EV Policy Compared: An International Comparison of Governments' Policy Strategy Towards E-Mobility

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Abstract This paper addresses and explores the different strategies governments pursue to support the introduction of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs). This paper presents findings from a European research project that mapped current policies in eight countries, with California as a comparative case to contrast the European findings. The authors analysed the policy strategies that countries have put to practice and analyse how they have performed so far. Arguably, many countries appear to be on track to achieving their short-term goals; in that sense, EV policy is successful. However, once the longer term policy goals for e-mobility are taken into account, it is unlikely that the current policies will be sufficient. Therefore, the authors point out some lessons from current policies that may show a route into the next phase of the introduction of e-mobility. *The paper is part of the Interreg e-mobility North Sea Region (E-Mobility NSR) partnership project, which is co-funded by the EU and participating countries/regions/organisations.*

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1 Introduction

All over the world, governments attempt to support the transition to e-mobility. The introduction of electric driving is a complex and unpredictable process that is not likely to occur all by itself. Opposition power (such as from the fossil fuel-based value chain connected with motoring and also competing ultra-low-carbon vehicle technology corners, such as hydrogen) is strongly invested. The current (incumbent) market structure benefits continuation of regular cars, and consumers are not yet familiar with e-mobility; many have never driven an EV, let alone have considered buying one. Furthermore, EVs require a substantial investment by consumers. Due to expensive battery packs, the sales price of EVs is higher than those of comparable regular cars. Also, the residual value and life cycle of the batteries is uncertain (although this is tempered currently by manufacturers' warranties on electric batteries, or can be hedged for consumers through leasing models), and any benefits to be gained for consumer from vehicle-to-grid likewise. That makes EVs an *expensive* and *risky* purchase, even though the total cost of ownership is probably competitive to that of a regular car. Also, EVs produce *uncertainty* for drivers. The limited battery range and the uncertain availability of chargers make "carefree" driving difficult. And if there is a charger available, there are issues with *interoperability*, maintenance and the required time to charge. These are all problems that will eventually be solved, but nonetheless are current barriers to consumer take-up (for an overview of EV barriers see Beeton and Butte 2013). There is some momentum for EVs, but it remains a fragile and uncertain venture; the emerging market of EVs can still break down, especially in the early stage that it is in now (once more).

Governmental action is one of the possibilities to overcome the problems of an emerging market. There is a wide array of policy options available to government to support the introduction of EVs and charging infrastructure. Therefore, governmental intervention requires choice; governments wonder which policy to choose, which group or sector to target, what the most effective size and scope of interventions should be and what timing best accommodates the emerging process of the market. Research into the influence of financial incentives and other socio-economic factors on electric vehicle adoption is currently ongoing (see for instance Sierzchula et al. 2014), and there is research into and commentary upon and recommendations towards the effectiveness of EV policy in particular countries (e.g. Green et al. 2014 on the US and Domingues and Pecorelli-Peres 2013 for Brazil). Critical studies attack fiscal subsidies for EVs in the short- and medium term with taxpayers money (Prud'homme and Konig 2012), whilst other authors calculate differently with social/societal lifetime (e.g. public health and atmospheric pollution) costs and come to more favourable results, depending also on the internalisation of the costs by government regulation (Funk and Rabi 1999). Notions of social lifetime costs of battery, fuel cell and plug-in hybrid EVs in relations to conventional vehicles as a more holistic concept may gather more traction in society (Delucchi and Lipman 2010). Not only there are many options to choose from, but there are also many different theories about what to choose for (see Van der Steen et al. 2012; Van Deventer et al. 2011).

Furthermore, it is worth reflecting on the "best" scale of governance for EV policy (see, e.g. Bakker 2014; Bakker et al. 2014). For some, and especially in an EU level, the notion of subsidiarity comes in, to be understood if constructive as a concept "to mean *sharing*, not *shedding*, responsibility in the context of a multi-level policy where the policy process (at least in the European Union) straddles supra-national, national, regional and local levels" (Flynn and Morgan 2004, p. 22). Hierarchically, there is the level of global agreements, e.g. through the International Energy Agency (IEA), which can drive innovation, collaboration and dissemination by a focus on standards and voluntary agreements, realise a policy focus on areas with some impetus funding for research, workshops, training, promotion (IEA IA-HEV 2011), such as through its "Electric Vehicles Initiative," "The Electric Drive Plugs in Implementing Agreement" for cooperation and the "Hybrid and Electric Vehicle Technologies and Programmes" (IEA IA-HEV 2012), as well as the "EV City Casebook" which is a collaboration of the IEA and several partners. There is then the level of trade blocs or integrated markets (such as the European Union, with mandatory standards around emissions for vehicles, urban air pollution, metrics for a New Driving Cycle, labelling and information; and also some US Federal programmes and policy framework initiatives setting the context within which US states operate and can built on); further, there is the national (e.g. EU member state) level, and for the purposes of this paper California as equivalent at that level, which will also have legislation, policy, financial instruments, R&D and demonstration programmes. Then there is the regional (e.g. Electric mobility pilot regions), and not least there is the local level which again has extra policies (e.g. Amsterdam or Utrecht, as cities which offer EV financial incentives on top of what is paid by central government or what the provinces may do, and which will review those extra levels themselves). EV policy is indeed a multi-level policy game, where policy makers continuously have to take into account and operate within frameworks and actions set elsewhere. Governance is *nested*, which is to say that the UK or German or Dutch national level cannot be seen separate from the EU level (see negotiations in the Council of Ministers and the European parliament over emission standards of vehicles, etc.), nor can the regional level be seen as disconnected from the national/Federal or international one in terms of investment, competition, standards (including for charging infrastructure), nor can the local one (e.g. air pollution from the EU one).

The point is that policy initiatives at, e.g. EU or US level do critically rely on dynamism and learning and experimentation and (varied, see the difference between Directive and Framework regulation in the EU) implementation at the national (and arguably regional and local) level, and need the kind of interaction with them (e.g. Plugged-in Places programmes in the UK, which all differed, and were expected and encouraged by the UK government to be varied and different). Nested means there can and would be expected to be variance of policy measures for a variety of reasons and motives, and one should learn from each other, whilst being in the same overall framework which influences what one has to address and to some extent the rules of doing so. A "best practice" example developed and shared (e.g. http://e-mobility-nsr.eu/fileadmin/user_upload/downloads/infopool/Regulation_Subsidy_Fast_Chargers.pdf) should hence be informed and have considered all those connected levels, with subsidiarity being designed, applied and implemented at the most appropriate level/scale.

