Measure No.1: Electric Battery and Fuel Cell Vehicles

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Activities fostering the use of vehicles that use electricity to power an electric motor.

Cities can encourage use of electric vehicles through their own public procurement policies, regulation (such as “low emission zones”), and local pricing systems (congestion charging and parking policies)

1.1 Context and background

There are growing numbers of EV on the streets of cities across the world, and the numbers of new electrically-powered vehicles purchased each year are increasing steeply in some nations. In many instances though this is driven by the financial and other support mechanisms available in a country, and at present, EV still only make up a small percentage of the total fleet of vehicles.

EVs are available in different vehicle categories (e.g. electric cars, trucks, buses, bicycles), and cities can further promote the use of EVs through a range of interventions at a local level – consistent with, and supportive of wider national policies.
Other measures that might be used to encourage the use of EV in a city are low emission zones (discussed in Measure Review No6 Environmental Zones), and pricing measures (No.7 Congestion Charging, No.8 Parking). Some cities are also allowing EV to use public transport lanes (see review No.5 Roadspace reallocation).

This review has considered several different categories of electric battery vehicles, which are described below (the abbreviations are used in the review itself).

Key messages:

- Electric vehicles currently meet the needs of a range of users - but not yet all users.
- Electric vehicles (EV) can be cost-effective for owners and operators under specific conditions.
- Cost-effectiveness depends on economies of scale. The more vehicles are produced, the more the production costs per unit decrease.
- Any cost benefit analysis (CBA) is heavily dependent on the assumptions used, (for example fuel and carbon costs) and national / local circumstances (such as subsidy levels for example)
- Societal benefits of investments into electric vehicles can be less clear than other technological change in vehicles.
- Electric vehicles can reduce local air pollution, benefitting human health and the urban environment.
- Effects on greenhouse gas emissions will depend on the technology deployed and the source mix for electricity generation.

Potential interventions:

- Purchasing policies to include EV in municipal fleets, or in city-owned public transport.
- Implementations of charging infrastructure.
- Support via regulatory measures (where applicable at city level)

PHEV (Plug-in hybrid electric vehicle): A duel-fuel vehicle which can either run on electricity or on gasoline/diesel. The vehicle can be plugged in to an electrical outlet to be recharged. Typically with more powerful batteries than HEV these vehicles have a greater range running solely on electricity.
BEV (Battery-electric vehicle): Electric propulsion only, relying exclusively on electricity from the power grid
FCEV (Fuel Cell Electric Vehicle): Powered by a fuel cell providing electricity for an electric motor generating energy from a chemical reaction between on-board stored hydrogen and oxygen.

Another term relevant to understanding how EV might play a role beyond just substituting for conventional vehicles is V2G (Vehicle-to-grid). This describes how EV may provide services to the power grid, the combined batteries providing a resource to draw on at peak times, feeding electricity back into the system to meet demand – before re-charging at off-peak times. Theoretically this would allow for peaks and troughs in power generation to be smoothed.

Note: Hybrid electric vehicles (HEV) are covered under Measure No2 Cleaner Vehicles, and vehicles that are constantly connected to the grid to draw electricity, such as trams, are also excluded from this review.

1.2 Extent and Sources of Evidence
Electric vehicles are subject to on-going research, focussed on technological improvements and externalities. As advanced electric vehicles have been only recently introduced to the market, ex-ante assessments dominate with little ex-post assessment available. The domination of ex-ante assessments may be explained by the novelty of advanced electric vehicles: Experiences on their life time and resale value are not available.

Some case studies evaluate cities' experiences. These cases provide important information on the feasibility of replacing conventional vehicles with electric ones and their reliability. Some of these studies also provide information on the impacts on externalities. However, they provide little documentation about the methodologies used.

Results are quickly out-of-dated with regard to cost-efficiency or ability to meet user demands, due to rapid technology and price development. Therefore only studies that have been published after 2010 are included in the present analysis. FCEVs are in a less mature stage than BEVs. 'Serial fuel cell' models are not on the market, yet. So hardly any specific evidence was found for fuel cell electric vehicles.

