GOOD PRACTICE GUIDE

Low Emission Vehicles

C40 CITIES
CLIMATE LEADERSHIP GROUP

C40 Cities Climate Leadership Group

The C40 Cities Climate Leadership Group, now in its 10th year, connects more than 80 of the world's greatest cities, representing 600+ million people and one quarter of the global economy. Created and led by cities, C40 is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, well-being and economic opportunities of urban citizens. www.c40.org

The C40 Cities Climate Leadership Group has developed a series of Good Practice Guides in areas critical for reducing greenhouse gas emissions and climate risk. The Guides provide an overview of the key benefits of a particular climate action and outline successful approaches and strategies cities can employ to implement or effectively scale up these actions. These Guides are based on the experience and lessons learned from C40 cities and on the findings and recommendations of leading organisations and research institutions engaged in these areas. The good practice approaches are relevant for cities engaged in C40 Networks as well as for other cities around the world.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Transportation is one of the most significant contributors to global climate change, accounting for 27% of global CO_2 emissions.[i] With the expected addition of 2 billion cars globally by 2050,[ii] transport-related emissions are projected to grow between 120% and 230%.[iii] Much of this increase will be the result of urban population growth and land cover expansion occurring at rates never seen before.[iv] As more and more people move to cities, urban transportation systems will play an increasingly critical role in driving responsible climate action and reducing global emissions.

Cities are currently taking a three-pronged approach to reducing emissions from transport: (i) reducing the need for journeys through transit oriented developments; (ii) moving journeys to more efficient modes like public transit and non-motorised transportation; and (iii) improving the efficiency of fleets, through shifting to low-emission technologies.

Low Emission Vehicles (LEVs) are vital for addressing climate change and improving the efficiency of vehicle fleets as they emit lower levels of greenhouse gases than conventional fossil fuel vehicles. Despite notable technological advances, cities have encountered some barriers in increasing the uptake of LEVs, including a lack of cost-effective options for consumers, municipalities and public transport operators. Nonetheless, a number of cities are seeing the expansion of LEVs in their markets, and are actively facilitating this uptake through innovative incentive programmes and other policies and strategies. These successful approaches include:

- **Focus on city fleets**
- **Provide infrastructure**
- **Tackle purchasing and technology**
- **Provide incentives**
- **Introduce zoning**
- **Work with partners**
- **Focus on education and awareness**

The C40 LEV Network was established to support cities in accelerating and advancing policies and actions to increase the uptake of LEVs, facilitating the sharing of good practice and technical expertise amongst C40 cities.

The purpose of this Good Practice Guide is to summarise key city strategies to support LEVs for global dissemination, highlighting the success of C40 cities in incentivising LEV uptake to drive carbon emission reductions.

1 BACKGROUND

1.1 Purpose

The C40 Cities Climate Leadership Group has developed a series of Good Practice Guides in areas critical for reducing greenhouse gas (GHG) emissions and climate risk. The C40 Good Practice Guides provide an overview of the key benefits of a particular climate action and outline successful approaches and strategies cities can employ to effectively scale up these actions. These Guides are based on the experience and lessons learned from C40 cities, and on the findings and recommendations of leading organisations and research institutions engaged in these areas.

The following Good Practice Guide focuses on the key elements necessary to incentivise LEV uptake in cities, with a survey of best practices leading to better economic, social, and environmental outcomes for cities. These approaches are relevant for cities engaged in C40's Low Emission Vehicles Network as well as for other cities around the world.

1.2 Introduction - why transportation?

Transportation is one of the most significant contributors to global climate change, accounting for 27% of global CO2 emissions, and is the fastest growing contributor to greenhouse gas emissions.[v] Much of this staggering rise is related to the unprecedented growth of urban regions around the world. Urban areas are expected to expand at twice the rate of urban population growth, resulting in an increase in urban land cover during the first three decades of the 21st century that exceeds the cumulative urban expansion in all of human history.

These figures demonstrate the need to harness urban transportation systems to drive climate action. For example, transport-oriented urban policies could reduce CO2 emission growth by 30% in Chinese and Latin American cities and 40% in Indian cities, when compared to their baseline scenarios. Transportation policies can also limit the future increase in urban energy use from the global 2050 baseline of 730 EJ to 540 EJ. In addition, the European Union is currently aiming for a mandatory 40% reduction in automobile-based GHG emissions by 2021, delivered entirely through the uptake of LEVs.[vi] In line with such global trends, cities participating in the C40 LEV Network can have a profound influence on reducing emissions and positively impacting planetary urban futures.

2 LOW EMISSION VEHICLES AND CLIMATE CHANGE

2.1 What are LEVs?

Low Emission Vehicles emit significantly lower volumes of greenhouse gases during operation than fossil fuel vehicles. The term LEVs can encompass a range of vehicle types and technologies with various levels of emissions, including biofuels, hybrids and electric vehicles.

