidy for private chargers up to 10,000 kroner or 60% of cost	
Other incentives	• 120-140 g CO_2/km limit for government vehicles • Transnova/Enova support for research activities • Grønn Bil outreach activities[13] • Special EV license plates	• Municipal fleet all-electric by end of 2015	• Bergen: 25% of government fleet EVs by 2011, 50% by 2015 • Bergen: new acquisitions should be EVs • Bergen: government subcontractors required to use EVs

13 As of April 2016, the Grønn Bil website is defunct.

4 Comparison of EV markets and incentives

This section compares different countries and cities in an attempt to identify practices that lead to large-scale EV adoption.

4.1 COMPARISON OF NATIONAL INCENTIVES AND EV SHARES

All of the countries in this comparison provide fiscal incentives for EVs, but the type and level of incentive vary widely. Figure 26 shows the level of incentives for private and company cars for a medium-sized BEV as a percentage of the price (including taxes and fees) of a comparable gasoline car. For Germany, the reduction of taxable income for company cars has no effect for a medium-sized BEV, so the progressive ownership tax is the only fiscal incentive for purchasing an EV. On the other end of the spectrum, Norway offers a wide range of fiscal incentives, including reductions of the registration tax, ownership tax, VAT, and company car tax. When considering incentives for private and company cars together, the UK, France, and the Netherlands have similar levels of fiscal incentives; nevertheless, the Netherlands has a considerably higher market penetration of EVs.

Figure 26 also shows the density of charging infrastructure in the different countries of the comparison, defined as the number of public and semi-public charging points per 1,000 registered cars. Similar to incentive levels, charging infrastructure availability varies widely. Germany has the lowest density of chargers, with 0.13 chargers per 1,000 registered cars, while Norway has the highest density with 2.4 chargers per 1,000 registered cars.

Lastly, the bottom panel of Figure 26 presents EV market shares of new car registrations in 2014 and EV market shares of all registered passenger cars in the five countries. For Norway and the Netherlands, the comparatively high incentive levels and charging point density is reflected in EV registration numbers. As the country with the most prominent EV incentives, Norway has more than three times as many EVs as the second-place Netherlands. In turn, EV uptake in the Netherlands overshadows Germany, the UK, and France; on a percentage basis, EV shares of new registrations and car fleet are at least five times higher in the Netherlands than in those three countries.

