Measures for the promotion of electric vehicles

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A study for Greenpeace e. V.

Ecologic Institute

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Executive Summary

The transport sector is a key source of air pollution and contributor to climate change. In order to limit the global temperature increase to 1.5°C and reduce air pollution particularly in cities, governments have to take a holistic approach to avoid traffic, shift it to cleaner modes, such as public transport, cycling and reduce emissions from remaining vehicles. The introduction of electric vehicles (EVs) is one way to significantly reduce emissions from cars — if combined with a transition to a renewable electricity system — thus helping countries meet their climate and air quality goals. With a view on limiting global warming to 1.5°C, internal combustion engine (diesel and petrol) cars need to be phased out in Europe by 2025; hybrid vehicles by 2028 (see e.g. DLR, 2018); EVs play an important role as an alternative option.

Numerous governments around the world have already implemented or are considering measures to accelerate the uptake of EVs. This study analyses a range of existing measures that have a direct impact on the increased uptake of electric passenger cars, particularly battery electric and fuel cell electric vehicles. It does not address disincentives for internal combustion engine (diesel and petrol) cars or private cars as such. Therefore, measures like diesel, petrol or CO_2 taxes as well as e.g. road pricing are not included. As an exception, the study does consider bans of internal combustion engine cars since this is comparable to the final step of EV support, i.e. a 100 % EV quota. The analysis is based on a literature review including research studies, reports and scientific papers, as well as official websites. The study focuses on measures in the European Union (EU), but also discusses international examples where these provide useful insights, in particular schemes from the U.S. and Norway for which detailed information is available.

The study examines ten types of measures including both financial and non-financial incentives. It assesses 1) the measures' overall effectiveness in incentivising EV purchases; 2) the ease of administering them; 3) affordability for governments; and 4) the consistency with other goals, mainly with the goal of reducing traffic.

EV support measures examined in the study:

EV quota for car companies (see Chap. 2): Governments can oblige car companies to produce a minimum quota of EVs. Non-compliance is subject to a penalty fee. California and China have provisions for a certain share of low or zero emission vehicles while the EU takes an indirect approach via setting CO_2-targets for the car fleet of an automaker. Quota or targets need to be both ambitious and feasible. Therefore, policy-makers often take into account the company size and capacity of automakers.

Bans of new internal combustion engine cars (see Chap. 3): Banning internal combustion engines cars — both diesel and petrol — encourages the development, production and purchase of alternatives such as EVs. A range of countries and regions recently announced such plans in light of global warming and air pollution, e.g. Norway, the UK and California.

Public and private procurement provisions for EVs (see Chap. 4): Procurement describes the process when a company or public administration buys goods and services. It aims at gaining the best value for money. In many countries, the government is a very powerful procurer; thus, green or sustainable public procurement rules can substantially increase the market for green products, including for EVs. However, to date, green procurement remains purely voluntary. Sweden, Catalonia (Spain), China and Korea have made initial attempts to implement provisions for governments. No entity has implemented obligations for private companies so far.

Grants for the purchase of EVs (see Chap. 5): EVs are still more expensive than internal combustion engine cars. Grants aim at making them more affordable, aiming in particular to make a difference for buyers of lower-end EVs. In some countries, car sellers discount the EVs in their stores and collect the subsidy after the purchase while in others the purchasers have to apply for

the grant after the purchase. Access to and size of the grants usually depend on specific national criteria. South Korea, some countries in the EU and the city of Ghent (Belgium) provide grants.

Tax benefits during EV purchasing (see Chap. 6): Governments can make EVs more attractive by providing reductions or even full exemptions of taxes that are applicable at the point of purchase. This includes reduction or exemption from the Value Added Tax (VAT) or of the one-time registration tax. A prominent example is Norway that offers a VAT and registration tax exemption. In Norway, both taxes are comparatively high for diesel and petrol cars, so the exemptions can close the financial gap between an internal combustion engine car and its electric alternative.

Tax benefits for electric company cars (see Chap. 7): Companies offer cars to their employees as extra remuneration on top of the salary. Employees can use these cars also for private purposes, which means that it is a benefit in kind. Many governments apply a tax on the private use of company cars. The tax rate usually depends on different criteria including engine power, fuel type and/or CO_2 emissions. Employees using an electric company car can benefit from tax rebates or exemption in many countries. As company cars are often leased for a limited time and then sold on the used car market, exemptions or rebates on these taxes can help create a more affordable secondary market for EVs.

Tax benefits during ownership of an EV (see Chap. 8): In many countries, car owners have to pay annually for having a car, which is in use on public roads. The tax is commonly referred to as ‘circulation tax’, ‘ownership tax’ or ‘road tax’. Countries apply this tax based on a wide set of criteria but mainly related to engine power and/or CO_2 emissions. Many countries offer tax exemptions or rebates for EVs including the United Kingdom and France. As the level of the tax for diesel and petrol cars varies significantly between countries, the tax benefits associated with an exemption for EVs also vary.

Free parking for EVs (see Chap. 9): Regional and local governments can offer free parking to EV drivers. Most cities combine free parking with reserved areas and charging stations for EVs. The financial as well as timesaving benefits for EV owners can be substantial, particularly in cities where parking is expensive and space is limited. However, free and reserved parking encourages EV owners to use their car in city centres contradicting the shift to public transport, cycling or walking which is especially needed in densely populated areas.

Access to bus lanes for EVs (see Chap. 9): Regional and local governments can allow EVs to use bus lanes and other special lanes, which can substantially reduce commuting time. However, the approach only works for early-movers and for a limited number of EV drivers in a city. More and more EVs on the street will result in traffic jams expanding to special lanes, blocking buses that should pass unhindered. As public transport remains the preferred transport mode from an environmental perspective, benefits to EV owners should not come at the costs of making buses less attractive.

Without charging infrastructure, no support scheme will be effective (see Chap. 10): EVs run on rechargeable batteries. Thus, potential EV purchasers look for a good charging network but infrastructure investors need a certain amount of users. To overcome this chicken-and-egg problem, many governments subsidise the built-up of charging infrastructure. Standardisation of chargers is key in this context as there are different charging modes, connection cases and plug types available on the market. Governments, private investors and EV owners have a strong interest that EV plug-ins also fit charging stations in neighbouring countries in order to make best use of the infrastructure.

Table 1: Evaluation outcome for measures to promote EVs

Evaluation criteria / *Name of the measure*	Effectiveness to incentivise EV purchases	Ease of administration	Affordability for governments	Consistency with other policy goals
EV quota for car companies				
Bans of diesel and petrol cars				
Public and private procurement provisions				
Grants for the purchase of EVs				
Tax benefits during EV purchase or registration				
Tax benefits for electric company cars				
Tax benefits during ownership of an EV				
Free parking for EVs				
Access to bus lanes for EVs				
Charging: financial support and requirements				

Source: Ecologic Institute.

Legend: low = medium = high =

Overall, the main findings of the evaluation are:

Prescribing the use of EVs or phasing out internal combustion engine cars is most effective: Governments can oblige car companies to produce a minimum quota of EVs; they can completely ban internal combustion engine cars and use public and private procurement provisions to stipulate the use of EVs. These legal requirements have the highest rating in terms of their overall effectiveness as well as their affordability for governments and consistency with other policy goals, if these requirements are set at ambitious level.

Charging infrastructure is crucial: A reliable network of charging stations is still missing in most countries — in cities and on highways. However, without good infrastructure, any other incentive or regulatory measure has little impact on EV purchases, as consumers will be reluctant to buy EVs if there are limited charging stations. Governments might therefore support an early built-up of charging infrastructure through e.g. subsidies or public and private partnerships as long as the charging stations cannot be operated economically. Importantly, governments have to aim for standardisation at national and international level to make the infrastructure available for all users.

Any support scheme needs to reflect rapid changes in the electric mobility sector: The EV market develops rapidly with advances in battery and vehicle technologies and with car manufacturers being aware of policy goals. Innovations and in particular large-scale market introduction of EVs reduce their price. Governments that offer financial and non-financial incentives need to adjust any support to EVs to reflect market developments. Financial incentives should reflect price differences between internal combustion engine cars and the electric alternative. The non-financial benefit of being able to use bus lanes should take into account the number of EVs on the street and their impact on public transport.

Combining measures and sequencing them over time is key for inducing full market transformation: Analysis shows that countries, such as Norway, with a mix of support measures have been most successful at quickly ramping up the EV share. Governments may thus put in place a mix of policy measures which should also reflect the stage of the EV market: 1) for early adopters, governments can open bus lanes and provide separate parking spaces with charging stations. Early public procurement provisions that prescribe e.g. an EV quota for new purchases of public authorities is in line with the role model function of the public sector which can push up market penetration and positively influence public perception. 2) A combination of an EV quota for car companies and financial support to EVs at the lower-end of the price range can trigger large-scale market introduction. The financial benefits reduce the prices of EVs, thus tackling a crucial barrier that prevents middle-income households from buying EVs. The EV quota can start low but it clearly signals policy targets to car companies. 3) Finally, governments might phase-out any conventional diesel and petrol car thus shifting the passenger vehicle market to zero emissions.

Financial benefits for EVs are most effective when combined with disincentives for internal combustion engine cars: Governments can increase the effect of financial support to EVs when they penalise internal combustion engine cars at the same time. Increasing taxes on high-polluting cars (in terms of CO_2 emissions and air pollutants) in combination with grants and/or exemptions from taxes for EVs can close the financial gap between internal combustion engine cars and their electric alternative. This is the case in Norway. In addition, taxes on high-polluting cars can provide a revenue stream by balancing grant payments, such as the bonus-malus-system in France shows. This combination rewards consumers buying clean vehicles and disadvantages those purchasing polluting ones.

Finally, car purchasers might not be fully aware of financial benefits and other incentives. Thus, governments should promote and provide **information and guidance about EV measures** that are easy to understand; thus ensuring their maximum usage.

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1 Introduction

The transport sector is a key source of air pollution and contributor to climate change. In 2016, transport accounted for one quarter of global greenhouse gas (GHG) emissions — this was roughly 75% higher when compared to 1990 with the increase mainly coming from road transport (IEA, 2019). In the European Union (EU), transport emissions have increased since 2013. One major source are private cars that accounted for roughly 60% of transport emissions in 2016 and which are the main reason for the increase of transport emissions since then (EEA, 2018a).

There is a need to revolutionise our transport system by avoiding traffic, shifting the remaining traffic to cleaner modes and making sure that remaining vehicles emit as little emissions as possible. In the light of the Paris Agreement, research shows that in the EU, internal combustion engine (petrol and diesel) cars should not be sold later than 2025 and hybrids no later than 2028 to contribute to limiting the global temperature increase to 1.5°C (DLR, 2018). This is in line with national policy commitments about the phase-out of fossil-fuel based cars e.g. in Norway (see Chap. 3). A key part of the solution is the electrification of cars through the widespread introduction of electric vehicles (EVs) if the electricity comes from renewable sources. The shift to EVs also reduced air pollution in particular in cities. EVs produce less air or smog-forming pollutants over their life cycle when compared to internal combustion engine cars (see ISI 2019). At the street level, EVs have no exhaust emissions and produce no engine noise, thus contributing to air quality and noise reduction especially in cities with high traffic volume. However, the first priority should be to reduce the number and use of individual cars as EVs also have environmental and climate costs.

Around the globe, many governments support the promotion of EVs and most major vehicle markets have already introduced some type of incentives for EVs or are considering the introduction of such measures. This study analyses a range of existing measures that have a direct impact on the uptake of electric passenger cars, particularly battery and fuel cell electric vehicles. It does not address disincentives for internal combustion engine (diesel and petrol) cars or private cars as such. Therefore, measures like diesel, petrol or CO_2 taxes, as well as e.g. road pricing are not included. As an exception, the study does consider bans of internal combustion engine cars since this is comparable to the final step of EV support, i.e. a 100 % EV quota. Whilst predominantly aimed at European policymakers, the study scrutinises EV measures from a variety of countries worldwide to provide a broader picture.

The analysis is based on a literature review including research studies, reports and scientific papers, as well as official websites. Following a short description of the selected measures, the analysis assesses 1) the measures' overall effectiveness in incentivising EV purchases; 2) the ease of administering them; 3) affordability for governments; and 4) the consistency with other policy goals. The overall effectiveness of the selected measures is evaluated by their effect on the increased sale and uptake of EVs. Ease of administration focuses on the process of setting up the respective measure; it does not systematically analyse potential resistance from the public and/or industry. With regard to affordability for governments, EV measures can represent direct payments or foregone tax revenues, and/or include only limited administrative costs. Lastly, the analysis includes the measures' consistency with other policy goals to identify possible positive and negative side effects.