Emission levels attributed to LEVs can be evaluated by "direct emissions", which are emitted through the tailpipe, as well as through evaporation from the vehicle's fuel system and during the fuelling process. LEVs have different direct-emission levels depending on the vehicle technology, but their direct emissions are generally lower than those of comparable conventional vehicles. Electric vehicles (EVs), for example, produce zero direct emissions. Vehicle emissions can also be evaluated by "well-to-wheel" emissions, which include all emissions related to fuel production, processing, distribution, and use. In the case of electricity, which fuels EVs, most electric power plants produce emissions, and there are additional emissions associated with the extraction, processing, and distribution of the primary energy sources they use for electricity production (which can range from coal, nuclear, gas, hydropower, to new renewables).

While traditional fossil fuel vehicles such as petrol and diesel are becoming more efficient, the need to rapidly reduce the level of urban pollution and mitigate against climate change requires cities to focus on the uptake of ultra low and ultimately zero emission vehicles. Therefore, hybrid and full-electric technology is the main focus of the C40 LEV Network, and of this guide.

In addition, when looking at the opportunities for urban emission reductions through LEV uptake, there are different types of fleets over which cities have varied powers and influences:

City fleets: City fleets (buses, light duty, emergency, cargo, passenger, service vehicles etc.) often operate under the purview of the municipality. As such, cities have stronger control over these fleets and can take a more direct role in improving their environmental performance.

Taxis: Taxi fleets are comprised of different levels of both municipal and private sector ownership, depending on the city. Cities can therefore either take a direct role in LEV uptake for taxis, usually through regulation, or provide policy and incentives to encourage the uptake of LEVs in private-sector fleets.

Private fleets: Cities have little direct control over private vehicles but can still put in place policy measures to curtail transport emissions. By providing incentives such as removing taxes for electric vehicles, providing free parking, tolls and access to exclusive lanes such as bus lanes, cities can create conditions that have a significant impact on urban LEV uptake.[vii]

2.2 Benefits of LEVs

LEV technology results in significantly lower emissions than from conventional vehicles, increased health benefits through improved air quality, a reduction in noise pollution, increased energy security and the potential for grid balancing. Some of these key benefits from LEVs are:

GHG emission reductions: An increase in LEV uptake has the potential to significantly reduce GHG emissions. Even as some regions will see an increase in personal vehicle and mass transit usage in the coming years in response to growing populations, LEVs can curtail the rise in transportation-related GHG emissions under a business-as-usual scenario. For example, cities of the C40 Low Emission Vehicles Network collectively forged an international Clean Bus Declaration, demonstrating a commitment by signatory C40 cities to reducing emissions and improving air quality by incorporating low- and zero-emission buses in their fleets. If signatory cities achieve their clean bus goals by 2020, GHG savings would be almost 1 million tonnes per year.[viii]

Health, air quality and noise benefits: Studies of the sources of air pollution have shown that transportation accounts for a large proportion of nitrogen oxides, particulates and carbon monoxide emissions. These emissions are directly responsible for many of the air quality problems faced in major urban areas. For example, carbon monoxide readily bonds with hemoglobin in blood, taking the place that would normally be occupied by oxygen molecules. Nitrogen oxides are also problematic for urban dwellers because sunlight causes hydrocarbons and nitrogen oxides to react and form ozone. Even at low concentrations, ozone damages the body's cells and tissues and causes respiratory ailments. A high level of PM2.5 can lead to premature mortality due to lung cancer, cardiopulmonary disease, and acute respiratory infection from inhaling PM2.5 emissions.[ix] In London, for example, nearly 9,500 people per year die prematurely because of poor air quality.[x] LEVs produce significantly lower or zero tailpipe emissions, and the large-scale uptake of LEVs can help to reduce the negative impacts on health related to vehicle-borne emissions. Furthermore, plug-in hybrids and fully electric vehicles are significantly quieter than combustion engine vehicles and can significantly reduce noise pollution in urban areas.[xi]

Energy security: In cities and regions where significant amounts of fossil fuels are consumed for road transport, the uptake of LEVs can help urban systems become less dependent on fossil fuels, and therefore more resilient to price spikes and supply disruptions associated with a dependence on fossil fuels. For example, Bogota's uptake of LEV taxis helped move energy sourcing from fossil fuels to hydropower. These taxis emit 60% less greenhouse gasses than conventional taxis. Due to this, the region has become less dependent on the unstable fossil fuel market through the procurement of LEVs (see Bogota Biotaxi section below).

Grid balancing: LEV uptake can lead to energy grid balancing through the introduction of large-scale intelligent power supply networks in cities. These networks utilise smart technologies to advise users on when and where to re-charge, based on power supply availability and stress on the grid. Once in place, these systems can go beyond LEVs to apply the same philosophy to other urban activities requiring power from the grid (see the Infrastructure section for more information). More efficient utilisation of the grid will also result in reduced overall costs for urban energy supply management.

2.3 Challenges to LEV uptake

Despite notable technological advances, the large-scale and impactful uptake of LEVs in cities has seen some challenges including:

Cost: One of the most significant challenges facing EVs at present is the cost of their components, particularly the battery. These cost barriers have resulted in slow EV sales in important automotive markets. In addition, uptake at large-scale citywide levels, while representing a significant market opportunity, is likely to remain a challenge unless manufacturers and partners take steps towards making these vehicles and their components more affordable.