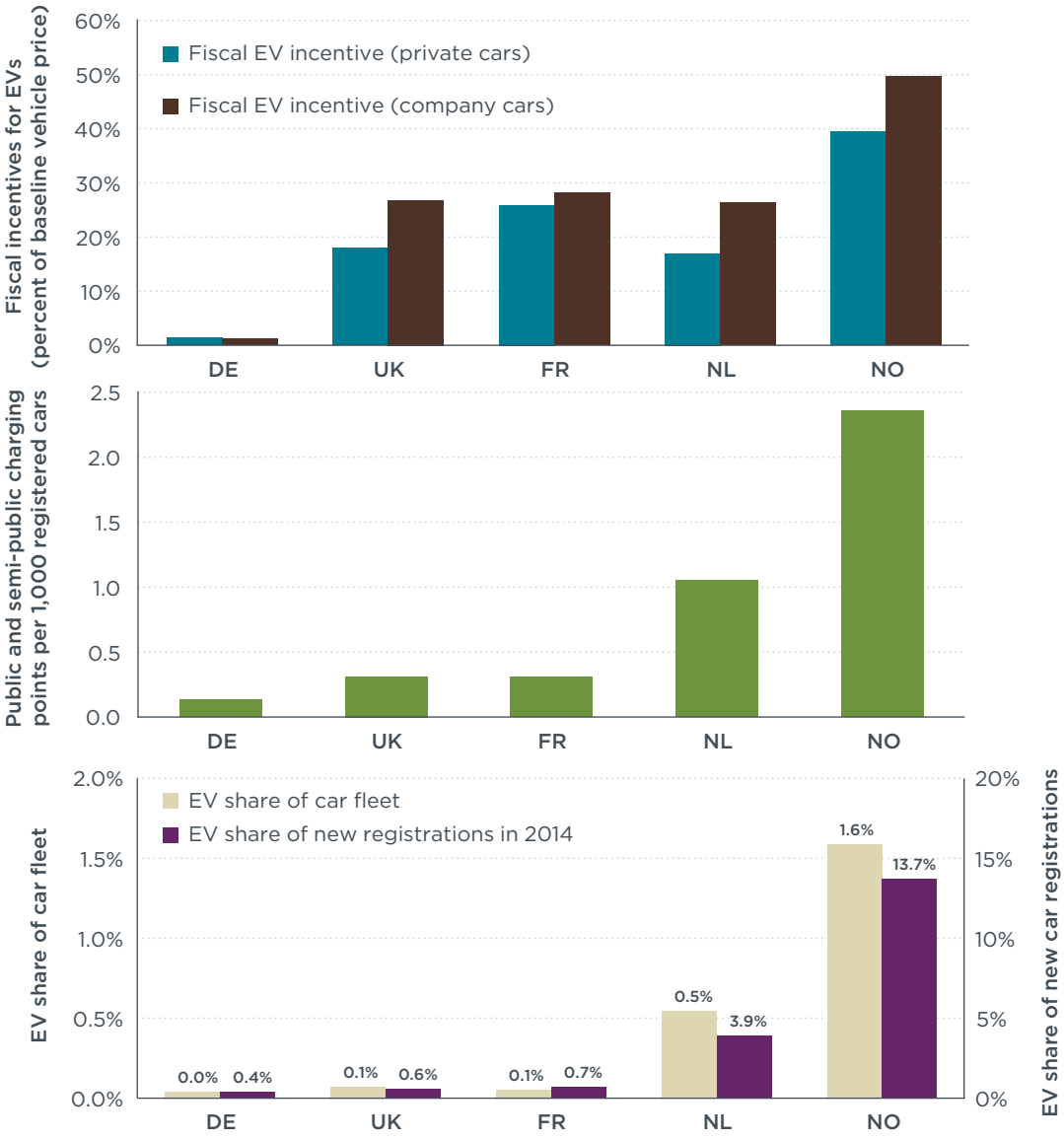

Figure 26. EV market and incentives in five European countries. Top: comparison of fiscal incentives for a medium-sized BEV. Middle: density of public and semi-public charging infrastructure. Bottom: comparison of EV shares of new registrations (2014) and car fleet.

Compared to fiscal incentives, the five countries show less divergence in terms of non-fiscal incentives, i.e., indirect incentives and complementary policies (see Table 11). All countries have implemented electric mobility strategies, conduct some form of consumer outreach and education, and fund research and development of electric mobility. Only the UK and Norway have not specified a particular absolute sales target for EVs. Most national governments also set targets or incentives for purchasing EVs for public fleets, although the Netherlands has not expressed preference for EVs for government cars. Three countries—the UK, France, and the Netherlands—also provide incentives for electric company fleets in the form of tax deductions, favorable depreciation rates for EVs, and fleet targets. Funding for public charging infrastructure is also available in all countries, though the level of funding and the type of funding varies. For instance, Germany primarily funds charging infrastructure through its

Electromobility Model Regions and Showcase Regions, which lack national coverage. The other four countries provide funding for public charging infrastructure on a national scale, although support for home charging equipment is typically made available at state- or city-level. Lastly, preferential access includes free or preferential parking, dispensation from congestion charges, and access to bus lanes, among others. While incentives related to preferential access are generally implemented at the state or city level, Norway has nationwide incentives including free access to toll roads, reduced ferry rates, access to bus lanes, and free public parking.

Table 11. Overview of national non-fiscal incentives for EVs in five European countries

Type	Incentive	Germany	UK	France	Netherlands	Norway
Regulatory incentive	Sales target	• 1 million by 2020 • 6 million by 2030		• 2 million by 2020	• 200,000 EVs by 2020 • 1,000,000 EVs by 2025	
Indirect incentives	Preferential access					• Free access to toll roads for BEVs • Reduced ferry rates for BEVs • Free parking • Access to bus lanes
Charging infrastructure	Funding for charging infrastructure	• Showcase and model regions; SLAM	• Plugged-in Places • 40 million euros for 2015 to 2020	• 50 million euro funding for charging infrastructure • Public-private partnerships	• E-laad foundation: 3,000 charging stations with 25 million euros • Green Deal: 33 million euros • MRA-E: 1,200 charging stations	• Funding for charging stations 2009-2010: ~12 million euros • Ongoing funding for fast chargers
Comple-mentary policies	R&D support	• Showcase and model regions	• Advanced Propulsion Centre	• Funding available for battery and EV research	• Various R&D programs	• Support for research activities
	Public procurement preference	• Increased allowable spending and EV target		• EV target for government		• 120-140 g CO_2/km limit
	Outreach and education	• Showcase and model regions	• Office for Low Emission Vehicles • Go Ultra Low campaign	• Various outreach activities	• Education and promotion events • Web portals	• Grønn Bil web portal • Special EV license plates
	Fleet purchasing incentive		• Favorable asset depreciation rates for EVs • EV taxi scheme	• EV target for business fleets • Subsidy for car rental and taxi firms	• Subsidy for vans/ taxis • Environmental Investment Rebate • Favorable asset depreciation rate	

	Home charging support		• Electric Vehicle Homecharge Scheme	• Tax credit		

4.2 COMPARISON OF CITY CASE STUDIES

In addition to national EV incentives, cities and regions can introduce local incentives to promote electric mobility. The analysis covers 10 case studies, consisting of 10 cities/ regions, including five European capitals.