To fully appreciate this, and for policy makers to best develop, share and apply insights, a relational perspective on space/territory and actors in terms of formal and informal economies and the geographies of knowing and learning is needed (Bathelt and Glückler 2011). In the context of movement in space with electric vehicles, it may be that in the short- to medium term the drive in NSR and EU members states to create interoperability for charging infrastructure in their national territory may well be prioritised over wider cross-border (with exceptions between directly cooperating neighbouring countries and regions) interoperability, thus potentially creating barriers and local lock-in, for both reasons of priority policy targets and also commercial/economic interests of some of the economic agents/actors (Bakker 2013). Also, one needs to clearly consider the motivations and strategies of stakeholders with their commercial interest but also beyond these, with many stakeholders recognise other opportunities presented by EVs: "The most powerful argument in that respect is the potential synergy between EVs and ever increasing renewable electricity shares and many stakeholder activities aim at learning about this opportunity. These activities are however quite limited in scale and mostly focused on off-street charging. Therefore they do not [currently] add, significantly, to the realization of a public recharging infrastructure." (Bakker 2013). However, in the medium term this may change, though, with a likely focus mostly on home charging (Kotter 2013), and with some researchers predicting, e.g. for Germany, that grid-to-vehicle concepts have more of a viable future under the current incentive and policy landscape than vehicle-to-grid concepts (Loisel et al. 2014).

There is a growing literature on EV policy at national, and to some extent regional and local level, and now also supranational level. But only some is of a comparative nature, and usually only between two countries/national levels, other than relatively brief project reports (e.g. Trip et al. 2012) or commissioned consultancy studies undertaking benchmarking at regional level (e.g. E4Tech 2013). Lane et al. (2013), for instance, present a study developing operational definitions of two identified motivations of industrial policy and risk management and uses them to characterise the public policies of six political jurisdictions: California, China, the European Union, France, Germany and the United States. They find that while the European Union is focused primarily on risk management, China, Germany and the United States are primarily engaged in industrial policy. California and France are seen as intermediate cases, with a substantial blend of industrial policy and risk management. Contrast and comment on how California and France both promoted electric and hybrid vehicles to reduce urban air pollution, but differently so and with differeing results at that time for—the authors arguue—differences in the cultural context. Some authors even make policy insight conclusions and recommendations beyond vehicle type (e.g. Yang 2010). Karplus et al. (2010), for instance, undertake an equilibrium-based economic modelling of PHEV penetration in the US and Japan.

Browne et al. (2012) evaluated a range of policies and measures from a range of countries, concluding that developing refuelling infrastructure, supported by tax incentives and awareness campaigns, should be prioritised in the short- to medium term. For them, identified longer term policies and measures could be highly effective include the forced retirement of vehicles that do not adhere to specific fuel economy and emission standards and mandatory import targets (albeit potentially resulting in additional costs for consumers and the domestic vehicle industry, as well as limit consumer choice. Their argument is that "policy-makers have a range of options and should consider the following: (i) develop a transition strategy and engage in scenario planning on a cooperative basis with industry stakeholders; (ii) identify potential "lead adopters" and develop a strategy for strategic niche management; (iii) develop stakeholder partnerships with industry and consumer groups; (iv) promote the adoption of a new socio-technological regime through awareness campaigns and education programmes; (v) change the taxation structure by taxing negative externalities such as [Greenhouse Gas] GHG emissions and creating positive incentives through excise relief and subsidies; and (vi) ensure a consistent mix of policy and regulatory signals, which offer long-term certainty" (Browne et al. 2012, p. 140). They propose that their "evaluation framework" could serve as a useful template for the identification and evaluation of barrier and policy priorities and could be modified depending on the system and/or geographical boundary. In addition, [this framework] can be adapted and used by policy makers in order to guide policy priorities and develop national [Alternatively Fuelled Vehicles] AFV policy strategies or local action plans for strategic niche management. It is sufficiently flexible to be modified for particular jurisdictions, depending on particular consumer choices, policy preferences and the stage of technological innovation. Furthermore, it is suitable for national or cross-country evaluation as particular barriers, policy measures and technologies might be more or less suitable, depending on the jurisdiction. However, as a qualitative tool, it is vulnerable to subjective evaluation and should be supported by empirical analysis, where possible. In addition, this framework should be applied at the particular level of interest and the evaluation should not be construed as universal as it may depend on particular system factors (Browne et al. 2012, p. 140).

A study by Steinhilber et al. (2013) focussing on the socio-technical inertia vis-a-vis the widespread introduction and take-up of electrical vehicles aims to contribute to understanding the key tools and strategies that might enable the successful introduction of new technologies and innovations by exploring the key barriers to electric vehicles encountered in two countries (UK and Germany), where the automobile industry has been historically significant, argues that: Immature developing technology is the major reason behind non-commercialisation of EVs, that EVs currently do not present a significant benefit to the electricity sector, that EVs rely on a mix of regulatory and government measures for their development, that EVs face lock-in problem of unsustainable technologies and related barriers, and that positive "ecosystems" for innovation in vehicle technology and business models are required.

This present chapter adds to this literature and explores the policy options for governments that want to support the further introduction of EVs. The authors aim to provide an empirical answer to that question, based on a study in which they have gathered all of the formally documented policies with regards to e-mobility that a selected group of governments put in place in the period between 2012–2014, to be developed further over time. The project is part of the Interreg *North Sea Region Electric Mobility Network* (E-Mobility NSR) that was launched in April 2011.

1.1 Scope, Methods and Limitations

This research focuses purely on *passenger vehicles*[1] and *multipurpose passenger vehicles*.[2] Furthermore, the present study focuses solely on a specific type of electrified drive trains; of the most commonly used categories—hybrid electric vehicles (HEVs),[3] plug-in hybrid electric vehicles (PHEVs)[4] and battery electric vehicles (BEVs)[5]—the authors take into consideration *only* policies concerning *PHEVs* and *BEVs*. Policy for HEVs is *not* part of the research. Also, the authors did not look at other possible options for clean mobility, such as biofuels, hydrogen or the substitution of cars for public transport (Van der Steen et al. 2014a, b).