Infrastructure: Some of the most urgent challenges to overcome with LEVs, and EVs in particular, are associated with infrastructure. There is much discussion surrounding the "chicken and egg" debate as to whether infrastructure (charge points, grid upgrades, etc.) is a necessary pre-condition for EV uptake or vice versa.

R&D and range anxiety: LEV technology has been improving over the last few years, but there are still a number of areas that need to be tackled. One issue is EV battery improvement, which will be an important innovation that will further reduce cost, increase the life of the battery and increase the range of EVs. In terms of range anxiety, both real and perceived limitations can hold back potential customers.

Consumer education and awareness: Many potential customers are not familiar with the basic characteristics of owning or driving LEVs. Given the relatively limited uptake of LEVs to date, many cities do not have comprehensive education campaigns where these LEV purchasing and ownership basics are explained and encouraged.

As a result of the challenges, cities have an important role to play in employing innovative strategies and policies to help overcome market barriers to LEV expansion. Many bold steps have already been taken around the world, with cities taking the lead, to expand LEV uptake in city fleets and make them attractive to mainstream consumers.

The best practices below provide an overview of some of the approaches being used successfully by cities to overcome these challenges.

3 GOOD PRACTICE APPROACHES FOR INCENTIVISING LEVS

3.1 Categories of best practice

Based on city actions in incentivising urban LEV uptake, the following categories have been identified as ones in which documented best practices can assist cities in reaching LEV goals and overcoming the challenges mentioned above:

- **Focus on city fleets**
- **Provide infrastructure**
- **Tackle purchasing and technology**
- **Provide incentives**
- **Introduce zoning**
- **Work with partners**
- **Focus on education and awareness**

3.2 Focus on city fleets

To overcome early market barriers, cities can often find opportunities in their own fleets where LEV uptake can be more cost effective and actionable. This can help demonstrate the market potential for manufacturers and possibly even shift current market conditions in favour of LEVs by demonstrating their feasibility in the city. Important examples of city fleet niche markets include urban bus fleets, freight transport and taxis, which are major contributors to congestion, pollution and emissions in urban centres.

Case study: *Shenzhen - New Energy Vehicles (including Electric Buses)*

Summary: Shenzhen pioneered an innovative business model, successfully mobilising vehicle manufacturers, grid companies, bus and taxi operators, policy research institutes and citizens to promote its *New Energy Vehicles (NEVs) Plan* in 2009 (NEVs include electric, hybrid and fuel cell vehicles). Since then, the city's strategy has been to prioritise electrified public transportation (buses and taxis), and then gradually transition private cars to NEVs as well. This project has set two main goals: a short-term goal of adding 35,000 NEVs in the next two years, and a long-term goal of reaching a zero-emission ecosystem.

Results: The project has already shown substantial results. The NEV fleet has enabled Shenzhen to reduce CO2 emissions by 160,000 tonnes between 2009 and 2013, which has led to the city being ranked in the top 10 for best air quality in China, according to China's Environment Agency. As of December 2013, 3,050 mostly electric buses (accounting for 20% of the public buses in Shenzhen), and 850 pure electric taxis (accounting for 6% of the taxis in Shenzhen) were operating in the city.[xii] In addition, there was significant investment in infrastructure with Shenzhen installing 57 new energy bus charging stations by September 2009.

Reasons for success: In 2009, Shenzhen was approved by the central government to be one of many cities for piloting new energy vehicle technology and infrastructure. With this support from the Chinese central government, along with commitment and actions by the regional and city level governments, a multifaceted approach to LEV development, production, and uptake was launched. By focusing on city fleets in the first instance and encouraging other sectors to gear their operations towards LEV uptake in the city through policy shifts, LEV uptake was expanded more rapidly. By recognising the importance of involving other sectors and stakeholders, including citizens, Shenzhen has been able to successfully transition to new energy vehicles across diverse markets and fleets. For example, Shenzhen provides an open platform to encourage communication between companies and organizations in related industries, spurring better relationships between public and private partners on new energy vehicles.

When/why a city might adopt an approach like this: Since cities generally have more control over their own fleets, such as buses, the uptake of LEVs in these fleets provides a major opportunity to reduce emissions and improve air quality in urban centres. Cities with influential municipal or regional governments with control over these assets can look to Shenzhen's NEV Plan to develop an integrated approach to significantly increase LEV uptake.

3.3 Provide infrastructure

Infrastructure development is one of the ways in which a city can play a crucial role in driving LEV uptake, including for both public and private LEVs. With infrastructure in place for charging, LEV purchasing becomes a more viable option over traditional fossil fuel vehicles. Not only does more infrastructure allow for greater use of LEVs throughout a city, the visibility of this infrastructure can also create public awareness of the technology and serve as a way to reduce range anxiety. As cities grow, it will be important to determine best practices for incorporating LEV infrastructure considerations in large-scale urban development, retrofitting, and maintenance programmes. In addition, it will be important to understand the optimal placement of this infrastructure, as well as the best type of infrastructure based on city needs.

