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Evaluating CO_2-reduction potential of EV incentives across European Cities and Regions

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Abstract

The challenge facing Europe to reduce GHG emissions is considerable. Increasing the proportion of electric vehicles (EVs) is considered a viable solution. However, EVs primarily offers a societal benefit and their uptake has been limited. Incentivisation is one approach to increasing the number of EVs on the road and one that has been adopted by a number of European member states and European cities with varying degrees of success. The Intelligent Energy Europe funded ICVUE project developed a decision support model (DSM) that related incentive to EV uptake and CO_2 emission reduction based on local and regional conditions. This paper describes the methodology used in exploring the relationship between incentive and acceptance, the development of the DSM and the work done in partnership with the cities of London, Vienna, Stuttgart and Barcelona on evaluating EV uptake and CO_2 reduction potential. The results show that benefit of an incentive needs to be viewed by how it interacts with the system into which it is deployed in addition to any measurement of its value in isolation. Furthermore, the results show an effectivity bonus (additional EVs / reduction in CO_2) from bundling of incentives compared to considering them in isolation.

Keywords: Electric Vehicle; E-mobility; Incentives; CO_2 reduction; Total Cost Ownership

1. Introduction

Incentives provide a stimulus to the uptake of electro-mobility by correcting market deficiencies, changing relative prices and making electric vehicles more attractive to compensate for features that may deter potential consumers from buying them. Across the EU there are incentives aimed at increasing uptake and use of EVs. Each of these incentives has a cost to providing the entity and in many cases the funding comes from taxes (either direct or indirect). There is a clear requirement to ensure that the impact of incentives is maximised, in terms of the introduction or use of electric vehicles (EVs), and that the incentives achieve a high cost-benefit ratio, e.g. per vehicle, per person-km or per year. Yet how to measure the success of incentives is not clear. Comparative assessment of incentives is problematic due to different political, economic, social, technical, environment and legal structures prevalent in different countries. Incentives that are comparable in scope have different impact depending on the market into which they are deployed.

The Intelligent Energy Europe (IEE) programme supported the Incentives for Clean Vehicles in Urban Europe (ICVUE) project, which aimed to increase the number of EVs in urban areas by creating a framework that, in partnership with city authorities, can be used to tailor incentive programs to increase the uptake of electric vehicles according to the particular socio-economic conditions. This paper describes the development of that framework and its application in support of EV uptake in four European cities (London, Vienna, Stuttgart and

Barcelona). For each city, it was considered how targeted changes to local policies and initiatives for sustainable transport would provide the opportunity for EV uptake and CO_2 reduction. The impact was subsequently quantified using a DSM (decision support model) developed specifically for this activity.

2. Methodology

The approach was based on the social scientific principle of triangulation, as conceptualised by Denzin (1970) and developed by Bryman (1988). Triangulation refers to the process of using more than one approach in the course of conducting an investigation. In order to achieve the aim, the work involved three components: a research stream focused on establishing a PESTEL framework (refers to the Political, Economic, Social, Technical, Environmental and Legal factors – see Oxford Learning Lab, 2014) for each city; a research stream focused on understanding variation in stakeholder preferences for each city; and a research stream focused on understanding the fit of EV within the broader policy objectives of the city (Fig. 1).

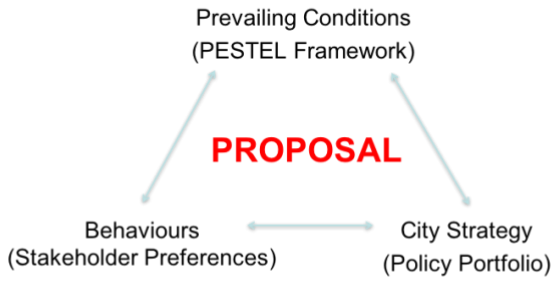


Fig. 1 Proposal development through triangulation, with each corner representing an independent research stream

This overall approach to the proposal development was of particular importance as within the research streams it was possible to compare and contrast the way in which the markets across different regions respond to similar incentives, whilst by bringing the research streams together it was possible to analyse the complex relationships between various actors in the region as well as the different factors influencing decisions. The following sections summarise the results of the approach and conclude with identification of the key incentive(s) that, based on the triangulation approach outlined above, should receive higher priority and those that in comparison could be consider to be of lower priority.