In order to collect the data for this study's, the authors have gathered all the documents they could find for the seven case countries in this specific study; the Netherlands, Belgium, Germany, Denmark, Sweden, Norway and the UK. California is added as a comparative case to contrast the European findings. California is widely regarded as a frontrunner in the transition to e-mobility

[1]Vehicle with a designated seating capacity of 10 or less (IEA, IA-HEV and AVARE 2013).

[2]Vehicle with a designated seating capacity of 10 or less that is constructed either on a truck chassis or with special features for occasional off-road operation (IEA, IA-HEV and AVARE 2013).

[3]HEV has the ability to operate all-electrically, generally at low average speeds. At high steady speeds such a HEV uses only the engine and mechanical drivetrain, with no electric assist. At intermediate average speeds with intermittent loads, both electric and mechanical drives frequently operate together. (IEA, IA-HEV 2011).

[4]A HEV with a battery pack with a relatively large amount of kWh of storage capability, with an ability to charge the battery by plugging a vehicle cable into the electricity grid. (IEA, IA-HEV 2011).

[5]An BEV is defined as "any autonomous road vehicle exclusively with an electric drive, and without any on-board electric generation capability." (IEA, IA-HEV, 2011).

(Plugincars 2013). To collect the documents, a "snowballing"-method was employed to gather more information about policy. Many documents contained references to other studies and sources that the authors then looked up and included into their model.

The analytical lens—or model—the authors employ is based on, firstly, a value chain approach to e-mobility (Beeton 2014), which the authors here have arranged into three chains—with interactions and interdependencies of the electric vehicle, the charging infrastructure and the (wider) enabling network (the grid, Information and Communications Technologies (ICT) and Intelligent Transport Solutions (ITS) and services etc. Second, the authors adopt Hood and Margetts' (2007) four different categories of tools for government to "steer," and use these four categories as a first lens to organise the policies. In the table below they explain the categories and apply them to policy for EVs. Thirdly, the authors looked at policy as originating from one of four levels of government; policy is *trans-national*, *national*, *regional*, or *local*.

With this first selection of documents the authors populated their database and ran a first scan of results. For each country, they drafted an analysis of its EV policies and asked a local resource colleague to take a critical look at the document; they then asked the local colleagues to correct their document and send them links to relevant documents not yet included in the study. The authors analysed this second set of documents and improved their country analysis on the basis of the feedback from the local colleagues. After that, the authors finalised their findings in a draft report. During 2013 they kept collecting new documents, in order to be able to keep the database up to date with new policies and new data about performances.

As a third round, the authors presented and discussed the draft report in four feedback sessions where expert representatives of the participating countries reflected on their interim findings. Representatives were selected from both the local academic community and the community of EV policy makers from that country, region or municipality. In each session, the authors presented a selection of the findings that were relevant to the particular audience (country). After that, the authors first asked participants if they recognised or could validate the findings and if they had additions or other (critical) remarks about them. Then, there was time for discussion about the more general implications of the findings and possible implications for policy. Each of the feedback sessions resulted in a general recognition for and support of the authors' findings, but also lead to interesting discussions about methodology and about the dilemmas of policy for EVs. In this discussion section of this chapter, the authors present some of those dilemmas and reflect on their implications for the next generation of EV-policy.

1.2 Outline of This Chapter

The authors start with a presentation of the framework used to analyse the policies. After that, they present the assorted variety of policies they found. In the discussion section, some broader observations about general patterns and dilemmas of public policy in the field of E-mobility are presented. Also, the authors reflect on what they think one can learn from these policies for the next phase in the introduction of e-mobility.

2 A Framework for Analysing EV-Policy

2.1 Lens 1: The Value Chain of E-Mobility

"EV-policy" suggests a coherent and single object and objective for policy. However, if one looks closer, e-mobility involves a variety of related but separate elements. Therefore, the authors looked at e-mobility as a value chain (Fournier and Stinson 2011/Squarewise 2010) where the different segments of the chain can each be targeted by policy. Also, e-mobility can be separated into three different value chains (In 't Veld 2005); the value chain of *vehicles*, the value chain of *charging* and the value chain of *surrounding network*. The latter is not so much a chain, but more a third category for policy. For the value chains of vehicles and charging, we see four segments in each chain. Policy can target at least one and possible elements of the chain. For instance, a purchase subsidy targets the vehicles value chain, and within that the consumer segment. Therefore, we categorise that particular policy as a vehicle-consumer-focused policy in our framework. Figure 1 presents the three value chains; Tables 1, 2 and 3 explain the different segments of the value chains.

2.2 Lens 2: Policy as Tools

In their classic *tools of government*-study, Hood and Margetts (2007) distinguish four different categories of tools for government to "steer." We use these four categories as a first lens to organise the policies. In Table 4, the authors explain the categories and apply them to policy for EVs.

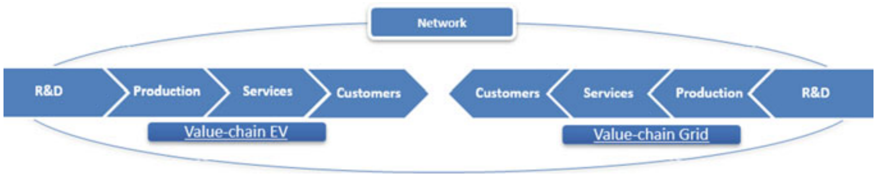

Fig. 1 Three value chains of e-mobility

Table 1 Vehicle value chain

Value chain—electric vehicle	
R&D	• Instruments focused on influencing the research and design of electric vehicles and EV components
Production	• Instruments focused on influencing the production of electric vehicles and vehicle components such as batteries and other hardware (original equipment manufacturers). This segment of the value chain also recognises the software used in electric vehicles
Services	• Instruments focused on influencing service providers for electric vehicles. Different service providers are recognised, such as car dealerships, mechanics, insurance companies, etc.
Customers	• Instruments focused on influencing customers of EVs. The study's methodology recognises individual consumers (end-users), but also fleet-owners (e.g. authorities and leasing companies) and public/governmental agencies (promoting consumerism)

Table 2 Infrastructure value chain

Value chain—charging infrastructure	
R&D	• Instruments focused on influencing the research and design of the complete charging infrastructure
Production	• Instruments focused on influencing the production of charging stations and EV system components such as the electricity network, energy production, etc.
Services	• Instruments focused on influencing service providers for charging stations. Different service providers are recognised, such as energy suppliers, power plants, grid managers, software developers, etc.
Customers	• Instruments focused on influencing customers of charging stations. By "customers" the study refers both to users (consumers) and owners (consumers, companies, public authorities and government). The different types of charging stations (private, public, fast, quick, normal) require different types of steering by governmental units

