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Policy Instruments to Promote Electro-Mobility in the EU28: A Comprehensive Review

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Abstract: Despite its environmental benefits, the amount of Electric Vehicles (EVs) in use within the European Union 28 is still very limited. Poor penetration might be explained by certain factors that dissuade potential buyers. To balance these factors and promote electro-mobility, Member States have established incentives to increase demand. However, the various measures are scattered. This paper contributes to fill the gap in the literature by offering an overall view of the main measures. The authors will focus on measures to promote electro-mobility within the EU28 until 2014. After an in-depth and comprehensive review of the relevant measures, the authors conclude that the most important policy instruments to promote EVs are tax and infrastructure measures in addition to financial incentives for purchasing and supporting R&D projects. Regardless of the scarcity of EV registration data, the available information allows us to conclude that higher EV penetration levels appear in countries where the registration tax, the ownership tax, or both taxes have developed a partial green tax by including CO₂ emissions in the calculation of the final invoice.

Keywords: electric vehicle; electro-mobility promotion; policy instruments; tax and infrastructure measures; financial incentives; supporting R&D projects

1. Introduction

In the European Alternative Fuels Strategy, it is believed that an appropriate combination of fuels will be able to break the dependence on oil and improve energy supply security [1]. Furthermore, the European Union (EU) also considers that the development of alternative fuels would improve economic growth, strengthen industry competitiveness, and promote employment [2]. Lastly, alternative fuels reduce greenhouse gas (GHG) emissions from transportation, which allows the targets set in the H2020 strategy to be attained.

The H2020 strategy is the most ambitious EU package to date and it seeks to fight against global warming. It includes a specific 20% target for increasing the share of the renewable energy source (RES), which is up to 20% for the final energy, and reducing GHG emissions up to 20% from the 1990 levels [3]. The European Council [4] extended this objective to 40% by 2030. Without setting an obligatory objective, the White Paper on Transport also establishes the aim of reducing 60% CO₂ emissions in transportation by 2050 [5].

As one of the main alternative energy sources for transportation, the electric motor could be used mainly on the highway, in cities, and rail transportation for travelers and for delivering goods. Electric vehicles (EVs) could reduce GHG emissions and improve city air quality and, therefore, the health of their populations because they only emit natural by-products rather than exhaust fumes [6–8]. Yet, from the potential buyer perspective, this environmental benefit may be less important because society,

by nature, is individual and hedonic [9]. There is critical research on this environmental benefit. In this sense, Perujo and Ciuffo [10] observe that EVs can really represent a realistic alternative both in terms of the electric grid available capacity and CO₂ emissions reduction. It could heavily impact the daily requested electric power. Moreover, Camus et al. [11] study different scenarios for EVs penetration and charging profiles and concluded for a strong EVs penetration scenario that local emissions (CO, NO_x, HC, and PM) decreased to 10% by the replacement of light duty Internal Combustion Engine Vehicles by EVs, but were replaced by 8% local emissions increase from electricity generation (NO_x, SO₂) when providing the extra energy for EVs recharging.

Despite the environmental benefits, the number of EVs in use is still very limited. In 2013, there were 123,188 EVs registered, which represents 1.1% of the total number of vehicles registered that year in EU28, which was a total of 10,801,973 vehicles [12]. The limited share of EVs is also present in the US [13] as well as in China and Japan [14].

Poor penetration might be explained by a number of different factors that dissuade potential buyers, which was reviewed by Coffman et al. [15] and the study by Sierzchula et al. [16]. Coffman et al. [15] group these factors into internal, external, and applied policies. In the first group, there is a higher initial investment [17–19], an extended recharging time, and a limited range [20]. Second, Coffman et al. [15] include relative fuel prices [16] and the characteristics of potential consumers, but the literature is inconclusive. The availability of charging stations is also important, which Sierzchula et al. [16] note as one of the most influential factors in the decision to purchase an EV, and public visibility/social norms. In the latter group, Coffman et al. [15] includes financial and non-financial incentives, public support for the construction of recharging infrastructure, and awareness-raising.

To balance these factors and promote electro-mobility, Member States (MSs) have established incentives to increase the demand. Like other, low carbon energy strategies, market penetration speed could be increased by public policies [21–23].

Often, the various measures appear scattered and they are not shown as a whole. As a consequence, research is needed but not only oriented to review measures in. It is also needed for analyzing national incentive frameworks to group measures in homogeneous sets and allow for the comparison between countries. In this paper, the research process implied feed-back between national authorities and coauthors before addressing measures in the right set. The aim of this paper is to fill the gap in the literature by offering an overall view of the main measures. This study will focus on measures up to 2014 to promote electro-mobility by using Plug-in EVs in the EU28. The end of the period under analysis coincides with Directive 2014/94/UE on alternative fuel deployment. Due to the lack of data on registered cars in EU after 2012, Directive 2014/94/UE constitutes a relevant milestone for further analysis when data is available. The Plug-in EV category includes the following list: Pure EVs or Battery EVs (BEVs), Extended-Range EVs (EREVs), and Plug-In Hybrid EVs (PHEVs). Hannan et al. [6] offer a recent and useful review of these alternative vehicles. In general, we refer to them as EVs. Nonetheless, many of the promotional measures presented in this paper also apply to other low carbon-emissions vehicles.

This paper is organized as follows. After this introduction, Section 2 analyzes the public policies applied to promote the acquisition of EVs such as taxes, measures to develop the recharge point infrastructure, the main financial incentives, the measures supporting R&D projects, and the actions aimed at improving consumer perception. In Section 3, the major findings in light of the relevant data available are discussed before drawing conclusions in Section 4.

2. Public Policies Applied to Promote the Acquisition of EVs

After an in-depth and comprehensive review of the relevant measures, the most important ones include tax measures, those oriented toward infrastructure, financial incentives for the purchase support of Research and Development (R&D) projects, and projects enhancing consumer perception.

All of them focus on correcting external and internal factors, which is pointed out by Coffman et al. [15]. Therefore, they fall within the third group of factors mentioned above: the policies applied, which are classified according to Table 1.

Table 1. Classification of measures analyzed in the EU.