The study examines ten measures including both financial and non-financial incentives: 1) EV quota for car companies (see Chap. 2); 2) Bans of new internal combustion engine cars (see Chap. 3); 3) Public and private procurement provisions for EVs (see Chap. 4); 4) Grants for the purchase of EVs (see Chap. 5); 5) Tax benefits for EV purchasing (see Chap. 6); 6) Tax benefits for electric company cars (see Chap. 7); 7) Tax benefits during ownership of an EV (see Chap. 8); 8) Free parking for EVs and 9) access to bus lanes (see Chap. 9); and 10) Financial support and requirements for charging infrastructure (see Chap. 10). Chapter 11 presents the conclusion and key findings.

2 EV quota for car companies

Governments can legally oblige car companies to produce a minimum quota of EVs. This is to push automakers to focus their development resources on the production of cleaner cars. Non-compliance is usually penalised with a fee. It is important that governments determine targets that are both ambitious and feasible within a specified period of time. This requires analyses as well as close dialogue with the stakeholders involved. Policymakers usually take into account the company's size and capacity. Moreover, they create additional incentives to reward the efforts of these automakers that surpass the set quotas.

A variety of countries and regions have adopted some kind of EV quota for car companies. The following chapter introduces three examples that illustrate the different possibilities for governments. California, China and the European Union have adopted measures that represent different approaches in implementing such quotas.

2.1 Examples of implementation

2.1.1 California (United States of America)

With the Zero-Emission Vehicle Regulation (ZEVR), the California Air Resources Board (ARB) seeks to promote the adoption of EVs (CARB, 2019a). From 2003 onwards, a certain quota of new cars delivered for sale in California must be emission-free. The ZEVR is part of the Advanced Clean Cars package and aims to increase the quantity of zero emission vehicles and plug-in hybrid electric vehicles in California. It applies to car manufacturers of light-duty vehicles, including passenger cars that have annual sales in California exceeding a set threshold (EIA, 2017). Each year, automakers need to submit a certain amount of credits, which they earn by selling cars that are in line with the clean vehicle definition. The earned amount differs per type of vehicle sold as well as the battery range.

In 2018, the credit requirement was 4.5%, which required around 2.5% of sales to be zero emission vehicles. In 2025, the requirement will rise to 22%, meaning that 8% of sales will need to be zero emission vehicles. The ZEVR defines zero emission vehicles as battery-electric, plug-in hybrid-electric and hydrogen fuel cell vehicles (CARB, 2019a). However, the amount of credits that can be obtained from the sales of 'transitional' zero emission vehicles — cars that still contain an engine — is limited. Plug-in hybrid-electric vehicles were only allowed to account for 55% of the credits in 2018.

The ZEVR constitutes a complex set of rules, which leaves automakers with a degree of flexibility on how to comply. To this end, they are able to save credit surpluses for future use ("banking"), sell or buy credits from each other as well as make up credit shortages within pre-defined timeframes (CARB, 2018). In the case that automakers fall short on credits, they face a penalty of USD 5,000 per lack of credit (Weissler, 2017).

In addition to California, nine other U.S. states have adopted the ZEVR — representing around one third of the American market — as well the province of Québec in Canada (Simard, 2016).

2.1.2 China

China's New Energy Vehicle (NEV) mandate policy is the first zero emission vehicle mandate at the national level worldwide. It took effect in April 2018 and applies to passenger cars (Cui, 2018). The NEV definition includes cars with new-type power systems, mainly or completely driven by new energy sources, which includes plug-in hybrid EVs as well as battery and fuel cell EVs. While it is expected to substantially advance the EV market in China, the Chinese NEV mandate may also be a turning point for the global auto industry. The NEV mandate policy has the potential to influence

a worldwide transformation to a zero emission car fleet, as China has the world's largest auto market with a global market share of about 40% in 2016 (EIU, 2017).

China set annual mandatory NEV requirements for automakers with an annual production or import volume of at least 30,000 passenger cars. Automakers can achieve the targets by importing or producing cars that fulfil the NEV definition. The NEV targets specified so far are 10% of the internal combustion engine car market in 2019 and 12% in 2020 (Cui, 2018). EVs get a certain amount of credits depending on indicators such as their energy efficiency, rated power or fuel cell systems and electric range, with higher performance cars getting a higher score of up to six credits (ICCT, 2018). This means that automakers can comply with the NEV mandate of 12% in 2020 with a 2% share of high-performance cars rated with six credits in their overall production plus imports.

The Chinese system allows for some flexibility as automakers can generate NEV credits if they overachieve the target for the year. The credits can be sold or transferred to other companies. They can also be used for compliance under the Chinese fuel efficiency regulation for passenger vehicles. In case automakers are unable to meet the targets, China's Ministry of Industry and Information Technology (MIIT) will deny the approval for new car models, which do not hit the standards until the offset of deficits is guaranteed. The automakers that do not comply with the rules will be added to a blacklist, with this information being distributed to the public (ICCT, 2018).

2.1.3 European Union

The EU has not introduced a direct quota for EVs or zero emission cars. Instead, the EU introduced a CO_2 target for the car fleet of each automaker (Regulation 443/2009). This is likely to incentivise the production of EVs since compliance with this target is hardly doable without integrating low or zero emission cars into the fleet.

The 2015 target, limiting the fleet average of automakers to 130 grams of CO_2 emitted per kilometre (g CO_2/km), was accomplished in 2013. For 2021, the CO_2 emission target — phased in from 2020 onwards — will be 95 g CO_2/km. However, the underlying measurements of fuel consumption and CO_2 emissions of new cars do not reflect real world values. Thus, the new proposal for the period 2020 to 2030 changes the requested measurement procedure to the so-called Worldwide Harmonised Light Vehicles Test (WLTP), which should provide more realistic fuel consumption and CO_2 emission values (COM, 2018). The new proposal also sets targets for 2025 and 2030 that are 15% and 30% lower when compared to the 2021 target. If the fleet average exceeds the CO_2 emission target, the responsible automakers are obligated to pay penalty fees for each car registered (COM, 2016).[1]

Emission limits are determined by taking into account the mass of the vehicle, implying that heavier cars can emit more than lighter cars (COM, 2016). As this measure addresses the fleet average, it is possible to manufacture cars that emit emissions above the limit if these are offset by other cars below the limit (ICCT, 2014).

The regulation further promotes EVs and other low emission vehicles through "super credits" that automakers can earn by producing cars with emissions below 50 g/km; for example, one low-emission car will be counted as two in 2020 and 1.67 in 2021. Furthermore, the instalment of innovative technology can also lead to extra credits that constitute annual maximum savings of 7 g/km (COM, 2009). The new proposal (COM, 2018) keeps the super credits until 2022 and changes

[1] They need to pay EUR 5 for the first g/km of exceedance, with this fee increasing to up to EUR 95 from the fourth g/km onwards. From 2019 onwards, the penalty fee of EUR 95 applies already from the first g/km of exceedance.

then to a crediting system which gives automakers a less strict CO_2 target when the share of low and zero emission vehicles exceeds 15% for the years 2025 to 2029 and 30% in 2030.

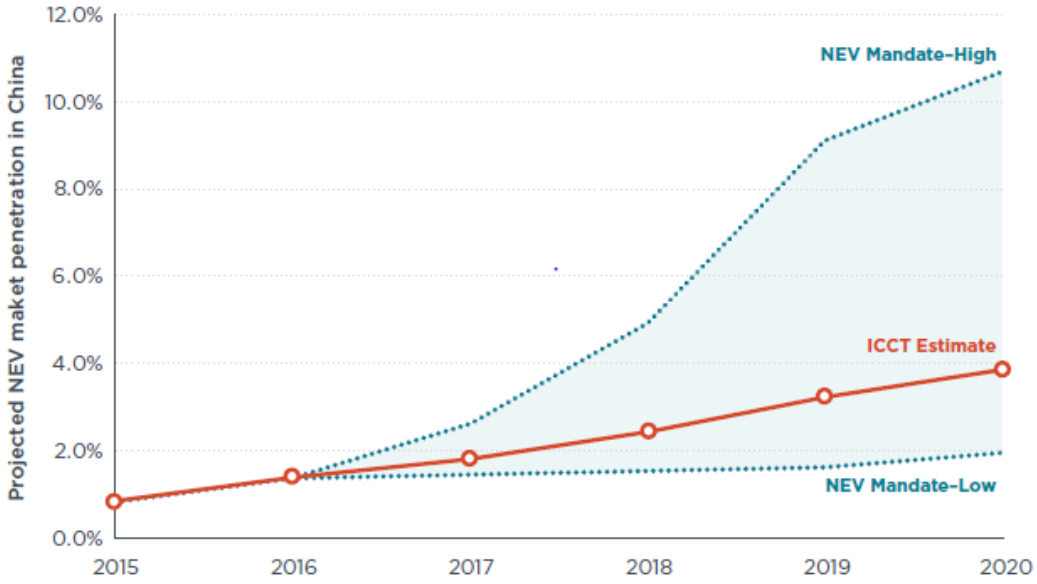
2.2 Effectiveness to incentivise EV purchases

Overall, the introduction of a direct EV quota for car companies appears to be an effective measure in promoting EVs. However, their effectiveness depends on the level of ambition of the actual targets set by the measures.

In California, the ZEVR incentivised the sales of EVs to some extent: zero emission cars made up 5% of new car sales in 2017, compared to 3.8% in 2016, and battery EVs sales accounted for the majority of ZEVR credits (CARB, 2019b; CA.GOV, 2019). The ARB estimates that around 8% of new vehicles sales in California will be zero emission vehicles and plug-in hybrids by 2025 (EIA, 2017).

The Chinese NEV mandate necessitates an increase of the annual “new energy passenger car” production until 2020. As illustrated in Figure 1 below, the required increase depends on the technology path (and respective scoring of single cars) that the car companies choose. On the basis of assuming around three credits per car (based on certain estimates of the electric range of EVs), the ICCT (2018) estimated that the Chinese NEV share of new passenger car sales will increase from around 1% in 2016 to about 4% in 2020. The government’s goal of 5 million NEV sales in total would then be achieved in 2020.

Figure 1: Projection of NEV market penetration in China



Source: ICCT (2018)

In the EU, the Regulation 443/2009 has yet to incentivise the sales of EVs but it may have led to a greater availability of different types of EVs of each car company (Gibson et al., 2015). Compliance with targets up to 2020 do not require any EVs or zero emission cars in the sales of car companies but instead can be achieved through efficiency gains of gasoline and diesel cars (EEA, 2018b). This might change from 2020 onwards with more ambitious targets planned and stronger emissions testing procedures being introduced. However, there is no penalty if car companies do not reach the required share of low or zero emission cars and targets are still not stringent enough to incentivise a significant increase of the sales of EVs and other zero emission cars.

2.3 Ease of administration

If governments want to introduce an EV quota for car companies and want to offer flexibility on how to comply, they will likely need to set up a complex and dynamic system of rules. This necessitates planning as well as an analysis of potential impacts. Additionally, close and continued monitoring is required to assess whether automakers are compliant or whether the policy is in need of revision.

The Californian ZEVR rulebook, as explained above, provides automakers with some degree of flexibility, yet also requires administrative efforts, such as gathering, checking and summarising data from automakers as well as managing the trading of credits. In China, the MIIT and other agencies supervise compliance and the credit market by checking and tracking the relevant information and companies (ICCT, 2018). In the EU, the European Environmental Agency (EEA) is responsible for gathering, checking and summarising data. The EEA is obligated to submit detailed information on each new car registry per calendar year. The European Commission uses this data to assess whether automakers comply with the regulations (Tietge, 2018).

2.4 Affordability for governments

The introduction of any kind of standard or regulation is a process that involves certain administrative costs. Technology-specific controls seem to be the cheapest to administer when compared with other policy measures. However, as the examples show, governments tend to include flexibility and technology-neutral approaches that include additional administrative costs related to regular reporting, monitoring and verification of production and imports and/or of emissions as well as of registries for credits and some form of trading oversight. Nevertheless, implementing an EV quota does not require any direct spending of governments and is not associated with losses through tax exemptions. Therefore, it can be an attractive measure from a financial perspective.

2.5 Consistency with other policy goals

Policymakers need to consider carefully how regulations interact with other policy initiatives and regulations in order to avoid conflicting mechanisms and duplications. The Californian ZEVR had a positive impact on innovation, with automakers investing in their research and developments in order to meet the requirements. This regulation may also have the positive side effect that it indirectly supports the policy goal of improving the charging infrastructure for EVs (Hardman et al., 2018). However, the flexibility of the NEV mandate in China may result in decreasing the stringency of the fuel efficiency standards for internal combustion engine cars (ICCT, 2018).