Table 3 Network value chain

Value chain—Network	
Network	• These are all of the instruments that focus on connecting stakeholders in the EV/infrastructure value chain. For instance, efforts intended to intensify contacts between different stakeholders, in order to improve value chain alignment and a more efficient functioning of the entire value chain. In addition to the value chain, this includes other policy measures aimed at the e-mobility ecosystem, which are taken into consideration. For instance, policy measures aimed at realising Smart Grids, Smart economies and Smart mobility Beeton (2012)

2.3 Lens 3: Policy at a Certain Level of Government

As a third lens for our analysis, the authors looked at policy as originating from one of three levels of government; policy is *trans-national*, *national*, *regional* or *local*—with a hierarchy but also interactions between levels and a multi-level governance

Table 4 Tools of government

Tools of government	
Legal	• All of the rules and directives designed to mandate, enable, incentivize, limit or otherwise direct subjects to act according to policy goals • E.g. legal requirements, local parking legislation, European legislation for standards for charging station accessibility, limited access to urban areas or roads
Financial	• The policy instruments involve either the handing out or taking away of material resources (cash or kind), in order to incentivize or disincentivize behaviour by subjects. The difference between financial and legal measures is that those affected are not obliged to take the measures involved, but are incentivized to do so by their own choice • E.g. purchase grants, tax benefits for consumers of EVs, government funding for battery research, subsidies on home chargers or free electricity for public charging
Communication	• Instruments that influence the value chain of e-mobility through to the communication of arguments and persuasion, including information and education • E.g. education in schools, government information campaigns
Organisation	• Actions by government that provides the physical ability to act directly, using its own forces to achieve policy goals rather than others. This includes the allocation of means, capital, resources and the physical infrastructure needed to act • E.g. government or public authorities acting as a launching customer, buying an own fleet of EVss, government installing public chargers

nature to it, and competition also between countries, regions and cities (c.f. Bakker 2014). Different countries work with different systems, where other levels of government are responsible for e-mobility. The model takes this into account, in order to be able to analyse the differences in various countries. Some organise policy from the local level, while others have a stronger national policy that is only marginally supplemented by local or regional policies.

3 Findings: An Analysis of EV Policies in Seven EU Countries

In this chapter, the authors compare the variety of policies at different governmental levels in different countries. They present the most important general findings and illustrate them with a range of examples of policies from different countries. The complete results and the total body of policies can be found in the project background report (Van der Steen et al. 2014a, b).

3.1 Finding 1: Most NSR Countries Focus on Financial and Organisational Instruments

The countries in this collated data set primarily focus on financial and organisational instruments. Most policies fall into either one of those two categories of tools.

As for financial instruments, countries adopt very similar policies. They are often conducted by the national government and are mostly fiscal (registrations bonus based on emissions, income tax measures and opportunities for businesses to relieve the cost of an EV against taxable profits). Also, governments apply a considerable number of organisational instruments. Especially at the regional and local levels, the authors observe a lot of "organization tools." Local and regional governments—but also some public–private partnerships—install many local project organisations that, for instance, carry out grant applications and are launching consumer initiatives. This generates extra dynamics to the incentives and benefits set out by the national government.

The focus on legal and communication instruments is limited compared to financial and organisational instruments (Tables 5 and 6).

3.2 Finding 2: Most NSR Countries Initiate Policy from the National Government Level

As summarised in Table 7, in most countries most policy is made at the national level. However, with that said, there are often also very active local and regional communities that provide all sorts of activities to stimulate e-mobility. The main body of policy is national—fiscal, regulation—but that is accompanied by local and regional policy that provides a local colouring and fine-tuning.

Table 5 Type of policy actions (Van der Steen et al. 2014a, b)

Type of policy actions				
NSR countries	Legal	Financial	Communicative	Organisational
Belgium	+	++	+	+++
Denmark	+	+++	+	++
Germany	+	++	+	+++
Netherlands	+	+++	+	+++
Norway	++	+++	+	++
Sweden	+	++	+	+++
UK	0	++	+	++
Comparative case: California	++	+++	+	+

0 = Limited information found/available
+ = Limited focus
++ = Strong focus
+++ = Prevalent focus area

Table 6 Examples of organisational tools used in different countries

Organisational incentives in NSR countries and California (USA)	
Denmark	**Platform** • *Information Centre*. In cooperation with the Danish Energy Agency, the Centre for Green Transport has established (Established in 2011) an information centre to exchange experiences on EVs between local communities in Denmark (Bakker et al. 2012/European Commission 2011/IEA IA-HEV 2014) **Project organisation** • *Copenhagen Electric*. Copenhagen Electric focuses on strengthening the capital region's international competitiveness and ensuring greater cooperation in the Øresund Region and other regions in Europe by providing objective information about electric vehicles to municipalities, companies and private individuals. Also projects, campaigns and partnerships on EVs are initiated (Copenhagen Electric 2014)
Germany	**Project organisation** • **Model regions** – *E.g. Elektromobilitat Model Region Hamburg*. The testing of diesel hybrid buses on lines. Innovative energy storage for rail vehicles. The use and development of electric cars and charging infrastructure. The use of electric vehicles in commercial traffic. These are the priorities of the projects in the model region Hamburg (BMVI—Elektromobilitat Model Region Hamburg 2014) – *E.g. Model region Bremen/Oldenburg*. In the model region Bremen/Oldenburg, the cooperation between project partners such as the University of Bremen, Bremer Energie Institut and Centre for Regional and Innovation Economics are another building brick in the development in electric vehicle technology. The local Daimler-Benz/Mercedes production plant will use the scientific knowledge to produce these new technologies. The same partnership resulted in plans by the local Daimler-Benz/Mercedes production plant to convert a tractor to an E tractor, to demonstrate the use of commercial Electric Vehicles in daily use (BMVI—Elektromobilitat Model Region Bremen/Oldenburg (2014)
Norway	**Project organisations** • *Gronn Bill*. Set up in 2009 to facilitate the introduction of 200.000 EVs and PHEVs on Norwegian roads by Energy Norway, Novatran, regional authorities and ZERO by 2020 (Bakker et al. 2012) • *Transnova*. Transnova is the public body assigned to reducing CO_2 emissions from the transport sector. Transnova was established in 2007 following a suggestion by ZERO. Today, Transnova has a budget of NOK 75 million per year (Transnova 2014) **Platform** • *Electric Mobility Norway*. The Electric Mobility Norway (EMN) project is being developed in the Kongsberg–Drammen–Oslo region. It is led by Kongsberg Innovation with the support of Transnova (which is managed by the Norwegian Public Roads administration) and Buskerud County Council. The main objective is the "establishment of an innovation and knowledge arena in that region" (Bakker et al. 2012)