Applied Public Policies [15]		Measures Implemented in the EU	
Incentives	Financial	Tax Aids/subsidies	
	Non-financial	Other benefits to EVs owner	
Public support for recharging infrastructure		Public or subsidized recharge points	
Sensitization of the population		Awareness Campaigns Support for R&D	

Source: Based on the classification of Coffman et al. [15].

2.1. Financial Incentives: Tax Measures

Based on the amount collected, the most important taxes in the EU are the value-added tax (VAT), registration fees, and the vehicle ownership tax. The first of these is not significant in this paper because no Member State (MS) has established a reduced VAT when purchasing EVs. Therefore, common rates are applied and the tax rates range from 15% in Luxembourg to 27% in Hungary. This section focuses on registration fees and ownership taxes. Some measures include personal income tax and corporate tax, which are also referred to in this paper.

2.1.1. Registration Fees

Registration fees work as a special tax on motor vehicles applied to the first and initial registration. It includes two types of taxes, which are the registration tax and the license tax. Both are paid when the vehicle is first registered although they involve a variety of concepts.

License fees are administrative fees. The purpose of these fees is to offset the administrative costs of the registration process. It is a fixed amount, which normally does not depend on technical or environmental parameters. However, in the cases of Cyprus and France, reductions do exist.

Cyprus applies a 15% discount for those which emit less than 150 g of CO₂ per Km [24–26]. In France, individual regions are allowed to establish a total or 50% exemption of the EV license fee.

Yet, the registration tax seeks to levy the purchasing power shown in the acquisition. The amount depends on the vehicle's value and technical specifications. Table 2 provides detailed information about the parameters that influence the amount of the registration fee in each MS.

Table 2. Determinants of registrations taxes in each MS of EU28.

Countries	No Registration Tax	Emissions	Environmental Standards	Others
Austria		●		
Belgium				◇
Bulgaria	●			
Croatia		●		●
Cyprus		●		
Czech Republic	●			
Denmark			●	
Estonia	●			
Finland		●		●
France		●		
Germany	●			
Greece			●	●

Table 2. Cont.

Countries	No Registration Tax	Emissions	Environmental Standards	Others
Hungary			●	●
Ireland		●		
Italy				◇
Latvia		●		
Lithuania	●			
Luxembourg	●			
Malta		●		●
Netherlands		●		●
Poland				◇
Portugal		●		●
Romania		●	●	●
Slovak Republic				◇
Slovenia		●		●
Spain		●		
Sweden	●			
United Kingdom	●			

Source: [26]. Note: Diamonds in the last column indicate that this tax do not consider any environmental characteristics. Black dots in the same column indicate the tax included in the environmental parameters.

Table 2 shows that eight MSs do not apply a registration tax. These countries include 35.1% of the EU population. Four of the countries (the diamonds in Table 2) that have established this tax do not consider any environmental characteristics. The other sixteen countries use certain environmental parameters.

Seven out of the 20 MSs that have established registration taxes include a tax credit for the registration of EVs. The detail is shown in the third column of Table 3. In those MSs, EVs enjoy full exemption.

Table 3. Tax credit in tax measures of EVs.

Countries	Registration Fee	Registration Tax	Vehicle Ownership Tax	
			Private	Commercial
Austria		BEVs are exempt. Hybrids have an allowance of €600	EVs are totally exempt	
Belgium		Individual regions may establish environmental bonus and penalties	EVs pay a minimum amount	
Bulgaria			Based on the horsepower and vehicle age [24]	There is a time-based vignette system in place for passenger cars and heavy-duty vehicles [27,28]
Croatia		No tax credit	Based on vehicle age	
Cyprus	15% discount for those who emit less than 150 g of CO ₂ /Km	Exempt for those who emit less than 120 g of CO ₂ /Km	EVs do not pay	
Czech Republic				Only applied to commercial vehicles and BEVs and hybrids are exempt
Denmark		BEVs had a limited exemption from 2010 [29] until 2015	Tax according to fuel consumption	Tax according to fuel consumption
Finland		BEVs pay the minimum	Amount varies between €20 and €605, according grams of CO ₂ [30]	
France	Individual regions are allowed to establish a total or 50% exemption	Exempt those who emit less 130 g of CO ₂ /Km	Vehicles that emit more than a 190 g/km pay €160 fee	BEVs are exempt, but hybrids enjoy an exemption for 2 years if they emit less than 110 g/km (for passengers vehicles)
Germany			EVs are exempts for ten years	After 10 years of total exemption, there is a 50% reduction (for passengers vehicles)
Greece		Commercial EVs are exempt	Vehicles emitting less than 100 g/km are exempts	
Hungary		BEVs are exempt. Hybrids pay only €247	Based on vehicle age, EVs are completely exempt	
Ireland		BEVs are exempts. A limit of up to €2500 rebate for PHEVs [26,31]	Zero emissions vehicles only pay €120 each year, €50 less than the next stretch	

Table 3. Cont.

Countries	Registration Fee	Registration Tax	Vehicle Ownership Tax	
			Private	Commercial
Italy		Individual regions may establish environmental bonus and penalties	EVs are exempt for the first five registration years and an exemption of 75% is given afterwards (According to regions)	EVs: there are no ownership tax for the first five registration years of a vehicle and an exemption of 75% is given afterwards (according to regions)
Latvia		BEVs are exempt	Based on vehicle age	
Malta		No tax credit	Based on vehicle age	
Netherlands		Exempt those who emit less 88 for petrol and 85 for diesel g of CO ₂ /Km	Vehicles emitting less than 50 g/km are exempts (until 2015)	
Poland		No tax credit		
Portugal		No tax credit	Based on vehicle age and emissions	
Romania		All EVs are tax exempt		
Slovak Republic		No tax credit		
Slovenia		No tax credit		
Spain		Exempt among those who emit less 120 g of CO ₂ /Km	Town halls have the authority to establish environmental deductions up to 75%	
Sweden			Hybrids and BEVs are exempts for five years if CO ₂ -emissions and energy consumption are under 120 g/km and 37 kw/h per 100 km	EVs up to 3500 Kgs are exempt for 5 years; hybrid buses pay only €115
United Kingdom			Vehicles emitting less than 100 g/km are exempts	

In Cyprus, France, the Netherlands and Spain, EVs pay no registration tax. These MSs account for 25% of the EU28 population and almost 40% of the 20 MSs' population that levy this tax.