Figure 27 and Figure 28 map EV market shares and charging infrastructure density for regions in the five countries as well as the 10 case studies. The figures show clear differences in market shares and charging point availability among the different countries, with Norway having the highest share of electric vehicles and the highest density of charging points followed by the Netherlands. It should be noted that PHEV registrations are missing for Germany and France as well as from the case studies in these countries. Figure 27 shows that differences in EV market shares typically are smaller within countries (comparing sub-national regions) than among countries. For charging infrastructure, this distinction is somewhat less pronounced. For instance, while Norway has the highest density of charging points among the countries in the comparison, charging infrastructure is considerably less abundant in the north of the country and some regions of the Netherlands, UK, and Germany have more charging points available per registered car. The figures also show that cities typically have higher shares of EVs and a higher density of charging infrastructure than their respective countries. For instance, every fifth car registered in Oslo during 2014 was an EV — roughly six percentage points higher than the national average. The density of charging infrastructure is approximately twice as high in Oslo compared to the average charge point availability in Norway.

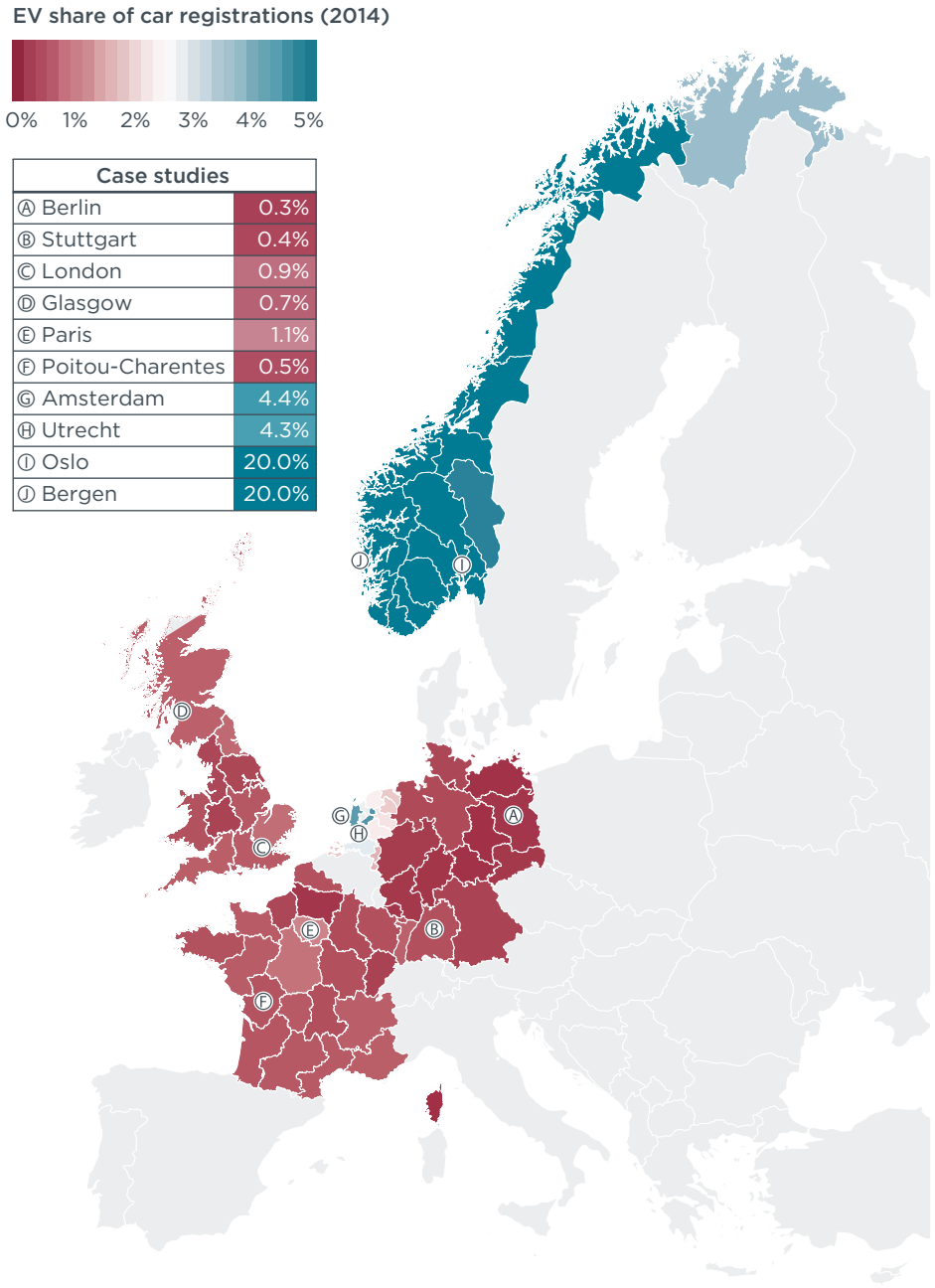

Figure 27. EV shares of new car registrations (2014) in the regions and case studies covered in the analysis.