(continued)

Table 6 (continued)

Organisational incentives in NSR countries and California (USA)	
Comparative case: California	• *Vehicle Technologies Program (VTP)*. Advanced Energy Storage technologies research programmes. Research portfolio is focused on battery module development and demonstration of advanced batteries to enable a large market penetration of Electric Driven Vehicles (EDV) within 5–10 years (EERE 2014a) • *Advanced Power Electronics and Electric Machines*. Subprogramme within the DOE VTP provides support and guidance for many cutting edge automotive technologies now under development. Research is focused on developing revolutionary new power electronics and electric motor technologies that will leapfrog current on-the-road technologies (EERE 2014c) • *LA Cleantech Business Incubator (LACI)*. LACI helps accelerate the commercialization of their clean technologies in addition to accelerating new products developed by independent entrepreneurs (LA Cleantech Incubator 2014) • *Clean city*. A national network of nearly 100 Clean Cities coalitions brings together stakeholders in the public and private sectors to deploy alternative and renewable fuels, idle reduction measures, fuel economy improvements and emerging transportation technologies (EERE 2014b)

Table 7 Government level of EV policy (Van der Steen et al. 2014a, b)

Government level			
Country	National	Regional	Local
Belgium	+	+++	+
Denmark	+	+++	+++
Germany	+++	++	+
Netherlands	++	++	++
Norway	+++	+	+
Sweden	+++	+	+
UK	+++	++	+
Comparative case: California	++	++	++

0 = Limited information found/available
\+ = Limited focus
++ = Strong focus
+++ = Prevalent focus area

3.3 Finding 3: In Most NSR Countries Policy Focuses on Vehicles Rather Than Charging

Policy instruments mostly focus on the vehicle value chain. Within the EV value chain, governments primarily focus policy on consumers. Some countries focus more prominently in R&D and in upstream segments of the value chain.

Table 8 Policy focus on the vehicle value chain (Van der Steen et al. 2014a, b)

Policy focus in the EV value chain				
Country	R&D	Production	Services	Customer
Belgium	+	+	+	++
Denmark	+++	0	+	++
Germany	+++	++	+	+++
Netherlands	+	++	+	+++
Norway	++	+	+	+++
Sweden	++	+	+	++
UK	++	+	+	++
Comparative case: California	+++	++	+	++

0 = Limited information found/available
+ = Limited focus
++ = Strong focus
+++ = Prevalent focus area

Little attention is given to the segment of services, which could be a missing link between the demand of consumers and the supply provided by manufacturers (Tables 8 and 9).

3.4 *Finding 4: Policy Mostly Targets the Downstream of the Vehicle Value Chain*

Most countries focus their policies downstream in the value chain; they adopt a large number of financial incentives, at different government levels (tax incentives, rebates, subsidies, local benefits, etc.). In Denmark, one-third of the steering instruments in the EV value chain focus on consumers. Different levels of government implement downstream policies. Subsidies and tax incentives are usually implemented at national level. However, local governments also provide financial incentives, often cash but mostly "in-kind." Examples are free or preferential parking, access to toll lanes, free charging, free access to ferries for EVs. At first glance, these are small incentives. However, their impact should not be overlooked. In a recent Californian survey, 59 % of the respondents indicated that access to the high-occupancy vehicle lane (HOV-lane) was extremely or very important in their decision to purchase an EV, making it the most important motivator for purchase found in the survey (CCSE 2014).

Although most countries target the downstream (consumers) of the value chain, some also work more upstream (R&D and production). Most of these instruments are financial (see Table 10 for examples). Germany is one of the countries with a strong focus on R&D in EV policy. This could be explained by the presence of

Table 9 Examples of financial instruments for EVs focused downstream in the vehicle value chain (consumer focused)

Financial incentives—downstream of the value chain (consumer focussed)	
Belgium	**Tax incentives** (ECN 2012) • 120 % of the purchase costs are deductible for companies under a corporate tax system for EVs. 100 % for PHEV with CO_2< 60 g/km (for companies under corporate tax system) • Individuals receive a subsidy of 30 % of the price of the EV up to 9.190 Euros (*by taxes, not directly from invoice*). In Wallonia, the motor vehicle tax for low emission cars is the lowest of all the taxes. In the Flemish region, EVs are exempt from motor vehicle tax **Rebates/subsidies** • *Bonus Malus*. In the Walloon Region, EVs are being promoted through an extra subsidy of 3.500 Euros through a bonus malus system (The New Drive 2014/ECN 2012) • *Subsidy*. Through the subsidy, the city of Gent receives through the CIVITAS demonstration programme. The city grants funds to individuals, taxi and courier services and also to car sharing companies to purchase EVs (CIVITAS 2014)
Denmark	**Tax incentives** (Bakker et al. 2012) • In Denmark, BEVs are exempt from registration tax until 2015. That amount is 105 % of the price of the car for the first 10.000 Euros and 180 % for the rest of the amount • BEVs and fuel cell vehicles are exempted from annual tax until the end of 2015 **Local benefits** (**'non-fiscal incentives'**) • *Parking*. In Denmark, several cities (Copenhagen) have reduced the parking fee for EVs and in some cities EVs are exempt from paying parking fees (Squarewise 2010) • *Toll Roads*. Free use of toll roads for EVs (Bakker et al. 2012)
Germany	**Tax incentives** • Exemption of annual circulation tax for EVs bought during the period of 18 May 2011 until 31 December 2015. The Federal government has decided that the exemption period will be doubled from 5 to 10 years (Spiegel Online 2012) • In Germany, the motor vehicle tax is determined by the amount of CO_2 emissions, which is a pro for EVs (Squarewise 2010) **Rebates/subsidies** • The German government grants subsidies up to 5.000 Euros for EV buyers (Squarewise 2010) **Local benefits** (**'non-fiscal incentives'**) • *Parking*. In several cities in Germany, EVs have privileges for parking (Bakker et al. 2012)

(continued)

Table 9 (continued)