In Belgium, registration taxes are defined by each region while the federal government also establishes measures that favor environmentally-friendly vehicles through the same tax [32]. Flanders and Wallonia use the registration tax to reduce vehicle CO₂-emissions (these two regions account for almost 90% of the Belgian population [33]). In March 2012, the Flemish Authorities modified the registration tax applied to green cars. The current tax is based on the type of fuel used, the level of CO₂ emissions, the Euro norm, and age. Cars that emit less than 81 g CO₂/km receive a premium of €500 to €3500. For cars emitting more than 146 g CO₂/km, an Ecomalus of up to €2500 applies. Yet, in the Brussels-Capital region, the registration tax is only based on horsepower and age [34]. Financial assistance with a maximum of €5000 has, nevertheless, been established for commercial vehicles.

In the case of Italy, provinces may establish a maximum surcharge of 30% for registration tax. Therefore, almost all of the provinces have established that maximum and only six have levied a lower surcharge for EVs, which accounts for little more than 4% of the country's population [33].

2.1.2. Vehicle Ownership Tax

The vehicle ownership tax is a local tax. This tax levies the ownership of mechanically-driven vehicles suitable for driving on public roads. It must be paid periodically by the vehicle owner. The amount depends on technical parameters and other aspects such as environmental impact, consumption, or business use. Table 4 shows the parameters considered, respectively, when taxing vehicle ownership for private and commercial purposes in the EU28.

In the Czech Republic, Estonia, Lithuania, and Poland, private vehicles are not levied by this tax. Eleven out of the remaining MSs only consider technical parameters. Therefore, only 13 MSs include some type of environmental parameter.

Age is used in Bulgaria, Croatia, Hungary, Italy, Latvia, and Malta. Paradoxically, despite older vehicles possibly having a greater environmental impact, only in Malta does the levy increase accordingly as the vehicle ages. Consequently, this discourages fleet renewal.

As far as we know, 25 MSs have established taxes for commercial vehicles. These countries include almost 99% of the EU28 population. Furthermore, these taxes depend mainly on technical characteristics such as weight, the number of axles, and the type of suspension. Only six countries include some type of environmental parameter (see Table 4).

Table 4. Determinants of taxes on vehicle's ownership in each MS of EU28.

Countries	No Registration Tax		Emissions		Environmental Standards		Others	
	Private	Commercial	Private	Commercial	Private	Commercial	Private	Commercial
Austria							◇	◇
Belgium							◇	◇
Bulgaria						●	◇	●
Croatia							◇	
Cyprus			●					
Czech Republic	●							◇
Denmark					●	●		●
Estonia	●							◇
Finland			●				●	◇
France			●	●				●
Germany			●			●		●
Greece			●				●	◇
Hungary							◇	◇
Ireland			●					◇
Italy					●			◇
Latvia							◇	◇
Lithuania	●							◇
Luxembourg			●					◇
Malta							◇	
Netherlands			●				●	◇
Poland	●							◇
Portugal			●				●	◇
Romania							◇	◇
Slovak Republic							◇	◇
Slovenia							◇	◇
Spain							◇	◇
Sweden			●		●	●	●	●
United Kingdom			●			●		●

Source: [26]. Note: Diamonds in the last column indicate that this tax does not consider any environmental characteristics and black dots in the same column indicate the tax included environmental parameters.

2.1.3. Measures Included in Income Tax and in Corporate Tax

In addition to the measures included in the registration tax and the tax on vehicle ownership, there are other measures affecting other taxes. The most relevant taxes to be considered are the income tax and the corporate tax.

Two types of incentives are included in the income tax. The first incentive, in the case of an employee receiving a company car, is that its value (total or partial) must be incorporated into the taxable base as a part of income. Second (Incentive 2 in Table 5), the purchase of an EV may produce a deduction in the tax. This is the case in Portugal, Belgium, the UK, the Netherlands, Sweden, and Germany.

With regard to Incentive 1, it is also necessary to consider that the private use of a corporate vehicle involves an income that depends on the value of the vehicle. Four countries have total (UK) or partial (the Netherlands, Sweden, and Germany) exemptions.

Some countries also have established tax measures for the corporate tax. Belgium and Portugal are two examples (see the last column of Table 5).

Table 5. Tax credit in tax measures of EVs (II).

Countries	Income Tax		Corporate Tax
	Incentive 1	Incentive 2	
Belgium	Until 2015, this income was exempt for EVs.	Reduction of 15% up to €4940. Brussels Regions has established a subsidy of up to €5000 for the acquisition of BEVs and hybrids commercial. BEVs only are subjected to the minimum tax solidarity contribution, an extra fee that must be paid for commercial vehicles utilized for private use [32].	Subsidizes the 20% of the extra cost involving the purchase of EVs and charging point installation up to €14,375.
Germany	Have an adjustment method to offset the higher value of EVs.		
Netherlands	Reduction percentage depends on emissions. EVs pay 4% instead of 25%.		
Portugal		Decreasing of 30%, with a limit of up to €796. There is an additional incentive of €5000 for a scrapped car.	There is a deduction of 50% of the purchasing price in corporate tax if an old vehicle is scrapped.
Sweden	Reduced by 40%.		

2.2. Financial Incentives: Aids and Other Measures

The use of financial incentives is less extended than previous political instruments but it is the most visible type of incentive for the EV purchase credit. Twelve MSs carried out remarkable initiatives, which is presented in Table 6. Most of these countries have opted for direct aid, which is shown in column 1. Nevertheless, some have combined this with other measures such as those detailed in the third column of Table 6.

Table 6. Financial Incentives applied in some countries of EU: direct aids and others measures.