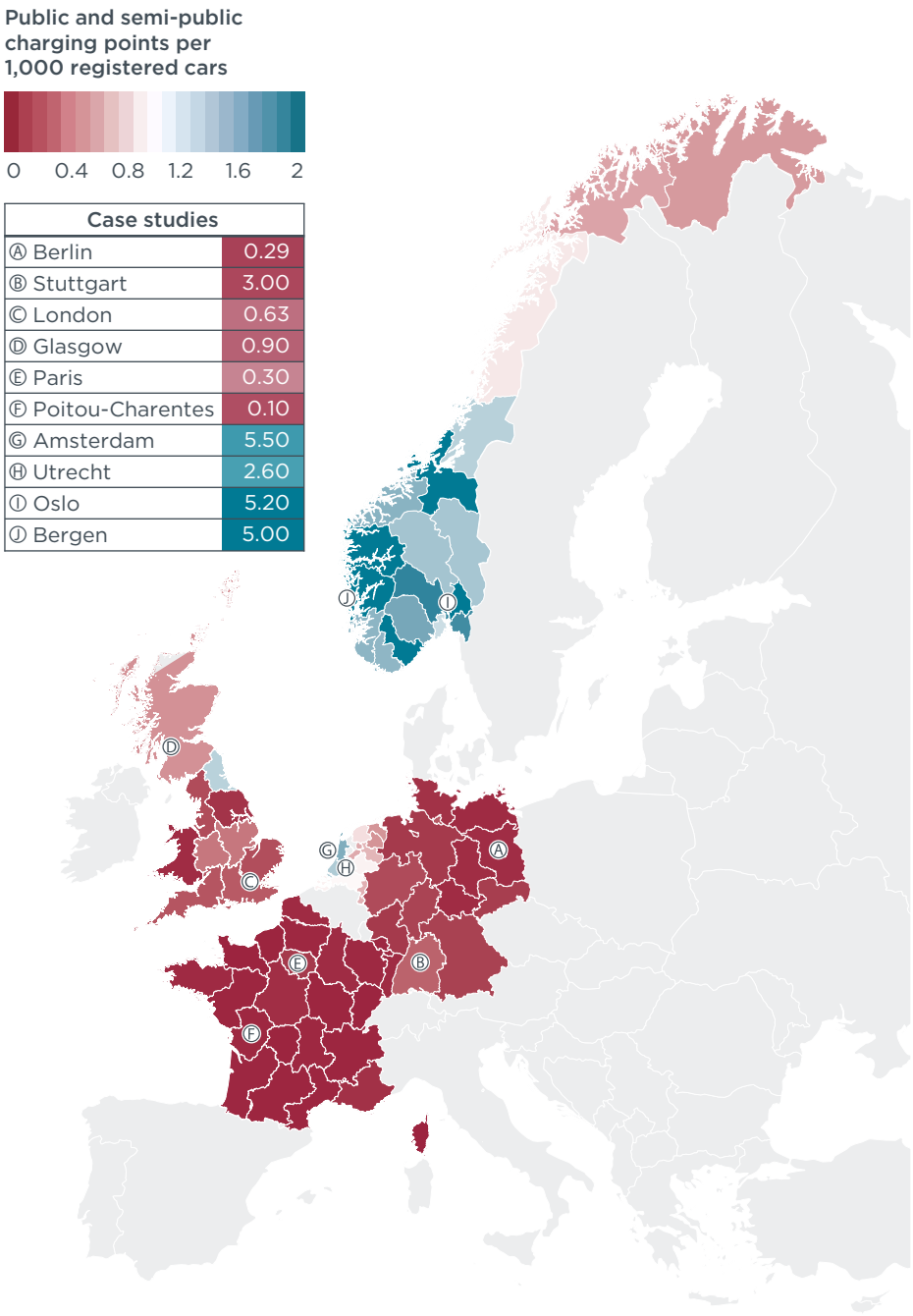

Figure 28. Density of public and semi-public charging infrastructure in regions and case studies covered in the analysis.

Figure 29 plots the relationship between the availability of fiscal incentives, charging point density, and EV market shares for all countries and cities in the comparison. The fiscal incentives refer to tax reductions and/or purchasing subsidies for a medium-sized battery electric vehicle in the different countries and regions, relative to the full price (including taxes and fees) of a comparable gasoline car. Note that the incentives presented in Figure 29 combine incentives for private and company cars. Because only tax exemptions and purchasing subsidies were quantified in this analysis, the level of fiscal incentives tend to be consistent within each country but vary significantly among

countries. In contrast, charging point density varies greatly within countries as the cities included as case studies have higher availability of public and semi-public charging infrastructure compared to national averages. For instance, five cities have more than 3 charging points available per 1,000 registered cars, but the highest charging point density for a country was 2.4, in Norway. While no statistical inference is possible from the small dataset, the general trend is that higher shares of EVs can be found in countries and cities with higher levels of fiscal incentives and charging infrastructure.