The CO_2 target implemented in the European Union brings mixed effects. As the emission limits take into account the mass of the vehicle, heavier cars can emit more than lighter cars. This does not incentivise the production of smaller and lighter cars. The possibility for carmakers to gain “super credits” with the production of particularly low emission cars enables them to, overall, increase their level of CO_2 emissions beyond the fleet-target — thus still selling high-polluting cars.

2.6 Findings

The effectiveness of measures that aim to introduce an EV quota for car companies greatly depends on the level of ambition of the targets. These levels of ambition are usually influenced by the automotive industry, which generally argues for lower shares. Nonetheless, ambitious targets have the potential to create momentum in the automotive industry and policymakers should push for new technological and market developments in order to accelerate the deployment of EVs. Furthermore, if car companies must sell EVs, they will invest in advertising, which contributes to the visibility of EVs in the market.

3 Bans of new internal combustion engine cars

Bans, i.e. standards that prohibit vehicles with certain technological features, are a common regulation in transport policy (Kazmierczyk, 2007). A ban of new internal combustion engine cars, i.e. petrol and diesel cars, encourages the development, production and purchase of new low and zero emission passenger cars — even if the ban will be implemented in a future time. The ban can take effect e.g. through restrictions around the registration of private fuel-motorised vehicles using petrol and diesel.

A range of countries recently announced plans to ban new internal combustion engine cars as rising greenhouse gas emissions and air pollution from the transport sector are on the political agenda. Norway plans to ban the sale of new internal combustion engine cars by 2025, as do the Netherlands, Ireland, Slovenia, Israel and India (all by 2030), Scotland (by 2032) as well as France[2], Britain and Taiwan (by 2040). China has restricted the construction of new factories for internal combustion engine cars (Huang 2018) and may end production and sale of internal combustion engine cars by 2040 (Burch and Gilchrist, 2018; Coren, 2018; Galeon, 2017). Costa Rica is regarded as the global frontrunner — the country plans to phase-out the complete use of fossil fuels in the transport sector already by 2021 in order to become the world's first decarbonised country (Embury-Dennis, 2018).

For most countries, little information is available on the details of these bans besides the general announcement to ban new fossil-fuel based cars at a specific point in time.

3.1 Examples of implementation

3.1.1 United Kingdom

As set in its "Road to Zero" strategy, the UK government "will end the sale of new conventional petrol and diesel cars and vans by 2040". The plan foresees three timeframes: by 2030, 50-70% of new cars and 40% of new vans sold should be zero emission vehicles; by 2040 "the majority" and by 2050 "almost every" new car sold is expected to be fossil fuel-free (Department for Transport, 2018).

Although the measure is clearly defined, no concept for the implementation of the phase-out has yet been established. In October 2018, MPs announced plans to postpone the start of the phase-out to 2032. A concrete concept to tackle the obstacles continues to be missing (BBC, 2018; Smith, 2018).

3.1.2 California

California is considering a ban of new internal combustion engine cars. At the beginning of 2018, Assembly Member Phil Ting presented a draft for the Clean Cars 2040 Act to the California State Assembly. It outlines a ban of the registration of new internal combustion engine cars in the state — starting in 2040 (Burch and Gilchrist, 2018). The proposal aims to "require global automobile manufacturers to develop, build, and market a full range of ZEV [zero emission vehicle] options for drivers" (Ting, 2018).[3] The bill would "prohibit the department from accepting an application for original registration of a motor vehicle unless the vehicles is a zero emissions vehicle" (Ting, 2017).

[2] France is currently considering prescribing the phase-out of internal combustion engine cars in its Mobility Law.

[3] "The bill does not apply to commercial motor vehicles weighting more than 10,000 pounds, and allows people moving into California to keep their vehicles, whether ZEV or not" (Ting, 2018).

In December 2018, Ting reintroduced the legislative act to the California State Assembly but it has not been adopted yet (Dawid, 2018).

3.2 Effectiveness to incentivise EV purchases

Generally, an announced phase-out of a certain technology sends a strong signal to the affected industry to change their production in a specific way. Thus, it is expected that the manufacturing of EVs will increase and take over the respective market share of internal combustion engine cars. Many automakers are already planning to sell many of their future models as electric versions (Burch and Gilchrist, 2018) — on the basis of announcements of bans or other measures.

Although there is no implementation example today of a complete ban of internal combustion engine cars, one can have a look at the impact of e.g. the local bans of diesel cars in cities. The sales of new diesel cars in the EU dropped significantly after cities implemented local bans to reduce air pollution following Dieselgate (Kodjak, 2018). Consumers shifted from diesel to petrol cars as they were not affected by the policy interventions; thus the drop in sales of diesel cars was completely offset through the sales of new petrol cars (ACEA, 2019). Similarly, banning internal combustion engine cars will most likely lead to a shift of motor-type *i.e.* consumers will most likely shift from internal combustion engine cars to EVs. With regard to the examples, most governments expect the sale and production of EVs to rise with the announcement of the phase-out of new internal combustion engine cars. UK MPs assume that the target "would accelerate the uptake of electric cars across the country" (Smith, 2018). In response to California's proposal, the Centre for Climate Protection argues that phase-outs and related efforts "leverage market forces" towards emission-free vehicles (Burch and Gilchrist, 2018; Hancock, 2018).

3.3 Ease of administration

In general, the introduction of bans of internal combustion engine cars is easy to implement because the respective governments only need to adapt the related legislative documents with respect to e.g. criteria for car registration. Pure announcements do not have any implementation procedures.

The compatibility of such national bans with EU law is not straight forward. Usually, a European type approval allows the sale of the respective car model in all Member States. However, Member States may implement national provisions with a higher ambition of environmental protection than the EU legislative acts prescribe. They must design the national protections in a way that they do not discriminate car companies from other Member States that export to the respective country and do not unduly affect the free movement of goods (Verheyen and Pabsch, 2017). Overall, a detailed legal analysis of the specific bans would be necessary to determine their compatibility with EU law.

3.4 Affordability for governments

The implementation of a ban of internal combustion engine cars does not involve high costs for the government but limited costs associated with administration as checks and registration procedures for new cars already exist.

3.5 Consistency with other policy goals

A ban of new internal combustion engine cars is likely to lead to a shift in motor-types only: instead of buying diesel or petrol cars, consumers will turn to an available alternative which would be mainly EVs. Thus, the ban is not likely to affect the total number of cars sold and can therefore not help to address transport problems related to the overall amount of cars whose

presence occupies significant space and contributes to congested streets in overcrowded city centres.

The phase-out of unwanted technology always affects the respective industry in some form. Thus, parts of the automotive industry argues against such bans mainly through loss of jobs and local value creation. However, new technology opens new opportunities, and parts of the automobile industry also welcome the governmental incentives and support a set exit timeline (Vaughan, 2017). A survey from ICCT also confirms these findings, recognising that a clear direction from governments helps companies to plan successful development and does the industry a favour by setting firm deadlines (Burch and Gilchrist, 2018).

The general population might be concerned about not being able to afford a new car — as EVs are currently more expensive than a comparable internal combustion engine car — and might also be worried about the current lack of charging infrastructure (Schäfer, 2017). However, as bans come into effect around 2030 or later in most countries, one can expect that the price difference will be diminished, and that governments will have significantly improved the infrastructure. In addition, governments may provide supplemental support through grants or tax incentives.

These factors need to be considered in the context of each specific country's situation. In any case, policymakers seem to handle those restrictions with care as "they recognize the political cost of requiring adoption of a new technology, even if that technology is superior to the old one" (Burch and Gilchrist, 2018).

3.6 Findings

At present, countries have announced bans of new internal combustion engine cars without legal implementation plans yet. California is the only state that has presented a specific draft. However, the introduction of this measure is likely to have an influential impact on the automotive industry and consumers who start to see little future for new diesel and petrol passenger cars. Both industry and consumers are likely to shift to alternatives, with consumers also having the option of buying second-hand cars or using other transportation types if available.

4 Public and private procurement provisions for EVs

Procurement describes the process of acquiring goods and services from an external source. It aims at establishing provisions that include ensuring the best value for money.

In many countries, the public administration is a very powerful procurer with a big purchasing volume, thus exercising influence and buying power. For instance, in Europe, public authorities consume 16% of the EU's GDP (Palm and Backman, 2017). In order to ensure economic spending of public funds and in order to protect competitors from abuse of this market potential, a public procurement law prescribes a certain procedure for authorities when purchasing the goods and services they need to fulfil their responsibilities. Green or sustainable public procurement has two objectives: the purchase of products with a smaller environmental impact than their conventional equivalents, as well as being a tool to stimulate the entrance of sustainable products in the market.

Legal provisions on the European, national and regional or municipal level govern public procurement. Consideration of "green" criteria i.e. green public procurement plays a purely voluntary role. Apart from pilot or research projects (for example in Catalonia), there is no EV quota in public procurement provisions and no priority is given to EVs. Nonetheless, there is a lot of support for voluntary green public procurement, for example on the European Union level.

In addition to the government, private companies are major procurement players. There seems to be no legal obligations that force companies to have a certain quota of EVs in their fleet or even to implement any sustainable procurement at all. Standardised environmental management systems such as the European Eco Management and Audit Scheme (EMAS) and the international standard ISO 14001 do not include obligatory sustainable procurement provisions. Instead, they encourage businesses to review and set their own environmental goals (Regulation (EC) No 1221/2009; ISO14001.com.au 2018). However, governments can provide support to companies by means of grants and tax incentives like rebates of the company car taxation (see Chap. 7).

4.1 Examples of implementation

4.1.1 European Union

The EU's Clean Vehicle Directive[4] requires that purchases of road transport vehicles need to consider their environmental impacts — whilst not setting a mandatory quota for EVs. In order to help public authorities with these considerations, the EU has published green public procurement criteria on road transport (COM, 2019). However, the use of these criteria is voluntary. It is up to each individual authority to decide if they integrate them partially or fully into the tender documents.

The criteria aim at identifying different types of vehicles (rental cars, mobility services, busses, waste collection trucks) with good environmental performance — which also includes internal combustion engine (petrol and diesel) cars. EVs play a prominent role.

In 2011, the EU carried out a monitoring exercise to evaluate the uptake of their green public procurement criteria. It showed that a number of Member States have either referenced the criteria or reflected on them. In the UK, for instance, the Government Buying Standards largely correspond to the EU's green public procurement criteria (COM, 2017).

Apart from providing these criteria, the EU has funding mechanisms in place to support green public procurement such as the GPP2020 programme (see GPP2020 2019).

[4] Directive 2009/33/EC on Clean and Energy Efficient Road Transport Vehicles

4.1.2 Sweden

Sweden is an example of a country that developed a joint public and private green procurement programme. As far back as in 1994, the city of Stockholm and the state-owned energy company Vattenfall set up a joint procurement approach to demonstrate the country's potential for EV use. Supported by the Swedish Energy Agency, the programme was extended in 2010 to include further procurement entities and private organisations (Green Fleets, 2013).

Among these procurement entities is the city of Malmö, the third largest city of the country. In 2015, Malmö decided on an eco-car strategy requiring its light vehicle fleet to include 80% of natural gas, electric, plug-in hybrid or hydrogen vehicles. The remaining 20% are allowed to be fuelled with gasoline or diesel (Palm and Backman, 2017).

4.1.3 Catalonia (Spain)

The government of Catalonia, an autonomous region in Spain, uses green public procurement to support its environmental strategy goals. It set up a fourfold plan to tackle air pollution via procurement by:

- Providing guidelines on the public procurement of vehicles — the government issued a guide that provides advice on technical specifications and sets criteria.
- Government agreements on green public procurement. Several of these agreements have been set up to promote certain procurement activities — one of them specifically focuses on the procurement of lower emission vehicles (electric, hybrid and gas).
- Ecolabelling: The Catalan government developed its own Ecolabel for goods and services that met certain environmental requirements beyond what is compulsory. In 2017, it was awarded to 30 product and service groups, including vehicles fleets; 40 companies have purchased 6226 of these labelled vehicles in total.
- Setting up a public-private platform for the promotion of sustainable mobility (PROCURA, 2017).

In this context, some exemplary measures were tested, for instance the purchase of fully electric vehicles in the Barcelona Metropolitan Area. For the renewal of parts of the vehicles fleet, a minimum of ten EVs is necessary (GPP2020, 2016).

4.1.4 China

The Chinese government set up a New Energy Vehicles Demonstration, Promotion and Application Programme in 2009, which aimed to create lead markets for EVs in selected cities. This included a public sector demonstration in which government agencies or state-owned public transport companies received subsidies for EV purchases. In order to be subsidised, procurers had to choose the EVs from a catalogue of recommended vehicles models set up by the relevant ministries. The selected cities had to set up a three-year-target (Li and Rigby, 2015).