Case study: *Kyoto - Managed Charging*

Summary: Clustering can happen when multiple electric vehicles charge in a community and place a strain on local distribution grids. This can be an obstacle to LEV uptake, especially amongst private vehicle users. Alleviating this concern would help reduce barriers to LEV uptake caused by clustering. Centrally managed charging discourages EVs from charging at peak times, avoiding problems such as power overloads and feeder congestion. Kyoto's EV Charging Management Centre has been established to study how to control demand from EVs by collecting data on EVs in operation through a 3G network. The centre then relays information to drivers advising them when to recharge, and at which charging stations, to avoid congestion and grid disruption. The Management Centre operates alongside home and building energy management systems to optimise energy supply and demand for the entire community.

Results: Starting in the winter of 2012, the Centre's demand response requests showed high conformance rates among participants. During the peak demand period, trials found a recharging volume reduction of approximately 12% in the summer of 2013. With strong conformance rates, the system has proven itself to be both user-friendly and capable of reducing system overload. This is helping the city ensure that people are not discouraged from purchasing EVs due to issues with recharging the vehicles.

Reasons for success: Participants who adhere to demand response requests from the Centre are given incentives to continue their practices, such as gaining shopping points at participating establishments. While the Centre's requests help manage EV charging more efficiently, adding additional incentives makes it even likely that the requests will be followed.

When/why a city might adopt an approach like this: Cities that have an interest in establishing charging infrastructure to support LEVs but are concerned about clustering and exhausting city electrical grids can employ management strategies similar to Kyoto's EV Charging Management Centre.

Case study: *Koto City - EV Ready Buildings*

Summary: The growth in EV uptake will require, and be supported by, the provision of necessary electrical infrastructure for new developments. Koto City (a special ward located in the Tokyo Metropolis in Japan) is taking steps to make such provisions available in new buildings and major redevelopments, thereby curtailing costs that could be brought on by the need for future retrofitting. With significant construction taking place in preparation for the 2020 Olympics, city planners are anticipating urban realities several decades ahead and incorporating expectations into construction happening now and in the immediate future. City planners, policymakers, and stakeholders have recognised the preparation for a major event as an opportunity worth harnessing.

Results: Located on the waterfront of Tokyo Bay, 80% of Koto's rapidly growing population lives in multi-unit dwellings. Approximately 70 new apartment blocks are being constructed yearly with more expected, especially with the upcoming 2020 Olympics.[xiii] Under these revised planning guidelines, which went into effect in 2010, parking lots for new condos are encouraged to have sufficient EV charging facilities for more than 10 percent of the total parking spaces. The number of EV ready new multi-unit dwellings increased from 5 out of 29 in 2010 to 49 out of 263 in 2013, laying the foundation for increased LEV uptake in the area.[xiv] This type of initiative was a first for Japan.

Reasons for Success: The city anticipated more favourable conditions for LEV uptake in the future and recognised that installing charging infrastructure would curtail retrofitting costs by simplifying the installation process, making better provision for the changing needs of its citizens, and avoiding any future disruption by accounting for future LEV uptake at the time of new construction. By seizing the opportunity that came with development for the Olympics, the city was able to incorporate provisions for long-term trends and future realities.

When/why a city might adopt an approach like this: Cities, especially those that are anticipating major urban redevelopment and new builds for a growing population and/or hosting global events, can use the approach of Koto City to new construction projects, ensuring future LEV uptake is accounted for now. In addition, cities that want to create a better environment for electric vehicles, but may not necessarily be anticipating major new development, can incorporate LEV infrastructure into planning guidelines as a requirement for all new and large-scale development to cut potential future costs.

3.4 Tackle purchasing and technology

When it comes to purchasing LEV technologies, major obstacles often relate to high battery (and ultimately vehicle) prices and charging times. At the moment, battery costs for LEVs have made them disproportionately more expensive than their fossil-fuel counterparts. Furthermore, recharging them often takes longer than refuelling traditional vehicles, which has contributed to the prevailing view that batteries are inefficient fuel sources, especially for vehicles that travel long distances. As such, directly tackling the high price and recharging of batteries can help address one of the primary reasons for the lack of LEV uptake in cities in public and private fleets, despite progress in technological development and municipal interest. To do so, it is important for cities to understand the specificities of fleet operations, and how batteries and their prices can be altered to fit associated needs. By examining specific characteristics of fleets and identifying the most appropriate type, cities can work closely with other sectors to develop plans for LEV uptake among both private and public fleets even in the absence of favourable wider market conditions.

Case study: *Amsterdam - Battery Sizing*

Summary: Fleet vehicles operating at airports provide an ideal option for battery alterations that can reduce the overall price of LEVs. With this in mind, Amsterdam's Schiphol Airport has electrified its fleet with reduced battery sizes to account for the limited travel required of the vehicles.