1.3 What the Evidence Claims
Studies that examine the costs and benefits of electric battery and fuel cell vehicles usually focus on one or more of the following aspects:

i. Cost-efficiency of replacing conventional vehicles with electric ones
ii. Feasibility of replacing conventional vehicles with electric ones
iii. Effects on externalities form motorized road transport such as greenhouse gas emissions, local air pollution and noise

1.3.1 Cost efficiency

Today, acquisition costs are usually higher for electric vehicles then for conventional diesel or gasoline vehicles. However, lower operational costs and other savings or revenues can lead to a higher cost-efficiency of electric ones over the vehicle life time. The overall cost-efficiency depends to a large extent on local circumstances (for example, fuel / energy prices, taxes, and subsidies) and the evaluation perspective: In a societal cost-benefit analysis monetary benefit from the reduction of externalities is usually included, while investors (vehicle owners or operators) usually take only the direct acquisition and operational costs into account.

Christensen and Christensen (2011) conducted a cost-benefit analysis for a BEV and a diesel vehicle in Denmark to compare their cost-efficiency to society and to the private consumer. For the electric vehicle a battery switching technology was assumed. Based on costs of investments, operation, maintenance, environmental impact, refuelling / battery switching time, noise and METB (marginal excess tax burden), the overall life time costs of an electric vehicle were found to be 0.8 per cent less than for a comparable diesel vehicle. From the perspective of the private consumer (accounting only for direct costs and benefits) electric vehicles life time costs are 22% higher than a diesel vehicle.

Noel and McCormack (2014) investigate the cost-effectiveness of a V2G-capable school bus compared to a diesel school bus in an ex-ante assessment. The authors take into account acquisition costs, infrastructure costs, energy costs, V2G-revenues, maintenance costs as well as external environmental and health costs. The study is based on actual prices in the state of Delaware (USA). The cost-effectiveness over the lifetime of the bus (14 years assumed) was investigated. The authors find that one bus would save a school district \$6.000 per seat or \$230.000 per bus compared to a similar diesel bus. The net benefits for the electric buses are strongly influenced by the revenues from the electricity frequency regulation market. The V2G bus provides electricity storage when connected to the charger and receive compensation for that service. When the revenues from V2G services are excluded, the savings are significantly reduced and the diesel bus might be slightly more profitable. The sensitivity analysis highlighted that the differences in the regulation price for V2G services and the regulation capacity have a significant effect on the overall results. The results were less sensitive to battery replacement costs, diesel and electricity inflation rate or the social costs of CO2 emissions. Noel and McCormack (2014) also tested the international transferability of the results by adopting diesel costs, electricity costs and regulation price to the conditions in France and Denmark. With \$7.852 per seat in France and \$8.617 in Denmark the cost-effectiveness was even higher than in the US. Factors such as differences in the electricity generation mix were not taken into account.

Lajunen (2014) investigated energy consumption and the costs and benefits of hybrid, plug-in hybrid and electric city buses compared to a diesel bus on an ex-ante basis. The cost efficiency of the buses was based on the lifetime costs over 12 years including vehicle acquisition, investments in charging infrastructure, operation costs (i.e. fuel consumption and maintenance) and energy storage replacement costs (battery or ultra-capacitor). The vehicles' salvage value was not included. The impact of different bus technology on local emissions (HC, CO, NOx and PM) was also calculated, but not factored into the life time costs. The study was based on modelled data using the vehicle simulation program ADVISOR and investigated the performance of the different buses in the different test cycles (Helsinki, Braunschweig, Manhattan, New York and Orange Country). Even though the energy consumption per kilometre varied in the different test cycles, the energy consumption for plug-in hybrid and electric buses was much lower than conventional buses in all test cycles. The study also took into account that due to charging requirements, more buses are needed in a fleet for a specific route. The overall life cycle costs of the different vehicle technologies vary by driving cycle, and in most cycles investigated the hybrid electric buses had similar overall costs to diesel buses. Some differences occurred between parallel and serial hybrid buses, and the all-electric bus had the highest life cycle costs in all driving cycles. The analysis further showed that the life cycle costs varied largely between the different operating routes, thus the authors stress the fact that the vehicle technology should be chosen on the basis of the route. In a sensitivity analysis, the author shows that the life cycle cost of the PHEV and the BEV are highly sensitive to the costs of the energy storage system. It is assumed that costs for batteries will decrease in the future, which would lower the life cycle costs. The life cycle cost only included the direct costs to the vehicle operator, whereas effects on externalities are investigated separately and not included in the cost-assessment (see below).