4.2 Effectiveness to incentivise EV purchases

Public procurement can contribute to a market to a certain degree — this seems obvious when considering its combined buying power of 16% of GDP EU-wide — but it is not sufficient as a stand-alone measure (Palm and Backman, 2017). By 2016, around 90% of Malmö's fleet of around 850 vehicles was made up of EVs (Malmö stad, 2017), overachieving the goal of 80%. In Catalonia, no numbers on EV uptake within the scope of the strategy are available; however, the procurement projects saved 7,166 tCO_2 in total. In China, the progress of participant cities has been uneven. No

city has achieved its three-year target (2009-2012) that were set up under the New Energy Vehicles Programme. The overall fulfilment ratio was only 26%; however, this is primarily due to the unrealistic goals set by the cities in the first place. In absolute numbers, public bodies procured 23,000 EVs under the programme (Li and Rigby, 2015).

The voluntary nature of most available procurement provisions is a drawback. The accompanying research of the case of Catalonia concluded that mandatory environmental requirements for public administrations were necessary to increase the number of vehicles in line with the procurement criteria (PROCURA, 2017).

At present, the biggest chance of using the state's purchasing power to establish new environmentally friendly industries is the signal it sends — and public authorities should be a role model. Furthermore, it provides opportunities for people to be exposed to the cars, which may act as a multiplier. In Sweden for instance, people had a more positive image of EVs after actually using them at their workplace. Furthermore, they could see that EVs were more diverse than expected. This experience influenced them to consider purchasing a private EV in the future. However, it requires joint effort to reach significant buying power and to reach an economically noticeable effect. This is best achieved if all branches of government combine their procurement procedures, ideally resulting in economies of scale such as lower vehicle purchase prices (Palm and Backman, 2017).

A factor that may be hindering the effectiveness of green public procurement is the cost distribution. In the case of Sweden, municipalities had to bear the extra cost of the EV procurement, which disincentivises them from following the policy (Palm and Backman, 2017). This suggests that authorities are more likely to follow voluntary procurement policies if they include no extra financial burden.

4.3 Ease of administration

There are different levels of implementation to consider since in the EU, there are national and regional or municipal levels providing public procurement provisions. In general, existing guidelines entail new criteria for any procurement process, which requires a certain administrative effort to define and formulate them. The effort is expected to be limited as there are blueprints that can serve as a starting point or could be directly implemented. This includes e.g. the European Green Public Procurement Criteria. The same would be true for implementing private procurement provisions. However, it is unclear to what extent it is legally possible to prescribe procurement provisions to companies such as stipulating an EV quota for company fleets. This may also depend on the specific national legal context.

A difficulty in the implementation of procurement rules is the careful selection of the actual criteria since it must fit a broad range of needs within different types of authorities. In the Swedish case, for instance, rural areas' municipalities were reluctant to buy EVs because of a lack of charging stations (Palm and Backman, 2017). As long as infrastructure is lacking, hybrid vehicles might be a temporary alternative solution. When designing green procurement criteria, policymakers should be aware of such specific needs.

Smaller authorities also face difficulties because they may not have the necessary capacities to develop the respective internal administrative processes (Palm and Backman, 2017).

4.4 Affordability for governments

The establishment of public or private procurement provisions has little administrative cost unless green products are more expensive than the conventional equivalents. This was the case for Sweden. The municipalities involved were willing to incur the financial loss in order to protect the

environment (Palm and Backman, 2017) — but not all authorities in all countries may come to the same conclusion.

4.5 Consistency with other policy goals

There is a potential conflict between the public procurement principle of “best value for public money” and environmental incentives. The first is often a legal obligation and means that the cheapest offer must succeed. There is no legal clarity as to what extent environmental considerations may (or even have to) override cost aspects. In Sweden, for example, half of the interviewed municipalities responded that they had never prioritised environmental arguments over the lowest offer (Palm and Backman, 2017). It seems that if environmental criteria are included from the beginning of the procurement procedures, offers may include them.

In order to ensure that purchased products are sustainable throughout their entire life cycle, purchasers can, for example, take into account life cycle assessments when setting up the purchasing criteria. In this respect, the European Green Public Procurement Criteria is helpful because it includes such considerations (COM, 2019). The lifecycle analysis of EVs show that the environmental performance of EVs is already better than internal combustion engine cars (Le Petit, 2017). This is likely to increase as the battery life and the share of renewable energy in the grid grow, which power electric vehicles.

Green procurement criteria can be used to shift to EVs from high-polluting cars; however, the criteria generally do not decrease the total amount of public and company cars purchased as the decision of purchasing is taken before. Thus, green procurement provisions do not per se incentivise authorities and institutions to reduce their fleets and encourage other means of transport.

4.6 Findings

In creating green public procurement provisions, public authorities can send a strong signal and act as role models for a widespread EV use. For the moment, however, this depends on their individual willingness and resources. The voluntary green public procurement criteria should, therefore, be turned into compulsory ones. There are many pilot projects on the municipal level that could act as a starting point from where the criteria can be extended to the regional and state level. The accompanying research of the Catalonian case, for instance, concluded that the experience had proven that the market for low carbon vehicles was ready to deliver — and that specifications for EVs could and should be ambitious (PROCURA, 2017).

Concerning private procurement, no mandatory requirements exist — potentially because this would be an unlawful restriction of entrepreneurial freedom. Other measures are less intrusive, such as subsidies or tax incentives for company cars. Nevertheless, it is certainly effective to continue encouraging companies to lower their environmental footprint, for instance with certification systems like EMAS.

5 Grants for the purchase of EVs

Countries in the EU, North America and Asia offer grants on different administrative levels to make EVs more affordable — as they are still more expensive compared to comparable internal combustion engine (petrol and diesel) cars. The available grants vary in their size and are usually linked to specific criteria such as the date of purchase and/or requirements for the types of EV. They are also often part of a set of measures, typically including tax advantages or support of improving the charging infrastructure (Hall et al., 2017).

There seems to be a trend of reducing grant support. In the UK, for instance, the government reduced its Plug-in Car Grant by late 2018, referring to substantially lowered EV prices (Roberts, 2018). China reduced its purchase grants in 2018 and plans to phase them out by 2020 (Tabeta, 2018) since the New Energy Vehicle Mandate (see Chap. 2) is supposed to ensure widespread EV uptake.

5.1 Examples of implementation

5.1.1 European Union

In the EU, a range of countries offer grants for EV purchases. Table 2 provides an overview of grants in selected countries. Although they have different names (bonus, grant, subsidy), they are all non-repayable funds which consumers receive at the point of purchase.

Table 2: Selection of grants in the EU (as of 2018)

Country	Grant
Austria	EUR 3,000 for EVs; EUR 1,500 for hybrids; models that cost more than EUR 50,000 are excluded from the grant
Belgium: Flanders	“Zero Emission Bonus” of up to EUR 5,000 for the purchase of battery electric and hydrogen-powered cars
France	Bonus/malus system with premium of EUR 6,000 for EVs and hybrids emitting 20 gCO_2/km or less (“bonus écologique”) Additional grant of EUR 2,500/1,000 for switching from ≥11 year internal combustion engine car to a cleaner car (EV/internal combustion engine car)
Germany	Bonus of EUR 4,000 for EV and fuel-cell vehicles Bonus of EUR 3,000 for hybrid and range-extended EV
Romania	Grant of EUR 10,000 for EV; EUR 4,500 for hybrids Additional grant of EUR 1,500 for scrapping a vehicle > 8 years
United Kingdom	2011-2018: Grant for 25% of recommended retail price, max GBP 5,000 (around EUR 5,700); as of 2019: max. GBP 3,500 (around EUR 4,000)

Source: Own illustration based on findings in ACEA (2018), Bundeskanzleramt AT (2019), Monschauer and Kotin-Förster (2018) and Green Car Congress (2010)

France has set up a bonus/malus system which supports EVs while disincentivising the use of high polluting cars: the system offers grants (“bonus écologique”) when purchasing an EV but the price for high emitting cars is increased through an additional fee (“malus écologique”) (GOUV.FR, 2017). In addition to the bonus/malus system, EV purchasers that scrap an old internal combustion engine cars can get an additional one-off payment from the scrapping-scheme (which is also available to purchasers of internal combustion engine cars). In 2018, the malus generated enough

revenue to cover both the financial support for EV purchases and the financial support for scrapped vehicles (Monschauer and Kotin-Förster, 2018).

The UK government introduced the “Plug-in Car Grant” in 2011 but it was significantly reduced in 2018. Initially with funding of GBP 230 million (around EUR 260 million), it subsidised 25% of a car’s recommended retail price up to a maximum of GBP 5,000 (around EUR 5,700) (Green Car Congress, 2010). A further GBP 500 million (around EUR 570 million) was made available for another funding period from 2015 until 2020 (Knight et al., 2015). In October 2018, the Office for Low Emission Vehicles (OLEV) announced a change in the grant levels. The support is now only granted to the cleanest cars with CO_2 emissions below of 50g/km and that can travel at least 112 km electrically. Moreover, financial support has dropped to GBP 3,500 (around EUR 4,000) per purchase (OLEV, 2018a). In practice, EVs receive a discount at the point of purchase with the automakers claiming the subsidy.

Romania pays a high grant of up to EUR 10,000, which is notable given the relatively low cost of living in the country. The total budget for this funding programme called “Rabla Plus” is comparably low, amounting to around EUR 25 million. This is an equivalent of roughly 2,500 EVs supported (Blajin and Nicola, 2018).

5.1.2 The city of Ghent (Belgium)

The city of Ghent aims for climate neutrality. For this goal, car sharing plays an important role. The city included in its climate plan an extra grant for EV purchases of up to EUR 6,000 if the EV is used for sharing purposes (Stad Gent, n.d.). So far, around 75 EVs were subsidised in this way (Matthijs, 2019). The exact requirements are expressed in the city’s subsidy regulations (*Subsidiereglement*):

- the EV needs to be registered with a car sharing company;
- each EV needs to be used by a specific car sharing group consisting of at least four people registered in Ghent;
- at least 40% of the travelled kilometres need to be “shared”, i.e. driven by someone else than the registered owner;
- the EV cannot be sold for the first five years.

People who benefit from this grant are required to take part in a meeting with the carsharing provider and the city and to prove annually that these conditions are fulfilled — affidavits are mostly sufficient as proof. The city can reclaim the grant in case of false statements (Matthijs, 2019).

5.1.3 South Korea

Besides Japan and China, South Korea is an example of an Asian country that awards EV purchase grants. The central government awarded the grants from 2011 onwards to car buyers. In addition, local governments have also awarded grants, which varied in size (Korea Ministry of Environment, 2019). The individual grants’ sizes are considerable as they amounted up to KRW 14 million (around EUR 11,000) until 2017 (Stratas Advisors, 2017).

In January 2018, the government tightened the standards for the grant guidelines: the size of grants was adjusted to the EV’s specific energy capacity. The government is increasing the targeted number of EVs by gradually lowering the amount of the individual grant size. In 2019, the individual grants' size from central government is KRW 9 million for BEV and KRW 22.5 million for FCEV. (Korea Ministry of Environment, 2019) This year the government allocated a budget of KRW 462 billion (around EUR 350 million) to support the purchase of at least 57,000 EVs, which is a 76% increase from 32,000 EV units in 2018 (Korea Ministry of Environment, 2019).

5.2 Effectiveness to incentivise EV purchases

EV purchase grants seem to influence the share of EVs positively. A majority of studies found that, in general, purchase grants are an effective method to increase EV uptake if they are sufficiently large (at least USD 1,000) (Hardman et al., 2017). In detail, the relationship can be complex: in a British study conducted with grant recipients, less than 5% cited the grant as a reason for buying an EV. At the same time, many respondents explained that they could not have afforded the EV if they had not received it. Nearly 90% of respondents also stated that the grant had been important in their decision to buy an EV (Knight et al., 2015). A study concerning the EV purchase subsidy in the United States estimated that 70% of EV purchases would have been made without the subsidy (Bosworth and Patty, 2017).

A review of existing studies summarises the findings as follows: grants (as well as other purchase incentives) should target EVs at the lower end of the price range where the incentive makes a significant difference for the buyer; purchasers of high-end EVs generally have a very high incomes and can buy an EV in the absence of financial incentives (Hardman et al., 2017). Nevertheless, grants need to go hand-in-hand with well-performing EVs with a good range and price-performance-ratio. No grant programme will be able to spur EV ownership otherwise.

5.3 Ease of administration

In general, implementing EV subsidies is manageable. Governments are required to set aside a budget and determine the eligibility and size of the grants. The allocation of these grants is accompanied by administrative necessities. For example, the UK's Plug-in Car Grant is distributed directly to consumers via a discount at the point of purchase, with the automakers claiming the subsidy (Green Car Congress, 2010). In South Korea, EV owners register for the grant with their provincial governments (Bo-gyung, 2018).