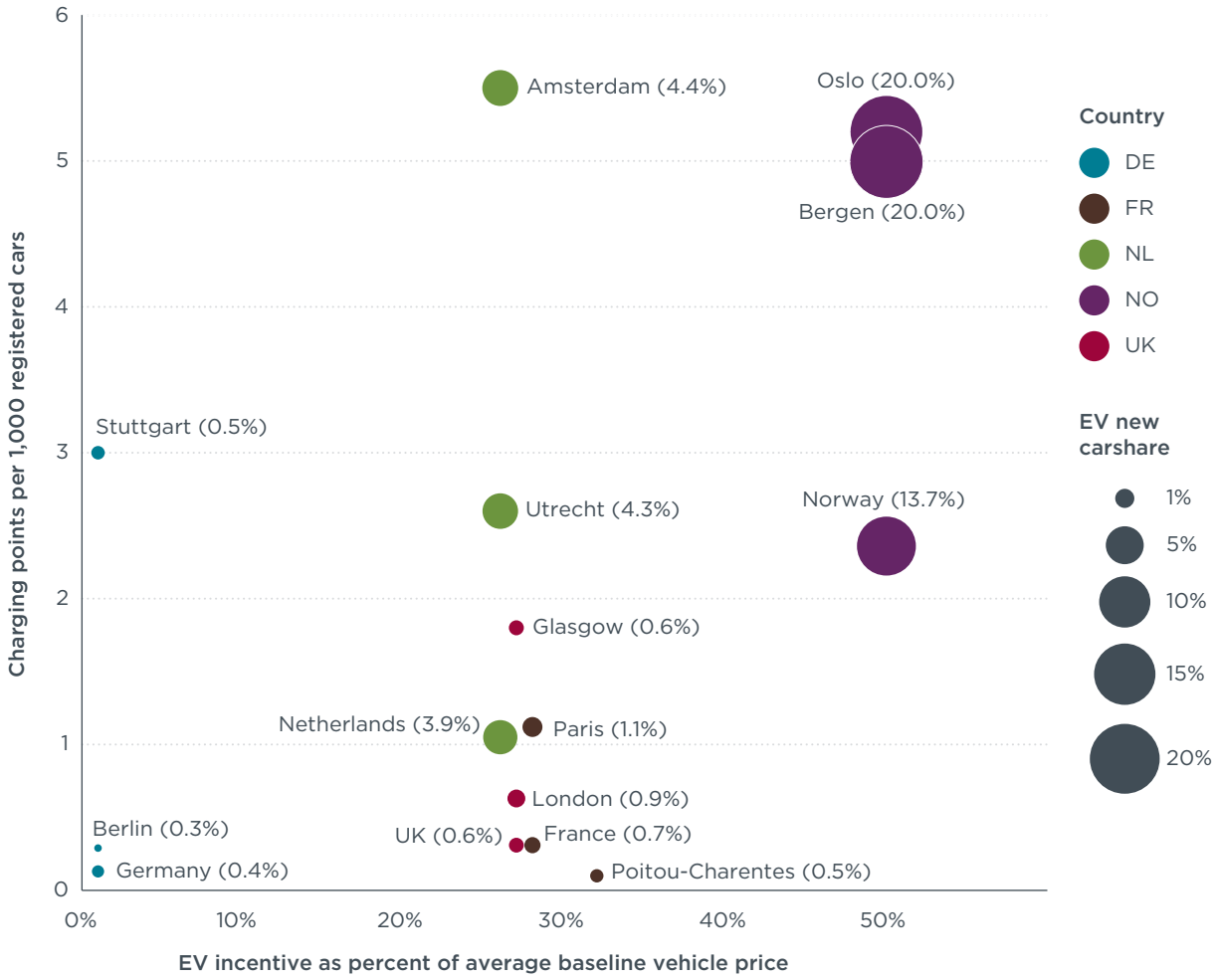

Figure 29. Fiscal incentive and public and semi-public charging point density for five European countries and 10 cities/regions. Fiscal incentives are presented as a percentage of the full cost of a comparable gasoline car. Marker size represents the EV share of new cars in 2014 (also presented in parentheses).[14]

The cities included in the study employed a range of non-fiscal incentives to promote electric vehicles (see Table 12). Six regions have specified sales targets for EVs while all regions conduct customer education and outreach of different forms. Nine of the 10 case studies also provide financing for public charging infrastructure. Electric car

14 Several local incentives (e.g., low-interest loans, subsidies for a limited number of vehicles, etc.) were difficult to quantify on a comparable basis and were thus excluded from the figure. Official PHEV registration numbers for Berlin, Stuttgart, Paris, and Poitou-Charentes were not available but were estimated to allow for an evenhanded comparison of different regions. EV market shares in this figure may therefore differ from respective country maps.

sharing is a uniquely local way to introduce EVs to the car fleet and to promote the visibility of EVs, and a number of cities financially support such programs. The most notable example is the Autolib' program in Paris. Three of the cities in the comparison also complement funding for public charging infrastructure with financing for home charging equipment. In total, the Dutch cities of Amsterdam and Utrecht make the most use of non-fiscal incentives studied, while Berlin stands out with the lowest number of non-fiscal incentives.