Experience from real life operation is provided by Wiesinger (2013) for all-electric buses in Vienna. The local public transport provider "Wiener Linien" purchased 12 electric 'microbuses' for the city centre. The overhead tram power lines were used to recharge the buses. The purchasing costs per bus were 400,000 Euro, which is about twice the costs of a comparable diesel bus. Charging points were installed at each end stations (90,000 Euro per charging point) and at the bus depot (320,000 Euro). Cost savings were expected from lower energy costs and lower maintenance cost (estimated at 8,000 Euro per year). However, cost-efficiency analysis is not provided in the available documents.

Menga et al. (2013) showed the difference in cost-efficiency of electric vehicles from the perspective of society as a whole as well as for an individual owner or operator of a vehicle. In their analysis for the city of Milan, it is shown that electric cars and vans are causing much lower external costs in terms of CO2 emissions, effects on ecosystems, human health and energy import costs (see below). While the external costs for an internal combustion (ICE) powered car amounts to 5.6 Euro-cent per kilometre, the external costs of electric cars are found to be only 1.4 Euro-cent per kilometre. Similarly, electric vans are more favourable from an external cost perspective (i.e. 2.8 Euro-cent/km compared to 7.6 Euro-cent for a conventional van). In contrast, the total costs of ownership (based on acquisition costs, energy costs, taxes, insurance, maintenance etc.) are higher for an electric van (0.66 Euro/km) than for an ICE van (0.63 Euro/km) as the higher acquisition costs are not fully compensated for by the lower energy costs. Non-energy running costs were the same for both alternatives. However, economic advantages for electric vehicles could result from national or local measures (e.g. tax incentives, access rights).

Results of an ex-post assessment of a trail with electric vehicles for urban freight in London are presented by Browne et al. (2011) and Leonardi et al. (2012). In the trial a local supplier of office supplies replaced its 3.5 tonne diesel delivery vans which transported goods from a suburban depot to customers. Under the new scheme, goods were transported with an ICE truck to an urban consolidation centre to be reloaded to electrically assisted cargo tricycles and electric vans. Data for the studies was collected between December 2009 and July 2010. According to the operator the new distribution system based on electric vehicles had the same operating cost as the previous one based on diesel vehicles (Browne et al. 2011). Costs increases resulting from the operation of the consolidation centre and higher driver costs were balanced by lower vehicle operation costs. Absolute costs are not provided due to commercial confidentiality. Significant reductions in externalities were achieved (see below).

All in all, the different sources of evidence reveal that the cost-efficiency of electric vehicles depends on the perspective and local circumstances. From the perspective of a vehicle operator Christensen and Christensen (2011), Lajunen (2014) and Menga (2013) came to the conclusion that electric vehicles are not cost competitive (yet). Noel and McCormack (2014) expect economic advantages from electric vehicles for the operator. However, in case of Noel and McCormack the economic benefit is based on revenues from V2G. From a societal perspective, electric vehicles can provide an economic advantage due to reduced external costs as Christensen and Christensen (2011) and Menga et al. (2013) revealed. The example of Browne et al. (2011) from London shows that the replacement of conventional vehicles with electric vehicles should not be seen too narrow. Direct comparison of conventional and electric vehicles can mask the potential of electric vehicles in the context of additional changes to transport organisation.