5.4 Affordability for governments

Grants are non-repayable funds. The respective governments need to bear the costs of the EV grants. The size of the grants depends on the specific budget. The idea of grants, in general, is to support an industry in its early stages of development. During this time, costs are high so that grants are supposed to stimulate demand until costs are so low that the industry succeeds on the market on its own. There is a risk that, if grants do not stimulate demand enough to ensure this development, they end up being a mere wealth transfer (Bosworth and Patty, 2017). Therefore, their impact needs to pass a certain threshold in order to initiate a long-term development trend. The budget needs to be considerable in order to have this effect. So far, the grant sizes range from roughly EUR 2,000 to EUR 11,000; in the EU, the average grant size is around EUR 5,000. However, it is unclear what size would be best and results in the greatest cost-benefit-ratio (Hardman et al., 2017).

France's bonus/malus system is almost cost-neutral by now, with the revenue from the malus being somewhat higher than the spending for the bonus. This was not the case during the first years of its implementation when the bonus payments were higher compared to the revenues from the malus. In order to find the right balance and to not overburden consumers, it is crucial to find the right threshold for the bonus and malus and to constantly adjust them (Monschauer and Kotin-Förster, 2018). The UK's Plug-In Car Grant was financed by the government with a budget of GBP 230 million (around EUR 260 million) for a 4-year period from 2011-2014 ((Green Car Congress, 2010). For the period from 2015 to 2020, the government increased the budget to additional GBP 500 million (around EUR 570 million) (Knight et al., 2015). In South Korea, a budget of KRW 240 million (around EUR 190 million) was made available for the year 2018 (Lee, 2018).

5.5 Consistency with other policy goals

The benefits of EV purchase subsidies seem to concentrate on high income households while the costs need to be paid by tax-payers, i.e. the general public (Bosworth and Patty, 2017). Therefore, it may be a fairer solution to finance EV grants from taxing high-polluting, fuel-intensive cars (see e.g. Narassimhan and Johnson, 2018; ZEIT Online, 2016). France's bonus/malus system seems to be a very good example for this approach as it provides subsidies to EV purchasing while taxing internal combustion engine cars.

5.6 Findings

Grants for the purchasing of EVs need to be substantial in order to support a critical mass of EVs, while also influencing consumption trends sustainably. Grants are most effective if they target EVs at the lower end of the price range where the incentive makes a significant difference for the purchaser. Purchasers of high-end EVs tend to have a high income and can afford EVs without grants. However, there is significant uncertainty about the optimal size of a grant and one should not overestimate its impact. In addition, arising costs for governments can be significant if paid from the state budget. However, fees or taxes on high-polluting cars can provide a revenue stream balancing the grant payments, like the bonus/malus system in France shows. Such a system can be optimised by not only considering CO_2-emissions but also air pollutants when taxing internal combustion engine cars (malus).

6 Tax benefits during EV purchase or registration

Governments use tax rebates and tax exemptions at the point of purchase or registration to incentivise the uptake of EVs:

Some countries incentivise the purchase or leasing of EVs by reducing and eliminating the Value Added Tax (VAT) on the purchase price or leasing rate. This exemption or rebate has a similar effect to the consumer than a grant (see Chap. 5), as it reduces the purchase price of the EV. The VAT exemptions and/or deductions can be subject to different limitation. Austria, Iceland, Israel, Norway and Portugal have all opted to introduce VAT exemptions or deductions.

The registration fee is a one-off charge whereas the registration tax is levied on the vehicle's net or gross price (Kalinowska et al., 2009). Countries reduce or eliminate this tax for EVs in order to reduce the costs associated with the purchase of EVs. Some countries limit the exemption or rebate to a specific period of time or only for EVs below a certain price threshold. Different EU countries, as well as other countries worldwide such as Norway, Singapore and Hong Kong have implemented exemptions from tax or tax deductions for EVs.

6.1 Examples of implementation

6.1.1 European Union

As illustrated in the below table, many countries in the EU introduced exemptions or rebates from their registration tax or fee for EVs. While different countries outside of the EU such as Norway introduced VAT exemptions for EVs, Austria and Portugal are the only countries in the EU that opted for this measure.

Table 3: Overview of EU countries that introduced exemptions or rebates from their registration tax/fee and/or VAT for EVs

Country	Exemptions and rebates from VAT and/or registration tax or fee for EVs
Austria	Exemption from the standardised consumption tax (Normverbrauchsabgabe)
Belgium	Registration tax exemption for electric and plug-in hybrid vehicles in Flanders (until end 2020) (otherwise tax based on fuel, age, euro standards and CO_2 emissions in Flanders) & tax based on CO_2 emissions (Wallonia)
Croatia	Registration tax based on price, CO_2 emissions and type of fuel used and CO_2 emissions adjustment for registration fee (rates are reduced by 15% for vehicles that emit less than 150g CO_2/km)
Cyprus	Registration tax exemption for cars emitting less than 120g CO_2/km
Denmark	Registration tax exemption for BEVs, hydrogen-powered and fuel cell EVs until end of 2020 (BEVs pay 90% of tax in 2019)
Finland	Pure EVs pay minimum level of CO_2-based registration tax
France	Regions can opt for registration tax exemption (either 50% or 100%) for vehicles powered by compressed natural gas (CNG), liquefied petroleum gas (LPG) or electricity and for petroleum/diesel hybrid E85 vehicles
Greece	Registration tax exemption for EVs and hybrid vehicles
Hungary	Registration tax exemption for electric cars and plug-in hybrids
Ireland	Registration tax based on CO_2 emissions, from 14 to 36%

Country	Exemptions and rebates from VAT and/or registration tax or fee for EVs
Luxembourg	Electric and fuel cell vehicles benefit from tax allowance on registration fees of EUR 5,000
Malta	Registration tax based on CO_2 emissions, length and vehicle value
Netherlands	Registration tax exemption for zero emission cars (otherwise based on CO_2 emissions and fuel efficiency)
Poland	Registration fee exemption for EVs and plug-in hybrids
Portugal	Registration tax exemption for pure EVs and 75% reduction for plug-in hybrids with all-electric mode up to 25km / Deduction from VAT for EVs (with price <EUR 62,000) and plug-in hybrids (with price <EUR 50,000)
Slovakia	Lowest amount of registration tax for pure EVs (EUR 33)
Slovenia	Registration tax based on CO_2 emissions and purchase price
Spain	Registration tax based on CO_2 emissions, from 4.75% (121-159g/km) to 14.75% (200g/km or more)

Source: Own illustration based on findings in ACEA (2018)

As these taxes and fees vary considerably between the countries, reductions and exemptions result in very different financial benefits for the consumer. For example, Poland has a fixed registration fee of roughly EUR 42; Slovakia's registration tax varies from EUR 33 to EUR 3,999 depending on the engine power. Denmark applies a tax of minimum of EUR 2,700 without an upper limitation depending mainly on the taxable value of a car (85% for cars with a taxable value below EUR 25,000 or 150% for cars above EUR 25,000) (for more details see ACEA, 2018). Thus, an exemption from the registration tax in Poland is less advantageous when compared to Denmark.

6.1.2 Norway

Norway introduced the exemption from its 25% VAT on the purchase and leasing of zero emission vehicles in 2001 (Norsk elbilforening, 2019). Norway levies high VAT taxes compared to other countries. Exemptions from this tax hence reduce the price of an EV substantially. The VAT exemption in Norway is still valid until the end of 2020. After 2020, the VAT exemption will need to be revised (Johnsen, 2017). In addition, Norway also has a progressive registration tax that is calculated based on weight, CO_2 and NOx emissions making registration for polluting cars costlier than for lighter, low emission cars (Norwegian Tax Administration, 2019).

6.1.3 The Netherlands

The Netherlands aims to incentivise the purchase of EVs by introducing exemptions to the country's registration tax, which is levied on new passenger cars. This tax increases with the vehicle's CO_2 emissions value. Due to this progressive taxation scheme, zero emission vehicles are exempt. Petrol passenger cars with CO_2 emission values below a certain limit, especially below 73 g/km, incur relatively low taxes. Owners of diesel passenger cars with 63 grams or more CO_2 emissions per kilometre have to pay a surcharge. The registration tax can be higher than EUR 10,000 for vehicles with high CO_2 emissions (Belastingdienst, 2019).

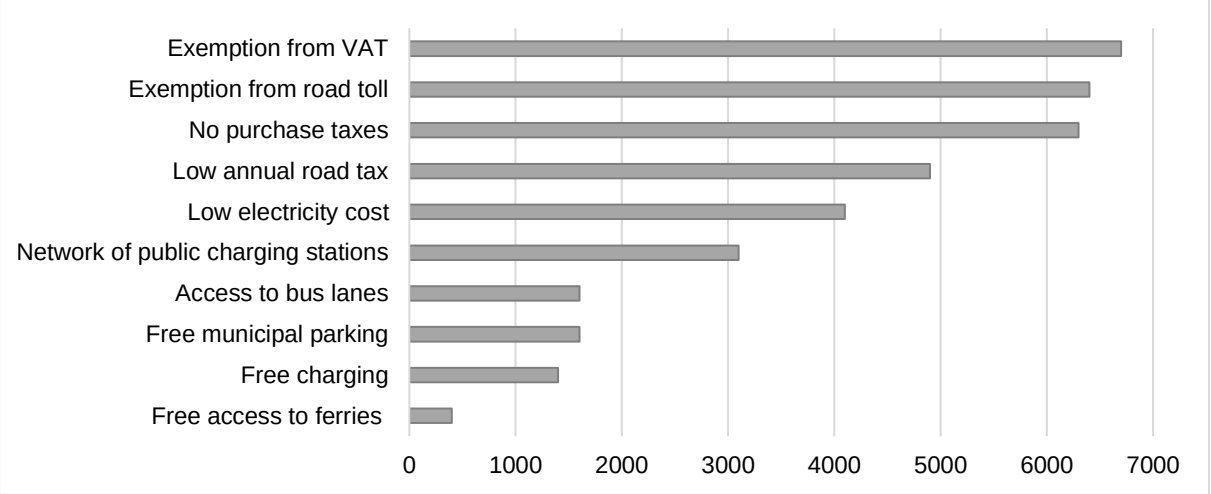
The Dutch government has adjusted these registration taxes over time by decreasing the CO_2 threshold for cars that benefit from low taxation levels while increasing the financial penalty for cars with high emissions. A car with up to 102 g CO_2/km was exempt from the tax until 2012. But this changed in 2015 so that only zero emission vehicles are now completely exempt (Tietge et al., 2016).

6.2 Effectiveness to incentivise EV purchases

Tax exemptions and rebates at the point of purchase including VAT exemptions are regarded as the most effective financial incentives, particularly in countries with high tax rates for internal combustion engine cars. Benefits that apply at a later stage are useful but seem to be less effective. However, VAT and registration tax exemptions and rebates for EVs only have an impact on purchases when they result in a notable price difference (Hardman et al., 2017).

In Norway, the registration tax and VAT exemptions are found to be most important for promoting the purchase of battery EVs (Haugneland et al., 2017; Norsk Elbilforening, 2018; Ystmark Bjerkan et al., 2016). In fact, the exemption from VAT and the registration tax result in similar purchase prices for battery EVs as for the comparable internal combustion engine cars (Haugneland et al., 2017). Figure 2 illustrates that Norwegians perceive VAT exemptions are the most important incentive for the purchase of an EV; the registration tax (here: purchase tax) exemption follows with almost the same significance on rank three.

Figure 2: Significance of Norway's measures to promote EVs according to Norwegian EV owners (Question of survey: Select the three most important EV incentives)



Source: Own illustration based on Haugneland et al. (2017)

As previously mentioned, the Dutch government adjusted and tightened its taxation scheme so that now only zero emission vehicles are exempt from the registration tax. The exemption does not apply to hybrid EVs anymore. This increases the pressure on citizens to buy zero emission vehicles. However, it has also been a reason for the decline of the overall (hybrid and battery) EV registrations (Tietge et al., 2016). This illustrates that the registration tax seems to have some impact on the purchases of EVs (Tietge et al., 2016).

6.3 Ease of administration

The implementation of tax or fee rebates and exemptions during the registration of a vehicle appears to be a relatively straightforward process, as many countries already apply a set of criteria for determining the registration tax or fee. VAT rebates and exemptions seem to be introduced not as often in the European Union, as illustrated in the table above, despite the fact that their implementation is similarly straightforward as the registration of tax benefits. In addition, policymakers usually have experience in implementing taxes and tax rebates as governments repeatedly make use of these measures. Tax incentives belong to the most common financial downstream incentives to promote EVs (van der Steen et al., 2015).