Table 12. Non-fiscal incentives in each country and city/region of the comparison[15]

Incentive	Germany	Stuttgart	Berlin	United Kingdom	London	Glasgow	France	Paris	Poitou-Charentes	Netherlands	Amsterdam	Utrecht	Norway	Oslo	Bergen
Sales target	X				X		X	X	X	X	X	X	X	X	X
Vehicle charging infrastructure funding	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Research & development support	X	X	X	X			X			X			X		
Public procurement preference	X	X		X	X		X				X	X	X	X	X
Preferential access	X	X			X	X		X			X		X	X	X
Outreach and education	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Company fleet purchasing incentive				X		X			X	X	X	X			
Home charging support				X		X	X				X	X			
Local car sharing link		X						X	X		X			X	
Local electric vehicle strategy					X						X	X			
Total	6	6	3	6	6	5	6	4	5	5	9	7	6	6	5

15 For the cities, incentives at the state/province/regional level are also included.

5 DISCUSSION OF RESULTS

5.1 DISCUSSION OF FISCAL INCENTIVES

The national and city-level comparison of EV incentives highlights a number of important patterns. The findings indicate that fiscal incentives are an important driver of early EV uptake, echoing findings from other studies of EV incentives (e.g., Lutsey, Searle, Chambliss, & Bandivadekar, 2015). Norway and the cities of Oslo and Bergen are prime examples of how generous incentives can induce EV sales. Nonetheless, the comparison of the UK, France, and the Netherlands highlights that substantial fiscal incentives alone are not enough to ensure a rapid uptake of EVs. While those three countries have similar levels of fiscal incentives, their EV market shares vary significantly (see Figure 26). The density of public charging infrastructure is roughly three times higher in the Netherlands than in France and the UK, potentially contributing to the more rapid EV uptake in the Netherlands; however, the high share of public and semi-public charging points in the Netherlands may partially be necessitated by low availability of private parking — only 42% of households have access to private parking in the Netherlands — compared to the other countries in the analysis, which all have more than 60% private parking availability (Figenbaum & Kolbenstvedt, 2015a). Another explanation for the disproportionately high share of EVs in the Netherlands is the incentive for companies to purchase EVs, including favorable asset depreciation schemes. This explanation is supported by the fact that more than 90% of EVs in the Netherlands were registered by companies. Attention must thus be paid to each market's context, non-fiscal incentives, and the design of fiscal incentives.

An important consideration when implementing incentives for EVs is how each country's vehicle taxation schemes are structured and how EV incentives fit into the existing framework. The countries with the highest EV shares in the comparison levy considerable taxes on high-emitting vehicles. Norway and the Netherlands, two countries lacking domestic car manufacturers, respectively levy 5,812 euros and 10,795 euros in registration and ownership taxes on a medium-sized, gasoline private car. In contrast, Germany and the UK levy less than 400 euros in taxes (excluding VAT) on the same vehicle model. In the latter countries, tax exemptions are not sufficient to promote EVs. The UK has implemented subsidies, namely the Plug-in Car Grant, to drive the uptake of EVs. The German government, however, has not introduced substantial subsidies or other significant fiscal incentives for EVs, explaining at least in part why Germany lags behind the other countries in terms of EV registrations.

Tax exemptions for EVs may have unintended consequences. Progressive vehicle taxes are by design disproportionately higher for larger vehicles than for smaller vehicles, so tax exemptions for EVs disproportionately benefit larger EVs. For example, in the Netherlands, two large models, the Mitsubishi Outlander and the Volvo V60 PHEVs, accounted for 57% of all EV sales in 2014 (ICCT, 2015). The high share of large EVs in the Netherlands is also linked to tax exemptions for company cars. Company cars are a common job benefit in many European countries. Company cars are also typically larger and more premium than private cars. More study is therefore needed to determine to what extent tax exemptions for large EVs and electric-drive company cars undermine the intended environmental benefits of electrifying personal transport.

5.2 DISCUSSION OF INDIRECT INCENTIVES AND COMPLEMENTARY POLICIES

Non-fiscal incentives can serve to increase the visibility of EVs and to inform consumers about electric mobility. The countries and cities studied commonly use sales targets and electric vehicle strategies to accelerate the uptake of electric mobility from a top-down perspective while creating demand for EVs with outreach and education activities, fleet purchasing incentives, preferential access for EVs, and fiscal incentives from a bottom-up perspective. Other non-fiscal incentives, such as local car sharing links and preference for EVs in public fleets, can help to create the critical mass needed for wide-scale EV adoption.