1.3.2 Feasibility

Advanced electric vehicles came on the market relative recently and the technology is still subject to extensive research and development. So besides cost efficiency and sustainability impacts, it is important that electric vehicles can meet the requirements in the proposed field of application. Thus, finding evidence of the feasibility of the application of electric vehicles is of interest in this context as well. The city of Rotterdam in cooperation with local energy suppliers did an extensive trial of the suitability of electric vehicles for different purposes (City of Rotterdam et al. undated). The initiative was part of pilot projects on behalf of the Ministry of Economic Affairs. The study was conducted between 2012 and 2013, although the vehicles had already been purchased in 2010 and 2011. At this time the electric vehicles purchased were mainly manually converted vehicles. As vehicle and charging technology is continuously evolving, it is expected that even better results would be achieved with vehicles available today. 75 electric vehicles (BEV/PHEV) and 129 charging points were monitored and tested by 100 drivers. Based on the experience during the trial, it was concluded that 60 per cent of the light delivery vans owned by the city could be replaced by fully electric ones. The two local energy suppliers who participated in the trial had larger range requirements, thus only 18 and 27 per cent of their fleet were suitable to be replaced by electric vehicles. The reliability of the electric vehicles was not optimal for the converted vehicles, but the new generation of vehicles provided satisfying reliability and user comfort. The vehicles were charged mainly at work or at home and most vehicles were plugged-in in the early evening.

In their analysis of the potential of electric vans in urban freight distribution in Milan, Menga et al. (2014) revealed that the average daily mileage of delivery vans is 36.8 km, while 95 per cent have a daily mileage of less than 100 km. Thus, all electric vans that are available today would be suitable in most cases from a range perspective.
Wiesinger (2013) showed how electric buses can be successfully integrated in existing system and infrastructure. In Vienna, electric buses are recharged at their final stations by using the existing overhead line system. Each charging process only lasts five to eight minutes. During this time passengers can enter or leave the vehicle. The buses used have a capacity of 46 passengers and a top speed of 62 km/h with a maximum range of 150 km. This scale of bus fits the requirements of routes through the historic centre of Vienna. Some technical alterations in terms of heating for the batteries were necessary to ensure proper operation during wintertime. It was noted that the maximum range would decrease during the Winter to 120 km due to the energy consumption of the heating system.

The example of the London logistics trial with electric vehicles (Browne et al. 2011, Leonardi et al. 2012) revealed that measures should not be looked at in isolation. The integration of an urban consolidation centre in the arrangements made it feasible to cover deliveries with electric tricycles and electric vans in an efficient manner.
All in all, the evidence reviewed would suggest that electric vehicles can already meet the requirements in many – but not all, fields of application.

1.3.3 Effects on externalities

In general, the reviewed studies agree that electric vehicles reduce externalities related to fuel consumption in road transport. Positive effect are reported for greenhouse gas emissions (mainly CO2) and local air pollutants (Hydrocarbons (HC), Particulate matter (PM), Carbon monoxide (CO) and Nitrogen oxides (NOx)). These emissions have negative effects on the environment, the building structure and human health. It is noted though that merely replacing an ICE vehicle with an electric one will not address other issues such as congestion or land-take for infrastructure (i.e. for roads or parking).