Countries	Direct Aids	Other Measures
Austria	<p>1. 2007–2013: 10,000 EVs were funded with €10.8 Mio., among them: 7778 E-Bikes, 566 E-Scooter/Motorcycles, 1118 E-Cars and light duty vehicles.</p> <p>2. New funding flat rates for EVs are: E-Bikes, €400, E-Scooter €500, E-Car €4000.</p>	The 'klima:aktiv program' [35,36]: It included the traffic climate action program for climate-friendly mobility that proffers integral aid in this field to private companies, local associations, and communities.
Belgium		15% assessment of the environmental criteria on the score of the contract adjudications. The goal that 50% of all public acquisition processes correspond to sustainable procurements. In accordance with that, the public contract adjudications have to be made based on an ecological score system. A minimum eco-score for cars of 70/100 was established as desirable share for the procurement of vehicles of public institutions from 2010 with the additional consideration that public vehicles having an eco-score value below 50 should be avoided.
Bulgaria	<p>1. There is a program with a global budget about €1.3 billion whose preference is to reach the goal of incrementing the number of eco-friendly vehicles.</p> <p>2. Project that finances the development of programs promoting the use of renewable energy including procurement programs for EVs. These programs can be financed with grants and loans up to 20% [37].</p>	
Cyprus	<p>1. €22,566 as premium for the purchase of an EV. The limits were a maximum bonus of €700 for the purchase of new EVs not exceeding the limit of 120 g/km CO₂ emissions and bonus of €1200 at max for the procurement of a hybrid EV.</p> <p>2. There is a program of incentives for withdrawing an old vehicle from circulation. Subsidies vary from €257 to €1800 [38].</p>	
France	Purchasers obtain an incentive of €5000 when acquiring a car that does not exceed 60 g/km CO ₂ emissions.	In 2011, the Environmental Ministry of France arranged the distribution of 50,000 EVs to about 20 public and private companies.
Ireland	These actions provide investment support for the first 6000 EVs sold.	To implement these measures, the aid is supplied to selected EVs dealer, which are responsible for providing the discounts to the final purchasers of EVs.
Italy	Vehicles emitting less than 50 g/km including BEVs and hybrids receive a subsidy of 20% after tax (limit of €5000).	
Luxembourg	BEVs and PHEVs, which emits less than 60 g/km, may receive a €5000 subsidy in the procurement if the purchaser contracts a green electricity supply.	

Table 6. Cont.

Countries	Direct Aids	Other Measures
Portugal	<ol style="list-style-type: none"> 2008 and 2010: purchasers received a grant of €1000 if they substituted a 10–15 years old vehicle for a new one that does not exceed the limit of 130 g/km CO₂ emissions. This incentive amounts to the €1250 if the vehicle age was more than 15 years. From 2010, this grant was diminished to €750 or €1000, respectively. 	
Slovak Republic	Public transportation benefited from this measures because it included the purchase of new transportation equipment/vehicles for it. The funding volume covers 85% of the investment maximum (FREE Governmental Program for Competitiveness and Economic Growth (2007–2013)).	
Spain	<ol style="list-style-type: none"> Local authorities offer investment support with incentives from €2000 to €7000 for purchasing EVs and other low CO₂ emissions cars. For municipalities with 50,000 or more inhabitants (145 cities) a 20% subsidy is applied for the purchase of EVs (€6000 max/unit). Incompatible with the specific grants for EVs included in the plan MOVELE depending on the region of Spain. The amount could surpass €5500. 	Since 2012, the government of Spain launched the PIVE Plan, which had the objective to renew private and light commercial vehicles. With an allocation of €1120 Mio, 1,185,000 vehicles were removed from circulation and substituted for others, which, for the most part, emit less than 120 g/km.
Sweden	<ol style="list-style-type: none"> Investment aid in 25% over extra cost, with maximum levels of €10,259.11 € and €5129.55 € for the first 75 EVs and the next 1000 EVs sold, respectively. An extra-bonus for low emission vehicles may be also applied since early 2012 with investment aid for an amount of up to €4103.60 [39–41]. 	The taxable appraisal of the EVs is diminished by 40% when compared with similar fossil fuel cars, with a limit on this diminution of €1639.15 per year.
United Kingdom	Since 2011, the purchase of a BEV or PHEV emitting less than 75 g CO ₂ /km receive a one-time bonus of 25% of the car (maximum of about €5600) [29,40,41].	

2.3. Infrastructure

Within the EU28, there are widespread measures to promote EVs, which prioritize infrastructure use. In this sense, Directive 2014/94/UE of the European Parliament and the Council [42] on the deployment of alternative fuel infrastructure commits MSs to setting up sufficient charging points available to the public before 31 December, 2020. The aim of this directive is to facilitate circulation in densely populated areas especially in urban and suburban areas and networks determined by these MSs.

Malvik et al. [43] list several policy measures to promote BEV infrastructure. These include free parking in publicly-owned parking areas, the development of certain charging infrastructures, access to bus lanes for high occupancy vehicles and no road toll, and more. The development of dynamic tariff systems may be added in order to minimize charging costs and prevent grid congestion [44].

Table 7 outlines some of the main infrastructure development measures implemented by eighteen countries to promote EVs.

Low Emission Zones in Holland are also being introduced in an effort to improve air quality in cities [45]. Column 5 of Table 7 provides some examples of the largest urban areas in the Netherlands where such environmental zones have been introduced. The objective is to restrict the entry of non-'environmentally friendly' vehicles such as old diesel cars and large trucks.

In Sweden, several regional initiatives and regulatory changes have been introduced to promote EVs, which you can see in Table 7. In Germany, several cities have implemented special incentives for EV infrastructures, which are oriented toward converting its fleet into EVs. In Luxembourg, several measures have been included in the Global Mobility Strategy and the Transportation Sector Plan.

In the case of Ireland, the measures adopted imply that all counties and nearly 90% of major Irish cities have access to EV charging infrastructure. Pilot projects are operating in major Italian cities. In addition, projects related to infrastructure and eco-friendly mobility developed by local bodies may be financed by a government fund of €380 Mio.

In Spain, the program Movele was initiated between 2008 and 2011 with a budget of €10 Mio. Additionally, €35 Mio were invested in electric grid-related communication systems [46].

Portugal is a leader in EVs adaptation based on clean wind energy. This is due to the Renault-Nissan alliance. This arrangement also included the set-up of a national EVs infrastructure developer named MOBI.E [47].