6.4 Affordability for governments

The measures discussed in this chapter do not involve direct costs for governments, such as grants. However, reduced taxes represent foregone revenues for governments. Depending on the generally applied tax rate, exemptions and rebates can lead to high losses for the state budget.

In Norway, the foregone revenue from VAT exemptions is estimated to be around EUR 200 billion and from the exemption of the registration tax around EUR 85 billion in 2020 (Fearnley et al., 2015). In spite of these costs, Norway decided to extend the VAT exemption. Nevertheless, the price of EV measures, especially the VAT exemption, are increasingly being discussed in Norway. However, Norway's wealth and budget surplus allow the country to tolerate such tax cuts (Steinbacher et al., 2018).

In the Netherlands, the exemption of registration tax on EVs led to a decrease of 5% in tax revenue of that tax in 2017 compared to 2016, with 8,000 and 4,000 vehicles sold, respectively. However, the reduced popularity of plug-in hybrid vehicles — due to their normalised fiscal treatment — led to an increase in tax revenue of around the same magnitude (M. Snel et al., 2018). In October 2018, the Dutch State Secretary of Finance noted that tax benefits for EVs are untenable in the long run, largely because of the foregone revenues (Snel, 2018).

6.5 Consistency with other policy goals

Due to the recent successes in the Norwegian EV market, some critics argue for the phasing out of the expensive tax exemptions as they may encourage private vehicle ownership and thus work against the goal to incentivise the use of public transport, biking and walking. Increased individual motorised transport can be a potential adverse effect of tax benefits for EVs (Steinbacher et al., 2018).

In addition, EV tax benefits are likely to be awarded mainly to high-income households, which are the main purchasers of new EVs while the costs need to be paid by tax-payers, i.e. the general public (this is the case also for other financial support measures that directly address private EV purchases; see Chapter 5.5). The problem can be addressed by granting the tax exemption only to a maximum purchase price such as it is done in Portugal.

6.6 Findings

VAT and registration tax exemptions and rebates for EVs only have an impact on purchases when they come with a notable monetary benefit — in particular for EVs at the lower end of the price range (this is similar to purchase grants; see Chap. 5). The previously analysed VAT and registration tax exemptions have been important for reducing the costs of EVs compared to internal combustion engine cars in Norway and the Netherlands, as these countries apply comparably high tax rates on conventional cars. Thus, tax exemptions or rebates should be introduced together with high tax rates for internal combustion engine cars. In this way, governments increase the effectiveness of their exemptions. In addition, revenue from high taxation on internal combustion engine cars can compensate payments for the EV incentives.

7 Tax benefits for electric company cars

Companies can give company cars to their staff as extra remuneration on top of their salaries. Usually, companies lease or buy these cars and provide them to their employees for their business and/or personal travel (Naess-Schmidt and Winiearczyk, 2010). Using company cars for private travels is a benefit in kind on which governments usually levy taxes on an annual basis.

The tax rate usually depends on different criteria, including fuel type, catalogue price or CO_2 emissions. Many countries around the globe exempt or reduce the company car tax for EVs with the aim of incentivising their use. The tax benefit can concern a large share of new vehicles; in Germany for instance, almost two thirds of new passenger car registrations in 2018 were commercial cars (Kraftfahrtbundesamt, 2019). Companies will often only lease these cars for a limited number of years and they then enter the used car market where they are purchased by private customers.

7.1 Examples of implementation

7.1.1 United Kingdom

The UK provides company car tax benefits for low emission vehicles. The tax rate for the employer depends on the company car's value and its CO_2 emissions. There is currently a 100% first-year allowance available for companies buying ultra-low emission cars, which represents a full tax exemption on the car's cost in the year of its purchase (OLEV and Office for Low Emission Vehicles, 2018b). British employees have to pay a tax for the private use of company cars, as it is a benefit in kind (BIK), i.e. a bonus on top of the salary. There are different tax rates for company cars, the so-called BIK rates, which depend on the car's specific CO_2 emissions and the employees' income tax bracket. The company car tax changes with the tax year. The British government increased the BIK tax rates in 2018/19 so that now a higher company car tax applies (GOV.UK, 2019b).

The UK government announced that the BIK rates will change in 2020/21 benefitting mainly EVs. In order to encourage the increased use of EVs, the BIK rate will decrease from 16% to 2% for the cleanest cars — in stark contrast to 37% for cars at the end of the emissions scale. For cars with 75 CO_2/km emissions, the BIK rate increases from 19% to 20% in 2020/21; for cars with above 75 CO_2/km CO_2 emissions the percentage then continues to rise by 1% for each increase of 5g CO_2/km, to a maximum of 37%. Furthermore, the tax rate will depend on the zero emission mileage distance, i.e. how many miles the EV can drive without producing any emissions (OLEV and Office for Low Emission Vehicles, 2018b). This change will reward hybrid EVs with a better pure-electric range. As a result, a long-range plug-in-hybrid car, with more than 130 miles in zero emissions mode, would be treated equally to a battery EV (HM Treasury, 2016). The reasoning is that owners of a plug-in hybrid can drive predominantly electrically and thus long-range plug-in hybrid EVs should be promoted like a battery EV (Hauff et al., 2018). For both vehicle types, employees will need to pay only the 2% of the company car tax rate (Hauff et al., 2018).

7.1.2 France

The company car tax in France, the so-called TVS (taxe sur les véhicules de société), is also CO_2-dependent and applies to passenger cars as well as light commercial vehicles. Depending on the fuel type, a fixed rate of EUR 40 per year for diesel cars and EUR 20 per year for gasoline cars applies. Vehicles below 50 gCO_2/km are exempt from this tax.

7.2 Effectiveness to incentivise EV purchases

Exemptions of or rebates on recurring taxes are criticised due to the fact that they often do not have a strong price signal and are thus not as effective in increasing the purchase of EVs (Runkel et al., 2018). However, the reduced rates of the company car tax for EVs represent a significant incentive for EV purchases, especially for medium and large vehicles, as in this segment the tax rebate can lead to a significant cost reduction. In the UK, the combination of the company car tax rebate and the purchase grant can decrease the cost of EVs below that of a comparable internal combustion engine car in some cases (Tietge et al., 2016). The announced tax changes for 2020/2021 will further promote EVs over internal combustion engine cars; employees who are concerned about the driving range limitations of battery EVs in regions with limited charging infrastructure have the option to use long-range plug-in hybrid EV (e.g. Hauff et al., 2018).

Overall, there is only limited data available on the effectiveness of exemptions and rebates from recurring taxes, (see e.g. Hardman et al., 2017) due to the fact that comprehensive evaluations of exemptions from the company car tax are missing.

7.3 Ease of administration

Usually, governments charge the company car tax during the income declaration as it is a benefit in kind. As governments use income taxation to provide incentives and disincentives for various other expenses, the granting of company car tax reliefs seems a rather straightforward process.

7.4 Affordability for governments

Rebates or exemptions need to have a certain size in order to make a difference but at the same time result in foregone revenues for governments (see also Chap. 5). At present, this foregone revenue e.g. in the UK and the Netherlands is relatively low due to the limited number of EVs that benefit from the company car tax reductions.

7.5 Consistency with other policy goals

Benefits in kind are usually taxed lower than the actual salary, which means that the same economic performance is taxed differently: employees who receive their income in cash pay more taxes than those who receive a part of their income in the form of a company car (FiFo et al., 2011). Thus, the company car taxation system is regarded as problematic with respect to equal treatment. In addition, it is also problematic with respect to resource use and environmental performance as the company car taxation system usually incentivises the ownership of any kind of vehicles. If governments reduce the company car tax for EVs, the tax treatment further falls apart and there are further incentives for motorised individual mobility. In addition, foregone revenue is money that the country cannot spend on other policy goals, which would benefit the whole population and not only single EV buyers.

7.6 Findings

The reduced rates of the company car tax for EVs can represent an important incentive for the use of EVs as company cars. However, employees who receive their income in cash usually pay more taxes than those who receive a part of their income in the form of a company car — a situation that becomes worse with exemptions from the company car tax. In order to increase the effectiveness of the measure and leverage tax loss, the benefits for EVs could be implemented with tax increases for internal combustion engine cars (see Chap. 6 and 8). Increasing the share of EVs among company cars can also help to grow the secondary market of more affordable used EVs; in particular in countries where a large share of company cars are only leased for few years.

8 Exemptions or reductions from the circulation tax

The circulation tax is a recurring tax, which owners usually pay on an annual basis for their car that is in use on public roads. It is also known as 'ownership tax' or 'road tax'. A variety of countries exempt or reduce this tax for EVs to incentivise their purchase — sometimes with certain limitations (e.g. In Italy, there is an exemption for EVs during the first five years after the initial registration).

8.1 Examples of implementation

8.1.1 United Kingdom

The UK government exempts zero emission vehicles with a value under GBP 40,000 (around EUR 46,000) from the country's annual circulation tax, known as the Vehicle Excise Duty (VED), in order to promote the use of cleaner cars (GOV.UK, 2019a). Owners of vehicles with a price at or above GBP 40,000, including zero emission cars, have to pay a surcharge for the first five years (OLEV and Office for Low Emission Vehicles, 2018b).[5] The first year rates of the scheme depend on the vehicle's CO_2 emissions. The tax rates from the second year onwards depend on the price of the vehicle. The government introduced this new annual tax scheme on 1 April 2017. Due to this change, hybrid cars are no longer exempt from the tax (Hauff et al., 2018).

8.1.2 France

Like in the UK, the French government adapts its vehicle taxes every year. The two countries both have stepwise changes in tax rate increases with the CO_2 values (Hauff et al., 2018).

The annual "malus" in France applies to passenger cars that were registered for the first time in France from 1 January 2009 onwards and depends on the car's CO_2 emissions. While owners of cars that emit more than 250 gCO_2/km had to pay this annual vehicle tax in 2009, the system has become stricter as this level was decreased to 190 gCO_2/km in 2012 (ACEA and European Automobile Manufacturers Association, 2018). This yearly tax is a fixed rate of EUR 160 (Hauff et al., 2018).

8.2 Effectiveness to incentivise EV purchases

Exemptions of or rebates on recurring taxes are criticised due to the fact that they often do not have a strong price signal and are thus not as effective in increasing the purchase of EVs (Runkel et al., 2018). In the UK, the overall purchase price (including/excluding VAT) is considered to be most important for EV uptake. The importance of the circulation tax for incentivising EV purchases is considered to relatively low. In Norway, the exemption from recurring taxes is less significant when compared to tax exemptions at the point of purchase and thus, this measure ranks behind others by a clear margin (see Figure 2, Chap. 6) (Haugneland et al., 2017).

Overall, there is only limited data available on the effectiveness of exemptions and rebates from recurring taxes (see e.g. Hardman et al., 2017) and no information was available from France — perhaps as many studies focus on the comprehensive French bonus/malus system applied during registration.

8.3 Ease of administration

The vehicle taxation landscape is rather heterogeneous and complex, with many differences among the various countries. However, governments are often using tax relief in order to create

[5] An exemption are zero emission capable taxis that are exempt from this surcharge from April 2019 onwards.

incentives. It is hence a rather straightforward process, with policymakers often able to draw from years of experience.

However, both the UK and France introduced stepwise changes for the tax rates that increase with the specific CO_2 emissions of vehicles. This can lead to unfair comparisons between cars having similar specific emission values. A better approach seems to be the use of a single formula which avoids threshold effects such as those implemented in France for the registration malus (see e.g. Runkel et al., 2018). In addition, exemptions and rebates only constitute a benefit when there is a working tax collection system. In Great Britain, the Driver and Vehicle Licensing Agency (DVLA) is responsible for collecting and enforcing the circulation tax. However, in 2008, loopholes in the DVLA enforcement processes led millions of late-paying drivers being able to evade detection, which resulted in a GBP 214 million (approx. 240 million EUR) revenue loss in 2006 (Webster, 2008). The procedure has been improved since then in order to reduce the revenue loss.

8.4 Affordability for governments

Rebates or exemptions need to have a certain size in order to make a difference, yet at the same time result in foregone revenues for governments (see also Chap. 5). At present, this foregone revenue e.g. in the UK and the Netherlands is relatively low due to the limited number of EVs that benefit from reductions of the circulation tax.

However, countries should provide exemptions and rebates where most effective — and the majority of analysis show that this is the case when tax benefits are granted at the point of purchase (Hardman et al., 2018; Narassimhan and Johnson, 2014).

8.5 Consistency with other policy goals

Tax exemptions and deductions from recurring taxes may encourage private vehicle ownership and hence may work against the goal of reducing overall individual motorised mobility. In addition, foregone revenue is money that the country cannot spend on other policy goals, which ultimately benefits the whole population and not solely single EV buyers.