Buekers et al. (2014) investigated the effects on external cost relating to health and environmental impacts from electric vehicle introduction in EU countries. The effects were based on various pollutants that result from vehicle operation (Tank-to-Wheel or TTW) or fuel/electricity production (Well-to-Tank, WTT) and external costs from battery production. The external costs included negative impact on human health (from NOx, SO2, PM, NMVOC) and on the environment (from CO2). The results indicated that the introduction of electric vehicles leads to reduction of external costs in 21 of 27 EU countries, when the 2010 electricity mix is taken into account. Annual reductions in external costs from a 5 per cent penetration of electric vehicles are highest in France (98.2 million Euros), Germany (54.3 million Euros) and Italy (48.4 million Euros). In some countries BEV introduction would not be associated with a monetary benefit unless local electricity production changed to cleaner sources. Slight increases in external costs or no effect on external costs were reported for Estonia, Greece, Cyprus, Malta, and Romania. For Poland, where electricity production relies heavily on coal, strong increases in external costs are found. The study further investigates the external costs for a 2030 scenario, with alterations in the electricity production based on current trends. For this scenario, reduction in external cost can be achieved by electric vehicle penetration in all Member States, except Poland and Estonia. All in all, Buekers et al. (2014) provide significant evidence for the reduction in external costs resulting from the replacement of ICE vehicles with BEVs. It is also shown that this effect is highly depended on local conditions especially in terms of electricity production. For a city that is considering measures to foster the deployment of electric vehicles in their SUMP, TTW emission might be of higher relevance than upstream emissions e.g. from electricity production. With tailpipe emissions being zero for electric vehicles, this provides a strong argument for the application of electric vehicles in an urban environment – for example in municipal fleets of service vehicles, or buses for example.

In their cost-benefit analysis of a vehicle-to-grid (V2G) capable electric school bus, Noel and McCormack (2014) also investigate the health and environmental externalities related to diesel and electricity consumption. They calculate that health externalities from a heavy duty diesel vehicle are about \$0.08 per mile due to emissions of different pollutants, and based on the local electricity mix in Delaware, they estimate the health externalities from electricity production for an electric bus at \$0.0149 per mile. For the environmental externalities Noel and McCormack (2014) take the CO2 emission of diesel consumption and electricity production into account. \$300 of overall benefit of a V2G-electric bus compared to a diesel bus of \$6.000 per seat results from the reduction of externalities (see above).

In the ex-ante analysis of different bus technologies, Lajunen (2014) also investigated the effect of plug-in hybrid electric and hybrid electric buses on local air pollutants (HC, CO, NOx, PM). The PHEV lead to 75 to 95 per cent reductions of local air pollutants compared to a diesel bus. The serial HEV led to reduction in hydro carbons of 68 to 92 per cent, and reductions in CO, NOx and PM emissions between 12 and 62 per cent. Reductions were slightly smaller for the parallel HEV.

As reported by Wiesinger (2013), the environmental impacts of the all-electric microbuses used in Vienna were calculated by the Technical University of Graz. In an ex-ante assessment it was found that the busses would lead to significant annual emission reductions compared to the liquid gas buses that were used previously (emission reduction: 5.3 t CO2, 1.7 t NO, 0.06 t NO2). The emission reductions were calculated based on the electricity mix of the local energy supplier, who derives more than 80 per cent of its supply from wind or water. No further details on the methodology of the environmental impact assessment were provided by Wiesinger (2013).

In their assessment of the potential of electric vehicles in urban transport in Milan, Menga et al. (2014) analysed the external costs for the country of electric vehicles compared to ICE vehicles. The monetisation factors for the different pollutants were obtained from CE Delft et al. (2011). The calculations were based on Italy's electricity mix. The health costs as a result from bad urban air quality were about 1 Euro-cent/km for ICE cars and 0.3 Euro-cent/km for electric cars. Highest health costs were found for ICE vans (about 2.5 Euro-cent/km). External costs from the impact on ecosystems and degradation of buildings were found to be low in all cases. The monetary value of CO2 emissions were 0.8 Euro-cent/km for an ICE car and 0.3 Euro-cent for an electric car. In addition, the study also included energy import costs for the country as external costs. The energy import costs made up about half of the external costs for all vehicle technologies. All in all, it was found that electric cars and vans result in much lower external costs to society than ICE vehicles.