2.1. PESTEL Framework

The purpose of this activity was to create and populate a stable platform enabling comparison of different factors relating to EV uptake across a number of different cities. The results provided an intriguing insight into the problems of transfer of incentives across national boundaries (to cities in different countries). For example, from an economic perspective, if there were to be a manipulation of the cost of energy (fossil based fuels cf. electricity) then it would be at first construed that this would likely have a more significant impact on the vehicle market in Germany, where the cost of electricity is higher relative to the cost of traditional fuels than in other European states (in 2015 for households in Germany the average cost per kWh for electricity was 0.27 Euros cf. 0.15 Euros in Norway – Source ICVUE project results). But one then has to be aware that EV uptake in Norway is higher than in other regions that have similar distribution of energy costs, but which demonstrate lower EV uptake (UK has similar household costs for fossil based fuels and electricity as for Norway, but the 2015 EV uptake was 0.3% of total vehicle sales for the UK cf. 15% for Norway – Source ICVUE project results). This is an extreme example, but for other PESTEL factors the same results can be arrived at. For further details on the PESTEL framework analysis please refer to Davies et al. (2014). Therefore, it is simply not a case of altering one factor, but it is part of a larger multifaceted problem. Indeed, from a political perspective the intervention in the market has to be underpinned by a benefit appraisal. In turn, this benefit appraisal can take a multitude of forms. The benefit could be social (reduction in cost of mobility leading to direct uptake of EV), technological (supporting an increase in economic activity or even preserving existing activity in a new form) or environmental (improvement in air quality or meeting international emission reduction targets).

2.2. Stakeholder Preferences

This research stream was based upon a call for evidence to seek stakeholder experience and knowledge on the role of incentives in the uptake of EV across a number of EU member states. The analysis sought to understand how different incentive measures have been perceived. The call for evidence had a very positive response rate – receiving 110 fully completed questionnaires containing over 40,000 words. The sample quality was also notable – respondents spanned the entire spectrum of EV stakeholders from director or CEO-level, or equivalent, down to end user and represented a fairly balanced view of the EV landscape – and the quantity of responses was appropriately balanced across the EU member states under discussion. The key result, as to be expected, was that each of the incentives saw positive (strong/partial/indirect) outweighing the non-positive. However, a more interesting result was the distribution in terms of the positive and negative responses between the member states. The example in Fig. 2 shows the distribution of positive and negative responses for the UK when compared to the distribution for the survey as a whole. The comparison of the responses provides an indication of where those stakeholders in the given member state have a different acceptance to those of the stakeholders forming the wider study (so where the UK maybe performing strongly, in the opinion of stakeholders, relative to others). This type of analysis isolates, to an extent, the inherent variation that would be expected in incentives, whereby those that have a direct impact maybe viewed more strongly than those that have an indirect impact (an example being a purchase incentive cf. an incentive to improve the manufacturing efficiency of a product – both of which may result in lower purchase price).