Financial incentives—downstream of the value chain (consumer focussed)	
The Netherlands	**Tax incentives** (IEA IA-HEV 2011) • EVs are exempt from the registration tax and from the annual road tax. Fuel cell EVs follow the same ruling • For leased cars, an income tax measure makes EVs and HEVs attractive. A normal tariff of 25 % of a leased car's value that is added to the annual income tax is eliminated (7 % from 2014) for zero-emission cars (less than 50 g CO_2/km) or will be 14 % or 20 % according to the fuel type and CO_2 emissions if the cars are fuel-efficient • Tax relief regulation for purchasing commercial electric vehicles • Through the MIA and VAMIL regulation of the central government, entrepreneurs can receive a subsidy for purchasing an EV or installing charging infrastructure (RVO NL 2013) **Rebates/subsidies** • The city of Amsterdam grants subsidies up to 5.000 Euros to purchase EVs which are being used for business and up to 10.000 Euros for purchasing electric taxis and courier cars (Programmabureau Luchtkwaliteit 2010)
Norway	**Tax incentives** (WSDOT 2011/Bakker et al. 2012) • EVs are exempt from non-recurring vehicle fees • EVs are exempt from sales tax • EVs are exempt from annual road tax. Tax free allowance given for this tax (calculated as NOK/km) i.e. for trips to/from working places and for business trips is considerable higher for EVs. Reduction for companies: 75 % for EV and 50 % for HEVs • EVs are exempt from taxation for company car benefit tax from 1 January 2009 • Registration tax is calculated according to weight, motor power and CO_2 emissions. The vehicles are classified by groups per CO_2 'tax. EVs are exempt from this tax • Reduced tax for leasing EVs **Rebates/subsidies** (Bakker et al. 2012) • *Grants for individuals*. The Norwegian government grants subsidies (approximately €4.000) to individuals who buy an EV or HEV class N1 or M1 • *Grants for companies*. To purchase EVs, the funding is 50 % of vehicles price; up to 50 % are given to companies **Local benefits ('non-fiscal incentives')** (WSDOT 2011/Bakker et al. 2012) • *Domestic Ferries*. EVs have free use of domestic ferries • *Free access*. EVs have free access to public areas • *Free parking*. EVs can park for free in public parking places. This measure has been in place since the beginning of the 1990s • *Toll roads*. EVs can use the toll roads for free • *Use of Bus and Taxi lanes*. EVs are permitted in bus and taxi lanes. This measure has been in place since 2003

(continued)

Table 9 (continued)

Financial incentives—downstream of the value chain (consumer focussed)	
Sweden	**Tax incentives** (IEA IA-HEV 2012/Bakker et al. 2012) • Taxation is based on the amount of CO_2 emission. This tax has been raised with 33 % in 2011 to stimulate the use of EVs • Hybrid vehicles with CO_2 emissions of 12 G/KM or less and EVs with an energy consumption of 37 kwh per 100 km or less are exempt from the annual circulation tax for a period of 5 years from the date of their first registration starting on 1 January 2010 • For EVs and Hybrid vehicles, the taxable value of the car for the purposes of company car taxation is reduced by 40 % compared with the corresponding or comparable petrol or diesel car **Rebates/subsidies** • A clean vehicle premium of 40,000 SEK (approximately €4.500) has been introduced (from January 2012) for vehicles emitting less than 50 g CO_2 per km **Local benefits** (**'non-fiscal incentives'**) (IEA IA-HEV 2012/Bakker et al. 2012) • *Parking*. In about 50 % of the 70 cities in Sweden where you have to pay to park EVs get a discount or can park for free (Parking. In about 50 % of the 70 cities in Sweden where you have to pay to park, EVs get a discount or can park for free) • *Toll*. EVs bought before 1 January 2009 are exempt from paying toll tax in Stockholm until 2012. Cars bought after 2009 are not exempt. From 1 August 2012, this incentive has been cancelled • *Congestion Charge scheme*. A congestion charging scheme was implemented on a permanent basis in August 2007 in central Stockholm. A fee is charged during times of traffic congestion. PHEVs and EVs are exempt
UK	**Tax incentives** (Bakker et al. 2012) • *Vehicle excise duty or VED (the UK's circulation tax)*. Electric vehicles exempt. VED for other vehicles is graduated by CO_2 emissions (for tailpipe emissions < 100 g CO_2 per km) • *Company car tax*. Employees and employers exempt from income and national insurance contributions • *Van benefit charge*. Exemption for electric vans from income and national insurance contributions (maximum of £3.000) • *Fuel benefit charge*. Electric Vehicles exempt *Enhanced capital allowances*. 100 % first year allowance (FYA): business can relieve entire cost of purchase of an electric car or a van against taxable profits in the year of acquisition for businesses buying low emission cars, a mechanism that effectively allows companies to claim back the cost of the purchase from HM Revenue and Customs (HMRC), which was extended until March 2018 through the 2013 UK budget, with the qualifying threshold will dropping from cars with emissions of less than 110 grams of CO_2/km, to 95 g/km in April and fall again to 75 g/km from April 2015, effectively making it more attractive for companies to purchase the lowest emission vehicles on the market. However, the 2012 budget had *removed* the 100 % FYA for *leasing* vehicles and this was not revised in the 2013 budget. The policy move was nominally designed to counter the possibility of companies

(continued)

Table 9 (continued)

Financial incentives—downstream of the value chain (consumer focussed)	
	leasing low emission cars in the UK and then driving them abroad, which would have no benefit to the country. The British Vehicle Rental and Leasing Association (BVRLA) argues that this threatens to leave leasing companies at a distinct disadvantage when it comes to marketing low emission and electric vehicles, with the risk of so-called cross-border leasing being overstated and that the industry was now being unfairly penalised http://www.businessgreen.com/bg/analysis/2256630/budget-2013-tax-allowances-could-drive-corporate-fleets-away-from-greener-cars **Local benefits** (**'non-fiscal incentives'**) (Bakker et al. 2012) • *Parking Charges*. Some local authorities provide exemptions or a reduced charge for electric cars • *London congestion charge*. *London congestion charge*. 100 % discount for many types (but not all, e.g. hybrid) EVs, saving up to £2,000 per annum **Rebates/subsidies** (Berkeley 2012/Kotter and Shaw 2013) • *Plug-in car grant*. The purpose of this grant programme is to enable the purchase of ultra-low carbon vehicles. This subsidy programme has a £43 m consumer incentive scheme for EVs and PHEVs, up to 2015. This grant, first available from January 2011, reduces the cost of eligible cars by 25 % up to a maximum of £5,000 for both private and business buyers • *Plug-in van grant*. Aimed at light truck (N1) vehicles that fulfil qualifying criteria; these grants will enable purchasers to receive 20 % off the cost of a van up to a maximum of £8.000 • *Local grants*. Funding through the Local Sustainable Transport Fund (LSTF) will replace the Local Transport Plan funding stream, with £560 m available for 2012–2015
Comparative case: California	**Tax incentive** • Tax credits for purchasing electric vehicle (between $2,500 and $7,500 per vehicle, depending on battery capacity) **Rebates/subsidies** • A credit equal to 10 % of cost up to a maximum of $4,000 is available for kits that will convert a standard vehicle to plug-in EV • Clean Vehicle Rebate Project offers rebates for the purchase or lease of qualified vehicles. Rebates up to $2,500 per vehicle