In their societal cost benefit analysis of electric and diesel cars Christensen and Christensen (2011) found that diesel vehicles cause external costs due to emissions of 0.148 DKK/km (about 0,02 Euro/km), whereas emission costs from electric vehicle are 0.003 Euro/km. These results are broadly in line with those provided by Menga et al. (2014). In addition, Christensen and Christensen (2011) also calculated the costs due to noise pollution. Based on an average annual mileage of about 18.000 km, electric vehicles resulted in annual cost from noise of 1.583 DKK (about 212 Euro), while costs from diesel vehicles were 5.203 DKK (about 700 Euro).

The 'before and after' assessment of the urban logistics trail in London revealed positive effects on externalities from the replacement of 7 diesel vans with 6 electric tricycles, 2 electric vans and 1 diesel truck (Browne et al. 2011). Distance travelled per parcel was reduced by 20 per cent, CO2eq emissions per parcel were reduced by 54 per cent. However, electricity was assumed to be entirely from renewable, carbon free sources. As additional benefits to the city, the daytime road space occupation was reduced by 56 per cent per parcel.

According to City of Rotterdam et al. (2014) during their one year trial with 75 BEV and PHEV vehicles more than 700.000 electrically-powered kilometres were driven leading to CO2 emission reductions of 67 per cent and 10 per cent less particulate matter emissions covering the entire chain and taking into account the Dutch energy mix. NOx emissions are reportedly reduced by 100 per cent. However, no details on the methodology and the data basis for emission reduction are given in the available documents. It was revealed that the effects are also strongly affected by outside air temperature (low temperatures lead to higher energy consumption of EVs), driving style and – in terms of PHEV – charging behaviour.

There is strong evidence for a positive effect of the replacement of ICE vehicles with electric ones from a perspective of external costs. However, bodies or private persons that purchase and operate the vehicles do not usually include these considerations in their purchasing decisions, because they do not affect their budget.

1.3.4 Methodologies and caveats

The evidence from the studies outlined above is not particularly comparable. Many studies provide theoretical ex-ante assessments partly based on cost estimate, whereas only limited before-and-after studies are available. The reviewed studies apply different methodologies and take different factors into account. For instance, external costs resulting from noise pollution are neglected in most studies except the work by Christensen and Christensen (2011).
The calculation of emissions from electricity production can introduce some bias in the results for external costs. Most study based their emission calculation based on the national electricity mix. In contrast, Wiesinger (2013) and Browne et al. (2011) calculated emissions based on the mix of the local energy supplier with a high share of renewables. This approach neglects the fact that if one customer obtains a high share of renewables, the share of electricity from fossil sources increases for another customer, as long as no new capacity for renewable energy production is installed. Thus, the emission factor of the electricity mix is a more appropriate basis for the assessment of external costs from electric vehicles.

The monetization factor applied for CO2 can also affect the overall results and varies between the studies cited above: Buekers et al. apply a monetization factor of 20 Euro/tonne, Noel and McCormack use $36/tonne (about 30 Euro/tonne) and Menga et al. (2013) apply a monetization factor of 40 Euro/tonne.

Advanced electric vehicles were introduced to the market very recently and developments are expected in terms of price and energy efficiency and energy storage. Not all studies are based on actual market prices for electric vehicles. For instance Lajunen et al. (2014) estimated the costs for different electrified buses configurations. Furthermore, there is uncertainty concerning the future costs of the battery, which affects the life time costs of an electric vehicle due to the need for battery replacement. For instance, Noel and McCormack assume that battery costs are halved by the year of replacement.

1.4 Lessons for Successful Deployment of this measure

An important aspect that has to be been considered in relation to EVs is that the environmental impact of electric vehicles is largely determined by the electricity mix. Considerable reductions in emissions can be achieved by replacing diesel or gasoline vehicles with electric ones in a country with a high share of renewables, whereas benefits are limited in a country where electricity generation relies heavily on fossil sources. However, benefits to the urban environment and public health from the reduction of on local air pollutants from vehicle tail pipe emissions are independent of the location and thus transferable across cities and countries.