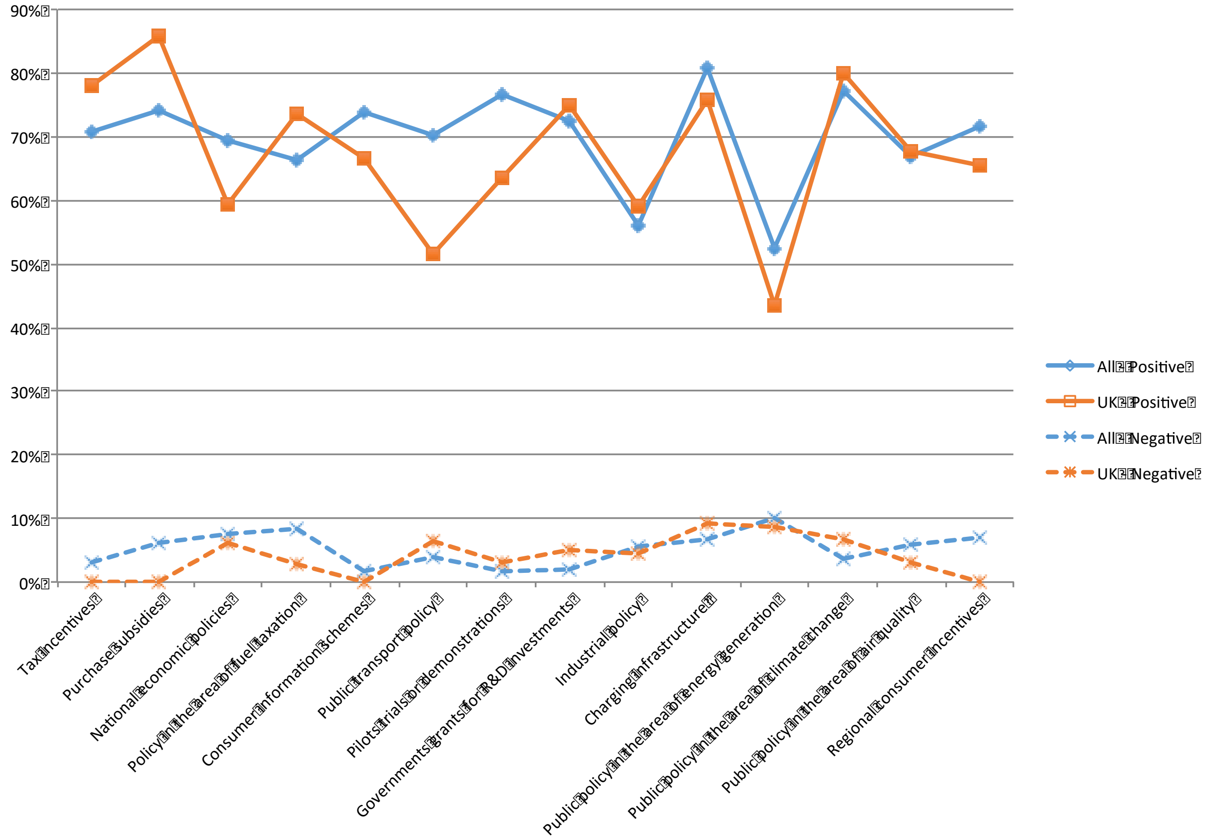


Fig. 2 Example of survey responses showing UK stakeholder view of the positive and negative influence on EV uptake in comparison to the overall study region (the combined responses)

In all cases, the variations in acceptance levels were supported by analysis of the commentary. As an example the UK has had a purchase incentive for EVs (more correctly low-carbon vehicles as the UK has based purchased incentives on CO_2 emissions) and there has been a fair degree of stability with this incentive. This has led to a positive acceptance of purchase incentives from EV stakeholders. In other markets where purchase incentives have also been deployed the acceptance has varied (cf. UK) based on the long term stability of those incentives. For further details on the stakeholder analysis please refer to Davies et al. (2016). What was clear is that the results of this analysis supported the hypothesis that the way the different EU member states (and hence the cities within those states) are structured in terms of the political, economic, social, technical, environmental and legal (the PESTEL framework) is leading to a divergence of responses (so similar incentives are perceived differently due to the way those incentives may fit within the existing PESTEL framework). The data and the interpretation of the data therefore provide a vital step in understanding the success of incentives in different markets.

2.3. City Requirements

The final stage of the process was to incorporate the requirements of the city into the triangulation process. Each of the cities supported the process and a semi-structured interview was conducted with a city representative(s). The interview with London was held during the UK Low Carbon Vehicle event in 2016 and involved discussion with representatives from TfL (TfL, 2017), for Barcelona it was a semi-structured interview with Angel Lopez the lead for the LIVE platform (LIVE, 2017), for Vienna it was with a discussion with Dieter Häusler who was responsible for the development of e-mobility policy at the city (Wien, 2016) and for Stuttgart the information collection was conducted as part of an ICVUE e-mobility workshop hosted by the Mayor's office. The results of these discussions and interviews were informative. Although facing similar challenges the approach of the individual cities varied in the detail. The extent of the challenges and the significance of existing issues facing the cities (congestion, air-quality, existing transport provision) determined the response in terms of policy direction and the horizon to which they were looking. The approach to e-mobility, the fit with the overall policy portfolio and the relationship with national policy determined to a large extent the overall requirements. For example in Barcelona the role of EV in the policy framework of the city could be summarised as primarily providing environmental improvements (reduction in NOx pollutant, GHG and noise) with a secondary benefit identified as technology development. Taking the city requirements into account and triangulating with the other research streams resulted in the following overall strategies being agreed with the cities. A full discussion around the interviews leading to the formulation of the proposals shown below can be found by referring to ICVUE (2017).

London

- Higher prioritization of ULEV (ultra low emission vehicles) and the supporting infrastructure, but on a spatial basis to complement and not compete with existing public transport
- Lower prioritization of EV financial incentives including purchase and fuel taxation differentials so as not to enhance attractiveness of private transport option.

Barcelona

- Higher prioritization to incentives that distance EV from ICE including actions to increase TCO (Total Cost of Ownership) differentials and differential access to infrastructure (parking and road access)
- Lower prioritization to greater financial incentives for EV without other actions to control private car use.

Stuttgart

- Higher prioritization to actions and activities that reduce the cost of the (electric) vehicles and increase the availability of charging infrastructure.
- Lower prioritization to the support of PHEVs (Plug-in Hybrid Electric Vehicles).

Vienna

- Higher prioritization to infrastructure that complements existing public transport and to actions that raise the profile of EV
- Lower prioritization of financial incentives to increase EV use and for actions to increase fuel taxation differential in absence of other actions to reduce car use.

These scenarios were based on the principle of transfer of best practice between cities. These scenarios were used to inform the policy measures that were subsequently explored using the DSM. The measures selected included priority access (bus lanes, EV parking), restrictive access (zone entry); TCO alignment (purchase incentives and fuel taxation).