In Belgium, unlike most of the studied countries, measures such as tax rates are a regional responsibility. Since 2002, the Belgian regions (Flanders, the Brussels Capital and the Walloon Region) are responsible for the vehicle tax base, tax rates and exemptions

major vehicle manufacturers in Germany (which collectively comprise the largest automotive industry in Europe). Sweden also has a strong focus on R&D. Over one-third of the policy instruments found in Sweden focusses on stimulating Research and Development. In France, Renault has teamed up with the CEA (French Alternative Energies and Atomic Energy Commission) to work on electric vehicles, new energies and cleaner combustion engines. Compared to the European cases, California is very upstream (mostly R&D) focused. A lot of programmes fund research activities and experiments.

Table 10 Examples of upstream financial incentives

Financial incentives—upstream of the value chain (R&D and production focussed)	
Germany	**Research funding** (BMWI 2014/Squarewise 2010) • The storage battery programme is founded to build capacities in Germany for implementation throughout the whole supply chain in the production of storage batteries. The programme runs from 2009 until 2012, and the Federal government has granted 35 million Euros to this programme • The third mobility and transport research programme (BMWI) sets out the goals, for instance to research into drive technology. Special importance is attached to developing new vehicle concepts and technologies for reducing energy consumption and pollution by road transport • Through the BMBF ICT 2020 research for innovation, EENOVA receives 100 million Euros for research on energy management in EVs • The Lithium-ion battery alliance is a project to substantially increase the energy and performance density of lithium-ion batteries and to accelerate the possible use in production. The Federal government has granted 60 million Euros to this project
Sweden	**Research funding** • The government invested SEK 240 Million to partially finance research into environmentally friendly vehicles. The Swedish Energy Agency invested SEK 20 Million. One of the projects in which is invested in by the Swedish government is a project that is set up to develop and demonstrate EVs (Government offices of Sweden 2008) • The vehicle strategic research and innovation programme was started in 2009 as a cooperative effort between the government and the Swedish automotive industry. The programme finances common research effort, innovation and development activities. Public funds amount to SEK Million per year (approximately 105 million Euro) (IEA IA-HEV 2011) • The Swedish Hybrid Vehicle Centre Programme focusses on developing a competitive R&D centre for hybrid and electric vehicle technology through continuous cooperation between industry and academia (U.S. Commercial Service Global Automotive Team 2011) • The Environmental Vehicle Development Programme aims to contribute to global leadership within vehicle electronics and software and increase expertise in the efficient design of vehicles (VINNOVA 2013)

(continued)

Table 10 (continued)

Financial incentives—upstream of the value chain (R&D and production focussed)	
Comparative case: California	**Research funding** • Envia Systems Inc. will create a low cost, high energy density, high performance battery system for electric and plug-in hybrid electric vehicles. Grant amount $9 million from CEC and $4 million from American Recovery and Reinvestment Act • Advanced cells and design technology for electric drive batteries. This project will develop next-generation high-energy lithium-ion cells leveraging silicon anodes, doubling the capacity of state-of-the-art vehicle batteries. $4,986,984 • Advanced cells and design technology for electric drive batteries. This project will develop high-energy cells using a lithium metal anode and a proprietary solid polymer electrolyte that will significantly reduce battery cost and size, and improves life and safety. $4,874,391 • Advanced cells and design technology for electric drive batteries. This project will develop next-generation high-energy lithium-ion cells leveraging, high voltage composite cathode materials and silicon-based anodes doubling the capacity of state-of-the-art vehicle batteries. $4,840,781 • Advanced Energy Storage technologies research programmes. Research portfolio is focused on battery module development and demonstration of advanced batteries to enable a large market penetration of Electric Driven Vehicles (EDV) within 5–10 years • Fundamental basic energy research on enabling materials for batteries through the Energy Frontiers Research Centres • Transformational research on revolutionary, "game-changing" energy storage technologies. EDV-related projects include metal–air, lithium–sulphur, magnesium-ion, advanced lithium-ion and solid state batteries, as well as ultra-capacitors • Grid Energy Storage and Battery Secondary Use. The Luskin Centre is developing innovative strategies to enhance PEV value through secondary use of PEV batteries. This includes both vehicle-to-grid power (V2G) and post-vehicle repurposing of used PEV batteries ("second life") into stationary energy-storage appliances (B2G) **Production funding** • *Sales Tax Exclusion*. Advanced Manufacturing (CAEATFA programme). Provides a Sales and Use Tax Exclusion Programme for advanced manufacturing projects. Effective since 1 January 2013 **'Real world testing and experimenting'** • *EV Readiness research*. With funding from the U.S. Department of Energy (DOE) and the Commission for Environmental Cooperation (CEC), California's major regions are assembling PEV Readiness plans. The Luskin Centre is the prime research contractor. This research is aimed at informing the strategic development of public and other charging infrastructure necessary to effectively support a transition to PEVs in Southern California. Additional related projects include examining PEV parking policies • Clean fuel programme provides funding for research, development, demonstration and deployment projects that are expected to help accelerate the commercialization of advanced low emission transportation technologies. South Coast. Approximately $10 million annually

3.5 Finding 5: Few Countries Focus on Charging Infrastructure. also, Policy in the Infrastructure Value Chain Focuses Less on Downstream and Targets the Upstream Segments (Production and Services)

In the infrastructure value chain, the focus upstream can be explained by the relatively large number of policies that focus on the installation of (semi)-public charging points (mostly by regional and local governments). Many of those instruments focus on the installation of (semi-) public charging points. Studies show that most EV charging currently takes place at home (Snyder et al. 2012). For instance, the UK national government initiated from 2009 onwards the PIP (Plugged-In-Places) programme. It intended to support the development and consumer uptake of ultra-low carbon vehicles by introducing electric car hubs in six key British cities. Compared to the European cases, California has a lot of rebate/subsidy instruments which focus on the installation of a charging infrastructure. A lot of which are focused on home chargers.