Results: At the Schiphol Airport in Amsterdam, 8,000 vehicles make up the airport fleet, with typical fixed routes being less than 4 kilometres per day for these vehicles. This entire fleet has been electrified in a very short time, and Schiphol Airport was certified carbon neutral in 2014 by the Airport Carbon Accreditation group, largely due to the Airport's carbon reduction plan and the emphasis it placed on road transportation.[xv]

Reasons for success: With short rides at low speeds, it was more economical to electrify the airport fleet to reduce maintenance costs and increase emissions performance.

When/why a city might adopt an approach like this: Fleet vehicles operating at airports are a good example of fixed route vehicles where battery alterations can help reduce the overall price of LEVs and increase uptake. Cities that can identify such niche markets can look towards Amsterdam's electrification of Schiphol vehicles as a strong model for rapid uptake of LEVs.

Case study: *Hangzhou - Battery Swapping*

Summary: In the Chinese city of Hangzhou, a battery swapping mechanism has been developed for the city's electric taxi fleet. The city has developed a system that allows for depleted batteries to be rapidly exchanged for fully charged ones, allowing taxis to continue their routes without time-consuming refuelling requirements.

Results: The daily coverage of one electric taxi is about 230 kilometres, resulting in an energy demand of two to three fully charged batteries each day. The total time for the semi-automated battery swap to take place is five minutes and currently involves two workers and a robotic arm. When at the main switching hub, batteries are capable of storing power and balancing grid loads by allowing grid operators to manage the recharging process. With this dimension to the process, recharging can be managed efficiently through service providers that smooth demand of recharging and battery swapping by directing the flow of vehicles to facilities with low traffic throughout the day. The City of Hangzhou's goal is to reach a total fleet of 1,000 taxis, with 500 already delivered. With the uptake of 1,000 EV taxis, Hangzhou's road transportation system will be one step closer to achieving a zero-emission outcome.[xvi]

Reasons for success: With increased efficiency and convenience for drivers and passengers, battery swapping is becoming more common in other cities such as Shenzhen, Beijing, and Qingdao and among other city fleets, such as electric buses. The energy inputs required for these battery-swapping systems have not had an impact on local electrical grids due to demand management activities being undertaken. To implement such a programme successfully, the City of Hangzhou has worked closely on battery manufacturing and logistics standards with the Chinese State Grid Corporation.[xvii]

When/why a city might adopt an approach like this: Cities with taxi fleets that have the needed infrastructure for battery swapping, such as an extensive electric grid and energy resources that will not be compromised with the addition of larger charging stations, could learn from Hangzhou's example, and how it has been replicated and expanded upon in cities throughout China.

3.5 Provide incentives

Incentive programmes administered by local authorities, often in partnership with business and manufacturing sectors, can establish the conditions under which purchasing and using LEVs can become more attractive. These city-led programmes can include subsidies, fee and tax waivers, user-specific technology changes, licensing assistance, etc. and can make LEV purchasing and uptake more feasible by directly addressing local contexts and challenges. These challenges can be as diverse as high tariffs on foreign goods that hinder LEV purchasing, or environmental challenges such as topography or extreme weather conditions that may not be favourable to current LEVs on the market.

Case study: *U.S. Cities – ICCT Report*

C40 collaborated on the 2015 "Assessment of leading electric vehicle promotion activities in US cities" report, which was issued by the International Council on Clean Transportation. The report analyses 25 major U.S. metropolitan areas representing over 42% of the U.S. population, 46% of auto sales, 65% of new electric vehicle registrations, and 53% of the public electric vehicle charging infrastructure in the U.S. The report found that cities around the U.S. are committed to diverse actions regarding LEV uptake. From these various actions, best practices are emerging that show how to increase LEV uptake in cities under early market conditions.

From the report, the data shows a significant relationship between cities with active electric vehicle promotion programmes that include diverse incentives – such as San Francisco, Atlanta, Los Angeles, San Diego, Seattle, Portland, and Riverside – and greater electric vehicle uptake. Examples of incentives programmes include purchasing subsidies for private users, such as in Riverside and San Francisco where city governments provided purchasing incentives ranging from $400 to $2,500. As market conditions have altered with increased LEV purchasing, both cities have reduced their subsidies over time. Other examples of incentives programmes, found in cities such as San Francisco and New York, focus on usage such as providing users with carpool lane access and preferential parking at workplace and public areas. More information on the incentives programmes for each city can be in the ICCT Report (link in the 'Further Readings' section).

While the focus of the ICCT report is on U.S. cities, the relationship between incentives and LEV uptake can be observed in cities around the world. An example of city action to increase LEV uptake through incentive programmes is provided below.

Case study: *Oslo - Incentives Programme*

Summary: Oslo aims to become carbon neutral by 2050[xviii] and 60% of the city's emissions currently come from transportation. Despite unique challenges ranging from market conditions to topography and weather, Oslo has transitioned towards a sustainable transportation system through their high uptake of LEVs. Notably, this transition has taken place in only a few years, and was primarily achieved through a comprehensive incentives programme. Oslo's incentives programme (which also includes national incentives) comprises zero rated purchasing tax and no VAT charged on electric vehicles, free pass on toll roads, access to bus and taxi lanes, free parking on municipal parking spaces, and free travel on ferries that are part of the national highway system.