2.4. Decision Support Modelling (DSM)

For the estimation of EV uptake and CO_2 reduction potential due to incentive measures the vehicle technology scenario model VECTOR21 was used. Originally, this model was developed to model the powertrain competition on the German new vehicle market (Mock, 2010) but recent enhancements cover also other

European vehicle markets (Schimeczek et al., 2015). VECTOR21 focuses on the customers' new vehicle purchase decisions, vehicle manufacturer strategies to meet fleet CO_2 targets and the future development of important vehicle technologies with respect to e.g. powertrains, lightweight construction, and vehicle aerodynamics. In the ICVUE project VECTOR21 was adapted to consider additional non-monetary aspects of the purchase decision and to also cover the vehicle markets of Austria, the Netherlands and Spain (the model already included the UK).

Compared to various previous TCO calculations of, e.g., Al-Alawi & Bradley (2013); Rousseau et al. (2015); Wu et al. (2015), the DSM is a comprehensive and refined calculation model that includes purchase cost and resale values, profit tax reliefs, maintenance and repair cost, fuel and energy cost, motor vehicle taxes as well as purchase taxes and monetary incentives. Additionally, cost due to range limitations are considered for battery electric vehicles, as well as national taxation and incentive schemes for Austria, Germany, Spain, the Netherlands and the United Kingdom. Furthermore, different new-vehicle sizes and customer types, e.g. private customers or commercial fleet operators are taken into account. Non-monetary aspects of car ownership, i.e. well-to-wheel CO_2 emissions and driving dynamics, are considered using a utility-based approach (Redelbach, M. 2016), as are third party cost items, e.g. benefit in kind taxes for employees that privately use a company car (for information, a benefit in kind refers to a non-cash benefit granted to an employee by an employer).

To reflect on different national perspectives regarding non-monetary items a 'willingness to pay' survey was conducted (see ICVUE, 2016 for a detailed description). The survey was designed to cover all ICVUE cities and non-monetary aspects of interest, as well as corporate and private vehicle ownership types. The willingness-to-pay values drawn from this survey were included in the utility calculations and allow for a detailed comparison of the utility value for petrol, diesel and electric vehicles for a large variety of different customers. Furthermore, a short-term extrapolation module was designed, empowering its users to extrapolate the impact of policy measures on to different customer groups and vehicle markets and to assess the effects on electric vehicle (EV) market uptake and the CO_2 reduction potential, which will be presented as part of this paper. For further details on the development of the DSM see ICVUE, 2017.

The DSM is a discrete choice model. For each of the customer agents in the model, the list of available vehicles matching the customer's vehicle size preference is obtained and the utility calculated. If the utility value of the BEV exceeds a minimum parameter, the BEV is selected, otherwise, the utility values of the conventional vehicles are compared and the option with higher utility is chosen. In the simulations performed using the DSM three different scenarios are considered that differ by their EV affinity distribution function (Fig 3). The mean of this distribution resembles its maximum value and, at the same time, a 50% market share of battery electric vehicles if an average BEV has the corresponding utility value. The variance of this distribution reflects its broadness: Broader distributions represent a steadier but slower ramp up of the market, whereas thinner distributions are connected with a fast market uptake of electric vehicles. Therefore, the "Conservative" scenario has a higher variance than the "Basic" or "Progressive" scenario – the latter one has, in turn, the lowest variance. In comparison to the "Basic" scenario, the mean of the "Conservative" distribution is shifted towards higher BEV utility values, i.e. a higher BEV utility is necessary to achieve high BEV market shares. In turn, the "Progressive" distribution mean is shifted towards lower utilities creating a lower barrier for the BEV market uptake.

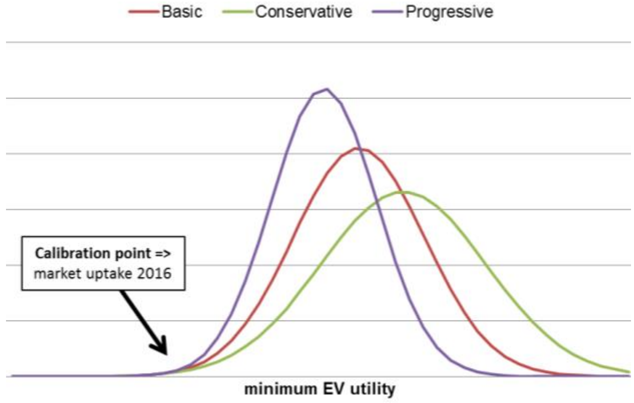


Fig 3 BEV affinity distributions by scenario; all distributions cross at the calibration.

In order to achieve results that resemble the real BEV market uptake in the considered country, the simulation needs to be calibrated. As the BEV affinity is more of a theoretical construct it is ideally suited as calibration parameter. Therefore, the distribution mean values are shifted by the calibration offset in such a way, that the simulated BEV market share is equivalent to the national BEV market uptake found in 2016. There, the BEV affinity distributions have been shifted in such a way that they cross at the "calibration point" corresponding to the real market share in 2016.