Table 11 shows the focus in policy for the charging infrastructure value chain. Table 12 presents a series of examples of financial incentives that target the downstream of the infrastructure value chain.

Table 11 Policy focus in the infrastructure value chain (Van der Steen et al. 2014a, b)

Policy focus in the charging infrastructure value chain				
Country	R&D	Production	Services	Customer
Belgium	0	+	++	++
Denmark	++	+	+	++
Germany	++	++	+	+
Netherlands	+	+++	+	+
Norway	+	++	+	++
Sweden	++	+	+	++
UK	+	++	++	++
Comparative case: California	+	++	+	+++

0 = Limited information found/available
\+ = Limited focus
++ = Strong focus
+++ = Prevalent focus area

Table 12 Financial incentives downstream in the infrastructure value chain

Financial incentives for charging—downstream of the value chain (consumer focussed)	
Belgium	**Tax incentives** • When a private actor installs a charging point on the outside of his house they are entitled to 40 % tax deduction with a maximum of 260 Euros for the year 2013 (Federale overheidsdienst financiën n.d.) • Additional deductibility of 13.5 % on the investment in charging infrastructure for companies under corporate tax system (ECN 2012)
Netherlands	**Tax incentive** (RVO NL 2013) • Through the MIA and VAMIL regulation of the central government, entrepreneurs can receive a subsidy for installing charging infrastructure **Rebates/subsidies** • Drive4Electric (Province of Friesland) introduced a subsidy on the creation of charging points. Customers and companies that create charging points on private space can get a discount of 500 Euros per charging point (ZERAUTO 2014) • The Rotterdam Electric Programme supports the first 1.000 EV owners with an electric charging point. On private property, a charging point is partly subsided (IEA IA-HEV 2012)
Norway	**Local benefits** (**'non-fiscal incentives'**) • *Free use of charging infrastructure*. EV users can use the public charging infrastructure for free (ECN 2012) • *Grants*. The Norwegian government has granted 11,9 Million Euro for new recharging stations (Bakker et al. 2012)
UK	*PIP (Plugged-in-places)*. Intended to support the development and consumer uptake of ultra-low carbon vehicles by creating electric car hubs in six key British city or city regions or hubs with the installation of charging point in various locations (Bakker et al. 2012/Kotter and Shaw 2013)
Comparative case: California	**Rebates/subsidies** • *PEV Home Charger Deployment Program*. Provides incentives for up to 2,750 residents who purchase a new plug-in electric vehicle and install Level 2 EVSE from qualifying vendors in Bay Area • *Free charging equipment*. ECOtality offers EV Supply Equipment at no cost to individuals in the Los Angeles and San Diego metropolitan areas. 1,786 EVSE in California installed. 2,785 in total project. The value of the project is $230 million. • *PEV Charging Rate Reduction*. Southern California Edison (SCE) offers a discounted rate to customers for electricity used to charge EVs. Two rate schedules are available for PEV charging during on- and off-peak hours • *Charger Installation Rebate*. The Los Angeles Department of Water and Power (LADWP) provides rebates of up to $2,000 for the first 1,000 residential customers who purchase or lease a qualifying EV and install a rapid, Level 2 charger and a separate time-of-use metre at their home. The programme expires 30 June 2013 • *ChargeUp LA*. LADWP provides rebates to residential customers for the cost of EV chargers and installation. The rebate will cover up to $2,000 of out-of-pocket costs • *PEV Charging Rate Reduction*. In Sacramento Municipal Utility District, this rate option is for residential customers who own or lease EVs • *PEV Charging Rate Reduction*. The LADWP offers a $0.025/kw discount for electricity used to charge EVs during off-peak times. The discount is only applicable for first 500 kWh in month

4 Conclusion

The study finds that EV policy captured here mainly targets the vehicle value chain. Also, most countries adopt policies that target the downstream segments of the value chain, especially consumers. Policy hardly takes into account the segment of services. Within this category of downstream oriented policy, most tools are financial. Especially Denmark, Norway and the Netherlands have strong financial downstream incentives. Three types of financial downstream incentives focusing on EVs are most common: tax incentives, rebates and specific local extra benefits for EV owners (e.g. free parking). The Netherlands and Norway both have a high number of tax incentives that make it very attractive for both businesses and consumers to buy or lease EVs. Interestingly, Denmark has similar financial downstream incentives but has so far seen much lower sales and EV penetration in the market. Only a few countries seem to focus explicitly on charging infrastructure. Also, in most cases infrastructure policies focuses more upstream in the value chain (stronger focus on government purchasing and tenders). In the documents the authors studied there was little clear relation between policy directed at vehicles and those focusing on charging. Although the two are evidently sides of the same coin, policy is often made in two separate silos. A more integral policy strategy could improve the performance of policy.

Given the current phase in the introduction of EVs, the emphasis on financial instruments is understandable. The purchase price of an EV and a private charger are high and this will withhold even the early innovators eager to drive an EV from buying one. Downstream financial instruments can overcome these important barriers and have probably been an important factor for the quite successful penetration of EVs in the market; downstream financial policies have been the backbone of the early market phase of EVs. However, if we take into account the exponential growth in the numbers of sales required for the next phase in the introduction, this policy strategy quickly becomes unsustainable. The exponential growth of the next phase of the introduction of EVs requires a self-enforcing loop in the sales of EV, not government policy that is "pushing" sales by a range of very strong and direct incentives; policy should become more oriented at managing such loops (see: Van der Steen et al. 2013). Already, countries' resources and public support are overstretched and there is societal pressure to downsize financial stimuli. As the quantity of vehicles grows, governments have to look for other tools to stimulate the market for EVs. It is safe to conclude that government policy greatly contributed to the first small but significant steps on the path towards full-scale introduction of e-mobility; however, policy makers will need a different strategy and different policy tools to further the next step in the introduction. This study displays and reviews the policies made to support the small first steps, now policies have to be developed that support the giant leap.

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