Results: LEV incentives were put in place, and at the same time Oslo increased its LEV infrastructure by adding over 1,000 charging stations. As a result of this multifaceted strategy, the number of registered electric vehicles in the Oslo area increased from 4,000 in 2012 to close to 30,000 by the end of 2015. Oslo has also seen a 100% increase in the number of electric vehicles passing through the Oslo central toll ring since 2012.[xix] In addition, across Norway, the total number of registered hybrid vehicles increased by more than 250% last year.[xx] Today, Oslo has the world's highest number of EVs per inhabitant. According to the City of Oslo, the uptake of LEVs, encouraged through incentive policies and programmes, has contributed to a 35% reduction in average CO2 emissions since 2012.

*Reasons for success***:** By providing favourable user incentives that relate directly to the challenges and realities of vehicle use in the area, such as dealing with congestion, Oslo was able to encourage residents to purchase LEVs for private use. By providing these usage and purchasing incentives, as well as the concerted development of LEV infrastructure, LEVs became a more cost-effective options.

When/why a city might adopt an approach like this: Cities that face a variety of challenges to LEV uptake (like high purchasing costs, congestion, and accessible charging) can use Oslo's comprehensive approach to simultaneously address many obstacles and ensure a significant LEV scale-up.

3.6 Introduce zoning

Demarcating urban areas to restrict the movement of fossil-fuel vehicles has the potential to transform the relative attractiveness of LEVs. Charges or bans on polluting vehicles can help increase the purchasing of LEVs while reducing pollution and emissions in urban centres.

Case study: *London - Charging Zones to Promote ULEVs*

Summary: London introduced a Congestion Charge zone in 2003, aimed at reducing high traffic flow in the centre of the city. The Congestion Charge zone covers 21 square kilometres (about 8.1 square miles) and operates on weekdays between 07:00 and 18:00 where most drivers must pay a daily charge of £11.50. Full electric, hydrogen and plug-in hybrid vehicles qualify for a 100% Ultra Low Emission Vehicle (ULEV) discount, providing an incentive to own and operate these types of vehicles. This discount is complemented by a range of initiatives elsewhere in London that include free on-street parking and electric charging to encourage early adoption.

Since 2008, London has operated one of Europe's largest Low Emission Zones (LEZ). Covering the entire city, the LEZ specifies emission requirements for heavy vehicles driven in the city all year round. These requirements have gradually been strengthened by the Mayor of London to correspond with the introduction of tougher European vehicle emission standards. The daily charge for non-compliance is up to £200 a day.

In 2015, the Mayor of London committed to introduce the world's first Ultra-Low Emission Zone (ULEZ) to address London's Nitrogen Dioxide challenge and encourage the use of cleaner vehicles. For the first time, emission standards will be set for every vehicle driven in central London, including the five million cars seen over the course of a year. These standards will be fully operational by 2020, 24 hours a day and 7 days a week, in the same area as the Congestion Charge. Smaller vehicles will be charged £12.50 a day and larger vehicles £100 a day if they do not comply. As part of the ULEZ package, the Mayor of London also set strict requirements for new buses, taxis and private hire vehicles to use ultra low emission technology and create demonstrator fleets. When combined, these specific fleets are forecast to contribute around half of the road transport emissions leading to poor air quality in the city's centre.

Results: London now holds a higher market share of ULEVs than in the UK overall and it has seen significant decreases in airborne particulate matter, achieving European legal limits for the first time.[xxi] The Central London ULEZ is expected to almost halve exhaust pollutants from road transport in 2020 and a third of the bus fleet will operate with either electric-hybrid or zero emission technology. Specific licensing requirements for taxis from 2018 and private hire vehicles from 2020 will see an accelerated introduction of ULEVs joining these fleets over time.

London has taken the approach to operate two distinct schemes that address congestion and pollution in the city. Whilst many public fleets, such as taxis and buses, are exempt from the Congestion Charge, they are however covered under the ULEZ scheme. During the launch of the Congestion Charge, extra buses and routes were introduced to take advantage of the increased traffic speeds and the greater demand for public transportation. Most recently, increased road capacity is being used to transform London's cycling infrastructure.

*Reasons for success***:** The Congestion Charge, LEZ and upcoming ULEZ are part of a comprehensive package of measures to reduce congestion and improve air quality, as well as provide incentives, resources and opportunities for city residents and industry stakeholders to transition to cleaner and more efficient vehicles. Regular drivers to the Congestion Charge zone save over £2,900 per year by switching to a full-electric or plug-in hybrid vehicle and they will also comply with the ULEZ requirements, avoiding a further £4,500 cost per year. This comprehensive approach has also provided economic opportunities, creating a positive feedback loop that has facilitated conditions for even more ambitious aspirations. Thanks to the Mayor of London's policy, London's iconic black taxis will benefit from an unprecedented makeover -- manufacturers have since responded with a £300m investment to research and produce ultra low emission taxis.