3. Results

This section explores the possible impact of different policy measures upon EV uptake and CO_2 emissions on a city by city basis. The cities were London, Barcelona, Vienna and Stuttgart. For each city, a number of policy measures were selected. These policy measures are related to the city specific scenario referred to earlier in section 2.3. For the purpose of this work, the policy measures have a defined value[1] and hence are intended to demonstrate a change in the response variables (the EV uptake and CO_2 emissions) – the actual results would depend on the value attributed to the policy measure (e.g. the value of the discount) and the impact therefore could be both higher or lower than is shown. Each assessment graph shows the impact of single policy measures as well as a bundle of two policy measures. All scenarios focus on battery electric vehicles (BEVs) and omit plug-in hybrid developments (PHEVs), since some studies indicate that plug-in hybrid vehicles may have only a low electric driving share when entering the mass market (Ligterink et al., 2013). In all of the following analyses it was assumed that the shown policy measures enter into force as from January 1st 2017 and are operative until at least end December 31st 2020. The results then depict, for the same time period, the cumulative amount of additionally registered BEVs in comparison to the expected BEV registrations without the policy measures in place as well as the CO_2 reductions corresponding to these additionally purchased BEVs in that market (the CO_2 reduction corresponds to the generation mix of that country as described in the development of the DSM).

3.1. London (UK)

Despite monetary incentives for purchase of low carbon vehicles, this includes PHEVs as well as BEVs, in the United Kingdom, and a reasonable differentiation between fuel and electricity prices, the share of new BEV registrations is lower in the UK (0.38% in 2016) than in Austria as an example (1.16%) (figures taken from EAFO, 2017). The interrogation of the DSM focused on understanding the relation between a reduction in BEV purchase cost (to bring it closer to ICE) and the increase in fossil fuel costs to increase ICE running cost. This aligns with the stated policy objectives of moving consumers to BEV, but not making private car use overall more attractive. The values chosen are realistic, but are primarily used to demonstrate as opposed to achieving a desired outcome.

Fig. 4 depicts the additional BEV sales in London by scenario and policy measure. The least impact can be seen from a 10% increase of the conventional fuel prices. A higher impact can be found for an increase of the Plug-in grant by £1,000 for BEVs, especially in the "Progressive" scenario. The results for the combination of both measures are strongly sensitive to the selected scenario and vary by a factor of about 3 between about 9,000 and 29,000 additional BEV registrations in London. Additional sales from combined policy measures ("Both") exceed those of the sum of the two measure by less than 20%. The "Basic" findings correspond to an increase of the BEV registration share to 0.7%, 1.6% or 2.0% for the shown measures.

[1] The value of the discount or utility value

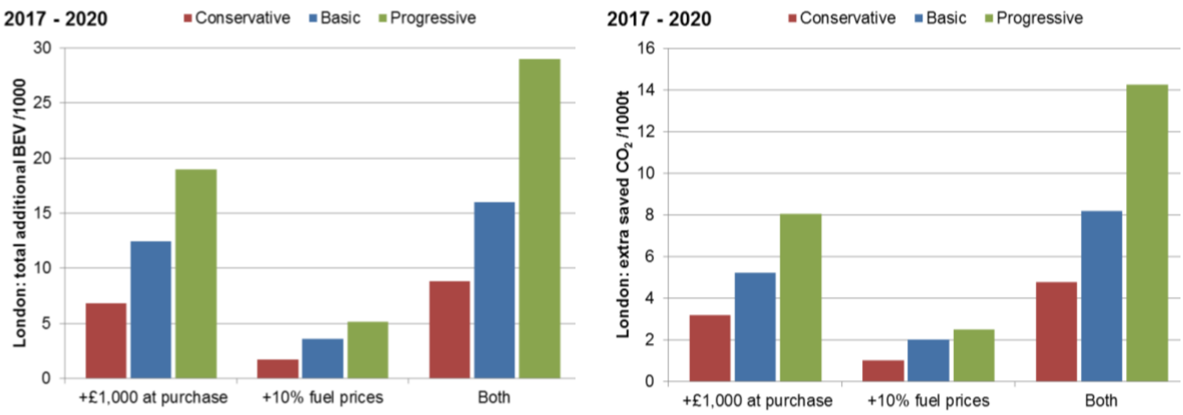


Fig. 4 Total additional BEV sales (in 1000s) and CO_2 saving (in 1000 tonnes) between 2017 and 2020 for London

In the UK, each additional BEV saves on average about 0.2 tonnes of CO_2 per year in the given years. The policy combination effectivity bonus (in the DSM each agent, or customer, in the model has different usage patterns, and the effectivity bonus is a measure of how intensive each EV is used cf. other options), although not large with respect to the BEV sales, is significant for the CO_2 reduction. Depending on the scenario, the additional CO_2 reduction is 13% to 35% higher for the combination of both policy measures in comparison to the sum of reduced CO_2 of the individual measures.