The Greek Parliament passed a newly developed law for EV charging systems on the 30th of July in 2014. In addition to coordinating all of the parties involved, a special committee set up at the Ministry of Energy will also take charge of a public information campaign [48]. The new legislation considers that charging points do not need to have a particular license for supplying electrical energy. Therefore, this is going to boost the EV charging systems market [49].

In Malta, the government is installing a National Charging Network to provide the possibility to charge through public accessible car charging points. This will be interconnected by a network of strategically placed parking areas throughout the country [50]. This project is also being used to demonstrate how the Intelligent Transportation System Action Plan may be applied in the area of EV charging facilities. Additionally, these will be linked to the proposed Traffic Control Center hosting the Intelligent Traffic Management System so that it is able to monitor the performance of the vehicles as well as their charging status. Likewise, the plan aims to study the effectiveness of Full Electric Goods Carrying Vehicles. This information will improve data available in the Urban Traffic Management and Control and provide additional data for policy decision making [51].

Poland initiated its first "e-mobility" project in 2009. It was financed by the EU. It developed networks of charging points in five cities [52]. Recently, the authorities of some cities such as Warsaw, Krakow, and Poznan announced incentives to motivate drivers to use low-emission cars.

In February of 2014, the Electro-Mobility Development Plan (2014–2016) was approved by Latvia's Cabinet of Ministers. This plan was prepared by the Transportation Ministry and Road Traffic Safety Directorate, which is the first Electro-mobility plan developed in Latvia [53]. Public institutions, public

persons, and those registered in Latvia as businesses may benefit from this plan through a support scheme for EV Charging Infrastructure (measure LV26 Electro-Mobility Development). This support has been provided for publicly available charging infrastructure with the project applicant required to be the owner of charging stations for at least five years after completing the project. Therefore, the applicant must have the right to use buildings and their land during this time [54]. The project's financial support rates over total eligible costs are 85% for public institutions, 70% for small and medium businesses, and 35% for large corporations with a maximum support for each charging station of €31,300.

In Lithuania, important changes are foreseen in highway rules as new signs associated with EVs such as EV charging stations and cases where road signs do not apply to EVs or their parking spaces. In addition, EVs will be allowed to drive on public transportation lanes, which will be marked with symbols of EVs [55]. The "Implementation Plan of the Strategy for National Climate Change Management Policy" includes the development of the infrastructure for EVs in cities [56].

Despite the interest in infrastructure in other countries, charging infrastructure is not a core activity at present in the UK even though some measures are being taken, which is reflected in Table 7.

Table 7 summarizes the main infrastructure measures carried out in the EU28 to facilitate the use of EVs. As column 2 shows, the most popular measure is to expand the number of charging stations in use.

Table 7. Measures to promote EVs infrastructure.

Countries	Charging Points	Free Parking Places	Free Charging in Public Parking	Low Emissions Zones	No Road Toll	Fleet Promotion
Austria	1000 (Between 2007 and 2013).					€400,000 are available for companies, local communities, and associations if they promote climate-friendly traffic measures particularly vehicle fleets turning to alternative drives such as Evs.
Czech Republic	2011: began building a network of public charging stations. Prague: installed 15 and this number is expected to increase significantly [57]. Points will be installed at the main railway station and Václav Havel Airport [58].	There are some free parking zones for electric cars [58].		Prague and Klimkovice are the most advanced cities [45].		Electric car-sharing pilot program, which introduces 35 electric cars throughout the historic city center.
Denmark			Odense and Frederiksberg			
Estonia	Several plans have been vested to support the introduction of EVs [59], which allows a quick charging network [29]. 200 will be installed along all primary and secondary roads at 40–60 km interval. Local governments will also install ordinary chargers [60].					
France	1250 in 20 cities (until 2012). 75,000 public and 900,000 private charging stations were ready at 2015. 2020: 400,000 publics must be installed.					Local administrations stimulate sales by increasing the EV share of their fleets.
Germany						Berlin has begun converting its fleet to EVs. The Initiative 120 project, which is carried out at the Berlin Police Department testing alternative driving systems for patrol cars.

Table 7. Cont.

Countries	Charging Points	Free Parking Places	Free Charging in Public Parking	Low Emissions Zones	No Road Toll	Fleet Promotion
Greece	13,000 by 2020 [61]. The planned program envisages an integrated “Electro-Mobility Network” performing as a pilot project.					
Hungary	Budapest has installed 10 public smart charging stations linked to the marketplace [62]. 68,000 chargers will be installed across the country by 2020 [63].					
Ireland	1000 until 2012. Until 2014: projected the installation of 46 fast charging stations throughout the main intercity itineraries and principal transportation hubs all along the island [64,65].					
Latvia	Electro mobility Development Plan (2014–2016) to support publicly available charging infrastructure.					
Luxembourg	850 must be installed in 2020 [66].		Building the first national platform for EVs, whose major milestone is the development of a smart energy system by creating a public charging infrastructure for EVs [67].			2013: Private sector Enovos Luxembourg and the developer of mobility projects City Mov’ jointly announced the launch of the first car sharing service whose customers will be professionals and municipal citizens. Its fleet will be mainly composed of “clean” vehicles such as electric, hybrid, or natural gas vehicles [68].
Malta	100 public smart charging and smart parking points are going to be deployed across Malta and Gozo (at 2013).					

Table 7. Cont.

Countries	Charging Points	Free Parking Places	Free Charging in Public Parking	Low Emissions Zones	No Road Toll	Fleet Promotion
Netherlands	More than 5000 by the end of 2013 (excluded private points). A fast-charging network is being rolled out along highways and in parking [69].	Amsterdam, Rotterdam (one year of free parking) [70].	Amsterdam.	Amsterdam, The Hague, Leiden, Rotterdam, and Utrecht.		
Poland	There are a network.	In some towns.		Specially in Krakow [71].		
Portugal	1300 until 2012 [47].					Deduction of 50% of the purchasing price in Corporate Tax if an old vehicle is scrapped.
Spain	343,350 must be installed in 2014. 2014: recharging-point-installation objective was 263,000 for company fleets, 62,000 in homes, and 6200 public road-side spaces.	12,150 public parking spaces.				
Sweden		Arlanda and Gothenburg [39].	Stockholm (70 points).			Alternative vehicles matriculated by 2008 enjoy a congestion toll road exemption in Stockholm
United Kingdom	Provides €36 Mio for three EV hubs (in Milton Keynes, London, and the North East). Future developments will be plans to install 11,000 recharging points [72].					