When/why a city might adopt an approach like this: Cities that aim to alter the relative advantage of fossil fuel vehicles to make ULEV purchasing more cost effective can look towards London's systematic zoning efforts for valuable insights. Cities may face significant challenges from private-sector stakeholders who will find it difficult to transition their activities to account for these new conditions. As such, the introduction of zones will be most effective in cities with strong relationships with other sectors to help address potential concerns, and in cities with significant power and authority to implement such a strategy effectively. Overall, initiatives to clean up the oldest vehicles whilst incentivising the latest technologies will help to ensure a balanced approach.

3.7 Work with partners

Cities can work in partnership with other sectors, such as private, development, or financial entities, to provide better conditions for the uptake of LEVs. Working together on multiple fronts allows for more comprehensive strategies that can directly tackle various aspects of the LEV economy such as policy, behaviour patterns, cost effectiveness and financial attractiveness.

Case study: *Paris - Autolib*

Summary: Through a partnership between the city and the Bolloré industrial group, Paris provides a car share service that offers a convenient and cost-effective alternative for residents facing increased congestion and costs of car ownership. The car share programme consisting of all-electric vehicles also provides a pathway to overcoming market barriers for electric vehicles by getting potential consumers more comfortable with using EVs.

Results: Autolib consists of over 2,500 electric vehicles, 4,710 charging stations, and has attracted over 6.6 million trips and 178,000 individual subscribers. These milestones have in turn resulted in the reduction of 7,575 tons of CO2 from 2011 to 2014.

Reasons for success: By transforming the relationship between people and cars, and making transportation a more communal activity, the Autolib programme has paved the way to decreasing the economic and environmental burden of personal transport. At roughly 20,000 persons per square kilometre, Paris is one of the densest cities in the world – four times the density of London.[xxii] Problems of pollution associated with high vehicular usage in a dense city made an electric vehicle driven Autolib programme an ideal solution to alleviate these concerns, while providing better transportation outcomes for users. In addition, the Autolib programme has proved that EVs are highly suitable for use in this type of urban setting.

When/why a city might adopt an approach like this: The Paris Autolib programme provides a notable blueprint for how obstacles to urban LEV uptake can be overcome through partnerships with other providers. Cities who face limited EV use due to pricing and congestion may find the Autolib project a good example of how partnerships can lead to new relationships between city residents and cars.

Case study: *Brussels - Logistics*

Summary: In Brussels, the freight company TNT, in partnership with the European Union's 'Strategies and measures for smarter urban freight solutions (STRAIGHTSOL)', piloted a mobile depot delivery system to reduce emissions from first and last mile freight logistics. The mobile depot is a custom-designed trailer that is fully fitted with depot facilities ranging from loading docks to data entry equipment. In the morning the trailer is loaded with all deliveries for the day at the main TNT depot outside Brussels. It then travels to a central location in the city where last mile deliveries and pick-ups are undertaken by electric tricycles and electric vans.

Results: This project has drastically reduced the emissions that came from multiple slow moving fossil-fuel vans entering the city each day to make deliveries with a 57% reduction in diesel kilometres per stop and 400 kilograms of CO2 reduction each week.[xxiii]

Reasons for success: With the close collaboration between the city and private sector, a niche for vehicular activity was identified in which an intervention would be effective. This collaboration has the potential to flourish further, and policy incentives for further uptake of LEVs in the logistics process are also being explored.

When/why a city might adopt an approach like this: Cities with significant freight operations, especially those that have sizeable and centralised distribution centres within or near city boundaries, can benefit significantly from an intervention similar to that of Brussels. Furthermore, this programme has helped deliver better business outcomes and reduced operation costs as well.

3.8 Focus on education and awareness

While early market conditions are often hindrances to large-scale LEV uptake, conditions can be highly variable depending on the policy, economic, and spatial conditions of cities. Cities can in fact have conditions in place that make LEV purchasing for private use a cost-effective option, but consumer perceptions of their unaffordability or technological limitations may hinder wider uptake. In this scenario, it becomes important to develop city-specific education and awareness programmes to overcome misperceptions and empower consumers and stakeholders to shift to LEVs.

Case study: *Shanghai - International Electric Vehicle Demonstration Zone*

Summary: Responding to a low level of awareness, confidence, and understanding of LEVs, and aiming to spur development of an urban electric vehicle market, Shanghai established an EV Demonstration Zone. This zone is devoted to helping individuals understand how and why LEVs are a viable option for transportation, with a variety of important benefits. This is helping overcome existing barriers to LEV adoption. Under an agreement with LEV manufacturers, up to 160 vehicles of different types are available for test-drives at the Zone, along with educational programming, one-on-one interviews, and outreach. Data and feedback provided by visitors is then relayed to manufacturers and other stakeholders to elicit more specific and strategic promotional initiatives that directly address the concerns of potential buyers and Shanghai residents.