3.2. Barcelona (Spain)

With BEV sales representing 0.18% of the new vehicle market in Spain (EAFO, 2017), the BEV sales share was the lowest of all the investigated countries. Although monetary incentive measures are in place, stakeholder perception (from the survey research stream) was that new vehicle customers cannot count on these incentives due to a very short time period in which these incentives can be claimed. In addition, operational savings of BEVs are rather low due to a lower difference between electricity prices and fuel prices (cf. other cities involved in this work). Furthermore, benefit in kind taxes of BEVs exceed those of conventional vehicles, leading to a reduced attractiveness of BEVs for company car users. Both the policy measures selected for the interrogation of the model align with the aims of the scenario developed in partnership with the city and stakeholders – the purchase incentives bring the cost of the EV closer to the combustion engine alternative and zone entry restrictions take action to restrict private car usage.

Total additional BEV sales by policy measure and scenario are shown in Fig. 5. The graph depicts results for the region of Barcelona. Similar to the results found elsewhere in this study, entry restrictions to urban areas for conventional vehicles are a powerful policy measure to promote electric vehicles. The combination of two policy measures yields again higher BEV sales than the sum of their individual application. This measure combination effectivity bonus varies between 33% and 68%, depending on the scenario. If additional monetary incentives are applied with year-round availability, the number of additional BEVs will be up to 3,000 in Barcelona.

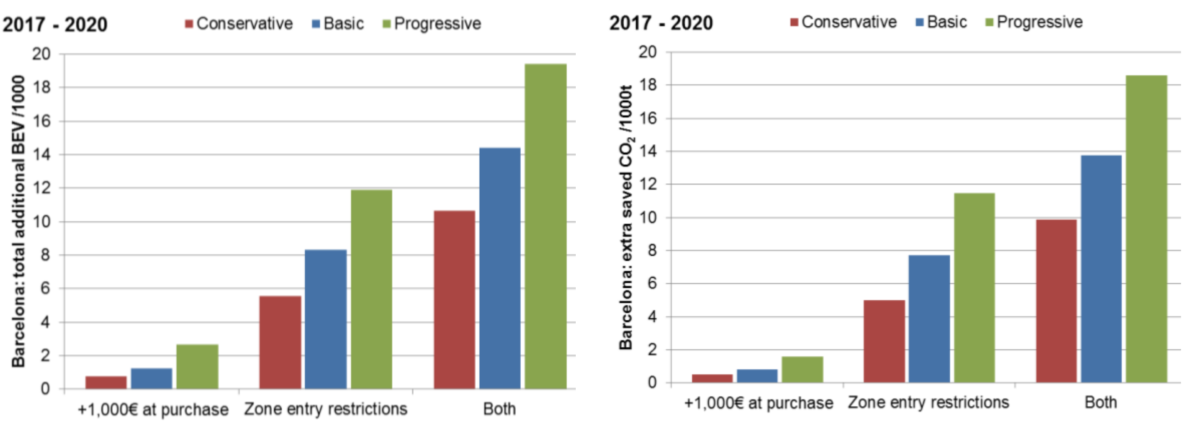


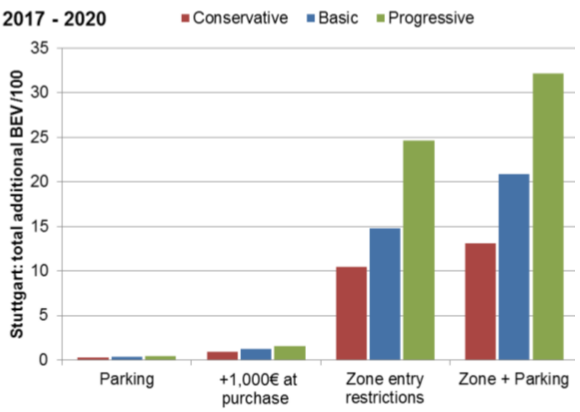
Fig. 5 Total additional BEV sales (in 1000s) and CO_2 saving (in 1000 tonnes) between 2017 and 2020 for Barcelona

The total amount of saved CO_2 emissions by additional BEVs in the timespan 2017 to 2020 in Barcelona was also calculated. Analysis of the results both revealed that the average CO_2 savings for the measure "+1,000€ at purchase" is lower (0.25 tonnes CO_2 per year and vehicle) than for the other policy measure or the combination of both measures (0.37 tonnes CO_2 per year and vehicle). This is caused by a different composition of the BEV customer group in case only the "1,000€" monetary incentive is applied. This customer group composition is also the cause why CO_2 savings per vehicle in Spain exceed those in the UK, although both countries have almost the same electricity production CO_2 emission intensity. The policy measure effectivity bonus is, similar to the findings in the UK, higher for the CO_2 reductions than for the BEV sales: The combined policy measures have a 40% to 80% higher additional CO_2 reduction than what would be expected from the CO_2 reductions of the individual policy measures.