2.4. Research Financing and Communication Programs

The 2010 European Parliament Resolution regarding vehicles establishes that innovating propulsion systems, which are both electric and hybrid, will help guarantee future competitiveness of the automobile industry [73]. This Resolution underlines that EVs represent a technological advancement that requires the integration of certain innovation strategies and technological developments through adequate financing and the promotion of R&D. In this regard, it would be beneficial for public aid packages offered to businesses to be linked to a set of clear-cut objectives with social, technological, economic, and environmental references. Noteworthy public aid packages include those from Austria, Germany, Denmark, Finland, France, Italy, Spain, and the UK. The main aspects are provided in column 2 of Table 8.

Together with the support measures for R&D, some MSs have approved measures that focus on improving consumer perception of the advantages of EVs. This is not limited to the European Union. In fact, a range of transportation labeling activities is taking place in International Energy Agency (IEA) member countries including voluntary and mandatory vehicle and tire labeling schemes. Labels are assigned to vehicles based on fuel consumption and emissions. Despite its limited use, this is a very important measure in line with the available literature. The results offered by Krause et al. [74] pointed out that people have a high degree of misperception about the basic features of EVs including their appearance, upfront and operating costs, and driving range. These results are in line with those from Carley et al. [13].

Table 8 shows EU28 countries that have developed the most relevant measures oriented toward R&D and consumer awareness.

Table 8. Measures oriented towards R&D and consumer awareness.

Countries	Research Financing	Communications Programs
Austria	Companies, municipalities, and cities also receive financial support to develop and implement environmentally-friendly mobility management, which adds solutions that are more effective in traffic. In this regard, funding rates are 20% of eligible costs of companies and 40% of eligible costs of cities, municipalities, and regions [35].	Thaler [36] pointed out that the 'klima:aktiv program' including significant information and important awareness campaigns oriented to informing the general population as well as the media and opinion leaders.
Belgium		New laws have required that dealers must show a fuel economy label to each model for sale, which helps potential purchasers learn about the effect on pollution of every vehicle by using a simple colored schema. A red color is assigned for the most highly polluting vehicles while a green color is assigned for vehicles with the lowest CO ₂ emission levels [32].
Denmark	The project 'Test-an-EV': consists in 2400 families that test in turns 300 EVs for day-to-day usage in order to analyze user experiences with EVs and disclose driving and charging patterns [43].	
Estonia		ELMO program promotes EVs with the purpose of accomplishing the development of more ecological and environmentally friendly cities [75]. It has developed a Demo project: 507 EVs received from Mitsubishi were given to use by social workers and the public sector. The goal of ELMO Rental is to make using EVs more popular and it provided an opportunity for everyone to try driving an EV [59].

Table 8. Cont.

Countries	Research Financing	Communications Programs
Finland	TransEco investigation program (2009–2013): was oriented to the development of technology for enhanced energetic efficiency and the reduction on emissions level on highway transportation [30].	Passenger car energy label: facilitates the potential buyer to compare the different CO ₂ emission levels for each vehicle as well as the diverse levels of fuel consumption. These labels are recommended but is not mandatory. Cars are distributed into categories (A to G) on the basis of fuel consumption and emissions. Best categories are those from A to C and satisfy the goal of not exceeding the limit of 130 g/km CO ₂ emissions established by the EU.
France	The programs for research, experimentation, and innovation in land transportation (PREDIT) financed EV research projects for a net worth of €107 Mio (2009–2010). The state controlled Fonds Stratégique d'Investissement (FSI) provides loans for innovative R&D projects.	
Germany	Has destined €2 billion for promoting the introduction of EVs including support focused on developing improved technologies toward EVs, research in battery technologies, R&D of intelligent supply networks, and standardization projects.	
Italy	Approved support and co-finance of up to 50% of projects promoting electro-mobility.	
Netherlands		Oriented to promote the concept of 'eco-driving' for all types of vehicle drivers. A list of best practices are incorporated in regular driving lessons [76].
Poland		"Mobilny Kraków" is a social campaign promoting the use of clean vehicles.
Spain	Provides €140 Mio for industrialization support and R&D and €173 Mio to priority R&D lines.	
United Kingdom	€170 Mio are provided to market players for R&D activities into "low carbon vehicles".	

3. Discussion

MSs offer both financial and non-financial incentives to promote electro-mobility. These include tax credits (discounted vehicle license, registration fees, and more), purchase subsidies, subsidies for the installation of charging stations, high occupancy vehicles lane access and free parking access, R&D projects funding, and educational programs. The available literature sheds some light on the subject, but not a significant amount of information about the variables that include the use of some type of promotional measure. Pablo-Romero et al. [77], Sánchez-Braza et al. [78], and Wang [79] show that the population size is a driver when establishing environmental measures including the promotion of EVs.

The review carried out in this article shows that more than 60% of the EU28 population live in a MSs where EVs pay no registration tax due to the existence of an ample CO₂ emission threshold that is below the limit for taxation. However, only five MSs establish fiscal incentives for commercially used EVs. This limited use of fiscal incentives should be reconsidered since the use of commercial vehicles is more intense than private vehicles and, therefore, these consume more fuel and are emitting more GHG.

The most popular measure using infrastructure to promote the use of battery electric vehicles (BEVs) is favoring the installation of charging stations. Yet, in most MSs, charging stations are limited to the major cities. Estonia represents the only exception since it has installed charging stations on highways. As discussed in Section 3, the integration of charging stations in Smart Grid Systems has

never been contemplated. The second, most extended measure is free parking for EVs. This measure is also limited especially in large cities. Together with the two previous measures, two MSs (Holland and the Czech Republic) have low carbon zones. Although it is not exactly a promotional measure based on the use of infrastructures, this section has included public EV fleets.