Results: The EV Zone has already provided up to 80,000 free test-drives, along with an established fleet of 160 cars from which it acquires performance and usage data. The Zone has plans to expand into the Pudong region in the near future.

*Reasons for success***:** The Zone is dedicated to establishing strong integration of LEVs and people's lives in the city through direct and interpersonal interactions that cater to the specific needs and concerns of visitors to the Zone. The usage data collection strategy has led to significant achievements in educating drivers about the links between their daily usage patterns and the benefits of purchasing LEVs, popularising the free test-driving opportunities the Zone provides city residents.

When/why a city might adopt an approach like this: Cities where purchasing LEVs is viable, even under early market conditions, or that have potential for significant presence of the LEV industry can look towards the Demonstration Zone as an option for integrating production, awareness raising, and adoption of LEVs.

4 FURTHER READING

A number of C40 partners have published comprehensive best practice guides that include information on incentivising LEV uptake in cities. Links to some of these are below:

- EV CASEBOOK 2014: http://www.cleanenergyministerial.org/Portals/2/pdfs/EVI_2014_EV-City-Casebook.pdf
- EV CASEBOOK 2012: http://www.cleanenergyministerial.org/Portals/2/pdfs/EV_City_Casebook_LR.pdf
- ICCT: http://www.theicct.org/leading-us-city-electric-vehicle-activities

[i] IPCC, 2014: http://mitigation2014.org/report/summary-for-policy-makers
[ii] IEA 2015: http://www.ieahev.org/assets/1/7/Report2015_WEB.pdf
[iii] OECD 2010: http://www.internationaltransportforum.org/Pub/pdf/10GHGTrends.pdf
[iv] IPCC 2014: http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter12.pdf
[v] IPCC, 2014: http://mitigation2014.org/report/summary-for-policy-makers
[vi] EU Action 2015: http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm
[vii] Voelcker, J. (2015). Norway's Goal: All New Cars Will Be Emission-Free By 2025 To Cut Carbon. *Green Car Reports*. http://www.greencarreports.com/news/1099324_norways-goal-all-new-cars-will-be-electric-by-2025-to-cut-carbon/page-1

[viii] "C40 Cities Clean Bus Declaration", http://c40-production-images.s3.amazonaws.com/other_uploads/images/233_C40_CITIES_CLEAN_BUS_DECLARATION_OF_INTENT_FINAL_JUNE30.original.pdf?1435685739

[ix] "Costs and Benefits of Motor Vehicle Emission Control Programs in China" http://www.theicct.org/sites/default/files/publications/ICCT_China_MVEC_benefits-costs_20150629.pdf

[x] Walton, H. et al. (2015). Understanding the Health Impacts of Air Pollution in London. Available at: http://www.kcl.ac.uk/lsm/research/divisions/aes/research/ERG/research-projects/HIAinLondonKingsReport14072015final.pdf

[xi] "Driving the Future Today: A strategy for ultra low emission vehicles in the UK" https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239317/ultra-low-emission-vehicle-strategy.pdf

[xii] "Shenzhen: New Energy Vehicle Promotion", http://www.c40.org/profiles/2014-shenzhen

[xiii] "EV Casebook: 50 Big Ideas" http://www.cleanenergyministerial.org/Portals/2/pdfs/EVI_2014_EV-City-Casebook.pdf

[xiv] "EV Casebook: 50 Big Ideas" http://www.cleanenergyministerial.org/Portals/2/pdfs/EVI_2014_EV-City-Casebook.pdf

[xv] "More airports working to actively reduce CO2, Schiphol certified carbon neutral" http://www.airportcarbonaccredited.org/library/press-releases.html

[xvi] "Biggest Bus & Taxi Order Ever for BYD", http://evobsession.com/biggest-bus-taxi-order-ever-byd/

[xvii] Competing and Co-existing Business Models for Electric Vehicles: Lessons from International Case Studies, http://www.cambridgeservicealliance.org/uploads/downloadfiles/2015%20January%20-%20Business%20Models%20for%20EV.pdf

[xviii] "Oslo: electric vehicle capital of the world (Norway)" http://www.eltis.org/discover/case-studies/oslo-electric-vehicle-capital-world-norway

[xix] "The Electric Vehicle Capital of the World" http://www.c40.org/case_studies/the-electric-vehicle-capital-of-the-world

[xx] The Norwegian Road AS (OFV AS): http://www.ofvas.no/registreringsstatistikker/category391.html

[xxi] Jones, Alan M., Roy M. Harrison, Benjamin Barratt, and Gary Fuller. "A Large Reduction in Airborne Particle Number Concentrations at the Time of the Introduction of "Sulphur Free" Diesel and the London Low Emission Zone." *Atmospheric Environment* 50 (2012): 129-38.

[xxii] "Revolutionary ideas needed to unclog Paris streets", http://www.ft.com/cms/s/0/86fba2ce-a60c-11e4-9bd3-00144feab7de.html

[xxiii] "TNT is delivering packages by bike in Brussels (Belgium)", http://www.eltis.org/discover/news/tnt-delivering-packages-bike-brussels-belgium-0

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