3.3. Stuttgart (Germany)

The German new vehicle market is the largest in Europe and thus of special importance with respect to CO_2 emissions. However, BEV registration shares in 2016 (0.34%) (EAFO, 2017) were one of lowest of the considered countries. The BEV registration share was even lower than in 2015, although new purchase incentives came into force in 2016. The economic conditions for BEV ownership in Germany are, despite existing purchase incentives, not good. Relatively low fuel prices and very high electricity prices lead to low operational benefits. Also, benefit in kind taxes for BEVs exceed those of conventional vehicles, leading to a reduced BEV attractiveness for company car drivers.

In Fig. 6 the total additional BEV sales in Stuttgart are shown for the timeframe 2017 to 2020, differing by policy measure and scenario in place. It can be seen that the reservation of parking spaces for BEVs has the lowest individual impact on the BEV sales, followed by additional monetary purchase incentives. Entry restrictions to urban areas for conventional vehicles, however, lead to a significant demand shift towards BEVs. The combination of policy measures, similar to the findings in other countries, results in stronger additional BEV sales than what would be expected from the individual measures: For example, the reservation of parking slots on its own results in about 25-45 additional BEV registrations in Stuttgart in the next four years. In combination with "Zone entry restrictions" for conventional vehicles, the same "Parking" measure achieves between 270 and 750 additional BEV sales in the same period and region. BEV reserved parking slots alone were shown to have no measurable impact on the BEV sales[2].



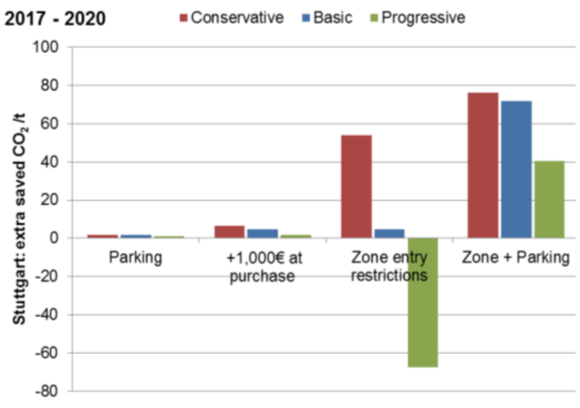


Fig. 6 Total additional BEV sales (in 100s) and CO_2 saving (in tonnes) between 2017 and 2020 for Stuttgart.

It can be clearly seen that in Stuttgart no significant CO_2 emission reductions can be achieved with the considered policy measures. In dependence of the scenario, there can be even adverse effects, with slightly increased CO_2 emissions in the year until 2020. This is mainly caused by the high CO_2 intensity of the German electricity production, which leads to only marginal CO_2 savings between -10 kg and +30 kg per vehicle and year, depending on the different BEV customer group compositions for each scenario and policy measure. Although the CO_2 savings of BEVs can be negative in Germany until 2020, there is the chance that even those vehicles may over their lifetime contribute to a CO_2 emission reduction. This, however, will depend on the success of the decarbonisation efforts for the German electricity sector in the upcoming years.

[2] Since November 2012, BEVs have been exempt from parking fees in Stuttgart.

3.4. Vienna (Austria)

Several policy changes in Austria in the past years resulted in Austria having one of the largest BEV market shares in Europe in 2016 (1.16%). Besides strong direct purchase incentives for BEVs, especially company car drivers and private owners profit from reduced vehicle taxes. As for the case with London, the policy options are selected on the basis of making EV more attractive cf. combustion engine cars, but without reducing overall cost of private car use and by looking at reducing the overall vehicle movements into the city.

Additional BEV sales in Vienna in the period 2017 to 2020 resulting from different policy measures are shown in Fig. 7, depending on the choice of scenario. The graph shows clearly, that a significant increase in BEV sales can be achieved. The least impact on the sales can be found for the additional monetary incentives. Effects of this measure depend only slightly on the employed scenario and the BEV market share can be raised to between 1.8% and 2.0% with this measure. “Zone entry restrictions”, a fiercer policy option, however, would have a much larger impact on the BEV sales and raise the BEV market share by 3% to 5.4%. The combination of both measures yields again higher additional BEV sales as the sum of both individual measures: the combination bonus lies between 40% and 50%, depending on the scenario. The combined policy measures yield a BEV market share of 6.5% to 9.8% in the next four years.