Undoubtedly, the penetration of EVs in each country does not depend solely on the promotional measures implemented by the public sector. Nevertheless, there is room for discussion when the EV registration data is available. Table 9 allows for this discussion. No statistics are available that allow us to create a temporal series of numbers for EVs in the EU28. Consequently, the conclusions extracted must be considered with care. This information can only be established for the 2013–2015 period based on the data supplied by ACEA [26,80,81] and not for all of the MSs within the EU28. For a fine-tuned analysis, data for the EVs fleet market share in each country based on the total fleet has been included along with the number of EVs per thousand inhabitants and the variation rates of both variables from 2013 to 2015.

Based on Table 9, it could be said that the Netherlands, France, Germany, and the UK are the countries with the greatest success in the penetration of EVs considering their joint market share and the number of EVs per 1000 inhabitants (see Figures 1 and 2). In all cases, the leading countries in the use of EVs greatly tap into public promotional measures oriented toward favoring their use.

Both the Netherlands and France have changed their registration taxes to incorporate an environmental criterion (level of GHG emissions) when calculating the invoice. In both cases, EVs are tax exemptions. Germany however, uses the ownership tax by which it establishes a fiscal incentive for EV with a 10-year exemption. It must also be stated that, together with the Netherlands, Germany is one of the few MSs that favors the use of EVs for commercial purposes since it includes the emission volume in the invoice calculation for the ownership tax. In this regard, it must be highlighted that both countries incorporate incentives for a personal income tax that favors the acquisition of EVs. In the case of incentives implemented through infrastructure measures, France appears to be the first country that expanded charging stations and delimited low emissions zones using infrastructure incentives. French authorities also make use of financial incentives to promote the purchase of EVs. However, Sierzchula et al. [16] state that there are other factors besides the financial inducements that incentivize the purchase of EVs. Lastly, while France and Germany fund R&D projects linked to EVs—the automobile industry is a major industry in both countries—the Netherlands sponsors communications programs to promote the eco-driving culture.

One specific comment regarding the limited use that MSs make of information programs goes against the recommendations of recent literature. Krause et al. [74] found that potential buyers have limited knowledge of public promotional measures, which restricts efficiency and shows that this information has not been correctly or adequately presented. Along this same line, education programs have plenty to do since potential consumers have, for the most part, incorrect knowledge about the basic cost and operating features of EVs. This degree of misperception decreases with the potential buyer's educational level. All else being equal, a potential purchaser with higher education expresses a greater stated intention to purchase.

Table 9. Main figures for EVs fleet in EU28 (2013–2015).

Country	EVs 2013	Market Share (%)	EVs per 1000 hab.	EVS 2014	Market Share (%)	EVs per 1000 hab.	EVs 2015	Market Share (%)	EVs per 1000 hab.	EVs per GDP in Miles of Millions	EVs per Total Miles of Vehicles	2013–2015 Market Share Change (%)	EVs per 1000 hab. Change (%)
Austria	3227	5.85%	0.38	3641	4.83%	0.43	2575	2.05%	0.30	7.47	0.54	−64.95%	−21.13%
Belgium	819	1.49%	0.07	2032	2.70%	0.18	4073	3.24%	0.36	9.93	0.72	118.45%	389.62%
Bulgaria	1	0.00%	0.00	2	0.00%	0.00	40	0.03%	0.01	0.88	0.01	1657.03%	3947.01%
Croatia *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cyprus *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Czech Republic	475	0.86%	0.05	583	0.77%	0.06	856	0.68%	0.08	5.08	0.17	−20.84%	79.87%
Denmark	650	1.18%	0.12	1612	2.14%	0.29	3701	2.95%	0.66	13.62	N/A	150.11%	464.65%
Estonia	150	0.27%	0.03	402	0.53%	0.09	45	0.04%	0.01	2.21	0.07	−86.82%	−70.08%
Finland	218	0.40%	0.04	440	0.58%	0.08	724	0.58%	0.13	3.45	0.22	45.88%	228.97%
France	9622	17.45%	0.15	12,488	16.58%	0.19	23,296	18.56%	0.35	10.60	0.72	6.35%	139.93%
Germany	7706	13.97%	0.09	13,118	17.41%	0.16	21,407	17.05%	0.27	7.03	0.47	22.02%	182.31%
Greece	4	0.01%	0.00	64	0.08%	0.01	70	0.06%	0.01	0.40	0.01	668.70%	1663.48%
Hungary	16	0.03%	0.00	43	0.06%	0.00	132	0.11%	0.01	1.19	0.04	262.39%	728.81%
Ireland	50	0.09%	0.01	256	0.34%	0.06	583	0.46%	0.13	2.22	0.28	412.17%	1063.02%
Italy	1174	2.13%	0.02	1473	1.96%	0.02	2539	2.02%	0.04	1.54	N/A	−5.00%	111.80%
Latvia	13	0.02%	0.01	391	0.52%	0.20	139	0.11%	0.07	5.72	0.20	369.67%	989.66%
Lithuania **	N/A	N/A	N/A	N/A	N/A	N/A	34	0.03%	0.01	0.91	0.03	N/A	N/A
Luxembourg *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Malta *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Netherlands	22,495	40.79%	1.34	12,920	17.15%	0.77	16,852	13.42%	1.00	24.42	2.08	−67.09%	−25.52%
Poland	1900	3.45%	0.05	3968	5.27%	0.10	3328	2.65%	0.09	7.74	0.16	−23.06%	75.31%
Portugal	221	0.40%	0.02	289	0.38%	0.03	868	0.69%	0.08	4.83	0.18	72.52%	297.30%
Romania	4	0.01%	0.00	7	0.01%	0.00	44	0.04%	0.00	0.27	0.01	383.18%	1006.12%
Slovak Republic	136	0.25%	0.03	169	0.22%	0.03	131	0.10%	0.02	1.66	0.06	−57.69%	−3.78%
Slovenia *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spain	883	1.60%	0.02	1405	1.87%	0.03	2345	1.87%	0.05	2.17	0.10	16.65%	167.50%
Sweden	1547	2.81%	0.16	4667	6.20%	0.48	6819	5.43%	0.70	15.19	1.46	93.62%	333.27%
United Kingdom	3833	6.95%	0.06	15,361	20.39%	0.24	34,938	27.83%	0.54	13.38	1.15	300.39%	800.97%
Total	55,144	100%		75,331	100%		125,539	100%		8.47	1.23		

* Not available information; ** Information available only for 2015. Source: [26,33,80,81].