There are also major differences between countries in respect of cost-efficiency for a vehicle owner / operator related to fuel prices. For example, the relation between gasoline / diesel and electricity prices can vary largely between countries. In Germany, the gasoline price (about 0.18 Euro/kwh) is much lower than the electricity price for domestic consumers (0.27 Euro/kwh), whereas in France and Norway electricity is 0.02 Euro/kwh cheaper than gasoline (Mock and Yang 2014). In addition, several countries provide additional monetary incentives for electric vehicles such as reduced taxes or subsidies.

Consideration needs to be given to a range of factors that might impact on performance of EVs compared to conventional vehicles. EV performance can be affected by routing, driving style, temperature and traffic conditions, as shown for instance by Lajunen (2014).

Some of the case studies presented here also benefit from specific local circumstances. For example, in Vienna, the existing tram overhead lines could be used for recharging the electric buses. This led to lower charging infrastructure costs and reduced vehicle acquisition costs as smaller battery systems were sufficient (Wiesinger 2013). The results of the EV logistics trail in London are transferable only in a narrow context, when delivery is limited to inner city areas and can mainly be performed by tricycles.

Upscaling of electric vehicle measures can have diverse consequences. On the one hand, bulk orders or higher electric vehicles sales numbers, can reduce the acquisition costs for the individual vehicle and can lead to higher cost-effectiveness of charging infrastructure installation. On the other hand, if a very high number of electric vehicles are charged on a specific location (e.g. fleet depot), effects on the local grid can occur, which require investment in enhanced grid capacity.
Electric vehicles can play an important role in a SUMP, helping to reduce externalities from motorized road transport, in particular EV have considerable potential in terms of road based public transport (i.e. buses, taxies).

In terms of private motorized modes and urban freight, it is important to explore electric vehicles in the wider urban transport context and not as standalone measure. One by one replacement of vehicles neglects the opportunities for additional sustainability effects. To reduce the need to travel and to shift trips to public transport and non-motorized transport need to be prioritized to tackle all transport related issues.

Local authorities such as a city usually have the necessary responsibilities and regulative power to promote the deployment of electric vehicles in the municipal fleet or in public transport. They can also promote private or commercial electric vehicles through (free) parking policies, exemptions from access restrictions, lower or no city tolls, support for the installation of charging infrastructure etc. However, national incentives such as tax policy and energy prices are likely to also play a major role.

Further evidence is needed on the long term application of electric vehicles and the associated effects from real-life examples.

1.5 Additional benefits

As well as the evidence of economic and financial benefits of interventions discussed above, there are a number of additional benefits that are claimed for policies promoting EV:

- Air Quality: Although the environmental impact of electric vehicles is largely determined by the electricity mix in a particular country, benefits to the urban environment and public health from the reduction of local air pollutants from vehicle tail pipe emissions are independent from the location and thus transferable across cities and countries.
- Noise pollution: A further societal benefit of electric vehicles is reduced noise pollution. Although this benefit is rarely monetised in the evidence, one Danish study found that an electric vehicle driven an annual average distance of 18.000 km would generate an annual cost from noise pollution of less than one third the cost generated by a diesel vehicle.

1.6 Summary

The following conclusions can be drawn in respect of EV at the present:

- Electric vehicle are only cost-effective for vehicle owners or operators under specific conditions. These circumstance will include a range of wider costs (such as oil and carbon), as well as the financial inducements and subsidies available in that location at that time.
- If considering operating costs only, there may already be situations in which operating EV is more cost-effective than conventionally fuelled vehicles.

Other statements on EVs that can be made with confidence include:

- EVs reduce local air pollution offering benefits for human health and the urban environment
- The overall effect on greenhouse gas emissions of an EV depends on the electricity mix in that location at that time.
- At this time, EVs meet the needs of different – but not all – users.

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No.18	New models of car use	Calvert, T. & Chatterjee, K [2,b]	Thomas2.Calvert@uwe.ac.uk
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