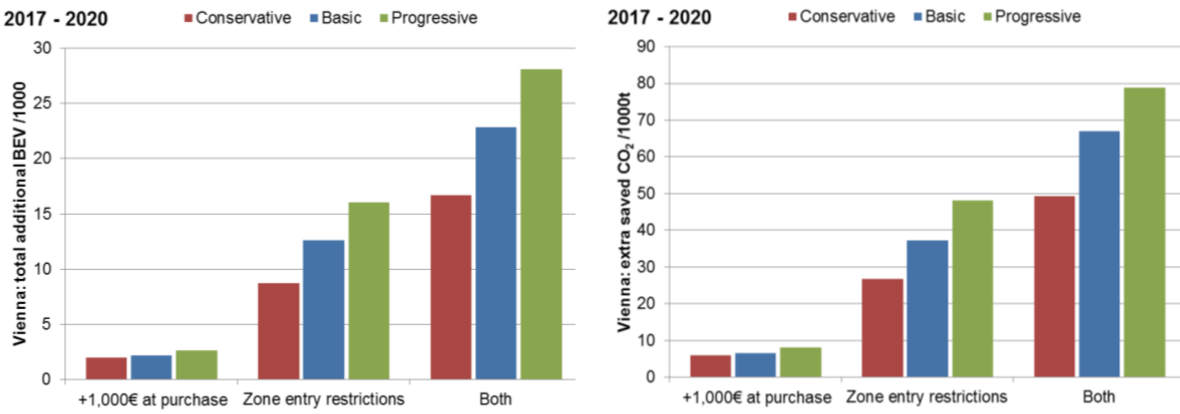


Fig. 7 Total additional BEV sales (in 1000s) and CO_2 saving (in 1000 tonnes) between 2017 and 2020 for Vienna.

Austria has the lowest CO_2 emission intensity for electricity, including production and (significant) electricity imports, of the considered countries. Therefore, the uptake of electric mobility in Austria leads to a significant reduction of CO_2 emissions. The CO_2 reduction bonus of the combined policy measures is 40% to 53% and thus almost in the same range as for the BEV sales, depending on the scenario. The average CO_2 savings per vehicle are remarkably higher than in all other investigated countries and are about 1.2 tonnes per year. This finding is virtually independent of the selected scenario or policy measure.

4. Discussion

A methodology was proposed that triangulated both qualitative and quantitative data with the purpose of furthering our understanding of incentives and their relationship to EV uptake and CO_2 reduction potential. The application of this methodology proved insightful. Dependent on the city, incentives of equal value resulted in differences in EV uptake. This showed that the benefit of an incentive needs to be viewed by how it interacts with the system into which it is deployed in addition to any measurement of its value in isolation. Furthermore, the bundling of incentives showed that there was an effectivity bonus whereby the benefit in terms of EV uptake and CO_2 reduction exceeds the impact of the incentives when considered in isolation. For the results shown in this study this could be by as much as 80%, but was more typically around 20-50%. It is therefore clear that incentives need to be viewed as part of a system and one with complex interrelationships. This was one of the achievements of this research. It was also beneficial to engage with the city authorities. From the meetings with the representatives of the cities it became clear that the policy portfolio (and hence objectives), far from being consistent were quite different. Clean air and GHG reduction are important, but other issues, for example congestion and behavioural change, and their relative importance cf. GHG/air quality means that the way in which EVs should be promoted differ. Indeed, the promotion of EV, whilst viewed as important, should not later in the diffusion of innovation curve stimulate wrong or unintended behaviour. Hence, whilst there are a number of examples of successful incentives implemented across the study region it should be noted that this research has shown it will not be simply a case of transferring success from one region to another unless there is a sufficient understanding of fit of the incentive in terms of the system into which it is to be deployed and the broader policy objectives of the city. In this regard, the DSM tool, as it takes into account regional variations, has been shown that it can support cities in evaluating incentives. Furthermore, through bundling of incentives the DSM tool can be used to support cost-benefit analysis.

5. Conclusions

The research presented in this paper has achieved the following:

- Demonstrated that the benefit of the incentive is different depending on the system into which it is deployed. Incentives with the same value achieve different outcomes depending on the city into which they were deployed.
- Shown that there is an effectivity bonus from bundling of incentives, whereby the benefit is greater that the sum of the individual benefits. Combining of incentives has provide benefits that are greater than the sum of the individual benefits associated with those incentives.
- Identified that cities have different requirements from incentives. Engagement with the city representatives it has been shown that incentives need to be shaped differently depending on the local policy requirements and the horizon to which they are looking
- Supported stakeholders (cities) with the opportunity via the DSM tool to evaluate incentives based on regional differences. Further to this the ability of evaluate combinations of incentives and establish an effectivity bonus enables policy makers to identify cost-benefit opportunities.

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