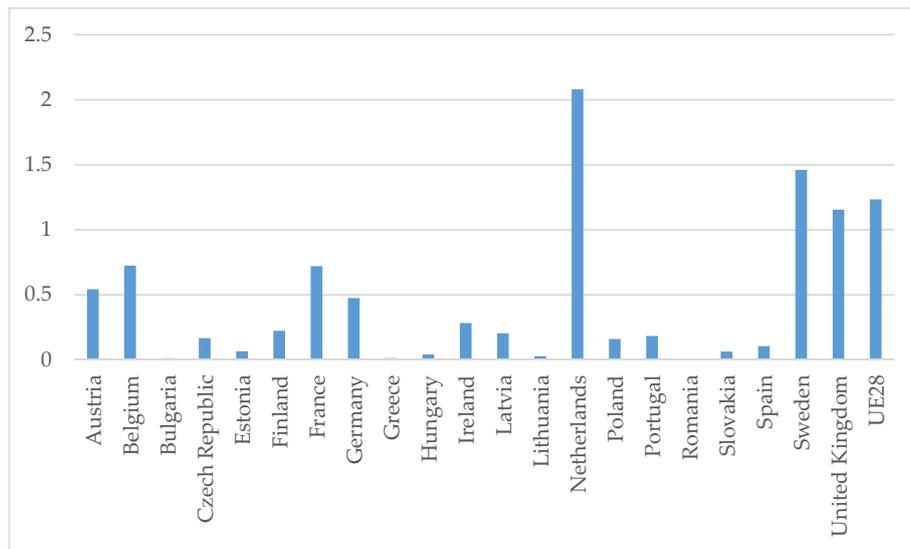


Figure 1. Ratio EVs per total vehicles (2015).

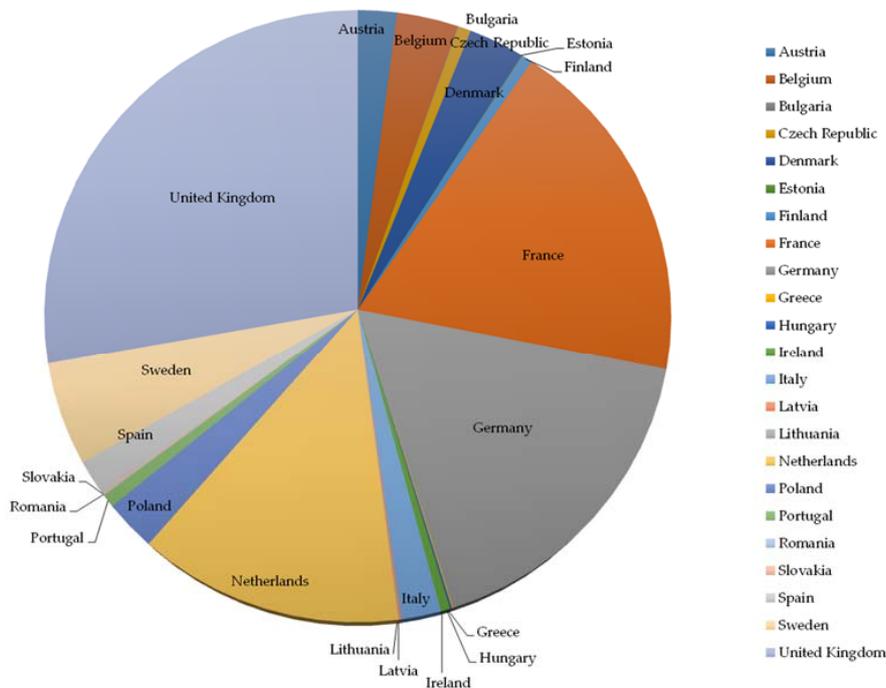


Figure 2. EVs fleet market share in each country based on the total fleet (2015).

4. Conclusions and Policy Implications

Despite the misperceptions, potential EV purchasers perceive the cost premium, range limitation, and recharging time of EVs as disadvantages compared to other vehicle types. Offering MSs the possibility to use a wide range of policy instruments to promote electro-mobility in the context of H2020 strategy is important. These policy instruments to promote the use of EVs are largely used in EU28 to facilitate this decision similarly to those used to promote RES for other uses.

Figures shown above led us to conclude that the most important policy instruments to promote the use of EVs are tax and infrastructure measures along with financial incentives for purchasing and supporting R&D projects. Despite the scarcity of EV registration data, the available information allows us to conclude that higher penetration levels of EVs appear in countries where the registration tax, the

ownership tax, or both taxes have developed into a partial green tax by including CO₂ emissions in the calculation of the final invoice. The countries with a more intense use of EVs also fund charging stations to facilitate electro-mobility. In the case of the the automobile industry being relevant at the national level, public funding also supports R&D projects by focusing on EV deployment.

After reviewing the most important policy instruments to promote the use of EVs in line with the available literature, some policy recommendations might be considered.

The vehicle age could be included as an additional parameter to calculate the final invoice for ownership tax. This could facilitate the replacement of older and higher polluting vehicles by newer and less contaminating EVs.

The ownership tax applied to commercial vehicles could include CO₂ emission levels when calculating the final invoice. This is particularly important because such vehicles are the most fuel demanding and the most responsible for CO₂ emissions when using internal combustion motors. Growth in e-commerce ought to lead to increasing use of EVs for parcel deliveries in urban areas. Measures to support EVs could be seen as a part of the effort required to meet the delivery services offered by e-retailers.

EVs could become part of future smart electricity systems in a twofold sense. First of all, their batteries could be considered as a (disperse) storage system for better management of demand peaks. Lessons learned from vehicle to grid pilot projects would be useful. Second, if a dynamic tariff system is deployed at the national level, different prices of electricity for charging EVs could reduce the risk of disruption by enhancing power capacity.

In addition, communication programs could play a crucial role in promoting electro-mobility through two ways. First, misperceptions of the main advantages of EVs could be reduced through adequate information programs co-funded together with private companies. Second, remarkable efforts in communicating available public incentives could help to shift potential consumers to EVs from other, more contaminating options.

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