8.6 Findings

The effectiveness of the exemption from the annual circulation tax for EVs is rated to be relatively low while contributing to foregone revenue for the respective country. The benefits for EVs could be compensated by an increase of the tax on internal combustion engine cars in order to leverage the tax loss and increase the effectiveness of the measure. The applicability, however, needs to be checked in detail, as the effectiveness as well as the costs and implementation depend on national circumstances such as the tax design and the applied tax rates.

9 Free parking and access to bus lanes for EVs

Free parking and access to bus lanes for EVs provide extra local benefits for EV owners and can be of high value for consumers (Malvik, 2013; van der Steen et al., 2015). **Free parking** of EVs is already available in a variety of cities in Europe and around the globe, including for example Dubai and China (EEA, 2016; He et al., 2018; Shahbandari, 2018). The approach opens up privileges for EV users by reducing or abolishing their parking fees (Lieven, 2015). Most cities have free parking spaces in combination with reserved parking slots and/or charging stations.

Several states and towns also permit EVs to use **bus lanes** with the goal of reducing wait times. There are various cities throughout Europe, in the USA or New Zealand promoting the use of EVs through free access to bus lanes[6] (EEA, 2016; Narassimhan and Johnson, 2018; Transport Agency, 2017).

9.1 Examples of implementation

9.1.1 Dubai (United Arab Emirates)

Dubai adopted a Green Mobility Initiative to encourage the use of EVs in 2016. **Free parking** for EVs is part of different, wide-ranging incentives. The city aims for free parking slots for EVs in all paid parking zones in Dubai. In 2018, Dubai implemented 220 parking spots for EVs in 40 locations across the city. They are clearly marked, while parking an internal combustion engine cars is punished with a fee. Moreover, EV owners are able to charge their vehicles for free on designated green parking spots until 2019 (Shahbandari, 2018).

9.1.2 China

Different towns in China offer **parking fee exemptions** for EV owners in order to incite the purchase and use of EVs. Some of the towns also added dedicated parking lots with charging options. However, big cities like Shanghai or Beijing do not provide free parking for EVs (He et al., 2018).

9.1.3 Oslo (Norway)

Norway offers **free parking** and free charging for EVs throughout the country (Haugneland et al., 2017). Since 2005, EVs are also allowed to use **public bus lanes** in Norway. This incentive applies all over the country. However, it has the greatest impact in the capital where there is a lot of traffic and access to bus lanes can significantly reduce waiting times for EV owners. The time saved due to the access to bus lanes during rush hour amounted to roughly 28h in 2014 (Figenbaum et al., 2015).

9.1.4 Auckland (New Zealand)

Since 2016, New Zealand has implemented its Electric Vehicle Programme with the goal of having 64,000 EVs on the roads by the end of 2021. As part of the programme, the government amended the Land Transport Act 1988 and Land Transport rule 2004 for opening up **special lanes for EVs** (Ministry of Transport N.Z., 2018). In 2017, the city of Auckland conducted a 12 months trial for EV access to special lanes (including high occupancy vehicle, transit, priority and bus lanes). This trial

[6] In this case, bus lanes include also high-occupancy vehicle lanes, which are available for vehicles with at least one driver and one additional passenger and for transit buses during peak travel times.

automatically ran out in September 2018 and was not extended as an enclosed evaluation because it showed that it had little to no impact on EV owners (Transport Agency, 2017) (see Chap. 9.2).

9.2 Effectiveness to incentivise EV purchases

In countries with municipal parking fees for internal combustion engine cars, **free parking for EVs** can make a substantial monetary difference when calculated over a specific period. The effectiveness of the incentive is likely higher in municipalities with limited and more expensive parking (Egnér and Trosvik, 2018). In London, for instance, the cost of a local council parking permit decreases from GBP 350 (EUR 405) a year to just GBP 35 (EUR 40.5) for EV users (Campbell, 2018). In Norway, an EV owner saves on average about EUR 400 per year compared to a driver of an internal combustion engine car due to the parking fee exemptions and reductions (Figenbaum et al., 2015; Steinbacher et al., 2018). In China, municipal parking fees are relatively high; thus, in the towns that offered the incentive, the monetary benefit was around EUR 1,300 in 2015 (He et al., 2018).

Although free parking (and free charging) can be important in some areas, it is not considered to be decisive when purchasing an EV (Figenbaum et al., 2015; Haugneland et al., 2017). In China, for example, free parking can support EV uptake in particular in the larger cities with limited parking spots and high fees (Zhang et al., 2016), but it seems less relevant in comparison to other measures such as direct subsidies (Yu et al., 2018). This is similar to Norway, where the proximity to a large city that offers free parking can increase the sale of EVs (Narassimhan and Johnson, 2018), yet overall, the exemption from VAT has a much higher impact on EV sales (Haugneland et al., 2017) (see also Chap. 6). In Dubai, the incentive of free parking zones has not yet resulted in an increase of EV purchase. So far, the government itself mostly uses the privileges — as the Dubai government is the biggest buyer of EVs in the country (Arabian Business, 2018).

Having **access to bus lanes** and other special lanes can save significant time in particular during rush hour in larger cities. In Oslo (Norway), it was probably the most important measure for the purchase of EVs for more than a decade after its implementation in 2005. As a result, the share of EVs in bus lanes increased from 20% in 2009 to 40% in 2013 (Figenbaum et al., 2015; Langbroek et al., 2016; Myklebust, 2013). In California, the access to special lanes was found to be a decisive factor for the purchase of EVs with 59% of EV owners saying it was extremely or very important for their decision to purchase an EV (Steinbacher et al., 2018; van der Steen et al., 2015).

However, a recent study from Norway found that the access to bus lanes is less relevant nowadays, ranking only on 7th place out of 10 — on a par with free municipal parking (Haugneland et al., 2017) (see also Figure 2 in Chap. 6). The trial in Auckland, New Zealand, showed that the access to special lanes is considered to be not important at all (Transport Agency, 2017): 27 % of the interviewees reported that they routinely use the special lanes and that the access to those lanes was seen as a bonus but not a motivation factor for buying an EV. Less than 1% said that the incentive was an essential factor for them, 10% responded it was one out of many factors, and 89% reported the access as not important at all. As a result, the Transport Agency concluded that access to special lanes as ineffective to promote the purchase of EVs.

9.3 Ease of administration

The implementation of both measures is rather simple. For allowing free parking, the central government in general allows municipalities to implement this kind of benefit; the local governments can then determine free parking spots and make them visible (see e.g. Egnér and Trosvik, 2018).

The access to bus lanes is easy to implement considering the respective government allows the use of already existing bus lanes. However, local governments might see a problem in enforcement

i.e. control of the use of bus lanes also by other internal combustion engine car drivers (Taefi et al., 2016).

9.4 Affordability for governments

Free parking for EVs is a relatively expensive measure for the public budget (Steinbacher et al., 2018) and it normally affects municipalities and not the state budget. The foregone income for municipalities is particularly high in cities, where parking space is limited and parking fees are high (see Chap. 9.2).

The access to bus lanes comes with administrative costs close to zero (Steinbacher et al., 2018). However, enforcement is rather difficult (Taefi et al., 2016) and would have additional costs for regular checks so that drivers of internal combustion engine cars do not start to imitate those of EVs.

9.5 Consistency with other policy goals

Free and reserved parking for EVs leads to reduced parking spaces for other users, reduces the circulation of different cars on the parking area and increases the traffic of drivers searching for a parking spot (Figenbaum et al., 2015). These effects are particularly unfavourable in densely populated areas with a high number of cars and limited space. In addition, free parking and reserved areas in city centres could lead to increased traffic, as it discourages EV owners from using public transport or other types of transport. Reserved and free parking lots can also come into conflict with social acceptance as the privilege to have reserved slots and park without costs is publicly disputed (Taefi et al., 2016). Overall, city centres profit if traffic shifts from individual motorised mobility to public transport, biking and walking. Making extra parking spaces available might send a wrong signal to the public.

Allowing EVs on bus lanes can affect public transport, as it may result in increased congestion on these lanes. The rising number of EVs will lead to capacity constraints on the lanes, thus affecting driving times for public busses and their punctuality, which in turn affects their attractiveness. This might also apply to biking, as in many cities, bikes are allowed to use these lanes for safety reasons. The more EVs that are authorised to use these roads, the sooner this measure runs out of potential (Haugneland et al., 2017; Lieven, 2015; Myklebust, 2013; Ystmark Bjerkan et al., 2016).

9.6 Findings

Access to bus lanes can positively influence consumer’s decision for EV purchase. However, it is not considered to be the most influential factor, and its success depends highly on the local transport and traffic situation. In addition, the measure should be monitored carefully as EVs in bus lanes can affect public transport and cyclists. Thus, this measure may only be a suitable approach early on in encouraging EV uptake.

Similarly, free and reserved parking for EVs can be very well received in some areas — particularly in large cities with limited parking space and high fees. At the same time, free parking can significantly reduce the municipality’s income and send the signal that the city privileges cars over other means of transport.

To sum up, both incentives seem suitable for kick-starting and promoting EV purchase for early movers but need to be reviewed with a rising share of EVs.

10 Financial support and requirements for charging infrastructure

Access to charging infrastructure is crucial for the increased uptake of EVs as they run on batteries that require recharging. Charging stations can be set up almost everywhere — in garages, workplaces, public parking spots and existing petrol stations. However, the still small number of EVs on the road may hold private investors back, which is why governments around the globe subsidise charging infrastructure (Bosworth and Patty, 2017). Subsidies are granted in the European Union (Germany, France, the Netherlands, the UK), in China, Japan, Canada and in the United States (Hall and Lutsey, 2017). They are often part of a set of measures, typically including tax advantages or EV purchase grants (Hall et al., 2017).

In addition to financial incentives, countries support the diffusion of charging infrastructure with national standards. As EV charging technology advances, there are different charging modes, different connection cases and different plug types available on the market. The charging speed differs in terms of the type of socket and of the type of electricity (alternating current or direct current) used. Some connector types even vary by automaker and region (Hall and Lutsey, 2017). These differences affect the user convenience of the charging infrastructure and increase “range anxiety” — drivers’ fear of stranding because their EV has insufficient range to reach their destination — not least across the European continent. Standardisation contributes to tackling this problem by ensuring interoperability of charging systems. This is important within a country but also across borders. If not addressed properly by governments, charging infrastructure might not fit EVs and potential purchasers will be discouraged as they consider the uncertainty around where to charge their car.

Countries have the possibility of adapting their legal frameworks to allow for and even impose charging infrastructure. The European Union, for instance, obliges constructors of new buildings to equip parking spots with a certain amount of charging stations.

10.1 Examples of implementation

10.1.1 United States

The United States is a vast country with a population that is used to regularly spending many hours driving. Therefore, improving charging infrastructure is crucial and challenging at the same time. The following table shows the main support programmes in the U.S., including the funds from the Clean Air Act Civil Settlement with Volkswagen which was concluded after the Diesel Scandal in 2016 (EPA, 2017).

Table 4: Financial support of charging infrastructure in the US

Name of the Programme	Time period	Type	Financial support granted
Tax Credit for Alternative Fuel Infrastructure	2005 - 2017	Tax credit	30% of the purchase cost up to USD 1,000
Federal Loan Guarantees for renewable energy and efficient energy projects	2014 - ongoing	Loan	No specifics; total budget USD 2,5 billion
Advanced Technology Vehicles Manu-facturing direct loan programme (ATVM)	2007 - ongoing	Loan	
Volkswagen Clean Air Act Civil Settlement; including Environmental Mitigation Trust	2017 - 2027	Private investment	USD 2 billion (infrastructure, EV promotion programmes)

Source: Own illustration based on EERE (2017), Hall and Lutsey (2017), LPO (2017), LPO (2016)

The White House announced in late 2018 to end subsidies for EVs by 2020 (The Week, 2018). Nevertheless, different subsidies also exist at the state level that will outlive this federal phase-out. Their design varies and includes rebates, grants or tax credits. They target investments at the residential, commercial or workplace level. The District of Columbia for instance grants a tax credit for EV supply equipment to residential and commercial claimants until 2026. The credit covers 50% of the cost or up to USD 1,000 (around EUR 880) for residential equipment (Bosworth and Patty, 2017).

Furthermore, the funds from the Volkswagen settlement remain available. Volkswagen committed itself to invest USD 2 billion (around EUR 1.7 billion) in charging infrastructure and other EV promotion programmes during a 10-year period commencing in 2017. For the first phase, Volkswagen plans to set up several thousand charging points in 900 sites nationwide. Furthermore, the settlement agreement establishes an Environmental Mitigation Trust that transfers funds directly to the states. The states may then invest up to 15% of their allocated money in charging infrastructure (Hall and Lutsey, 2017).