Nevertheless, the results show that non-fiscal incentives alone do not suffice to drive the electrification of personal transport. Germany's primary work on electric mobility is concentrated in the model and showcase regions, which serve as demonstration projects and testing grounds for the research and development of technologies and systems related to electric mobility. These regions have elevated EV shares compared to other regions of Germany; in the absence of substantial fiscal incentives, however, these policies have not created widespread, nationwide demand for EVs. Although the development of the German EV market and policies is in line with the government's strategy for electric mobility, in terms of EV adoption Germany is at an earlier stage of development than major European EV markets such as Norway and the Netherlands.

5.3 POLICY CONTEXT AND DESIGN

Policies intended to incentivize electric mobility must take into consideration the political, socioeconomic, and demographic context. From the comparison of five European countries, some common contextual factors can be identified. For one, due to range limitations, BEVs are better suited for densely populated areas. Countries like the UK and Germany therefore have targeted densely populated areas with localized demonstration projects. In general, the maps included in the analysis show that both EV registrations and charging infrastructure tend to radiate from highly populated urban areas to less populated regions (see Figure 27 and Figure 28), and all of the countries in the comparison tailored parts of their EV incentives to account for or even promote this development.

The comparison of EV incentives in five European countries highlights some effective incentives as well as some good practices for policy design. Germany focused its EV work on demonstration projects in two different programs, the Electromobility Model Regions and Showcase Regions for Electric Mobility. The two programs tie together approximately 100 projects and several hundred research and demonstration activities. This focus on a wide array of regional, small-scale demonstration projects has the disadvantage of fragmenting EV incentives and clouding the policy landscape because information and funds are spread out over many projects and regions. In contrast, other countries have implemented coherent, national EV incentives and provide one-stop shops to educate consumers about electric mobility: The UK provides information on EV incentives through the a dedicated website (Go Ultra Low), including calculators and guidance on the Plug-in Car Grant, while Norway provides information on incentives, vehicle registration statistics, and charger location on the similar websites. Such tools offer coherent and comprehensible information for potential EV buyers.

Stability is also a worthwhile consideration when designing EV policies. Many of Norway's EV incentives have been in place since before 2000 and have secure funding.

The other countries have more recent EV policies, with some of the incentives tied to budgets which may run out before widespread adoption can be achieved. Long-running incentives and secure funding provide planning security for potential EV buyers and signal continued support for electric mobility, so countries should take into consideration the long-term viability of EV incentives. In order to ensure the financial sustainability of EV incentives, feebate schemes, such as the bonus/malus scheme in France, could be considered as they can be designed to be cost neutral or even to generate revenue (German & Meszler, 2010).

Incentives for EVs can be tailored to the market in question. Norway, a country with archipelagos and mountain ranges, introduced reduced ferry rates and free access to tunnels, bridges, and other toll roads to incentivize the uptake of EVs. These tailored incentives in part explain the high uptake of EVs in coastal regions, where toll roads and ferry crossings are abundant. While a detailed discussion of the cost effectiveness and suitability of such incentives is outside the scope of this study, these examples demonstrate that countries can tailor incentives to consumer needs. In other words, while some of the identified policies should be considered, countries implementing incentives for EVs need not adopt a one-size-fits-all approach to policy design.

6 CONCLUSIONS

The comparison of EV incentives of five European countries and 10 cities/regions shows that well-designed policies are needed to ensure the market uptake of electric vehicles. Incentive levels, particularly financial incentives, were found to vary widely among the countries and cities in the comparison. The level of financial incentives and density of charging infrastructure generally predict EV market shares quite well.

The comparison of European countries and cities provides numerous examples of effective incentives for driving the uptake of electric vehicles:

- Direct consumer incentives: Substantial fiscal incentives are the most important driver of EV uptake. Countries and cities with high fiscal incentives have been more successful at transitioning to electric mobility. Among the countries in the comparison, Norway has the highest fiscal incentives and EV market shares while the opposite is true for Germany. Nevertheless, for the UK, France, and the Netherlands, the relationship between fiscal incentives and EV market shares is less clear, indicating that other factors must be considered as well. France stands out as a country that introduced a potentially cost-neutral feebate system to finance EV subsidies.
- Indirect consumer incentives: Fiscal incentives alone are not sufficient to ensure uptake. Promotion activities are needed to create consumer awareness. Promotion activities such as preferential access to low-emission zones or high-occupancy vehicle lanes, electric car sharing platforms, introducing EVs into public fleets, and consumer outreach events are common and effective measures to raise awareness of electric mobility. For instance, EV deployment in the cities of Bergen, Oslo, and Utrecht – where a greater number of EV promotional actions are in place — substantially exceed their national average EV market shares. It should be noted that EV sales mandates were not studied in the context of the five European countries, but have been effective in the California market at low public cost.
- Charging infrastructure: Availability of charging infrastructure is another prerequisite for electric mobility, as it helps overcome range anxiety. Countries with dense public charging infrastructure were found to have higher EV market shares, though other factors such as availability of fast charging infrastructure and opportunities to charge at home should also be considered.
- Policy design: Information on incentives and electric mobility should be transparent and easily accessible, as consumer awareness is a prerequisite for electric mobility. When designing policies, governments should take into consideration the financial sustainability of the policy, because stable incentives and secure funding ensure planning security and signal long-term support for EVs. By implementing strong countrywide incentives and developing national strategies for implementation, governments can ensure cohesiveness of EV incentives. Regional and city-level policies can complement national policies and tailor incentives to local needs.

Several areas of were outside the scope of this analysis but warrant follow-on analysis. First, detailed policy design choices, including how governments communicate EV incentives to consumers, deserve more attention. Second, sustainable funding sources such as feebate systems should be further investigated and developed. Third, the analysis revealed gaps in national and city-level data on EV registrations and charging infrastructure. More attention should be paid to disseminating and standardizing such

data. Both governmental and non-governmental organizations could improve the process of making the EV market more transparent. Fourth, access to fast charging infrastructure and home charging are topics that are deemed important in follow-up analyses as they are essential in everyday use of EVs. Lastly, differences in national EV markets, including model availability and supply constraints, deserve more attention in the context of growing EV markets worldwide.

Despite best efforts to compile a comprehensive and systematic comparison of EV incentives in the five countries, it proves difficult to draw conclusions about the cost-effectiveness of different incentive schemes. For one, time scales vary widely among different incentive schemes, making it difficult to attribute rising EV registrations to any one policy. Moreover, information related to costs of incentive schemes is frequently not publically available, further impeding comparisons of costs. Lastly, because some regions and cities complement national incentive schemes with local incentives, it is virtually impossible to comprehensively gauge total government spending on EVs.

This comparison of European markets provides examples of effective EV incentives that can inform policy decisions inside and outside of Europe. The incentives that were found to be effective in this study appear to match quite closely with conclusions from similar studies on the early market development in U.S. and China, for example, where there is also great diversity in policy, incentives, and complementary measures to promote EVs. However, there are many national, state, and city governments that are interested in transitioning to electric vehicles — but without such actions in place. Although there is uncertainty about how quickly EV technology will progress to higher volume and lower cost, it does seem quite clear that the implementation of such policies and incentives in multiple global markets through at least 2020 will be important in developing a mainstream EV market.

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APPENDIX

Area	Policy
Regional level 1 (e.g., European Union)	Vehicle efficiency standard
	Electric vehicle sales mandate (e.g., Zero Emission Vehicle program)
	Vehicle purchase subsidy or tax incentive
	Vehicle charging/refueling infrastructure availability and funding
	Research and development support
	Preference for electric vehicles for public procurement
	Outreach and education to vehicle owners and drivers
	Electric vehicles manufacturing incentive
	Low carbon fuel policy
	Fleet purchasing incentive
Regional level 2 (e.g., Germany)	Electric vehicle sales mandate (e.g., Zero Emission Vehicle program)
	Vehicle purchase subsidy or tax incentive
	Vehicle registration/testing fee exemptions
	Vehicle charging/refueling infrastructure availability and funding
	Research and development support
	Public procurement preference for electric vehicles
	Preferential access (e.g., to high occupancy vehicle lanes)
	Outreach and education to vehicle owners and drivers
	Electric vehicles manufacturing incentive
	Fleet purchasing incentive
Regional level 3, if applicable (e.g., Bavaria)	Electric vehicle sales mandate (e.g., Zero Emission Vehicle program)
	Vehicle purchase subsidy or tax incentive
	Vehicle charging/refuelling infrastructure availability and funding
	Research and development support
	Preference for electric vehicles for public procurement
	Preferential access (e.g., to high occupancy vehicle lanes)
	Outreach and education to vehicle owners and drivers
	Electric vehicles manufacturing incentive
	Fleet purchasing incentive
Regional level 4 (e.g., Munich)	Vehicle purchase subsidy or tax incentive
	Vehicle charging/refueling infrastructure availability and funding
	Research and development support
	Preference for electric vehicles for public procurement
	Preferential access (e.g., to low emission zones, bus lanes or parking spots)
	Outreach and education to vehicle owners and drivers
	Fleet purchasing incentive
	Local car sharing program link
	Local electric vehicle strategy
Utility	Preferential charging rate
	Home charging support
	Information outreach
Public-private or private business actions	Examples include workplace charging, preferential charging rate, home charging support, insurance incentive, information outreach, etc.