In the U.S., no mandatory standards exist (Field, 2016). In practice, most vehicle and charging system manufacturers support the specific connector type standard *SAE J1772* (HEV TCP, n.d.). The American National Standards Institute (ANSI) provided a Standardisation Roadmap for EVs which was last updated in 2013 (ANSI and American National Standards Institute, 2013) and which shows remaining standardisation gaps.

10.1.2 Japan

In 2013, the Japanese government set up a partnership with the automakers Nissan, Toyota, Honda and Mitsubishi that together formed the Nippon Charge Service, a nationwide network of charging stations. The service now operates as a private joint venture and comprises almost 7,500 stations. The partnership invested around JPY 100 billion (around EUR 800 million) by allowing grants to local governments and highway operators (Hall and Lutsey, 2017).

In addition, the subsidy has been picked up at municipal level — in early 2018, the Tokyo metropolitan government announced to set aside JPY 1 billion (around EUR 8 million) for the fiscal year 2018 to help spreading EVs by financing the installation of free charging devices in condominiums (Japan News, 2018).

10.1.3 European Union and Germany

The European Union provides a lively example of a clear standardisation practice, as it is one of the EU's goals to harmonise Member States' legislations. With respect to charging infrastructure, a recent study (Spöttle et al., 2018) concluded that the standards "*are sufficient to guarantee uniform quality, safety of charging and investor security for market actors*".

The Directive 2014/94/EU on the deployment of alternative fuel infrastructure requires Member States to ensure that an appropriate number of public charging stations is put into place and that these comply with a set of technical standards (Art. 4 § 4, Annex II). Germany has implemented these requirements in its Decree on Charging Poles (*Ladesäulenverordnung*). The Decree regulates the minimum requirements for public charging points in order to achieve a safe and interoperable infrastructure. For instance, it prescribes a certain standard for the type of power outlets used (§ 3).

In addition, Directive (EU) 2018/844 on the Energy Performance of Buildings regulates charging points in new buildings. Non-residential buildings with more than twenty parking spaces need to have a minimum number of charging points. New residential buildings need to be equipped with cable ducting system to enable the installation of charging points at a later stage (Art. 1 para. 5).

Member States have to implement these rules into national law until 2020 (Art. 3 § 1). As a result, Germany discusses changes in its building laws (Golem, 2018). Some states already prescribe a certain amount of charging connections in garages in their Garage-Decrees (see for instance § 2 para. 3 of the Garage-Decree of Hessen).

10.2 Effectiveness to incentivise EV purchases

The availability of charging infrastructure and EV uptake are strongly related (Hall et al., 2017; Zhang et al., 2014). Thus, infrastructure and EVs need to be developed hand in hand since they presuppose each other. Developing infrastructure that may partly be underutilised at the beginning but supports forerunners can also result in higher EV uptake (Narassimhan and Johnson, 2018). It is expected to have more of an impact than promising financial support of USD 1,000 to consumers (Zhang et al. 2014).

In the U.S., EV uptake has increased from around 2,500 vehicles in 2009 to more than 762,000 vehicles in 2017 (IEA, 2018). The number of public charging points[7] increased from 18,000 in 2014 to 36,000 in 2016 (Hall and Lutsey, 2017). Several studies confirmed a strong correlation between both factors specifically for the U.S. (Slowik and Lutsey, 2018).

In Japan, EV uptake has increased from around 1,000 vehicles in 2009 to more than 200,000 vehicles in 2017 (IEA, 2018). There is no need for “range anxiety” since the coverage of charging infrastructure heavily increased during the previous years. This seems to be partly due to the partnership with the automakers — the country saw an 8-fold increase in the number of EV charges between 2013 and 2016 (Wood, 2018). Japan’s high population density also seems to be responsible for this development: A study found that a country's level of urban density facilitates EV adoption since travel distances are shorter and users are therefore less scared by limited driving ranges (Sierzchula et al., 2014). Interestingly, the 40,000 existing charging points outnumbered the roughly 35,000 fuel stations already in 2016 (The Guardian, 2016).

10.3 Ease of administration

The implementation of support schemes for infrastructure development is a manageable process. Governments need to set aside a budget and determine the eligibility and size of the grants or loans, which requires certain administrative efforts. In Japan, the funding was part of a partnership with private businesses, which might facilitate the implementation even more.

Setting standards and policy requirements involves more administrative efforts. In order to ensure the enforcement of the best viable and state of the art norms, governments need technical expertise. Furthermore, governments need to set aside financial and personal resources to control compliance.

10.4 Affordability for governments

Financial support for the development of charging infrastructure is crucial as long as there is no business case, meaning that it is not financially attractive for companies (see Spöttle et al., 2018). The support can be cheaper for governments if designed in the form of low-interest loans to companies or individuals that invest in charging infrastructure. If governments choose grants, costs are higher since these are non-repayable funds. In the Japanese case, making a partnership with the automobile industry was another way of reducing costs for governments as private businesses bore most of the costs for the implementation of the charging infrastructure.

[7] Level 2 and DC fast chargers.

As for standardisation, the process of introducing standards or regulations involves certain costs. These are mainly associated with administration, but do not require any direct government spending and are not associated with tax losses. The same is true for the process of changing building or other laws. However, legal changes bring about an implementation effort such as compliance control.

10.5 Consistency with other policy goals

There are no obvious contradictions to other policy goals. The concern raised in the context of EV purchase grants that only wealthy households benefit from the grants is not relevant here — charging infrastructure is less expensive and it is made available for the general public; thus, loans do not only benefit a single person. In addition, charging infrastructure consumes hardly any space and is therefore easy to integrate into existing infrastructure such as parking spots, service stations and curbsides. Therefore, contradictions to urban or environmental policies are unlikely.

10.6 Findings

A full-coverage network of charging infrastructure is crucial in order to reduce drivers' range anxiety and hence increase EV uptake. However, the financing of charging infrastructure faces the "chicken-and-egg" problem: investors will not set up charging points until there is a significant number of EVs, and consumers will not switch to EVs if there is not enough charging infrastructure available. Thus, financial support from governments and partnerships can help to overcome this barrier. In addition, even charging infrastructure that might be underutilised at the beginning can help to raise awareness, help forerunners and accelerate the EV uptake. However, wherever there is a business case, governments should phase-out their support, as it is no longer necessary to incentivise investments by companies.

Any charging infrastructure as well as EVs should follow strong standardisation to be compatible in a country and across borders. This is particularly crucial on the European Continent with high cross-border traffic. This is not only relevant for EV owners but also for investors that have an interest in high utilisation of their charging points.

11 Conclusion and key findings

The present study explores various options for how Governments can best support the uptake of passenger electric vehicles. The results of the analysis reveal the benefits and disadvantages of the most common measures.

However, to develop its full potential the shift to EVs requires a simultaneous transition to a fully renewable electricity system. Furthermore it can only be a part of the solution for the various problems associated with the current road transport systems — which includes GHG emissions and air pollution but also overcrowded cities, long travel times due to congestion, noise and safety issues. A clean transport system that is available for all will require less personal cars and more shared journeys, better public transport, higher functioning urban spaces, as well as attractive bicycle and pedestrian pathways. The shift to EVs is therefore only a part of the solution.

Concerning the limiting factors to this study, the research encountered a rather limited knowledge base of analysis on the various options, and the information that exists is focused on certain parts of the world, in particularly on Norway and the U.S. In addition, findings tend to become outdated relatively quickly due to the dynamic developments, related costs of EVs and changing perceptions of the public and in particular of (potential) purchasers of EVs.

The table on the following page shows an overview on the examined measures according to the selected indicators. It must be noted that the effectiveness of most of these measures greatly depends on their design and even more on their level of ambition. For example, we assumed in this study that relatively ambitious EV quota are set for car companies (see Chap. 2). Bans of internal combustion engine cars (see Chap. 3) are introduced in most countries around 2030 — which would make this measure an important step towards an emission free transport system. However, at present, the few governments and cities with commitments to ban internal combustion engine cars have yet to clarify their implementation plans. Unlike the other measures, the evaluation of this measure thus refers to a future impact, despite the fact that plans to ban internal combustion engine cars may already have an effect on car companies and consumers today.

Similar to these two legal requirements, the effectiveness of incentives also depends on their design and financial benefits. While effectiveness differs between countries, properly financed grants or bonus systems for the purchase of EVs (see Chap. 5), as well as rebates at the point of purchase and especially VAT exemptions are regarded as quite effective, particularly in countries with high VAT for internal combustion engine cars such as in the Netherlands and Norway (see Chap. 6). Meanwhile, even though the effectiveness of the exemption from the annual circulation tax for EVs is rated relatively low, the reduced rates of the company car tax for EVs generate a medium level of effectiveness (see Chap. 8). While access of EVs to bus lanes is relatively ineffective, free parking for EVs is rated to be the least effective measure overall, even when the level of ambition is high (see Chap. 9). Both incentives seem suitable for kick-starting and promoting EV purchase for early movers but need to be reviewed with a rising share of EVs. The financial support and requirements for charging infrastructure (see Chap. 10) are rated to be quite effective overall.

Table 5: Overview of the evaluation of the selected measures

Evaluation criteria / Name of measure	Effectiveness to incentivise EV purchases	Ease of administration	Affordability for governments	Consistency with other policy goals
EV quota for car companies				
Bans of diesel and petrol cars				
Public and private procurement provisions				
Grants for the purchase of EVs				
Tax benefits during EV purchase or registration				
Tax benefits for electric company cars				
Tax benefits during ownership of an EV				
Free parking for EVs				
Access to bus lanes for EVs				
Charging: financial support and requirements				

Source: Ecologic Institute. Legend: low = medium = high =

The key findings of the study are the following:

Prescribing the use of EVs or phasing out internal combustion engine cars is most effective: Governments can oblige car companies to produce a minimum quota of EVs; they can completely ban internal combustion engine cars and use public and private procurement provisions to stipulate the use of EVs. These legal requirements have the highest rating in terms of their effectiveness as well as their affordability for governments and consistency with other policy goals, if these requirements are set at ambitious level.

Charging infrastructure is crucial: A reliable network of charging stations is still missing in most countries — in cities and on highways. However, without good infrastructure any other incentive or regulatory measure has little impact on EV purchases, as consumers will be reluctant to buy EVs if there are limited charging stations. Governments might therefore support an early built-up of charging infrastructure through subsidies or public and private partnerships as long as the charging stations cannot be operated economically. Importantly, governments have to aim for standardisation at a national and international level to make the new infrastructure available for all users. This is particularly crucial on the European continent with high cross-border traffic.

Any support scheme needs to reflect rapid changes in the electric mobility sector: The EV market develops rapidly with advances in battery and vehicle technologies and with car manufacturers being aware of policy goals. Innovations and in particular large-scale market introductions of EVs reduce their prices. Governments that offer financial and non-financial incentives need to adjust any support to EVs as to echo market developments. Financial incentives should reflect price differences between internal combustion engine cars and the electric alternative. The non-financial benefit of being able to use bus lanes should take into account the number of EVs on the street and their impact on public transport.

Combining measures and sequencing them over time is key for inducing full market transformation: Analysis shows that countries, such as Norway, with a mix of support measures have been most successful at quickly ramping up the EV share. Governments may thus put in place a mix of policy measures which should also reflect the stage of the EV market: 1) for early adopters, governments can open bus lanes and provide separate parking spaces with charging stations. Early public procurement provisions that prescribe an EV quota for new purchases of public authorities is in line with the role model function of the public sector, can push up market penetration and positively influence public perception. 2) A combination of an EV quota for car companies and financial support to EVs at the lower-end of the price range can trigger large-scale market introduction. The financial benefits reduce the prices of EVs, thus tackling a crucial barrier that prevents middle-income households from buying EVs. The EV quota can start low but it clearly signals policy targets to car companies. 3) Finally, government might phase-out any conventional diesel and petrol car thus shifting the passenger vehicle market to zero emissions.

Financial benefits for EVs are most effective when combined with disincentives for internal combustion engine cars: Governments can increase the effect of financial support to EVs when they penalise internal combustion engine cars at the same time. Increasing taxes on high-polluting cars (in terms of CO_2 emissions and air pollutants) in combination with grants and/or exemptions from taxes can close the financial gap between internal combustion engine cars and their electric alternative. This is the case in Norway. In addition, taxes on high-polluting cars can provide a revenue stream balancing grant payments such as the bonus/malus system in France shows. This combination rewards consumers buying clean technology and disadvantages those buying polluting technology.

Finally, car purchasers might not be fully aware of financial benefits and other incentives. Thus, governments should promote and provide **information and guidance about EV measures** that are easy to understand; thus ensuring their maximum usage. In addition, various stakeholders should be involved in the discussion about the selection and combination of these measures, including automakers, policymakers, the energy sectors, research institutes as well as the public and EV drivers to identify the best options, as well as to increase transparency and acceptance.

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